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TRANSACTIONS

OF THE

AMERICAN SOCIETY *of* AGRICULTURAL ENGINEERS

REPORT OF THE
TWELFTH ANNUAL MEETING
CHICAGO
DECEMBER, 1918

VOL. XII

TRANSACTIONS

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AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

REPORT OF THE TWELFTH ANNUAL MEETING
CHICAGO, DECEMBER, 1918
WITH BUSINESS RECORDS

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TWELFTH ANNUAL MEETING

American Society of Agricultural Engineers

OPENING SESSION

December 30, 1918

Mr. F. M. White, chairman of the Committee on Local Arrangements, called the meeting to order.

PRESIDENT'S ANNUAL ADDRESS

DANIELS SCOATES,[1] President Amer. Soc. A. E.

The signing of the armistice has caused the world to change again its program, and instead of bending all its efforts toward war it is to return once more to peaceful pursuits. The agricultural engineer has a busy time, no matter whether the world is at peace or at war. He has even a busier time when his country is at war, and it might be well to stop for a few minutes and review his work for the past year.

The agricultural engineer has first of all answered the call of his country. The A. S. A. E. has twenty-seven members in service. These men have gone to all branches of the service; most of them, however, were connected with some part of the army where their engineering knowledge and skill was of benefit to the cause—such as motor transport service, aviation, ordnance, tank corps and engineer corps. We are proud of their record.

The engineer connected with educational institutions has been called on to train men for various branches of the service. Perhaps the greatest amount of work done was training truck and tractor drivers, together with repair specialists. Thousands of men went to France for this work trained under the supervision of the agricultural engineer.

The engineers connected and cooperating with manufacturing plants were also called on to train men; and in addition, to manufacture in their factories, instruments of warfare, rather than the peaceful instruments of ordinary times. They were called to redesign their peaceful implements in order that they might become death-dealing devices—perhaps the most widely known example of this was the conversion of the caterpillar tractor into a tank, and military authorities tell us it was this machine which helped to bring the war to such an early end. This they all did gladly, and their record is certainly one to be proud of.

[1] Agricultural College, Mississippi.

A big job was accomplished by the good old U. S. A. in bringing this war to so speedy a conclusion, and we are proud that the agricultural engineer had his part in it.

Now that the war is over our part is not done. Many disabled soldiers are returning and they must be trained for new occupations. A great deal of this work will fall to the agricultural engineers, as many of the soldiers are going to want to go to farms, which will mean that they are to receive training in agriculture. A course in agriculture these days is far from complete unless agricultural engineering gets its share. Shortage of labor is to continue for some time, hence farmers must use newer and larger machines. The tractor must be utilized to a greater advantage. This calls for the agricultural engineer to institute educational work along these lines, such as gas engine, tractor, and farm machinery short courses.

War is a friend of improved farm machinery and motors, in that it shows the advantages to be derived from the use of machinery; it broadens the entire world because of an intermingling of its people; and it shortens the supply of labor, which makes it necessary for men to use labor saving tools.

There is no doubt in the speaker's mind but what the greatest year for agricultural engineers is just ahead of us. The stage is set and the people are ready for a big year's work, and it remains only for the actors—of which you, Mr. Agricultural Engineer, are one—to take advantage of the wonderful opportunity.

OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING

The passing of L. W. Page, director of the Office of Public Roads and Rural Engineering, came as a shock to all who knew of his excellent work. While Mr. Page was not a member of this particular organization, he was at the head of the Government work along this line. The vacancy left by Mr. Page will no doubt be filled before long by Secretary Houston. It would be materially to the advantage of the agricultural engineers of this country if the appointee was a member of this organization and in sympathy with the entire field of agricultural engineering. I would, therefore, urge each member, if he had not already done so, to write to his congressman urging him to use his best efforts to have such a thing brought about.

FINANCING THE SOCIETY

I appointed a special finance committee this year to look into the methods of financing this and other like societies, and to make a report with recommendations to this meeting. The time is here when we should have a permanent secretary, and I trust this committee will tell us how it can be done.

PUBLICITY

Every president soon learns the need of more publicity for this organization. I appointed a publicity committee this year and it has done excellent work; however, we are still suffering from lack of publicity. A permanent secretary would no doubt help this matter.

MEMBERSHIP

The secretary tells me that there are 50 new members enrolled this year. This is as well or perhaps a little better than has been done in late years, yet the membership could stand a much larger increase. We must make the society so vital that an agricultural engineer cannot well live without it.

THE HANDBOOK

The speaker's ambition was to have a handbook started during this year. This was not accomplished, due to the large amount of war work that the members of the Data Committee were called on to do. However, it is hoped that this project will be pushed during the coming year, as there is no one thing, other than a permanent secretary, that will so help to forward this organization's interests as a handbook.

I wish to take this opportunity to thank all officers, committees, and others who have assisted in this year's work.

DRAFT TESTS OF FARM MACHINERY[1]

E. J. Stirniman,[2] Member Amer. Soc. A. E.

Comparatively little data have been published on the drawbar pull of the various farm implements other than the plow. Recently more interest has been devoted to power required to operate a few of the other farm machines. You have, no doubt, noticed many of the tractor manufacturing companies rate their tractors in terms of plow bottoms as well as horse power. This brings about the question, 'What is a certain tractor's pulling capacity in terms of the various farm machines?" In order to answer this and similar questions, it is no more than reasonable that we discontinue part of the plow testing or tractor testing with plows and devote more time and energy determining the drawbar pull required to operate a few of the other farm implements.

There are a number of reasons why the plow is favored for testing purposes; but, in summarizing, it seems as though man in this respect is similar to electricity "following the lines of least

[1] Paper read by C. K. Shedd, Member Amer. Soc. A. E.
[2] Washington State College, Pullman, Wash.

resistance." During the past year Professor James B. Kelley and myself conducted at the Iowa State College, Ames, Iowa, a series of drawbar tests on the power required to operate various farm machines. The following report is a brief review of the tests as taken from our original report.

METHOD OF CONDUCTING TESTS

As far as possible, the machines operated were used on the farms, and they were tested as adjusted for actual farming conditions. Most of the field machines were of the horse drawn types; however, in these tests they were pulled by tractors or trucks.

INSTRUMENT USED TO DETERMINE DRAFTS

The instrument used to determine the drafts of the machines was the Iowa dynamometer. The dynamometer was calibrated before starting, and again after part of the test had been taken. A curve was plotted from which we could easily read the pull in pounds by measuring the height or average heights as indicated on our dynamometer card.

HITCHES

The dynamometer was hitched direct between the tractor or truck on light draft implements; but on the heavier draft machines, a reducer hitch was used. The reducer hitch was arranged so only one-third the draft was effective through the dynamometer. This eliminated the possibility of exceeding the dynamometer's spring capacity.

MACHINE CLASSIFICATION

The machines were classified according to the agricultural engineer's classification for farm implements. This method was used to facilitate filing, and also to give a standard system of referring to the test and others which may be conducted later.

IMPLEMENTS TESTED

1 Full disk harrow
1 Spader disk harrow
1 Cutaway disk harrow
1 Spike tooth harrow
1 Culti-packer land roller
1 Corrugated land roller
1 Grain drill
1 Corn harvester
1 Potato digger
1 Manure spreader.
1 Engine gang plow, (3-14 in. bottoms) not reported.
1 Engine gang plow, (2-14 in. bottoms) not reported.

Disk Tests.

(Classification Number .411-B)

The disk tests were run on oat and corn stubble fields on the Ed Morris farm 2 mi. N. and ½ mi. W. of Ames, Iowa, and also on corn stubble and alfalfa sod fields, fall plowed, on the College farm north of Squaw Creek.

SPECIFICATIONS AND DESCRIPTION:

Full Disk (P. & O. Star)

Manufactured by Parlin Orendorff Company, Canton, Ill.

The machine used was a single section three lever 10 foot full disk, having 20 disks 16 inches diameter and spaced 6½ inches apart. The total weight of disk, including tongue truck, was 710 pounds.

Spader Disk (Canton)

Manufactured by Parlin Orendorff Company, Canton, Ill.

The machine used was a single section three lever 10-foot spader disk having 20 disks 16 inches in diameter and spaced 6½ inches apart. The total weight of disk, including tongue truck, was 680 pounds.

Cutaway Disk

Manufactured by The Cutaway Harrow Company, Higgamin, Conn.

The machine used was a double section cutaway 6½ foot disk having one rigid frame over both sections.

The angle of the gangs are adjusted by two levers. Each gang has 6 disks 16 inches in diameter and spaced 6 inches apart.

The total weight of machine was 540 pounds. This machine had been used for several years but was in fairly good condition.

OPERATING CONDITIONS FOR DIFFERENT FIELDS

Oat stubble field:

The soil was a black sandy loam, covered with stubble about 6 inches high. The field was comparatively level. The surface was hard and dry, such that the disks would penetrate only 1½ to 2 inches deep when set at their maximum angle, and loaded with additional weight. The work was not satisfactory.

Corn stubble field:

The soil was a black sandy loam having a dry compact surface which was in a good tillable condition. The field was comparatively level. The disk penetrated from 2 to 3 inches deep when loaded with additional weight. The stubble was 6 to 7 inches high and free from large weeds. The rows were ridged 3 to 4 inches, due to cultivation. The work was satisfactory when working across the ridges.

Corn stubble field, fall plowed:

The soil was a black sandy loam, slightly rolling and in a good tillable condition. The disk did favorable work, cutting 4½ to 5 inches deep. The field was plowed 6 to 7 inches deep about 2 weeks before the test was conducted. A few of the corn stubs were exposed, which caused the disk to clog occasionally.

Old alfalfa sod, fall plowed:

The field, which was slightly rolling, consisted of a black sandy loam. The sod was a combination of alfalfa and bluegrass, having a larger proportion of the latter. The disk did fairly satisfactory work, cutting about 4 inches deep. The west end of the field was practically level and the soil was in a good tillable condition, but the east end had an abrupt slope which was rather wet near the bottom.

Note: The speeds of the different disks on the same field are approximately the same as shown by the individual tables.

The following table shows the manner in which the data were compiled. The table heading, card number, time, distance and remarks were tabulated in the field as the tests were conducted.

DYNAMOMETER TEST DATA OF FULL DISK ON OAT STUBBLE FIELD

(TABLE No. 1)

Additional Wt.=215 lbs. Total Wt.=925 lbs. (Spring Deflection=815 lbs. per inch.)

Card No.	Time: Min. and Sec.	Distance	Miles per Hour	Card Area	Card Lgth	Card Ave. Ht.	Total Draft Lbs.	HP	Remarks 10/12/17
1	0-37.8	167′ 9″	3.022	8.61	15.15	.5683	463.16	3.72	Disk set, angle=19° -0′ first notch
2	1- 8.4	338′ 6″	3.38	21.0	31.75	.6614	539.0	4.85	Disk set, angle=19° -0′ first notch
3	0-21	99′ 6″	3.29	5.03	8.812	.570	464.55	4.07	Disk set, angle=19° -0′ first notch
4	0-52	238′ 6″	3.13	14.05	23.313	.602	490.63	3.93	Disk set, angle=19° -0′ first notch
5	0-27	132′ 8″	3.342	7.13	11.06	.644	524.86	4.67	Disk set max. angle=20° -30′
6	0-39	174′ 3″	3.28	11.03	16.125	.684	557.46	4.86	Disk set max. angle=20° -30′
7	0 49	239′ 0″	3.28	9.50	22.8 1	.415	338.22	2.96	Disk set, angle=13° 0′, 4th notch from front
8	1-2	309′ 0″	3.39	13.33	27.75	.480	391.2	3.58	Disk set, angle=13° 0′, 4th notch from front
8¼	0-34	167′ 0″	3.35	2.57	14.7	175	142.6	1.27	10/13/18 Disk set straight, no angle
8½	0-23	121′ 4″	3.598	2.25	11.3	.190	154.85	1.48	Disk set straight, no angle

DYNAMOMETER TEST DATA FOR SPADER DISK ON OAT STUBBLE FIELD

(TABLE No 2)

Additional Wt.=215 lbs. Total Wt.=895 lbs. (Spring deflection=815 lbs. per inch.)

Card No.	Time Min. and Sec.	Distance	Miles per hour	Card Area	Card Lgth	Card Ave. Ht.	Total Draft Lbs.	HP	Remarks
9	1-12	370′ 0″	3.495	30.18	34.15	.8855	721.68	6.72	Disk set at max. angle=15°-30′
10	0-22	107′ 8″	3.331	8.81	9.7	.908	740.0	6.56	Disk set at max. angle 15°-30′
11	0-15	68′ 10″	3.12	3.86	6.12	.631	514.2	4.27	Disk set at angle =10° 0′ 3rd notch from front
12	0-26.1	111′ 0″	2.882	5.93	10.48	.567	462.0	3.54	Disk set at angle =10° 0′ 3rd notch from front
13	0-54	203′ 0″	2.56	15.79	9.02	8.29	673.6	4.58	Disk set an angle =13°-0′ 2nd notch from front
14	0-37.5	165′ 8″	3.0	12.23	15.875	.773	630.0	5.03	Disk set an angle =13°-0′ 2nd notch from front
15	0-13.5	52′ 10″	2.662	1.64	4.43	.37	301.55	2.14	Disk set straight no angle
16B	0-33	153′ 0″	3.158	3.93	14.5	.271	220.86	.185	Disk set straight no angle

COMPARISON TABLE OF SPADER AND FULL DISK TESTS ON OAT STUBBLE FIELD

Summary of Tables 1 and 2

(TABLE No. 3)

Spader Disk

Notch of Lever.	Angle of Gangs	Depth Disked	No. of Feet of Level Ground Tested	Miles per Hour	Ave. HP on Level Ground	Per Foot of Width: Wt.	Per Foot of Width: Ave. HP
Maximum	15° 30′	1½-2″	477′ 8″	3.413	6.64	89.5	.664
2	13° 0′	"	368′ 8″	2.78	4.8	89.5	.48
3	10° 0′	"	170′ 10″	3.001	3.9	89.5	.39
Last	0°	"	205′ 10″	2.91	1.162	89.5	.1162

Full Disk

Notch of Lever.	Angle of Gangs	Depth Disked	No. of Feet of Level Ground Tested	Miles per Hour	Ave. HP on Level Ground	Per Foot of Width: Wt.	Per Foot of Width: Ave. HP
Maximum	20° 30′	1½-2″	306′ 11″	3.311	4.765	92.5	.476
1	19°	"	844′ 4″	3.205	4.392	92.5	.439
4	13°	"	548′ 0″	3.335	3.245	92.5	.324
Last	0°	"	288′ 4″	3.474	1.375	92.5	.137

Note: (Fields having a 2 percent grade or less are classed as level for all disk tests.)

EXPLANATION OF RESULTS

A comparison of the test data of table 3 shows that the full disk requires less draft per foot of width than the spader disk, when doing the same quality of work on an oat stubble field.

This is shown more conclusively by comparing the tests of the disks when set at the same angle, 13°. The spader disk, although weighing 3 pounds less per foot, required .156 more horse power per foot of width to operate it. This is also shown by comparing the data when the gangs were set at their maximum angles. The full disk set at an angle of 20° 30′, required .476 horse power per foot of width, while the spader disk set at a smaller angle, (15° 30′) required .664 horse power, or a difference of .188 horse power in favor of the full disk.

The draft required per foot of width for both disks when set straight (no angle) was approximately the same for the given field conditions.

Each card was marked immediately after the run. The remarks, as place in the field, set of machine, etc., were also put on the cards as well in the proper column of the report sheet. In order to avoid using considerable space, it will be necessary to eliminate most of the field data tables, and give only those of comparison and summary.

TABLE No. 6

Spader Disk

Notch of Lever	Angle of Gangs	Depth Disked	Test on level Ground		Miles per Hour	Per foot of width	
			No. of feet	Ave. HP		Wt	Ave. HP
Maximum	15° 30′	2″-3″	521′ 8″	5.44	2.683	89.5	.544
2	13° 0′	"	359′ 3″	4.42	2.621	89.5	.442
4	7° 15′	"	109′ 4″	3.48	3.383	89.5	.348
0	0°	"	157′	3.57	3.85	89.5	.357

Full Disk

Notch of Lever	Angle of Gangs	Depth Disked	No. of feet	Ave. HP	Miles per Hour	Wt	Ave. HP
Maximum	20° 30′	2″-3″	450′ 6″	3.54	2.953	92.5	.354
3	15° 30′	"	153′ 6″	3.325	2.862	92.5	.335
4	13°	"	187′ 2″	3.06	2.962	92.5	.306
0	0°	"	129′ 0″	2.11	2.924	92.5	.211

COMPARISON TABLE OF CUTAWAY AND FULL DISK TESTS ON CORN STUBBLE FIELD, FALL PLOWED

Summary of Tables 7 and 8

(TABLE No. 9)

Cutaway Double Disk

Notch of Lever	Angle of Gangs	Depth Disked	Test on Level Ground		Miles per Hour	Per Foot of Width	
			No. of Ft.	Ave. HP		Wt.	Ave. HP
Maximum	18°	4½-5"	211' 0"	2.725	1.549	108.46	.416
3	11°	"	184' 9"	2.145	1.71	108.46	.324
4	5°	"	306' 8"	1.826	1.852	108.46	.281
0	0°	"	187' 4"	.97	1.232	108.46	.149

Full Disk

Notch of Lever	Angle of Gangs	Depth Disked	No. of Ft.	Ave. HP	Miles per Hour	Wt.	Ave. HP
Maximum	20° 30'	4½-5"	572' 11"	4.073	2.127	88	.4073
3	15° 30'	"	299' 7"	4.185	2.106	88	.4185
4	13°	"	148' 3"	3.655	2.137	88	.3655
0	0°	"	99' 6"	2.46	2.059	88	.246

COMPARISON TABLE OF CUTAWAY AND FULL DISK TESTS ON ALFALFA SOD, FALL PLOWED

Summary of Tables 10 and 11

(TABLE No. 12)

Cutaway Disk

Notch of Lever	Angle of Gangs	Depth Disked	Test on Level Ground		Miles per Hour	Per Foot of Width	
			No. of Ft.	Ave. HP		Wt.	Ave. HP
Maximum	18°	3½-4"	457' 3"	3.445	1.87	108.46	.53
3	11°	"	242' 0"	2.626	1.889	108.46	.405
4	5°	"	184' 7"	2.006	1.878	108.46	.308
0	0°	"	91' 10"	1.74	1.955	108.46	.268

Full Disk

Notch of Lever	Angle of Gangs	Depth Disked	No. of Ft.	Ave. HP	Miles per Hour	Wt.	Ave. HP
Maximum	20° 30'	3½-4"	250' 1"	4.096	1.94	88	.409
3	15° 30'	"	115' 7"	3.5	1.967	88	.35
4	13° 0'	"	179' 10"	3.635	2.027	88	.363
0	0°	"	133' 6"	2.9	2.14	88	.29

EXPLANATION OF RESULTS

The draft per foot of width of the double cutaway disk on old alfalfa sod, fall plowed, was not much greater than that of the full single disk, and the work done by the double disk was more satisfactory.

SUMMARY TABLE OF DISK TEST DATA
(Table No. 13)

Field	Full Disk				Spader Disk				Cutaway Double Disk			
	Angle of gangs	Mi. per Hour	Per foot of Width		Angle of gangs	Mi. per hour	Per foot of width		Angle of gangs	Mi per hour	Per foot of width	
			Wt.	Ave. HP			Wt.	Ave. HP			Wt.	Ave. HP
Oat Stubble	20° 30	3.311	92.5	.476	15° 30	3.413	89.5	.664	....	....	....	....
	19° 0	3.205	92.5	.439	13° 0	2.78	89.5	.48	....	....	....	....
Corn Stubble	20° 30	2.953	92.5	.354	15° 30	2.683	89.5	.544	....	....	....	....
	15° 30	2.862	92.5	.335	13° 0	2.621	89.5	.442	....	....	....	....
Corn Stubble Fall Plowed	20° 30	2.127	88	.4073	....	....	....	....	18° 0	1.549	108.46	.416
	15° 30	2.106	88	.4185	....	....	....	....	11° 0	1.71	108.46	.324
Alfalfa Sod	20° 30	1.94	88	.409	....	....	....	....	18°	1.87	108.46	.53
	15° 30	1.967	88	.35	....	....	....	....	11°	1.889	108.46	.405

Harrow Test
(Classification No. .411-c)

Test of Spike Tooth Harrow on corn stubble field, fall plowed, College Farm north of Squaw Creek, November 8, 1917.

Manufactured by The International Harvester Company, Chicago, Ill.

SPECIFICATIONS AND DESCRIPTION:

The harrow consists of four 6-foot sections. Each section is composed of five bars having seven teeth each, with the teeth extending 5 inches below the bar. It has a stiff steel frame. The angles of the teeth are adjusted by a lever. The four corner teeth have curved upper ends which act as runners for transportation when the teeth are thrown parallel to the ground. The total weight of the harrow is 548 pounds.

OPERATING CONDITIONS

The test was run on a corn stubble field which was fall plowed 6 to 7 inches deep. The soil was a black sandy loam and fairly dry. The field was free from large hard clods but the surface contained corn stubs that had not been well covered. The soil worked down well and adhered to the harrow to a very slight extent. The work was very satisfactory. For the first test four sections were used placed in pairs and tandem; and in the second test the rear pair was removed.

DYNAMOMETER TEST DATA OF A SPIKE TOOTH HARROW

(TABLE NO. 14)

(Spring deflection=815 lbs. per inch)

Card No.	Time Min. and Sec.	Distance in feet	Miles per hour	Total Draft lbs.	HP	Remarks	
1	0-41.5	110-5	1.82	762.7	3.69	Used 4 Sections	Max. angle of teeth being nearly a right angle
2	0-39.5	105-7	1.817	706.	3.41		
3	0-38	104-9	1.873	764.7	3.80		
4	0-29	83-6	1.96	611	3.18	2 wide and 2 deep	7th notch from rear giving a 37° angle
5	0-25	71-10	1.955	620	3.22		
6	0-32.5	89-5	1.87	336	1.67	Used 2 Sections	7th notch from rear giving a 37° angle
7	0-33	91-3	1.878	340.5	1.7		
8	0-38	107-3	1.922	447	2.28	2 wide and 1 deep	maximum angle
9	0-41	117-7	1.95	445	2.31		
10	0-57	159-9	1.906	435	2.2		max. angle up 3-4% grade

EXPLANATION OF RESULTS

Only one make of spike tooth harrow was tested. A comparison between single and double harrowing was made.

The maximum average horse power from tests 1, 2 and 3 was 3.633 (HP) when pulling the four sections hitched in pairs with pairs in tandem, with the teeth adjusted at their maximum angle of 90°. With the same hitch as described above, but with the angle of teeth set at 37° the average horse power was 3.20 (HP) as shown by tests 4 and 5.

The average maximum horse power from tests 8 and 9 when pulling one pair of sections with the teeth set at their maximum angle of 90° was 2.295 HP, but with the same hitch, with the angles of teeth changed to 37° the average horse power was 1.338 (HP) as shown by tests 6 and 7.

Subtracting the average maximum horse power of the tests of the two sections which was 2.295 (HP) from 3.633 (HP), the average maximum horse power from the tests of the four sections, gives the average maximum horse power 1.338 (HP) required to pull the second pair of harrows over the same ground.

The difference in draft between the first and second harrowing was considerably less when the teeth were set at an angle of 37°. In this case the draft for the four sections was 3.2 (HP) and the draft for the two sections being 1.685, gives a difference of .17 (HP) for the second pair of harrows; whereas, for the test of the maximum angle of teeth, the difference was .953 (HP).

The average maximum draft for single harrowing was 2.295 HP or .191 HP per foot of width; whereas, the draft for the second harrowing was 1.338 or .111 HP per foot of width.

The average draft for single harrowing when teeth were set at an angle of 37° was 1.685 HP or .140 HP per foot of width, while the draft required for the second harrowing was 1.515 or .125 HP per foot of width.

Land Roller Tests

(Classification No. .411-F)

Test of Culti-Packer and Corrugated Rollers on the E. Morris farm 2 miles N. ½ W. of Ames, Iowa.

October 6, 1917.

Culti-Packer-Roller

Manufactured by Dunham Company, Berea, Ohio.

SPECIFICATIONS AND DESCRIPTION:

The roller consisted of two corrugated sections, the front section having 21 wheels, 15 inches in diameter and the rear 22 wheel 22 inches in diameter. This machine is seven feet wide, weighs 1040 pounds, and being new was in good condition. The additional weight used was a 145 pound man.

Corrugated Roller

Manufactured by The Wilder Strong Implement Company, Munroe, Mich.

SPECIFICATIONS AND DESCRIPTION:

The roller consisted of one 8-foot corrugated section having 32 wheels, 18 inches diameter. The machine was new and in good condition. It weighed 1210 pounds and carried a 145 pound man.

OPERATING CONDITIONS

The test was run on a level wheat field recently seeded. The soil was a black sandy loam, the surface of which was medium lumpy, having 5 to 6 inch clods which were dry but mellow. The result of the work was very satisfactory.

CORRUGATED ROLLER (WILDER STRONG)

(Table No. 16)

Card No.	Time Min. and Sec.	Distance in feet	Miles per hour	Card Area	Card Lgth	Card Av. Ht.	Total Draft lbs.	HP	Remarks 10/6/17
10	0 57.2	169	2.006	4.615	10.65	.427	348	1.85	
11	2 20	367	2.05	12.63	34.10	.371	281.36	1.53	
12	2 50	357	1.948	14.09	33.25	.424	345.56	1.79	

RESULTS OF ROLLER TESTS

(Table No. 17)

Name of roller	Minimum HP: HP	Minimum HP: Miles per hour	Minimum HP: HP per foot of width	Maximum HP: HP	Maximum HP: Miles per hour	Maximum HP: HP per ft. of width	Average HP: HP	Average HP: Miles per hour	Average HP: HP per ft. of width	Total weight per foot of machine
Culti-Packer	.78	1.00	.111	2.7	2.982	.385	1.527	1.818	.218	169.28
Wilder Strong Corrugated	1.53	2.05	.191	1.85	2.006	.231	1.723	2.001	.215	169.37

Grain Drill Tests

(Classification No. .412-C)

Test of superior drill on a potato field ¾ mile south of campus, November 23, 1917.

Manufactured by Superior Drill Company, Springfield, Ohio.

SPECIFICATIONS AND DESCRIPTION:

The drill used was seven feet wide and had 12 single disk furrow openers, 13 inches in diameter, spaced 7 inches apart. The force feed device was of the double run type. The machine was old but in good condition and weighed 830 pounds.

OPERATING CONDITIONS

The test was run on a level well compact seed bed from which a crop of potatoes had been removed. The soil was a black sandy loam and in a good condition for seeding.

DYNAMOMETER TEST DATA OF SUPERIOR GRAIN DRILL

(TABLE No. 18)

(Spring Deflection 815 lbs. per inch)

Card No.	Time Min. and Sec.	Distance in feet	Miles per hour	Total draft lbs.	HP	Remarks 11/23/17
1	0–30	114–4	2.594	173	1.19	Max. depth 2½" drilling 2 bu. of oats per acre.
2	0–33	112–0	2.516	167.2	1.12	Max. depth 2½" drilling 2 bu. oats per acre.
3	1–22	271–3	2.253	205	1.23	Drilling 2 bu. per acre and 2" deep.
4	0–54	177–8	2.234	67.9	.404	Machine in gear but furrow openers out of ground.
5	0–15	42–5	1.93	100.6	.515	Machine out of gear and furrow openers out of ground.

EXPLANATION OF RESULTS

The field conditions were such that no doubt the minimum horse power required to operate this drill is given in the above data. As no other machines were tested or tests run under other field conditions, the above data stands without comparison.

The only explanation I can give for the varying results is that due to the slight variation in the condition of the surface of the field.

CORN HARVESTER TEST

(Classification No. .413-B)

Test of McCormick corn harvester on E. Morris farm 3 miles north of the college, November 9, 1917.

Manufactured by International Harvester Company, Chicago, Ill.

SPECIFICATIONS AND DESCRIPTION:

The machine used was a vertical binder with regular attachments, having a bundle carrier but no tongue truck. Weight 1420 pounds. The binder was in very good shape for cutting corn although it had been used for several years. A man weighing 165 pounds rode on the seat.

OPERATING CONDITIONS

The soil was firm and dry. The field was free from weeds except close around the corn hills. The corn was frosted and dry. The stand was very poor. The corn was checked and hilled medium.

DYNAMOMETER TEST DATA OF CORN BINDER

(TABLE No. 19)

(Spring Deflection 815 lbs. per inch.)

Card No.	Time Min. and Sec.	Distance in feet	Miles per hour	Total draft lbs	HP	Remarks 11/9/17
1	0-19	80-2	2.873	400	3.06	Four bundles during test.
2	0-28	111-5	2.705	299	2.15	Three bundles during test.
3	0-30	120-2	2.93	336	2.62	Four bundles during test.
4	0-20	81-8	2.776	315	2.33	Two bundles during test.
5	0-34	148-2	2.97	321	2.53	Six bundles during test.
6	0-54	242-3	3.034	276.5	2.23	Six bundles during test.
7	0-35	146-6	2.847	129.7	.982	11 16 17 Machine pulled out of gear.
8	0-32	161-7	3.438	122.7	1.12	Machine pulled out of gear.
9	0-30	144-0	3.262	190.1	1.65	Machine pulled in gear but not cutting corn.
10	0-30	151-8	3.433	244.2	2.33	Machine pulled in gear but not cutting corn.
11	0-12	80-11	3.442	230	2.29	Machine pulled in gear but not cutting corn.
12	0-20	105-0	3.571	296	2.81	Machine in gear and entire binding apparatus working but not cutting corn.
13	0-31	140-0	3.074	309	2.52	Machine in gear and entire binding apparatus working but not cutting corn.

EXPLANATION OF RESULTS

Test No. 1 in Table 19 being run in the heaviest stand of corn gives the maximum horse power that was obtained in this test. At this place in the field a bundle was collected approximately every 20 feet; whereas, in tests 2, 3, 4, and 5 a bundle was collected within a range of 29 to 40 feet.

The average of the tests was 2.5 horse power which would be a fair average for any field with conditions such as enumerated under operation conditions.

The maximum draft (863 pounds) was obtained just as the bundle was kicked out. This was found by measuring the height of the curve at the point of discharge. Comparing the average maximum draft (400 pounds) which is found in test 1, with the above maximum draft of 863 pounds shows that at the moment of discharge the draft is more than double the average.

The draft will vary from less than 190 pounds when not cutting to above 800 pounds when cutting and discharging a bundle, as shown by card 9 and the maximum as explained above.

Tests No. 7 to 13 inclusive were run on November 16th, three days after a rain, which caused the result of the tests to be somewhat higher than they would have been if completed on November 9.

Potato Digger Test
(Classification No. .413-G)

Test of elevator potato digger on a potato field ¾ mile south of campus, November 22, 1917.

Manufactured by Dowden Manufacturing Company, Prairie City, Iowa.

SPECIFICATIONS AND DESCRIPTION:

This machine was a chain bar elevator type of digger. The width of elevator was 22 inches, and of cutting edge of blade 20 inches. The machine had four wheels, two drivers and two for the tongue truck. It weighed 1040 pounds.

OPERATING CONDITIONS

The test was run on a potato field of which the crop had been removed. The soil was a black sandy loam and in a good condition for digging. The field was free from weeds.

DYNAMOMETER TEST DATA OF AN ELEVATOR POTATO DIGGER

(Table No. 20)

(Spring Deflection 815 lbs. per inch.)

Card No.	Time Min. and Sec.	Distance in feet	Miles per hour	Total draft lbs.	HP	Remarks 11/22/17
1	1-20	238-6	2.034	1239	6.68	Lever set in 4th notch from front digging 7" deep
2	1-12	124-8	1.178	1876	5.88	Lever set for max. depth digging 10" deep.
3	1-22	121-4	1.007	1881	5.01	Lever set for max. depth digging 10" deep.
4	0-25	83-2	2.234	1567	9.3	Lever set at 6th notch digging 10" deep.
5	0-18	58-0	2.19	144	.774	Machine in gear but out of ground and run on firm soil in tractor yard.
6	0-30	109-3	2.48	1793	1.13	
7	0-27	86-0	2.168	88	.507	Machine out of gear and out of ground, run on firm soil in tractor yard.

EXPLANATION OF RESULTS

This test was conducted on a clean potato field from which the crop had been removed and the surface left in a level condition. Tests 1, 2, and 3 would give what I consider about the maximum draft required for digging in fields of this type of soil. The draft would no doubt have been less in this type of soil if the rows had been well hilled up, because the soil then would be in a looser condition which would allow it to pass sooner through the shaker elevator, and also on account of the wheels running in the furrow the soil would not be lifted to such a height. The 9.3 horse power which was obtained in Test No. 4 was due to the blade striking a very compact subsoil which was probably due to shallow plowing.

Manure Spreader Test

(Classification No. .417-B)

Test of spreader top dressing oat stubble field on the E. Morris farm 2 miles N. ½ W. of Ames, Iowa, November 17, 1917, and December 1, 1917.

New Idea Spreader

Manufactured by New Idea Spreader Company, Coldwater, Ohio.

SPECIFICATIONS AND DESCRIPTION:

The spreader used had a capacity of 55 bushels and consisted of a double beater with distributer and an endless conveyer run over solid box bottom. The rate of unloading was varied by a lever which regulated the spread of the rachet mechanism. The beaters were operated by a chain and sprocket wheel drive which is governed by a lever on the left side of the driver's seat. The rate of unloading could be varied from four to twenty loads per acre.

OPERATING CONDITIONS

The test was run on a comparatively level oat stubble field. The surface of the ground was dry on November 17, 1917, but due to a heavy rain it was wet and slightly sticky December 1, 1917. The manure hauled on November 17 was short, dry and compact. This material was removed from a hog and cattle barn yard. The manure hauled on December 1 was wet straw from around a feed bunk. This manure had been deposited within two weeks previous to hauling.

SUMMARY OF MANURE SPREADER TEST RESULTS

(TABLE No. 23)

Kind of Manure	Rate of unloading	Weight		Miles per hour			Horse Power		
		Total	Net	Max.	Min.	Ave.	Max.	Min.	Av. of Load
No load out of gear		1980	0			2.12			12/1/17 .50
No load out of gear	Max.	1980	0			2.102			.741
Wet straw	Max. 17 loads per acre	4200	2220	2.51	2.143	2.204	3.74	1.98	2.94
Wet straw	Max. loads per acre	3880	1900	2.644	2.374	2.453	4.75	2.50	3.58
Loaded and out of gear		4200	2220			2.178			2.35
Yard	Max. 14 loads per acre	5570	3690	2.202	2.162	2.280	3.24	1.71	11/17/17 2.49
Yard	Max. 14 loads per acre	5315	3335	.2.048	2.102	2.084	2.82	.831	2.015
Yard	Notch 2 12 loads per acre	5430	3430	2.34	2.32	2.27	2.98	1.51	2.53
Yard	Notch 4 11 loads per acre	5320	3340	2.328	2.282	2.263	3.81	2.06	3.07
Loaded and out of gear		5315	3335			2.02	1.96	1.55	1.55

EXPLANATION OF RESULTS

In comparing the results of unloading the two kinds of manure as specified under operating conditions, the straw manure although weighing less per load required the greater draft. This would naturally be expected because wet straw manure will hang together and must be separated by the beater; whereas, dry yard manure is partially pulverized when loading.

The maximum horse power when unloading dry manure was 3.7 (HP) which was obtained when unloading at the rate of eleven (11) loads per acre. The reason for this horse power being the greatest although unloading at the slowest rate was on account of the manure being more compact and therefore required more power to pulverize it.

MAXIMUM HORSE POWER FOR MACHINES TESTED

(TABLE No. 31)

Machine	Size	Weight Machine	Weight Load	Work	Field	Max. HP	Miles per hr.
Star Full Disk	10 ft.	710	215	1½-2" deep max. angle	Oat stubble	4.86	3.23
Star Full Disk	10 ft.	710	215	2-3" deep max. angle	Corn stubble	3.82	2.87
Star Full Disk	10 ft.	710	170	4½-5" deep max. angle	Corn stubble fall plowed	4.32	2.16
Star Full Disk	10 ft.	710	170	3½-4" deep max. angle	Alfalfa sod	4.26	1.96
Canton Spader Disk	10 ft.	680	215	1½-2" deep max. angle	Oat stubble	6.72	3.49
Canton Spader Disk	10 ft.	680	215	2-3" deep max. angle	Corn stubble	6.75	3.38
Cutaway Disk	2 sec. 6'-6"	540	165	4½-5" deep max. angle	Corn stubble fall plowed	2.99	1.60
Cutaway Disk	2 sec. 6'-6"	540	165	3-4" deep max. angle	Alfalfa sod	3.64	1.93
Superior Drill (Single disk)	7-12	830	0	2 bu. A. 2-2½" deep	Potato	1.23	2.25
Potato digger (elev'tor type	......	1040	0	7-10" deep, no potatoes	Potato	9.30	2.23
Spike tooth harrow	4-6' section	548	....	double harrowing (max. angle)	Fall plowed corn stubble	3.80	1.87
Spike tooth harrow	2-6' section	548		single harrowing (max. angle)	Fall plowed corn stubble	2.31	1.95
Culti-packer roller	2-7' section	1040	145	crushing and packing	Winter wheat	2.70	2.98
Corrugated roller	1-8' section	1210	145	crushing and packing	Winter wheat	1.85	2.00
Corn binder (McCormick)	....	1420	165	crushing and packing	Corn field	3.06	2.87
New Idea Spreader	C	1980	1900	max. rate 18 loads per acre manure wet straw	Oat stubble	4.75	2.64
New Idea Spreader	C	1980	3340	11 loads per A. yard manure	Oat stubble	3.81	2.32

PLOW BOTTOM DESIGN

C. A. Bacon[1]

The bottom is the business end of the plow. Upon its performance depends the quality of the seedbed the farmer can prepare. Since the quality of the seedbed determines very largely the start a crop gets, it is obvious that a plow bottom is the vital part ofa farmer's equipment.

Usually plowing is regarded as breaking the soil into small particles and burying the surface materials. Beyond these two points the average individual understands little of the science of plowing.

When one begins to study different soil compositions, the effects of humus, lack of humus, soil fertility, moisture upon the countless soil textures, the times of the season when the farmer must plow, and what he hopes to accomplish by that plowing, the plow bottom problem assumes a complex form.

It can be asserted as fundamental that a farmer who hopes to secure the maximum results from his seedbed cannot plow his field the same in any two succeeding years. Yet, farmers go on plowing in the same way year after year, with little concern as to how their plowing is done. The big problem is to get it done one way or another.

Plow designers have been obliged to make bottoms that will approach the best work in all conditions under which farmers plow. This accounts for the vast number of different designs of plow bottoms.

If farmers could be educated to the point where they would plow the ground when it is in the right condition to be plowed, a great many of the perplexities and trials of the plow bottom designer would pass away.

Permit a digression from the subject at this point to say that when the agronomy, entomology, and mechanical departments of agricultural colleges, tractor manufacturers and plow makers get together and prepare a campaign of education to show farmers the necessity of having surplus power on the farm to do this work when conditions are right, the big question of crop production will be solved. This is a gigantic task, but nevertheless it should be undertaken, and that, too, in the immediate future.

There is a vast amount of work to be done by agricultural college professors in original research to learn why certain bottoms are better adapted than others to the soils in their respective states.

Before the days of standardization set in, the Oliver Chilled Plow Works manufactured over 750 combinations of different plow bottoms. No two of these were alike. We understand that

[1] Oliver Chilled Plow Company, South Bend, Indiana.

other plow manufacturers made an equally large number of styles and sizes. This little bit of information will serve to show that plow manufacturers have been striving for years to solve the plow bottom question.

It is a peculiar fact that in the waxy soils of Texas, plow moldboards have been made of steel, iron, glass, brass, aluminum, plaster paris, and hog hides. The peculiar part is that the plaster paris and hog hide moldboards worked more successfully in these soils than any other type of moldboard that has been invented.

SHAPE OF THE MOLDBOARD NOT THE ONLY FACTOR

Whether the shape of a moldboard has everything to do with its scouring, assuming it has the proper degree of hardness, is a question open to debate. The experiences gleaned from trying to develop a moldboard that would work successfully in the waxy soils of Texas developed so many sizes, styles, and shapes of plow bottoms that the plow bottom graveyard is full to overflowing.

These experiences must be regarded as very strong evidence that something is required other than the shape of the moldboard and the material from which it is made.

The reason given for the success of the plaster paris board is that the plaster wears away with the earth. This demonstrates that the adhesive force between the earth and the plaster is greater than the cohesive force of the plaster. It also demonstrates that the cohesive force of the earth is greater than that of the plaster paris.

The plaster wears away rapidly and the farmer is obliged to recoat his moldboard often—sometimes as often as every night. Considering that Texas farmers have different sizes and shapes of plow bottoms it is plainly evident that the shape of the bottom does not control its scouring qualities. The revolving disk is the only type of steel plow at the present time that is regarded as handling this soil successfully, but the disk plow does not scour in these soils, showing that the adhesive force of the steel disk and earth is greater than the cohesive force of the earth and the steel, and also that the cohesive force between the two is greater than the adhesive force of the earth particles.

This illustration of one Texas problem will suffice to point out the task that lies ahead of men who want to interest themselves in this work.

If it is a question of constant pressure of the soil against the moldboard, it is necessary then in the design of a moldboard to shape it so that it interferes as little as possible with the crumbling of sticky soils when turning them over.

It is the experience of anyone who has ever operated a plow to observe it scouring properly in a given field in one part of the season, and fail absolutely in another part of the same season.

All of us have seen moldboards scour in one part of the field and fail to scour in another on the same round. We have all of us seen plow bottoms scour for a few feet, stick for a few feet and then scour again. All these phenomena bring up mighty interesting points of study for the man who has to build plow bottoms. The unfortunate part of the whole proposition is the impossibility of prescribing a general panacea.

However, it has been proved that a great majority of the causes of failure to scour in some sections of the field when the ground is in plowing condition have been remedied by a change of plow bottoms and the materials from which the bottoms were made.

The plow must scour, or it will not shed the earth properly; at the same time it must crumble the soil, leaving it in a loose, friable condition, free from clods, if it is a satisfactory job of plowing.

CAUSES OF FAILURE TO SCOUR

It is far from easy to design a plow bottom that will always do these things satisfactorily. The Texas illustration must be regarded as conclusive evidence that the shape of the moldboard is not the only factor to be taken into consideration. The material from which the moldboard is made and the way it is made often have more to do with the success of the bottom than its shape. Very frequently a moldboard that from all standpoints of theory should do a better job than another type of bottom does the poorer quality of work simply because the moldboard fails to scour. This failure of the moldboard to scour can be due to a great many causes, but the chief causes are soft spots, inequalities, or depressions in the moldboard and the condition of the soil at the time of plowing.

It seems to be a well grounded theory that the successful scouring of a plow depends much upon equal pressure of the earth over all points of the moldboard and share. The plow moldboard must have the degree of hardness necessary for the shedding of the soil. This steel, again assuming that the moldboard is free from depressions, and is operating in a soil that has one of its component parts sharp silicon and plastic clay (as many of our soils do), must be harder than the silicon, or it is obvious that the sand will scratch the moldboard, and the plastic clay stick in the groove made by the silicon. Hence the plow will fail to scour.

This illustration readily serves to show that the material from which a plow bottom is made has as much to do with its scouring as its shape.

CHILLED STEEL BOTTOMS WITHSTAND EROSIVE INFLUENCES OF SILICON

This fact is what led to the manufacture of the chilled plow. It is impossible to temper steel hard enough to withstand the scratching of silicon. The search for a material that would be harder than the silicon led to the invention of chilled metal for use in plow bottoms.

This metal will withstand erosive influences of silicon and naturally will scour in soils where the steel bottom cannot. When one figures that by far the greatest percent of the soils of the United States contain silicon to a greater or lesser extent, it sometimes is a question as to whether chilled metal is not the superior material for the making of plow bottoms.

The nature of chilled metal is such that a plow bottom made from it is heavier than that made from steel, but from experiments it has been demonstrated that a chilled bottom of exactly the same shape as a steel bottom pulls much lighter draft on the team simply because of its superior faculty for scouring in gritty soils.

On the other hand, it is impossible in the manufacture of chilled metal always to be sure that the moldboards will not contain depressions, which are more easily overcome in the manufacture of steel moldboards. For that reason, where scouring is difficult in soil that is free from silicon coarse enough to scratch the moldboard, the steel moldboard is more preferable. But anyone who has been imbued with the idea that steel bottoms will entirely replace chilled, or chilled metal will entirely replace steel, must come to the conclusion, if these statements are correct, that there will always be a big field for both kinds of material.

The plow bottom is nothing more nor less than a three-sided wedge. The cutting edges of the share and landside are flat sides of the wedge. The moldboard and upper portion of the share are curved and made to invert the earth.

The curvature of the moldboard is the biggest problem for the plow designer at the present time. The fact that there are more than a thousand different combinations of curves in moldboards goes a long way in explaining the efforts of plowmakers towards producing satisfactory plows for every soil condition.

It is a peculiar fact that the designing of plow bottoms has always been done by practical men who have knowingly applied very few scientific or mathematical laws to the design of a moldboard. The work has been done almost exclusively by making certain shapes at the factory and then going into the field to see how they would work. The cut-and-try plan explains the system briefly, but in all these years plowmakers have developed from this method some remarkable bottoms.

The chief idea in the building of a plow bottom has been to make one that would pulverize the soil as much as possible with scouring. These two difficulties when they are met together are the biggest obstacles to be overcome.

No two of the original plow inventors seem to have followed the same system in their designing work, but the most common system was to make boards over dies or in the molds as closely as possible to the shape which they desired. Then the designer would take these boards into the field and study the course of the earth passing over the entire bottoms. If the earth happened not to touch a certain portion of the share or board, this indicated that that part was too low, and it was accordingly marked very carefully and taken back to the shop and that portion raised.

The edges of the moldboard were often raised or lowered, curved, or straightened as well as the rest of the board.

This process having been followed more or less by all original designers tends to show that there must be some mathematical or scientific law that controls the design of a plow bottom.

Another fact in connection with this method of designing would tend to confirm this belief.

James Oliver, in making his celebrated No. 40 plow bottom, developed an entirely different shape than did John Deere in making his first steel plow, and looking farther back into the wooden moldboard plow we find different shapes coming from different sections of the country. These variations all tend to show that different soils cannot be successfully turned with the same shape of plow bottom.

We know that John Deere experimented with his plow bottoms in clay types of soil. We know that James Oliver made his experiments in sandy soil. The radical differences in these plow bottoms should be regarded as ground work for a great deal of thought in plow bottom design.

IS LIGHT DRAFT COMPATIBLE WITH GOOD PLOWING?

Another exceedingly important phase of plow bottom design is the relation of the draft of a plow to the quality of work which the bottom does.

It always requires a certain amount of energy to produce a given amount of work. In the practical application of this law more energy is required than the work produced because of friction. The only loophole for argument centers round the definition of work. If we accept as good work in plowing, finely pulverized furrow slices, free from air spaces, and the trash well buried in the corner of the furrow, we must admit that more power will be required to do that work than if we accept as good work a furrow slice full of large clods, air spaces, and the trash half buried. This question is a mighty important one for plow designers at the present time, because everybody is talking light draft.

Accepting these premises as true, it naturally follows that the plow bottom which does the best work may require more energy or power than the one which does the least work. Hence, there must be a certain ratio between the quality of work and power required to do it. It logically follows, then, that the man who goes about boasting of a light draft plow bottom, instead of the quality of the work the bottom does, may be unconsciously confessing that it does an inferior grade of work.

From a practical standpoint, is the farmer interested in the plow bottom that pulls light or the one that pulverizes the soil into small particles?

Another side in plow bottom designing that is little known and has received but spasmodic attention is the effect of heat upon the scouring qualities of metal moldboards. One time a plow bottom designer was trying out a bottom in sticky soil. The field was wet on one side and dry on the other. The day was fearfully hot. In the morning it was observed that the plow was scouring successfully in the wettest and driest portions of the field, but where the two came together the plow refused to scour on going into the wet portion and also refused to scour on coming out. At noon the plow bottom was cleaned and left standing where the sun had a good opportunity thoroughly to heat it. The plow bottom became very warm, and the first two rounds in the afternoon the plow scoured. After that the designer encountered the same trouble he had experienced in the morning.

It is a matter of plow history that a Texas farmer devised a pan arrangement back of the moldboard, well down towards the share, to hold burning corncobs. The difficulty experienced in this device was the lack of uniform heat on all parts of the plow bottom. Those who witnessed the demonstration maintained that the moldboard scoured where the temperature was hot enough, but failed to scour on other sections of the bottom.

There may be more in this theory than some of us think at the present time, because it is a well known physical fact that heat is the best agent for separating molecules combined by adhesive force.

The man who is willing to study modern plow bottoms and soils particularly with reference to their density, their cohesive and adhesive forces, and the shape of the curves necessary to develop the force to properly pulverize the ground, will be embarking upon an endeavor that is bound to result in the greatest good, for the simple reason that it will lay a better foundation for all phases of agriculture.

(After reading his paper, Mr. Bacon showed some very interesting slides, illustrating the details of experiments conducted with different shaped plow bottoms. Some of the slides are reproduced on the following pages.)

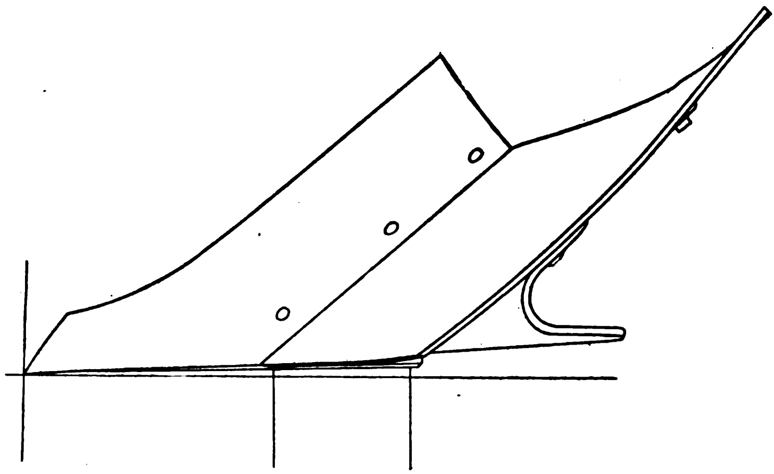


FIGURE 1

Mr. Bacon: Before going into the matter of the plow experiments, I should like to call your attention to the details of the plow bottoms shown in Figs. 1 and 2. In Fig. 1 the line parallel with the landside comes in contact with the plow point in front. The point protruding in this direction is known as the land suck, and is necessary to aid the bottom in taking and holding land.

In Fig. 2 the point of the plow resting on the straight edge parallel to the bottom of the landside illustrates the bottom suck

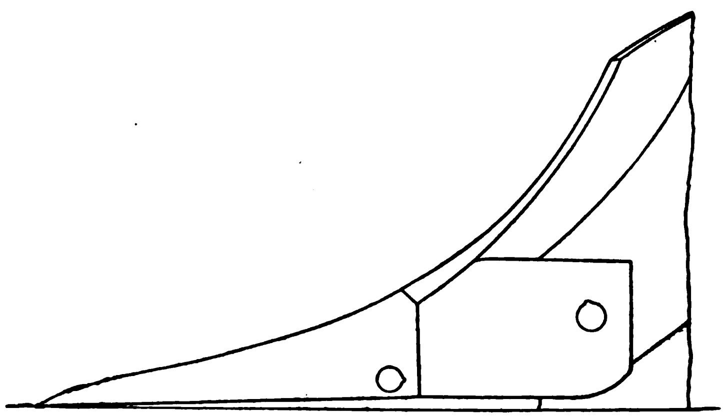


FIGURE 2

of the plow. This is necessary to help the plow penetrate the ground. One of the troubles frequently encountered when shares are sharpened by blacksmiths is that they bend the point too abruptly. The point should always be as close as possible to the shape in the illustration.

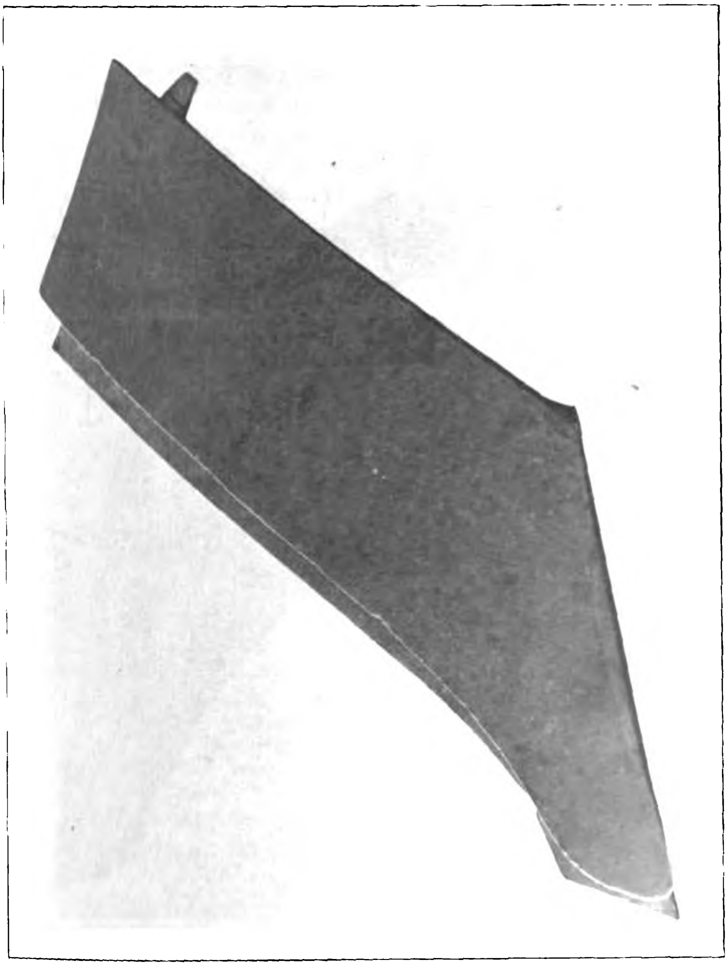


Fig. 3. Chilled share placed by the side of a new share of the same style

Figs. 3, 4 and 5 represent an experiment with a chilled and steel bottom on the same plow. The purpose of this experiment was to show the difference in the wear of hard, gritty soils upon these two metals. The steel share lasted only 8 hours, and the chilled share 51 hours.

Fig. 3 illustrates the chilled share placed by the side of a new share of the same style. Observe the small amount of wear on the point compared with the wear of the steel share shown in Fig. 4.

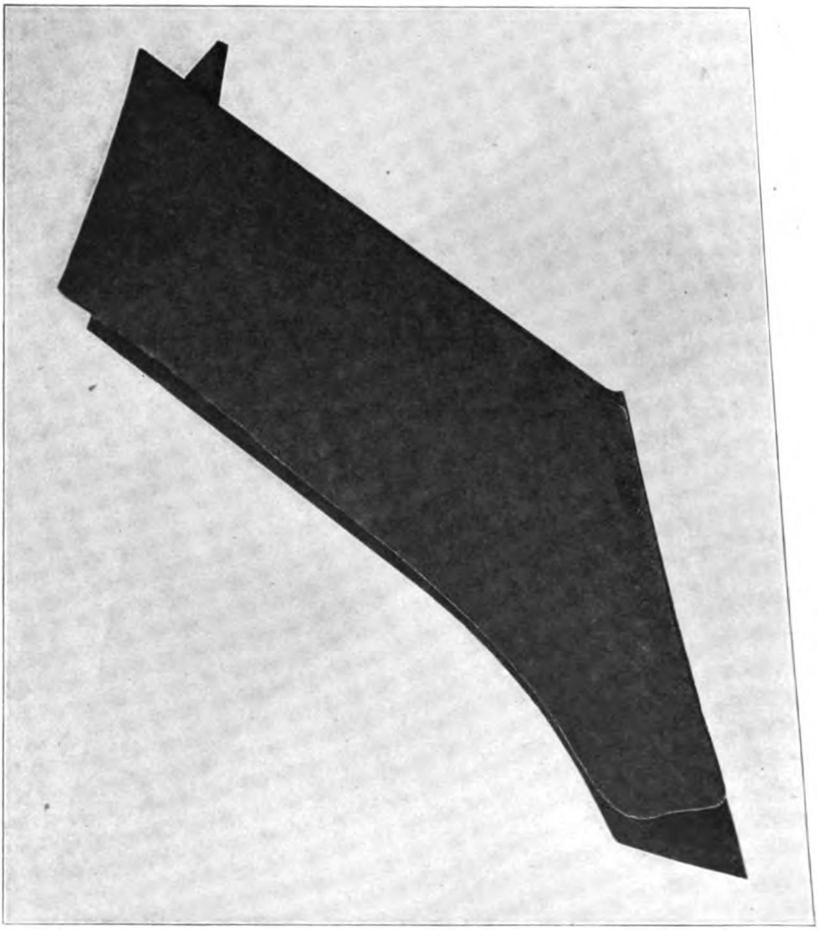


Fig. 4. Steel share after 51 hours' use placed beside a new steel share

Fig. 4 shows the steel share after 51 hours of use placed behind a new steel share exactly like it when new. Note the way the share is worn on the point. The effect of the silicon passing over the share is also noticeable.

In Fig. 5 the difference in the wear between the chilled and steel shares is very evident. Observe the greatest amount of wear appears on the underside of the point of both shares. That is one reason why the plow makers exaggerate the bottoms—to make them wear longer.

Now we come to some interesting experiments that we performed to determine the passage of the earth over moldboards. These experiments were all made in the same field—a clay soil saturated with water. We wanted a soil that would hold together so that we could get an idea of the real passage of the earth over the moldboards. The four types of bottoms used were made for widely varying soil conditions. These experiments were all made in the afternoon of the same day in order that the conditions should be as nearly uniform as it was possible to make them.

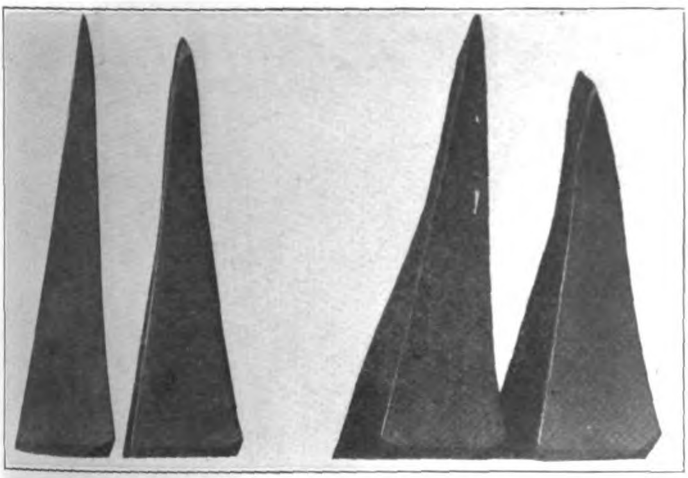


Fig. 5. Observe the greatest amount of wear appears on the under side of the point of both shares

Our first experiment was with a moldboard designed particularly for the sticky soils in the southwest. In our experiment field there was very little pulverization with this moldboard—the furrow slice seemed to be picked up and turned over without any molesting of the soil particles. It is necessary in building a plow bottom for these sticky soils that do not hold together, to make the board as straight as possible from the point of the share to a point almost three-fourths of the way to the top before an effort is made to put much curvature in the moldboard. This is done to break the soil as little as possible on account of the pressure necessary for scouring.

The fact that the soil sticks to the moldboard and yet hasn't enough force to hold itself together, gives one a good idea of the problems a plow designer is confronted with. One can take a disk plow and put it in the soil and get away with it successfully, but it doesn't scour. Our scientists have told us it is necessary to have air and proper moisture in the ground. The only way to get that is to irrigate the ground when plowing.

The next experiment was made with a type of plow radically different—one made for plowing sandy soil. This experiment was made in the same field as the other one.

We found that the clay soil was broken into large clods; even when the point of the share penetrated the ground the tendency was to break the soil into clods instead of pulverizing it.

The type of bottom used had a bluff front, in direct contrast to the gradual slope of the bottom used in first experiment, and

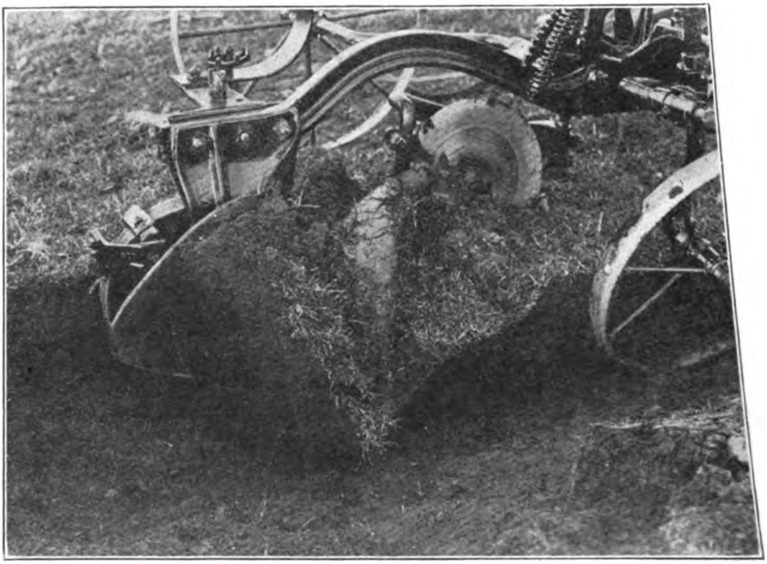


Fig. 6. Moldboard designed to plow a loamy type of soil

the results obtained showed a greater degree of breaking up of the soil than with the other moldboard.

The third experiment was with a type of plow bottom that is used almost universally through the great middle west. It is a sort of compromise between the first two bottoms—not as bluff as the last bottom used, and more so than the first. It has a different shaped share, and is designed particularly to plow a loamy type of soil. In Fig. 6 it is seen that the furrow slice is turned on edge, so that part of it rests on the furrow bottom, and the other against the top of the moldboard. The advancing movement of the plow bottom would have a tendency to crush the soil as well as turn it over.

In Fig. 7 observe that a portion of the earth is not restin

Fig. 7. Shows furrow slice cut further forward than Fig 6

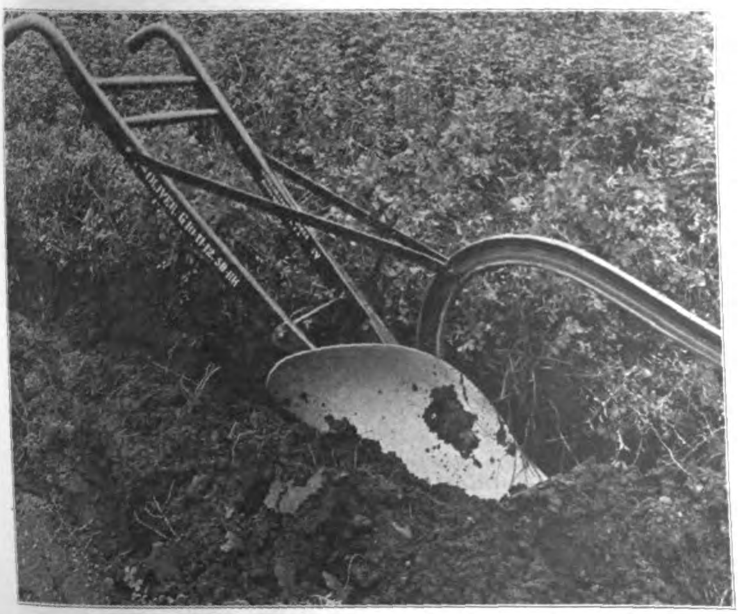


Fig. 8. Plow pulled back in the furrow showing earth sticking to moldboard in spots

against the plow bottom. This is a condition that often prevails, and is a cause for a good deal of scouring trouble on perfectly good bottoms. Anyone can see that not having pressure against the moldboard the earth will begin to stick in that place. There is enough evidence in this illustration to show that while this bottom is more particularly adapted to this soil than either of the preceding bottoms, yet it is not entirely satisfactory. Yet that same plow would scour successfully if the ground was in proper condition for plowing.

A type of bottom particularly adapted for a clay soil was used in the last experiment. This bottom forces the turned furrow slice farther forward against the earth, and puts more pressure

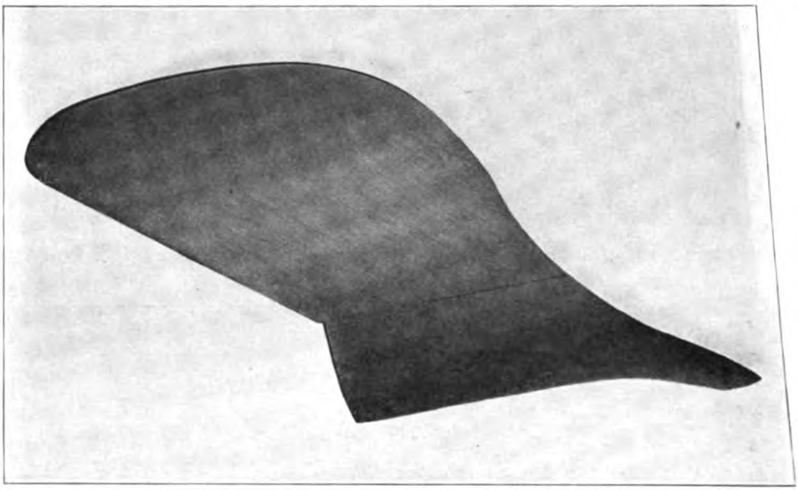


Fig. 9. Moldboard used in Fig. 8 test photographed after the test. Observe the scratchy condition of the moldboard

on it with the moldboard, which has a crushing effect. This crushing, grinding motion, where one part of the earth works right against the other, results in the pulverization of the soil. The moldboard, too, is longer than ordinary—a feature which adds to the strong pulverizing characteristics of this bottom. Naturally, that kind of a plow is going to pull harder than one that breaks the soil into clods. I would like to see every agricultural college man in the room take some plows into the field and determine whether my statement is true or false. The more we know about plow bottoms, the less argument there is going to be about the draft proposition; there will be more talk on quality.

In Figs. 8, 9 and 10 are shown the results of an experiment that was made to show the difference between the action of gritty soil on chilled and steel plows.

We often have our little arguments pro and con about the difference between chilled and steel metal. Fig. 8 shows a steel plow put in alfalfa soil. It scoured at times—not regularly, though. When we pulled the plow back in the furrow the earth was sticking to the moldboard in spots.

Fig. 9 shows this moldboard photographed after the test. Observe the scratchy condition of the moldboard, showing the abrasive influence of the sand, illustrating very forcibly the abrasive influence of gritty soils upon steel plow bottoms. It

Fig. 10. Plow pulled back, showing that no earth stuck to the moldboard

was out there for about an hour, and was literally cut to pieces by the sand.

Fig. 10 shows the chilled plow used in the same experiment for purposes of comparison. This plow scoured continuously. Observe that no earth is sticking to the bottom, and that no scratches are visible on the chilled bottom.

I will now touch on the quality of work that the different plow bottoms did. We had four bottoms in the field. We wanted to determine the difference in the draft as related to the quality of work. We hunted up a field that had clay and sand in it mixed together—you couldn't call it loamy soil, because it was mixed. The purpose of this test was to determine, if possible, whether a plow bottom that did the best work pulled heavier. The same plows were used in the test, the only difference being in the mold-board used.

The difference in the quality of work done with the poorest plow and the best plow was very marked, and served to show us that there is an immense difference in the types of plow bottoms required for doing different work. The plow bottom doing the best work pulled 14 percent heavier than the one doing the poorest work. This proves that the better the plowing, the more power required.

DISCUSSION

MR. WORTH: I'd like to ask Mr. Bacon about the position of the landside in the plows sold in the west and east. In some of the plows sold in the Mississippi valley, the landside would be vertical; in the east, the landside would be sloping in.

MR. BACON: The sloping landside is an idea of Mr. James Oliver's. He conceived the idea that in the sandy soil there was a question of draft coming up. He didn't know how to fit it. He got the idea he would make a sloping landside on his plow. He tried it out and found it worked. In plowing the sandy soil, the effect of that sloping landside is to cause the earth to drop down of itself and keep rolling over and over. You see, one has to sacrifice something to get that sloping landside. In all types of soil that are loose—that don't have the tenacity to hold together—you can do that very successfully.

MR. WORTH: The sloping landside, then, should be used in sandy soils?

MR. BACON: In sandy soils or loose soils of any kind.

MR. HAND: A few years ago I became interested in experiments on land and bottom suction plows, and of course it was not difficult to convince myself that the bottom suction was a feature of importance, but in order to test the proposition of landside success I took a chilled plow which was a nice, level-running plow, and took one plowshare, ground off all the landside until the side was flat, and also took a standard stock point which had a proper amount of land suction according to established rules. Then I had a share cast which had three-quarters of an inch of landside suction, probably four times as much as standard suction. I wanted to go entirely beyond the condition to see what the effect would be. I first adjusted the plow with the standard point of the share, getting the hitch on all running conditions accurate and the plow well balanced; then, without changing any of the hitched conditions, I changed plowshares, using the absolutely flat one, and then to one with three-quarters of an inch of land suction. I was not able to return them to dynamometer tests. I made no change at all in the conditions—simply pulled the plow back and changed the shares, taking particular care not to disturb the width of the furrow. We could not observe any difference in the dynamometer load or in the scouring action of the plow. What we expected to find was that the plow would misbehave and turn over, but we did not find that condition to be true.

Mr. Bacon: It seems to me that if there had been something wrong, your plow would not have operated correctly.

Mr. Hand: The only conclusion I could arrive at was that the landside suction was not an important point.

Mr. Bacon: It costs money to put that in and the plow manufacturers would not do it unless they had to. Where did you try that experiment?

Mr. Hand: Near Evansville, Indiana, a couple of miles out of the city, in medium clay soil—ideal conditions for chilled plow bottom work.

Mr. Bacon: Did you try it out with a chilled plow?

Mr. Hand: With a 10-inch chilled plow.

Mr. Bacon: The next time you try it with a steel plow.

Question: What do you predict to be the result of increased land suction?

Mr. Bacon: Well, I don't know that I grasp the meaning. If you increase the suction too much, it is hard to make it run right. You offset that with the hitch. There is not as much landside on a chilled plow as there is on a steel plow. I think if the experiment is continued long enough it will be found that there will be quite a difference.

Mr. Bunker: I should like to ask Mr. Bacon why it is that some manufacturers do and some do not put a slight crown in the share instead of its being in a straight line—curve the share to meet the moldboard.

Mr. Bacon: That is done on account of the necessity for having a uniform curvature for the earth to pass over the moldboard. You take a flat share and put it on a moldboard, and it will not conform to the curvature of the rest of the bottom. One of the shares in the slide was perfectly flat. You see, there has to be a certain curvature—an equal curvature—of the mold bottom. You can't change the curvature and expect to have an equal pressure. If you don't start the earth properly over the mold, you are going to have trouble.

Mr. Yerkes: It has been my observation that the chilled plow does pull a good deal easier.

Mr. Bacon: We find that the draft will range anywhere from 10 to 40 percent. I would like to have every one of the agricultural men send us some bottoms and let us demonstrate. I'd rather you wouldn't take my word for it; find out for yourself.

QUESTION: You say it is an expensive proposition to put the land suction in. How expensive is it?

MR. BACON: It is pretty hard to tell. That is part of the process of making the share. It amounts to a good deal in the manufacture of the share. It would be impossible to tell you how much.

A STUDY OF THE PLOW BOTTOM AND ITS ACTION UPON THE FURROW SLICE.[1]

E. A. WHITE,[2] Member Amer. Soc. A. E.

The moldboard plow is universally recognized as one of the oldest and most important of all our agricultural implements. Its development has been largely empirical. Men designed this implement according to their own ideas of what a plow should be, tried the machines thus produced in the field, and returned them to the shop, where alterations were made in order to better meet field conditions. This process has been repeated over and over again, furnishing mute but conclusive testimony to the lack of fundamental theory from which to work. In this connection I desire to pay my profound respects to the men who have developed our present plow bottoms. This tribute is paid not only to the plow designers now living, but also to those men now passed to the great beyond, who worked and labored on this perplexing problem. Truly no memorial which can ever be erected in honor of these great men will approach the monuments which they have builded for themselves. Generally without technical training, but endowed with courage, vision, and originality, these builders of plows produced implements which turn the soil successfully. One cannot make a careful study of our modern plows without being thrilled with admiration and respect for the men who developed them.

This work represents the result of an attempt to develop a theory for the design of plow bottoms. The desired end has not yet been attained, but many facts are unearthed which furnish an excellent basis for future work. In the beginning a large amount of time was spent in an attempt to develop a theory which could be used in designing plow bottoms if the conditions to be met were known. The problem was so complicated that this line of attack was abandoned and attention was turned to a thorough study of the present day plow bottoms. The results in this direction have been very gratifying. This study revealed the fact that the surfaces of a large majority of American manufactured

[1] A review of a paper bearing the same title published in the Journal of Agricultural Research, Vol. XII, No. 4.

[2] Department of Farm Mechanics, University of Illinois, Urbana, Ill.

plow bottoms contained sets of straight lines. This property is illustrated in Fig. 1. Through every point on the surface two lines pass which lie wholly on the surface of the plow bottom until passing off into space. Other bottoms show these same characteristics, but there is a decided break in the longitudinal lines;

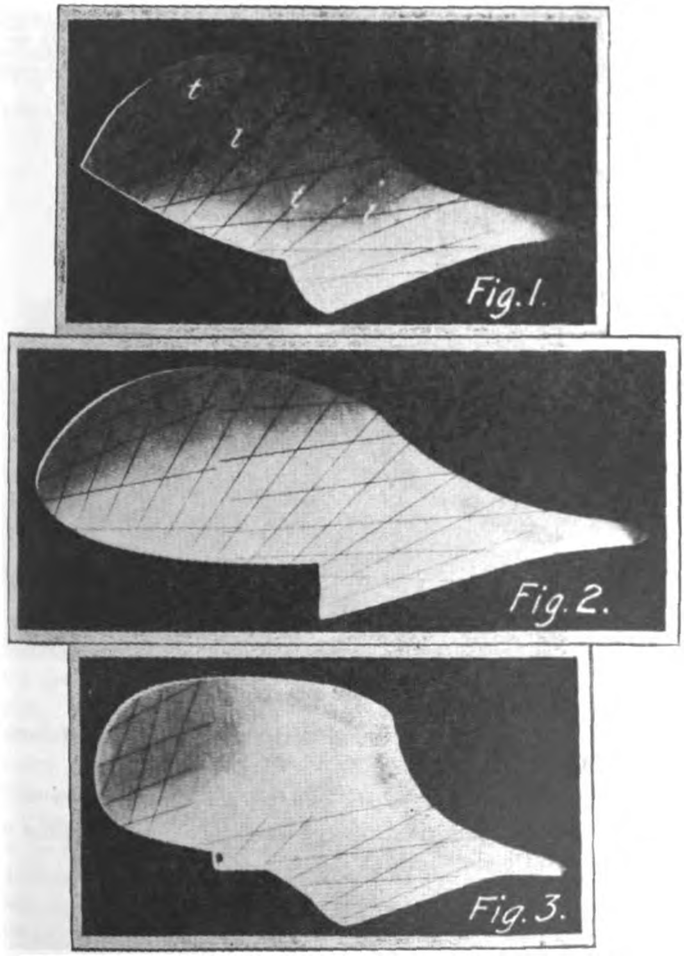
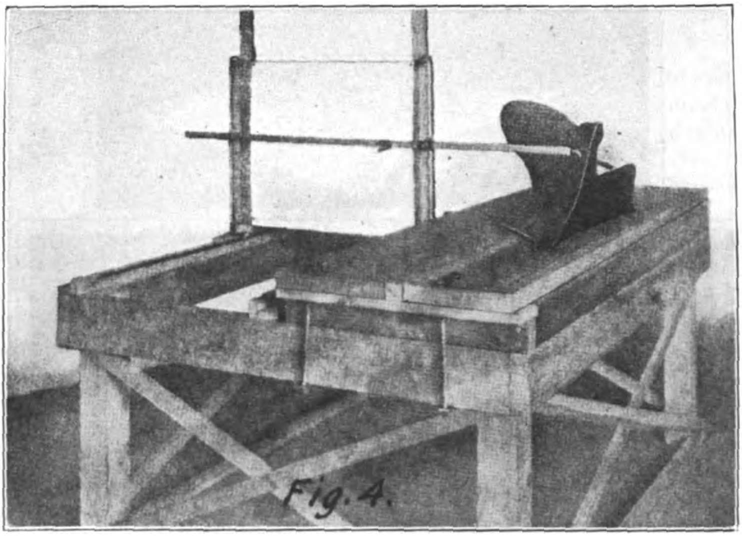


Fig. 2. In addition to these two classes there is still a third class, Fig. 3, in which the greater part of the surface of the moldboard contains no straight lines, although the share and the back part of the moldboard show the straight line characteristics the same as the bottoms illustrated in Figs. 1 and 2. To this third class belong a large number of the cast bottoms, while the forged bottoms nearly all come in classes one and two. It is very interest-

ing to note in this connection that some of the more recently developed cast bottoms have surfaces composed of straight lines.

In order to study plow bottoms the profile machine illustrated in Fig. 4 was designed and built. This machine allows movement in three directions so that the space coordinates of any point on the surface can be recorded. These lines which have been found on the surfaces of plow bottoms furnish the basis for developing an equation or equations which will describe the surface very accurately. By taking the front point of the share as the origin



Profiles machine for studying plow bottoms

of coordinates it has been found that an equation of the following form is the one desired.

$$ax^2+by^2+cz^2+2fyz+2gxz+2hxy+2lx+2my+2nz+d=0$$

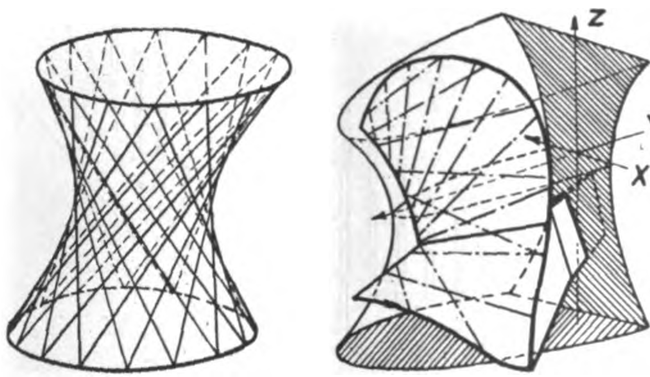
By translating and rotating the axes this general equation reduces to the following form:[1]

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}-\frac{z^2}{c^2}=1$$

which is the equation of a hyperboloid of one sheet, a vase-shaped figure illustrated in Fig. 5. The manner in which this figure fits the surface of a plow bottom is shown in Fig. 6. This study has revealed the fact that plow bottoms such as the prairie breaker and the stubble bottom, which show very little resemblance to each

[1] The constants a. b and c of this equation do not have the same numerical value as the previous equation.

other, belong to the same family from a mathematical standpoint. Thus it appears that empirical methods have resulted in developing plow bottoms, the surfaces of which are mathematically exact. That this result may not have been entirely accidental is possible, for the report of the New York State Agricultural Society for 1867 contains the following statement regarding the plows developed by F. F. Holbrook, which won a large number of prizes at the famous Utica Plow Trials: "We were interested in the most minute details of these plows by Gov. Holbrook, and the trials at Utica and subsequently at Brattleboro, Vt., showed very clearly the influence of the warped surface which is generated by his method, upon the texture of the soil. Gov. Holbrook is as yet unprotected by patent on his method, and we are therefore most reluctantly compelled to withhold a description of it, but we have no



Figs. 5 and 6. Hyperboloid and manner in which it fits plow bottom

hesitation in saying that it is the best system for generating the true curve of the moldboard which has been brought to our knowledge. This method is applicable to the most diversified forms of plows, to long and short, to broad or narrow, to high or low, no matter what the form may be, this method will impress a family likeness upon them all.

There will be straight lines in each running from the front to the rear and from the sole to the upper parts of the share and moldboard. None of these lines will be parallel to each other nor will any of them be radii from a common center. The angle formed by any two of them will be unlike the angle formed by any other two; a change in the angle formed by any transverse lines will produce a corresponding change in the vertical lines, and there will always, in every form of this plow, be a reciprocal relation between the transverse and vertical lines. Plows made upon this plan may appear to the eye to be as widely different as it is possible to make them, and yet, on the application of the straight edge and protractor, it will be found that they agree precisely in their fundamental character. The surface of the moldboard is always such that the different parts of the furrow slice will move over it with unequal velocities."

From this description it is evident that the surfaces of the Holbrook plows were portions of hyperboloid of one sheet. In commenting upon the Holbrook plows Mr. J. J. Washburn, of the Wiard Plow Co., Batavia, N. Y., stated that they did as good work as any which he has ever seen.

The theory advanced by F. H. King for the action of the soil particles as they pass over the moldboard is universally accepted and in general correct, but it needs some amplification in order to completely describe that which takes place. The studies here re-

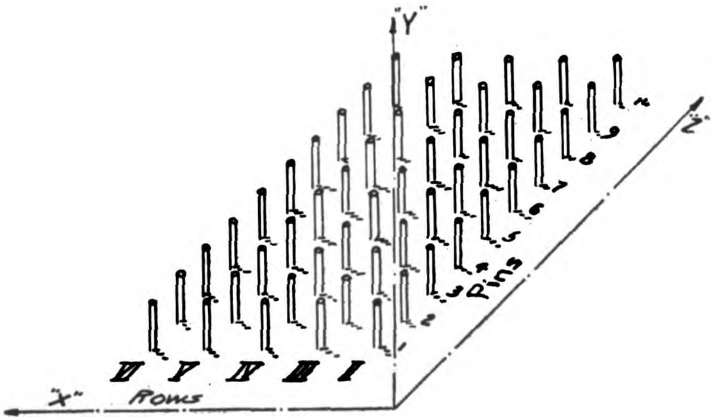


Fig. 7. Device for showing stretch and compression in furrow slice

ported on the motion of the soil particles were made on creek-bottom sod in the vicinity of Ithaca, N. Y. This soil was not well adapted to this work. It was not tough enough.

Observations of the furrow slice passing over the surface of the moldboard reveal some very interesting facts. When the furrow slice has been inverted and has come to rest it is neither stretched nor compressed, and the soil particles have the same relation to each other as before passing over the moldboard except that they are inverted.

While being acted upon by the plow the furrow slice is distorted. Cracks appear on the outside edge which increase and then close up again. In order to study more in detail the motion of the soil particles, rows of stakes, Fig. 7, were driven into the ground to the estimated depth of plowing.

In a cross section of the furrow slice, Fig. 8, the portion marked *A* would be compressed, *B* stretched, and the particles in the line *1j* neither stretched nor compressed.

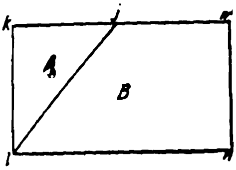
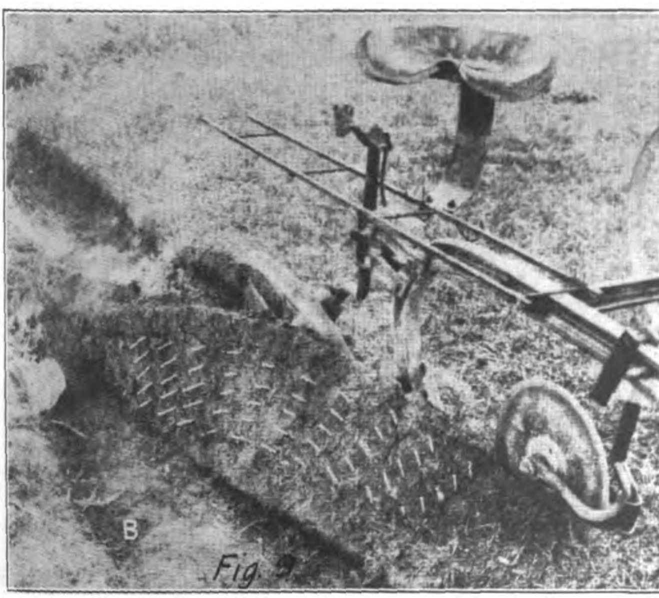


Fig. 8. Cross section of furrow slice

When the portion of the furrow slice in which the stakes were set passed upon the moldboard the stakes take the position shown in Fig. 9. By cutting away portions of the furrow slice and using the apparatus illustrated in Fig. 10 the relative position of any pin could be determined.

This study revealed the following facts:[1]

"The length of Row I, pins 1 to 10, on top of the furrow slice was greater than the length before the soil has passed upon the moldboard, indicating that this portion of the furrow slice has been stretched.



Furrow slice passing over moldboard

The length of Row I, pins 1 to 10, was greater upon the bottom of the furrow slice than its length before the soil pased upon the moldboard.

The length of Row V, pins 1 to 10, on top of the furrow slice was less than its length before the soil passed upon the moldboard, indicating that this portion of the furrow slice had been compressed.

The length of Row V, pins 1 to 10, on the bottom of the fur-

[1] From Journal of Agricultural Research, Vol. XII, No. 4, p. 163.

row slice was greater than its length before the soil passed upon the moldboard.

The lengths of Rows III and IV, pins 1 to 10, on the top of the furrow slice were approximately the same as their lengths before the soil passed upon the plow bottom, indicating neither compression nor stretching.

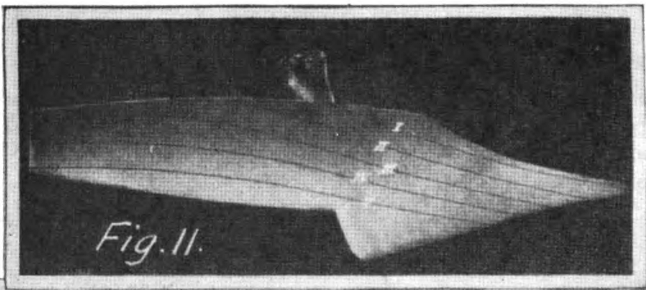


Fig. 11.

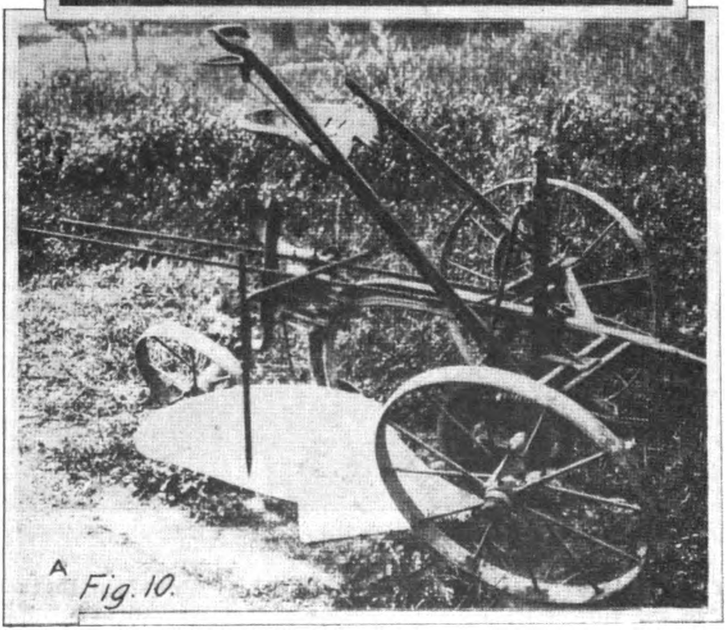


Fig. 10.

The lengths of Rows III and IV, pins 1 to 10, on the bottom of the furrow slice was greater than their lengths before the soil had passed upon the plow bottom.

The z distances of pins 10 on top of the furrow slice were approximately the same for each row, but less than the distance which the plow had moved forward.

The z distances of pins 10 on the bottom of the furrow slice were approximately the same for each row and equal to the distance which the plow had moved forward. (The coordinates of the pins at the bottom of the furrow slice were measured by cutting away a portion of the soil but leaving the pins in place.)"

When passing over the surface of the moldboard the soil particles follow very definite paths and, in some cases, these paths are plain enough so that they can be traced as shown in Fig. 11. When these paths are projected upon the plane $z=0$ the curves

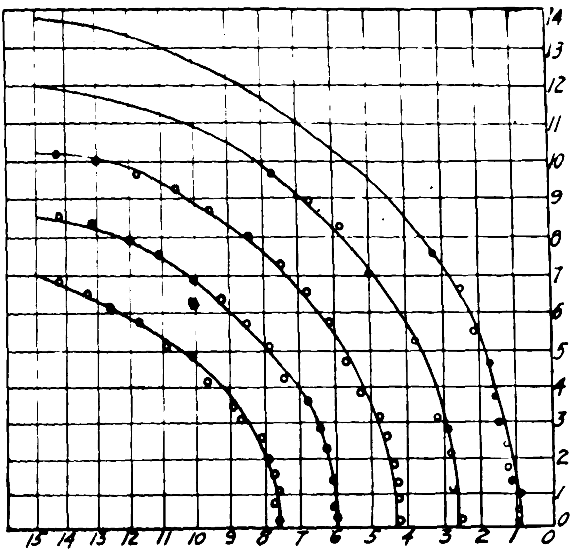


Fig. 12. Curves on plane $Z=0$

shown in Fig. 12 are secured, which can be described by equations of the general form:

$$ax^2+by^2+lx+my+d=0$$

When these soil paths are projected upon the plane $y=0$ the curves shown in Fig. 13 are secured, which can be described by equations of the general form:

$$ax^2+bz^2+lxz+mx+nz+d=0$$

The information regarding plow bottoms here presented furnishes an ample basis for believing that there is a mathematical form to which the surface of the plow bottom should conform. This being the case, it should be possible to develop a theory which will serve as a basis for the design of plow bottoms. The empirical designer will always play a most important part in developing plow bottoms. A proper theory would make the work more exact and furnish a basis for a study of the mechanics of plowing.

DISCUSSION

Mr. Bunker: What sort of a curve would be desired if the moldboard were a plain surface?

Mr. White: In studying the history of plows, it is surprising how many forms of mathematical surfaces have been supplied. Take Thomas Jefferson's plow, which is the same as the form used here. Jefferson took a straight line along here (drawing an imaginary line). He ran one straight line along here, took a point here and set it up, and drew a straight line from here to here (indicating). Every form of worked surface has been tried, and practical experience indicates today that there is a varied stipulation between the proper form of plow bottoms. I have been interested this fall to see our scouring trouble can be eliminated. I believe it comes from that little break I showed you. It won't eliminate all our troubles but it will part of them. We can also go ahead on this theory and figure out the effect.

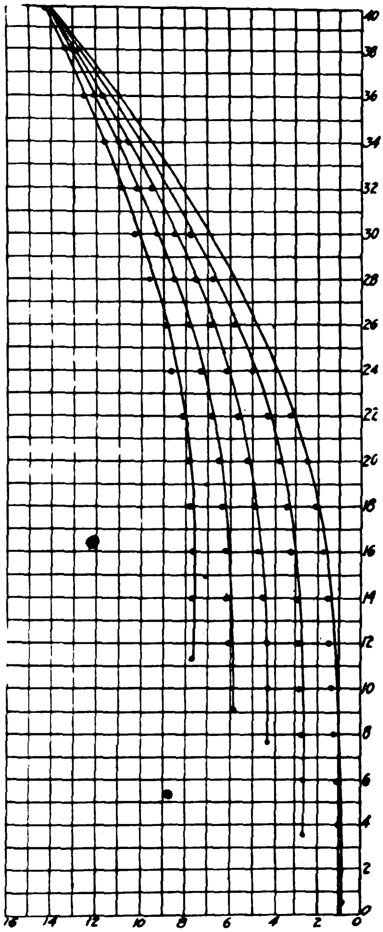


Fig. 13. Curves on plane $Y=0$

FARM BUILDING VENTILATION

W. B. CLARKSON,[1] Member Amer. Soc. A. E.

Farm building ventilation is a progressive science. The need for development in this science is as great as in any other phase of agricultural engineering, because good ventilation is necessary to conserve and develop the health and efficiency of both man and beast.

The barn of yesterday condemns itself, no matter whether it is the sod-barn of the western prairie, the old ramshackle barn of the middle west, or the eastern barn with its framing timbers hewn from walnut logs. None of these is now a money making investment.

The ideal modern barn must be judged by the scientific relation of its completed details rather than by the size of the investment. The man who invests $2000 in a new barn when he should have invested twice that much, stands to lose more money than he who lavishly spends more than necessary on his barn.

No farm building is complete without a properly applied ventilating system, yet it is safe to say that a very large proportion of all farm buildings have no provision whatsoever for ventilation, and a large proportion of the remainder are not half as well ventilated as good rules of sanitation require.

Some farmers have made money raising stock on the farm without a barn; others have learned that they can make more money by keeping their stock well housed; while a great many more are convinced that the most money is made by an additional investment in ventilation. What would you think of a farmer with 100 acres of grain to harvest, who had decided to purchase a binder, but on account of the high price, contented himself with the purchase of the harvester part of the machine, fooling himself with the notion that he could get along some way? The business judgment of the man who invests in a barn without a ventilating system is as faulty as he who invests in part of a machine.

As the dollar value of the farmer's herd enlarges, so must the need of additional investments in farm buildings increase. Not "how cheap," but "how good," is the slogan this society can best afford to instill in the minds of the farmers of tomorrow.

As there are no two farmers alike, neither can the plans for any two sets of farm buildings be the same, and this, with other things, emphasizes the necessity for ventilation as a special engineering problem.

The chief complaint of dissatisfied investers in farm building

[1] King Ventilating Company, Owatonna, Minn.

ventilation up to this time shows plainly a lack of the knowledge of fundamentals as well as a lack of the proper application of details.

There are hundreds of men who have a good working knowledge of the fundamentals of natural draft ventilation as this knowledge has been acquired through the study of textbooks and other literature. There is another class of men who are increasing their knowledge of the subject by occasional observation and perhaps some research. There is a third class who are putting their whole thought and energy into the study and practice of farm building ventilation.

All three classes are traveling on the same train. The first named are sitting on the plush seats of the observation car viewing things in the retrospect. The second get as far as the smoking car to talk it over. The third class are sitting in the cab of the locomotive ready to take all chances, but with a forward looking vision that intensifies their sense of responsibility.

Every member of this society should be fully impressed with his responsibility to the farmer. Whatever our vocation may be, if we expect the farmer to come to us for information, we must gain his confidence by showing him that we are willing to accept full responsibility for the results to him.

If we look at farm problems with a keen sense of our individual responsibility, we will then be much more likely to render the constructive service that begets confidence, and this will help to bring us nearer to the goal of our ambition as a society. Farmers generally are not looking for something cheap and the sooner we clear our minds of this fallacy and strive for quality and efficiency, the quicker we will gain their confidence and increase their respect.

THE FARM PAPERS

Most farm papers now maintain a department of agricultural engineering, or a column entitled "Farm Mechanics." This department of the farm press has been a wonderful power in educating farmers to the value of ventilation and the editor who realizes how hard it is to stay within bounds and how easy it is to lead his readers astray, is the man that is rendering real service.

At this critical stage of development in farm building ventilation there are two classes of men holding responsible positions who are unconsciously doing an infinite amount of harm; the editor who takes the responsibility for telling his reader how to build a ventilating system and the advertising manager who allows an advertiser to make extravagant statements. Morally, the paper is responsible for both errors.

Here are two examples, quoted from recent issues of farm papers that illustrate my point:

A Reader: "I have a barn 24 feet wide and 48 feet long and

14 feet to the plates, with a hip roof. On one side there is a lean-to cow stable 16 feet wide, and on the other side a horse stable 18 feet wide. I would like to know the best way to ventilate it." The editor in reply tells him in detail how to ventilate his barn and shows two cuts, an interior elevation and a sectional view of a wooden cupola with details showing how the foul air flues connect with it. The description ends with these words: *"This system is recommended as being the best under these particular conditions."* If the farmer takes this advice and has his carpenter build a system in his barn that does not prove satisfactory, the editor has been the direct means of getting both the reader and his paper into trouble.

In a recent issue of another farm paper, the following statement is printed in a full page ad: *"I have their complete ventilating system. It works perfectly. My cows give one-fifth more milk. My calves never get sick."* Of course we can argue that such an extravagant statement will kill the ad, but looking at the matter from another angle we can also see that such statements as these retard the general forward movement of the whole campaign of education.

AN OLD IDEA

Barn ventilation is not a new idea; it is much older than anyone sitting in this presence. I have a bound copy of *The London Illustrated News* published in the middle of the last century, containing an article on ventilation which is conclusive evidence that farmers have been thinking of this subject for a long time. Unfortunately, up to within the last few years, barn owners have been compelled to assume their own responsibility for securing the proper ventilation of their buildings.

The result has been that much time and money has been wasted in misapplied efforts at ventilation, and instead of the agricultural engineers leading the farmers on this subject, as they should do, the situation has been reversed and the farmers have led the agricultural engineers and literally forced them to do something.

One great trouble today is that there are too many men who carelessly assume to know all about the ventilation of farm buildings and too few that realize the many difficulties to be encountered.

A light, sanitary, well built barn is an asset. A dark, cold and insanitary barn is a liability. The progressive farmer of today realizes the necessity for well lighted, warm, dry and sanitary quarters in which to house his livestock and increase his percentage of profit.

The progressive farmer is the man with whom the agricultural engineers have to deal; he is your friend, and in the language of a clever Irish woman of my acquaintance who said, "It is out of your friends you will make your living; your enemies will never give you a chance." Your friend, the progressive farmer, is convinced of the vital need of proper ventilation in his building; thus far his education is complete. The non-progressive farmer is an enemy to this society, to mankind and to himself.

Our friend, the progressive farmer, then, is our chief consideration and his needs our greatest concern.

The farmer is a busy man with many irons in the fire, and in his study of farm problems he prefers to deal with men who will become responsible to him for the results he is looking for in every problem he has in mind. The ventilation of the barn is one of his greatest problems, and in its study, he is most impressed by the moisture and frost in the ceiling and walls.

Some men think that because their stock room is dry, it must be well ventilated, as their sense of smell does not make a strong enough impression as to cause them to spend money for ventilation. The average man does not realize that the greatest danger to the health of the stock is the chemical change in the air, that change which is the least apparent to the senses of sight and smell. The things that appeal to him most are the conditions that he can see.

During our investigation last winter the committee on farm building ventilation found moisture or frost on the inside surface of nearly every stock room visited, and in each case the reasons were quite apparent. In some cases the accumulation of moisture could easily be traced to the improper application of the ventilating system, while in other cases, the moisture and frost could be accounted for by other causes for which the ventilating system was in no way responsible.

While the movement of the air tends to reduce the relative humidity in the stock room, it alone cannot help the condensation of the moisture on a cold surface, and on the other hand, unless the accumulating moisture from the stock is constantly being removed, the best insulated wall will not remain dry.

As a sanitary precaution, light and ventilation go hand in hand, and for the dairy barn some authorities have set the minimum amount of light surface at not less than four square feet of glass per cow.

While this is as small an amount of glass as any barn should have, yet here again is a chance of trouble. First, because the greater the exposure, the harder it is to keep the room warm, and again, because in winter the windows will thickly coat with frost which cuts the light and thus defeats the main purpose of the windows.

In the barn a window should not be used for both light and ventilation at the same time. This particularly applies to the barn situated in a cold climate. If a storm sash is fitted to the outside of the casing so as to form, as near as possible, a dead air space between the two sashes, the glass is not very likely to accumulate a thick coat of frost that cuts the light. If a window is installed in this manner, the inside glass will remain approximately as warm as the inside air and thus be kept free from frost. The double glazed sash is not good for this purpose; in our investigation we find that it coats nearly as thickly with frost as a single glass.

DOORS

Frost covering the doors, in addition to looking bad, results in damage to the doors; therefore, it pays to have storm doors fitted so they will protect the inside door from the cold weather; this will also reduce the amount of exposure and help to keep the room warm.

You would be astonished if you knew the number of farmers who have to be told that a ventilating system is not a heating plant. We must impress on the farmer's mind that the heating plant in the barn is the stock, and that in a barn with a properly applied system of ventilation, the average cow must not be expected to heat more than 600 cubic feet of air surrounding her. A herd of cattle thus housed will hold the temperature of the room above freezing in extremely cold weather. This is simply a relative statement, your committee on farm building ventilation having not yet accumulated sufficient data upon which to base a definite statement.

In a calf barn, test barn or any other barn where the waste heat from the stock is not sufficient to heat the room, an artificial heating plant is necessary.

From the data accumulated by the committee, I am more firmly convinced than ever that the best system of natural draft ventilation is the one that is styled "Type X" in the committee reports, the fresh air entering the room at the ceiling and the foul air carried away from the floor. I am willing to admit that if a natural draft system has to depend almost entirely upon heat pressure for its motive power, perhaps there may be some advantage to installing a system as in "Type Y," but that is yet to be proved.

A properly designed ventilator situated on the highest point of a barn roof at the head of foul air flues, taking advantage of the wind pressure at the greatest possible elevation, and with the foul air flue openings about 1 foot above the floor (these flues extending up into such a ventilator), has proved to give the best service. First, because the foul air is drawn from the coldest part of the room. Second, the fresh air can be brought in at the ceiling, where the temperature is highest, reducing to a minimum the opportunities for a cold draft striking an animal. Third, circulating the air from the ceiling to the floor certainly has a tendency to keep down the impurities of the floor and carry them out through the floor flues.

FOUL AIR FLUES

From the data accumulated thus far, the advantage of a galvanized metal flue, when properly insulated, is very important for the following reasons: First, it will last longer without the necessity for being repaired. Second, it can be made round and in this form will carry a greater volume of air than other flue with equal area. Third, it can be made at a minimum of cost, under the supervision of a competent engineer who can then afford to guarantee its performance.

FRESH AIR INTAKES

To deliver the fresh air into the proper part of the room is a much more important matter than is generally understood. Even among reasonably well informed men, the prevailing idea seems to be that any old way the air can be conducted into the room will be all right. The evidence proves it is just as easy, perhaps more easy, to go wrong on the proper details for the fresh air intakes than for the details of the foul air flues.

The character of the wall, the ceiling, floor plan, ground level and other things equally as important, must all be considered in planning the intakes; I have known cases where one ventilating system required four different styles of intakes to produce the best results.

DIFFUSION BY CLOTH CURTAIN

When the report of the committee on farm building ventilation was presented one year ago, Mr. Dickerson asked if it would not be wise to include in our investigation some experiments covering intakes with some sort of cloth to diffuse the incoming air.

During the past year we have had a number of opportunities to observe the so-called cloth curtain ventilation of poultry houses, and in every case find the results were not as satisfactory as where provisions had been made for moving the foul air out and the fresh air in, though flues and intakes.

One test made epitomizes the whole story. Standing in front of a poultry house with the wind blowing directly from the south, an airmeter held in position facing the wind indicated a velocity approximately $8\frac{1}{3}$ miles per hour. Then holding the airmeter on the inside of the house close to a new curtain just installed, the wheel of the airmeter did not move. Curtains will fill with dust and the older the curtain the less chance there is for the air to penetrate it.

The late Prof. F. H. King, in his paper read to this society at the December meeting in 1910 (Note: See Volume IV, page 108, of the transactions of A. S. A. E.) has this to say: "Diffusion is far too slow ever to be made an effective factor in ventilation, and it is a mistake to look upon muslin walls, windows or screens as in any important sense effecting ventilation by diffusion. What ventilation is secured through muslin or cotton walls is almost wholly due to current movements through the meshes, induced by wind pressure, by wind suction and the difference in temperature. The diffusion effect is too small to be considered." Every cloth curtain device we have investigated emphasizes the points Prof. King has made.

IN CONCLUSION

Gentlemen: This paper has failed of its purpose unless it has brought you to a realization of the necessity for a serious consideration of the following facts:

1. There is need for more specialization on this subject by those who will assume full responsibility for good results.

2. The investigations of your committee show that our experiment stations, both state and national, have given very little consideration to the need of research work in farm building ventilation. It is quite evident that the little that has already been done has been forced upon them.

3. The past history of farm building ventilation is the best proof that the subject has not been handled correctly, and henceforth the members of this society should resolve to give it the careful consideration it deserves.

BARN ROOF DESIGN[1]

By J. L. STRAHAN,[2] Member Amer. Soc. A. E.

A survey of the field of barn framing shows that there are almost as many different types or kinds of frames as there are carpenters to build them. Each country builder has his own ideas, formed through personal observation in usually a rather restricted field, and based upon his own experience. Thus we find an almost unlimited number of variations in the details of construction of the various types of modern plank frames. Although almost each carpenter claims to have "invented" the particular truss which he builds, it is usually quite evident that it is merely a modification, and often a very slight one, of one of the more or less standard types. "More or less" is here used advisedly, because at least two of these types are credited to the ingenuity of a single individual and generally bear his name. The other types appear to have formulated themselves—to have grown up simultaneously in different sections, probably as a result of evolution from the older

[1] The author wishes to acknowledge the helpful advice and constructive criticism of Prof H. S. Jacobi of the Cornell University College of Civil Engineering, which was very helpful in the preparation of this paper.

[2] Department of Rural Engineering, Cornell University, Ithaca, N. Y.

types of heavy timber framing. Naturally there is here a wider range of variation as to details of construction, but nevertheless they generally conform in principle to their type.

Of those credited to individuals there is—first and preeminent—the Shawver truss, with which undoubtedly you are all familiar, and which I wish to discuss at length later. Another is a self-supporting type of roof known as the Flickinger frame, which is named for its originator, the late Mr. J. H. Flickinger of Seneca Falls, N. Y. These and other types are classified on the accompanying chart.

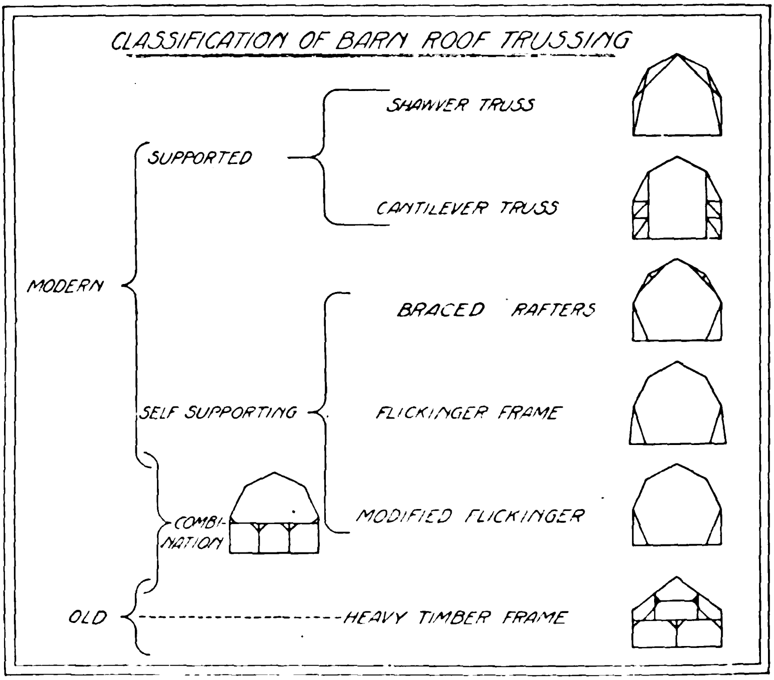


Fig. 1. Six types of barn roof trusses

Referring to Fig. 1, it will be noticed that all present day frames naturally fall into one of the two main divisions, namely, the modern plank frame structure, and the old style heavy timber frame. Of the latter class there are hundreds of varieties in different stages of development and change, ranging in age all the way from 1 to 125 or 150 years. This style of framing is rapidly disappearing among the newer buildings, and also, under processes of remodelling, among the older ones. (Incidentally, the remodelling of old frames is one of the most serious building problems with which our framers in the east are faced at present, and is one with which they will need specialized assistance in the near future.) However, for the present discussion this old style of frame is of interest only from a historical standpoint, and as it forms the origin from which our more recently developed framing types have arisen.

In the modern class of structure there are at least five distinct types. There may be others which have not come to our notice, but as far as our present observations go, these five basic types include all the various plank frames which have been built in recent years with the idea of conserving lumber and increasing clear, unobstructed mow space.

These are divided into two general classes under which undoubtedly all frames which may develop in the future may be placed. They are: (1) roofs which are supported on purlines which in turn are supported on specially designed trusses, and (2) roofs which are self-supporting. The presence or absence of the purline plate will always suffice to make this classification.

In the first class falls the Shawver truss and a frame which I have designated as a cantilever truss, because it acts as a cantilever in resisting the thrust of the roof.

The self-supporting roofs are all so constructed that the entire roof load rests on the four walls of the building, none of it being transmitted to the ground through inside posts. Some have the roof itself braced against distortion by means of ties across the hip angle—as in Type 3. The Flickinger barn (Type 4) has battered sides, the slope being ¾″ per foot off the perpendicular. It is held that this relieves the strain on the stays, which run from the plate to the floor, by taking some of the thrust of the roof in direct compression. The modified Flickinger frame (Type 5) has vertical sides with the stays a little farther in from the base of the wall at the floor.

Several examples of a combination old timber frame with a self-supporting roof have been observed. These in most cases were remodelled structures, but one was built new throughout. The carpenter was a trifle afraid of the apparent lightness of the newer type of construction.

From this brief general discussion of conditions as found to exist throughout New York state at the present time, I would like to pass to a more detailed discussion of that frame which is coming more and more into popular use. I refer to the Shawver truss.

THE SHAWVER TRUSS

The Shawver truss, as used as a support for roofs in New York and adjacent states, is built with many variations as to details of construction. Every variety of design, however, can be classified under one of two main heads, viz.:

(1) Those that are built with the purline post, Fig. 2a, (No. 5) a double member and the main rafter (No. 4) single.

(2) Those that are just the reverse, namely, the purline post single and the main rafter double.

This difference in design has an influence on the practical design of all the other members, as is apparent from the fact that the type of construction used (plank framing) requires that members shall interlock—that is, any member joined to a double member must be either single or triple in order to avoid a tortional strain on the truss and a consequent tendency to draw the nails

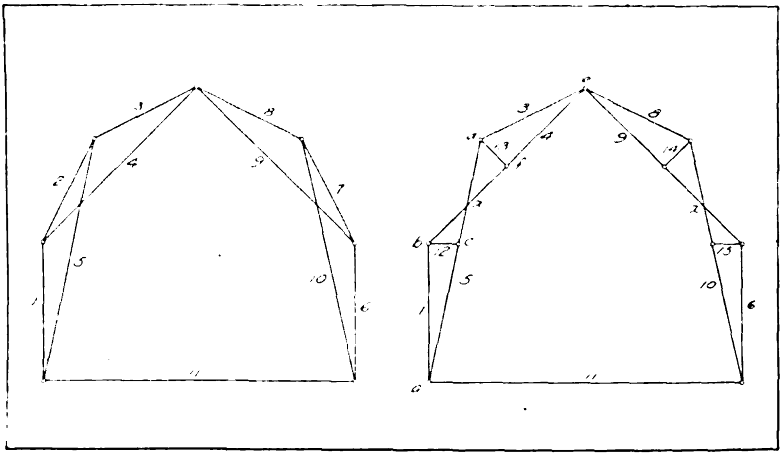


Fig 2a Fig. 2b

Two types of Shawver truss

or spikes. Hence, with a single purline post, the tie cord No. 11 must begin as a double member—which further requires that the wall post (No. 1) be either single or triple. As ordinarily constructed it is triple. On the other hand, the truss with the double purline post requires only a single tie member (from the standpoint of tensional strain, but probably triple when shear at the foot of the truss is considered as will appear later in the discussion of details of construction.)

A single tie (No. 11) necessitates only a double member wall post instead of triple, which in the light of further analysis would seem more reasonable.

The lower rafter (No. 2) has often been regarded as not being an integral part of the truss, and often the bents are raised without this member being present although such is not always the with which our framers in the east are faced at present, and is one with which they will need specialized assistance in the near future.) However, for the present discussion this old style of frame is of interest only from a historical standpoint, and as it forms the origin from which our more recently developed framing types have arisen.

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THE SHAWVER TRUSS

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It is therefore reasonable to assume the existence of pin joints in making a theoretical analysis either graphically or by direct computation. And further, although by reason of this divergence from the assumed ideal the stresses obtained theoretically may not be exactly those that actually exist in the truss itself under load, nevertheless the relative amounts found in the various individual members will bear a definite proportion to each other that will be true in actual practice. It is probable also that the actual figures obtained by theoretical analysis will vary from the true values by such a small amount as to be practically negligible, and will be safe to use as a basis for further refinements of design.

ASSUMPTION

In the following graphic analysis these assumptions were made:

1. The lower roof rafter acts as part of the truss.
2. The joints are pin joints.
3. The cross bracing in the unit triangles do not take any strain but act merely as stiffeners.
4. Span=36′. Height of posts=16′. Height to peak 34′. Rafters of equal length—lower 1 pitch, upper $\frac{1}{4}$ pitch. Bents 16′ on centers.

Fig. 2a then represents the main elements of the truss.

LOADING

The loads which this truss must withstand are four.

1. *Dead load* or weights of truss, rafters, sheathing, roofing and any other permanent element of the building supported by the truss. This load is divided at the peak, purlines and plates in the following ratio: peak $\frac{1}{4}$, purlines each $\frac{1}{4}$, plates each $\frac{1}{8}$.

2. *Snow load.* This is assumed to be maximum at 20 pounds per horizontal square foot on the upper rafter only, the lower one being too steep for snow to stay on. The load is divided so that $\frac{1}{2}$ is applied at the peak and $\frac{1}{4}$ at each of the purlines.

3. *Wind load.* This load is calculated on the basis of a maximum wind pressure of 40 pounds per vertical square foot. Such a pressure would be caused by a gale blowing at 100 miles per hour, which may be considered maximum for most places in this country and considerably higher than need be used in designing for a building to be placed in a sheltered spot.

Starting from the foot of the truss on the left side the wind load is applied as follows: One-half the load on the left wall acts at the foot of the post, and because it does not cause stress in any member is omitted. The other half is applied normal to the wall at the plate, where it is combined with one-half the pressure which acts normal to the lower rafter. (See graphic diagram Fig. 4d.) One-half the normal pressures are combined in the same way at the purline plate (4c) and one-half the load on the upper rafter is applied normal to that member at the peak.

4. A load at *the peak* is often present in the form of material carried on the hay carrier track. This has been assumed to be maximum at 1 ton, which is probably slightly in excess of what might ever be applied in this manner.

The value for all above loads are shown in the following table.

Loads	Left plate	Left purline	Peak	Right purline	Right plate	Total
Dead load	1141	2282	2282	2282	1141	9130
Max. snow load		1918	3837	1918		7673
Min. snow load		959	1918	957		3836
Wind on left side	8710	5490	1930			16130
Peak load			2000			2000

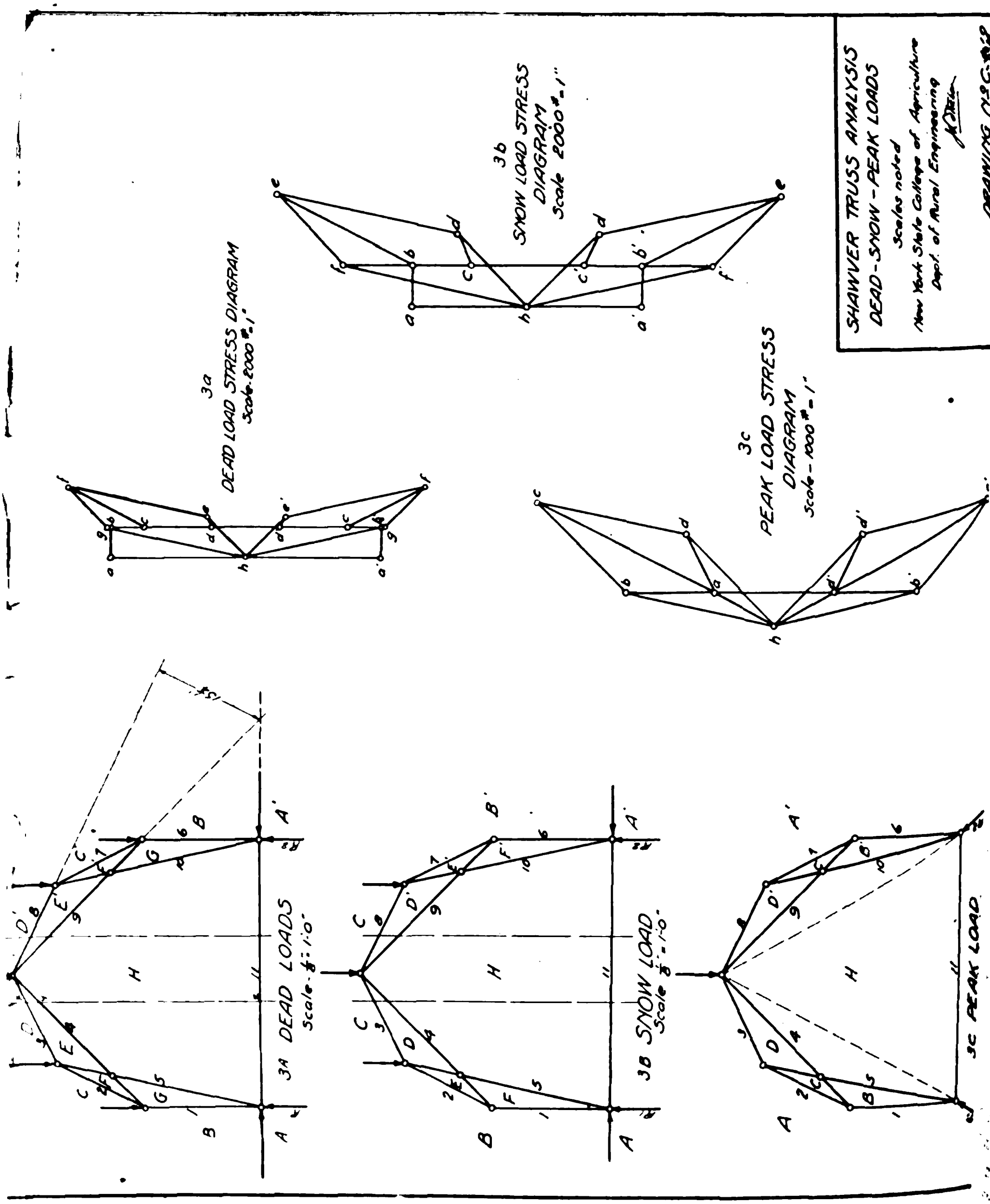
GRAPHIC ANALYSIS

The stresses in the members of the truss caused by each load are determined separately by the graphic method as illustrated in Figs. 3A, 3B, etc. A brief discussion of one will serve to explain all the determinations.

The analysis of any rigid structure in equilibrium requires that the direction and intensity of all external forces acting on it be known. In the case of roof or bridge trusses, the loads can be determined by a knowledge of the conditions under which they are to act, and from these known loads or forces, the reactions which hold the structure in equilibrium can be determined. The applied loads with the reactions constitute a system of forces which are held in equilibrium by the stresses set up by them within the members of the truss.

The *direction* and *intensity* of the external forces and the *direction* of the internal stresses being known, it remains to be determined the *intensity* of the internal stresses. The graphical method furnishes a quick and sufficiently accurate means for determining these values, which can be checked by a mathematical determination of one of the members involved.

A line drawing of the truss is made to scale with the application of load indicated by arrows drawn in the proper direction (Fig. 3A.) A force polygon is next constructed assuming a convenient scale in terms of pounds or tons to the inch which, when closed, gives the direction and intensity of the reaction which holds the forces in equilibrium. In the case under discussion (dead load diagram Fig. 3A) the reaction is equal to the sum of the loads and acts vertically upwards through the points A and A′. They are lettered R1 and R2.


SHAWVER TRUSS ANALYSIS
DEAD-SNOW-PEAK LOADS
Scales noted
New York State College of Agriculture
Dept. of Rural Engineering
3a
DEAD LOAD STRESS DIAGRAM
Scale-2000#=1"
3b
SNOW LOAD STRESS
DIAGRAM
Scale 2000#=1"
3c
PEAK LOAD STRESS
DIAGRAM
Scale-1000#=1"
3A DEAD LOADS
Scale-1/8"=1'0"
3B SNOW LOAD
Scale 1/8"=1'0"
3C PEAK LOAD

Before the stress diagram can be drawn, the stress in the tie member No. 11 must be determined. This may be accomplished by passing a section through the truss cutting the three members 3, 4 and 11 at *x*, *y* and *z*, and computing the algebraic sum of the moments of all forces on the left about the point *d* (at the peak). It will be observed that the stresses in the two upper members do not affect, as the direction of their line of action passes through the pivotal point *d*. Hence their moments are zero.

The forces which do act, therefore, are the loads applied to C and D with their reaction R1 and the stress in member No. 11. The moment equation may be stated as follows:

$(R_1\text{-}C)\ 18 - (D \times 12) - (S \times 34) = 0$ Where S = stress in No. 11

$$S = -1007 \text{ lbs.}$$

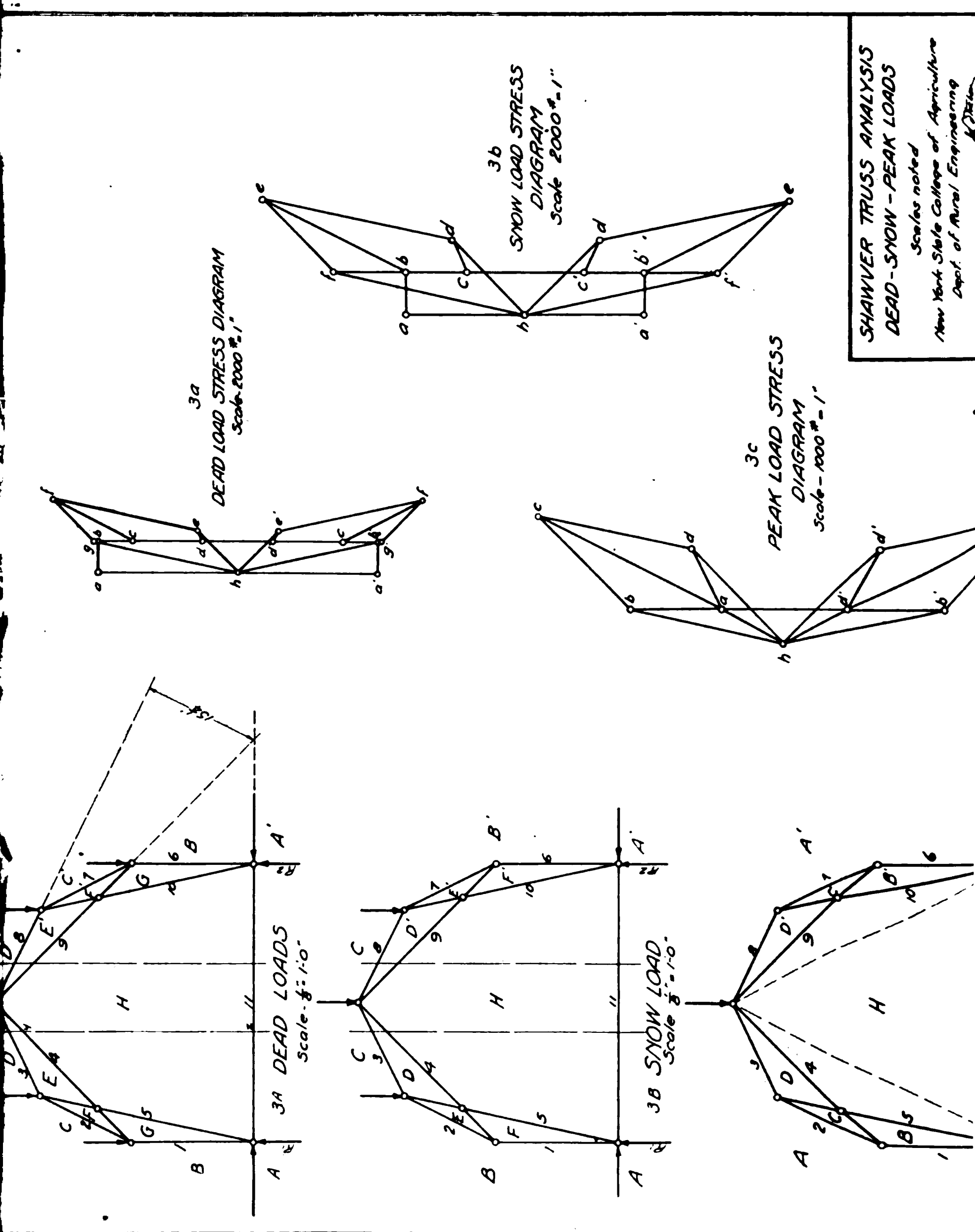
Its sign indicates that it acts counterclockwise and is therefore a tensional stress.

We now have known all external forces necessary to determine the stresses in the various members of the truss. This is best accomplished graphically by means of the stress diagram, which is built up on the closed force polygon.

Each joint or apex of the truss is the center of a system of forces, consisting of externally applied loads and internal stresses which are in equilibrium. If, therefore, a force polygon be drawn for each apex in turn, laying off the known forces in their proper direction to scale, and determining the magnitude of the unknown forces by the intersection of their lines of action, the direction of their action may be found by applying the principle that in a closed polygon of forces in equilibrium, the arrows indicating their lines of action all follow each other in the same direction around the polygon. Thus in Figure 3a the lines *ha* and *ab* represent in magnitude and direction the forces acting between HA and AB (Fig. 3A), while the lines bg and gh (3a) represent the stresses in the members 1 and 5 (3A). The direction of the first two forces being known, the arrows can be indicated on the diagram showing that the force *bg* acts away from the point and *gh* acts towards it. It is evident then that No. 1 is in tension and No. 5 in compression. They are so recorded by means of the plus and minus sign, plus denoting tension and minus denotes compression.

By completing the stress diagram for all other joints the magnitude and direction of each stress in the truss may be determined.

Such a diagram has been constructed for each of the loads mentioned above in order to be able to determine the maximum and minimum stresses to which each member might be subjected. All the diagrams are similar to the one just discussed except that for wind stresses. This differs only in the method of determining the reactions at the foot of the truss necessary to hold it in equilibrium. The truss here must be considered as a three-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3B SNOW LOAD
Scale 1/8"=1'-0"

Before the stress diagram can be drawn, the stress in the tie member No. 11 must be determined. This may be accomplished by passing a section through the truss cutting the three members 3, 4 and 11 at *x*, *y* and *z*, and computing the algebraic sum of the moments of all forces on the left about the point *d* (at the peak). It will be observed that the stresses in the two upper members do not affect, as the direction of their line of action passes through the pivotal point *d*. Hence their moments are zero.

The forces which do act, therefore, are the loads applied to C and D with their reaction R1 and the stress in member No. 11. The moment equation may be stated as follows:

$(R_1\text{-}C)\ 18 — (D\text{x}12) — (S\text{x}34) = 0$ Where S = stress in No. 11

$S = —1007$ lbs.

Its sign indicates that it acts counterclockwise and is therefore a tensional stress.

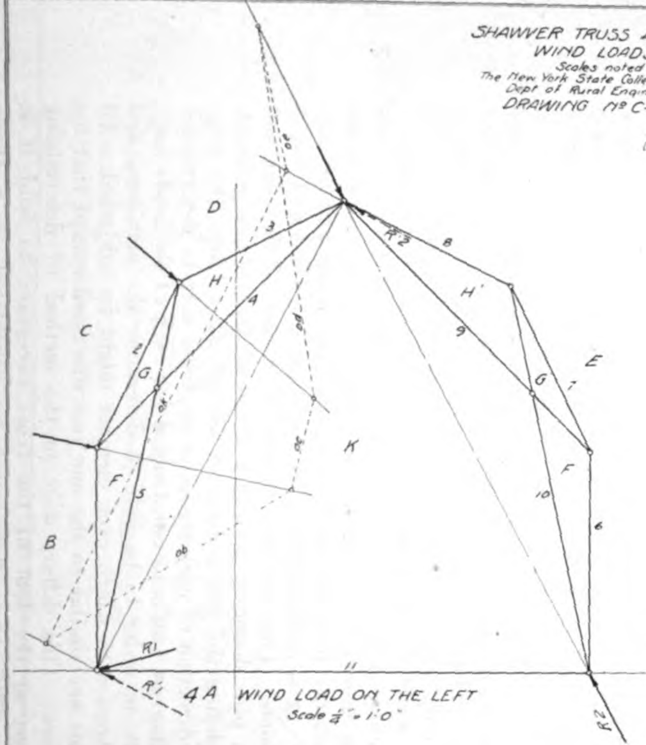
We now have known all external forces necessary to determine the stresses in the various members of the truss. This is best accomplished graphically by means of the stress diagram, which is built up on the closed force polygon.

Each joint or apex of the truss is the center of a system of forces, consisting of externally applied loads and internal stresses which are in equilibrium. If, therefore, a force polygon be drawn for each apex in turn, laying off the known forces in their proper direction to scale, and determining the magnitude of the unknown forces by the intersection of their lines of action, the direction of their action may be found by applying the principle that in a closed polygon of forces in equilibrium, the arrows indicating their lines of action all follow each other in the same direction around the polygon. Thus in Figure 3a the lines *ha* and *ab* represent in magnitude and direction the forces acting between HA and AB (*Fig.* 3A), while the lines bg and gh (3a) represent the stresses in the members 1 and 5 (3A). The direction of the first two forces being known, the arrows can be indicated on the diagram showing that the force *bg* acts away from the point and *gh* acts towards it. It is evident then that No. 1 is in tension and No. 5 in compression. They are so recorded by means of the plus and minus sign, plus denoting tension and minus denotes compression.

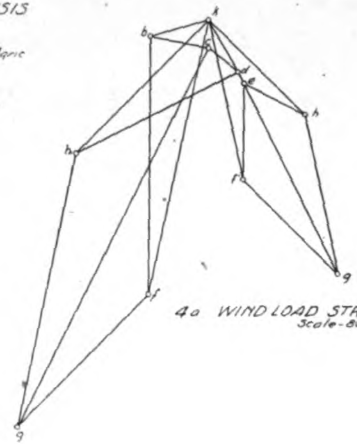
By completing the stress diagram for all other joints the magnitude and direction of each stress in the truss may be determined.

Such a diagram has been constructed for each of the loads mentioned above in order to be able to determine the maximum and minimum stresses to which each member might be subjected. All the diagrams are similar to the one just discussed except that for wind stresses. This differs only in the method of determining the reactions at the foot of the truss necessary to hold it in equilibrium. The truss here must be considered as a three-

SHAWVER TRUSS ANALYSIS
WIND LOADS
Scales noted
The New York State College of Agric
Dept of Rural Engineering
DRAWING No C-263



4A WIND LOAD ON THE LEFT
Scale 1/4" = 1'-0"



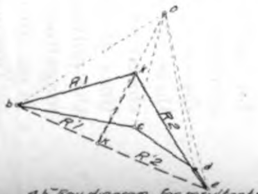
4a WIND LOAD STRESS DIAGRAM
Scale-8000# = 1"

TABLE OF STRESSES

1	2	3	4	5	6	7	8	9	10
Member	Dead load	Max. snow	Min snow	Wind left	Wind right	Peak load	Max. stress	% Stress	Column Combination
1	+150	+2220	+1110	-37600	+13950	+1475	-37450	64.5	2-5
2	+2840	-5100	+2550	-61000	+31000	+3350	-58140	100.0	2-5
3	+300	+1150	+575	-26175	+9950	+1085	-25875	44.5	2-5
4	-1800	-3380	-1690	+27350	-19600	-2075	+25550	44.0	2-5
5	-4800	-6230	-3115	+40900	-23750	-2540	+36100	62.2	2-5
6	+150	+2220	+1110	+13950	-37600	+1475	-37450	64.5	2-6
7	+2840	+5100	+2550	+31000	-61000	+3350	-58060	100.0	2-6
8	+300	+1150	+575	+9950	-26175	+1085	-25875	44.5	2-6
9	-1800	-3380	-1690	-19600	+27350	-2075	+25550	44.0	2-6
10	-4800	-6230	-3115	-23750	+40900	-2540	+36100	62.2	2-6
11	+1040	+1334	+667	+1620	+1620	+530	+5191	8.95	2-3-4-5-7

4c Resolution of wind loads at purline

4d Resolution of wind loads at plate



4b Ray diagram for resultants and reactions hinged arch, a theoretical hinge existing at the peak and at the foundation walls. The loads applied as indicated (Fig. 4A) on the left side cause reactions at the left foot and the peak and in the direction indicated by the heavy dotted lines. The intensity and direction of these reactions are determined by the pole diagram in Fig. 4b. The force polygon *bcde* is drawn by laying off to scale the external forces BC, CD and DE, and is closed by the line *eb* which gives the direction of the resultant of the given forces and which is equal to the sum of the two reactions R′1 and R′2. A conveniently located pole "*o*" is chosen and connected to the apexes of the force polygon by the lines *ob*, *oc*, *od* and *oe*. Beginning on the line of action of the force R′1, a line is drawn parallel to *ob* (Fig. 4b) until it intersects the line of action of the force BC (Fig. 4A). From this point a line is drawn parallel to the line *oc* (Fig. 4b) until it intersects the line of action of the force CD (Fig. 4A). This is continued until all the "rays" or lines from *o* to the points of the force polygon are used up. It will then be seen that one line *ok′* is needed to close this equilibrium polygon which has been built up on the lines of action of the applied forces (Fig. 4A). *ok′* is drawn, and through the point *o* in the ray diagram a line is drawn parallel to it until it meets the line *be*, which represents the resultant or the sum of the reactions. This intersection divides the resultant (*be*) into the two reactions, *bk′* and *ek′*, whose intensity may be taken off with the proper scale.

An inspection of the figure will show that the reaction thus obtained at the peak must be transferred through the two sides of the truss to the foundation wall if the point at the peak is to remain in equilibrium. These lines of reaction will pass through the peak and foot of the truss as is indicated by the dash lines. A resolution of this reaction R′2 along these lines will give the results as shown. R2, or the reaction on the right, will be equal to and act in the opposite direction from the right component of the original peak reaction, R′2. It is indicated by the heavy arrow R1. The left component of R′2 acts away from the point at the base and thereby creates the necessity for an equal reaction towards it. This must be combined with the reaction R′1 already determined as acting at this point as a portion of the original reaction of the external wind forces. Resolving R′1 and the left component of R′2 into one force, R1 is determined in both intensity and direction.

It is of interest to note that the vertical component of the final resultant of all forces acting on this point is equal to 2420 pounds or over a ton in an upward direction. The resultant of all the dead load forces on the same point is approximately 2 tons acting vertically downward, thereby leaving a balance of a ton in favor of the downward forces. This would probably be sufficient to resist wind action without bolting to the foundation were it not that the horizontal component of the wind load resultant is so great (nearly $4\frac{1}{2}$ tons). Friction on the wall would not suffice to keep the building from moving laterally although it probably would not raise up. It must therefore be bolted to the wall.

With the external forces known and their reactions determined, the procedure for arriving at the stresses is similar to that for the other loadings.

The diagram indicates that with the wind on the left, the wall post, lower and upper rafters on the left are all in compression while the same members on the right are in tension but under only about half so great a stress. The inside members, namely, the purline post and peak tie or main truss rafter, are in tension on the left and compression on the right. Wind on the right of course reverses all the stresses changing each from compression to tension, or vice versa as the case may be.

STRESSES

The following table gives the stresses for each member due to various loadings, together with the maximum stress due to the simultaneous application of all loads that could possibly act together. Such a combination will exist when the minimum snow load remain on the roof during a heavy wind. It is further conceivable that a load might be applied at the peak at the same time; as, for instance, in transferring material from one part of the building to another by means of the hay fork track. Although such a combination of loads will occur only in extremely rare cases, yet, because there is a bare possibility of its happening, the design must be carried out with it as a fundamental assumption.

Member	Dead load	Maximum snow load	Minimum snow load	Wind from left	Wind from right	Peak load	Maximum stress	% Stress Max. = 100%	Column combined for maximum stress
1 ..	+150	+2220	+1110	—37600	+13950	+1475	—37450	64.5	2-5-4
2	+2940	+5100	+2550	—61000	+31000	+3350	—58140	100.0	2-5-4
3	+300	+1150	+575	—26175	+9950	+1085	—25875	44.5	2-5-4
4	—1800	—3380	—1690	+27350	—19600	—2075	+25550	44.0	2-5-4
5	—4800	—6230	—3115	+40900	—23750	—2540	+36100	62.2	2-5-4
6	+150	+2220	+1110	+13950	—37600	+1475	—37450	64.5	2-6-4
7	+2940	+5100	+2550	+31000	—61000	+3350	—58140	100.0	2-6-4
8	+300	+1150	+575	+9950	—26175	+1085	—25875	44.5	2-6-4
9	—1800	—3380	—1690	—19600	+27350	—2075	+25550	44.0	2-6-4
10	—4800	—6230	—3115	—23750	+40900	—2540	+36100	62.2	2-6-4
11 ..	+1040	+1334	—667	+1620	+1620	+530	+5191	8.95	2-3-4-5-7

An examination of the values in the table shows that a combination of the peak load in particular and the other vertically applied loads to a lesser extent, with the wind load from the left, tends to relieve the stress in the members 1, 2, 3, 4 and 5, while it tends to increase the stresses in members 6, 7, 8, 9 and 10. The reverse is true when the wind load is applied on the right. From this fact may be deduced the curious conclusion that a wind pressure of such intensity could be applied on the left that would entirely neutralize the stresses in members 1, 2, 3, 4 and 5, causing them to relax all pressure on the joints. Upon a reduction or an increase of wind pressure, the joints would again take up their work. Thus a series of strains varying in intensity from zero to that caused by the greatest stress would be constantly occurring at the joints, tending to loosen them unless designed to withstand such action. It is probably for this reason that nail joints are not considered as good construction as bolt joints. They will tend to loosen up more readily than bolted joints—and undoubtedly a nail joint truss will fail sooner or at least tend to settle out of true shape more quickly. This is especially noticeable in buildings situated in exposed positions.

More definite knowledge on the strength of nail joints is needed before a correct use can be made of them in design. This is a field for experimentation and test that can well be entered with expectation of valuable results.

It will be remembered that, broadly speaking, all the various types of Shawver truss may be placed in two general classes which differ from each other fundamentally in the design of the two inside members—purline post and main rafter or peak tie. There is a relation between the amount of stress taken in these two members which varies with the points of application of the loads. The following table shows this variation in terms of percent of stress based on the greater as 100.

Load	Purline Post No. 5 Post Percent	No. 4 Tie Percent
Dead	100	37.50
Snow	100	54.25
Peak	100	80.50
Wind left	100	66.8
Wind right	100	82.5
Maximum stress	100	71.5

These figures show conclusively that in all cases the post takes the greater stress—and greater in proportion as the load is more uniformly applied. Thus for a dead load which is applied uniformly throughout the structure, the post has nearly three times as much internal stress as the tie, while for a load concentrated at the peak the stresses are in the proportion of approximately 5 to 4. For maximum stresses due to a combination of loadings that might occur simultaneously, the proportion of stress is between the two just given or approximately as 4 is to 3. Inasmuch as this last proportion is computed from the greatest stresses to be expected, these members may safely be designed to conform to it.

In the light of these results it may be concluded that the class of truss which has the post member heavier is the more rational of the two.

DESIGN

A possible design based on the figures obtained from the analysis is shown in the following table. The following assumptions are made:

Material: Long leaf yellow pine or white oak.
Ultimate crushing strength=5000 pounds per square inch.
Factor of safety in compression parallel to grain=0.28.
Safe working fiber stress in tension=1300 pounds per sq. in.
Safe working stress for iron rod=16000 pounds per sq. in.

Member	Maximum stress	Required area	No. pieces	Size of each
1	—37450	28 sq. in.	2	2 "x8"
2	—58060	79 sq. in.	7 1 iron rod	2 "x6" 1¼"
3	—25875	30 sq. in.	1 1 rafter	2 "x10" 2 "x6"
4	+25550	20 sq. in.	1	2 "x10"
5	+36100	28 sq. in.	2	2 "x8"
6	—37450	29 sq. in.	2	2 "x8"
7	—58060	79 sq. in.	7 1 iron rod	2 "x6" 1¼"
8	—25875	30 sq. in.	1 1 rafter	2 "x10" 2 "x6"
9	+25550	20 sq. in.	1	2 "x10"
10	+36100	28 sq. in.	2	2 "x10"
11[1]	+5191	Negligible		

[1] Strong enough to resist shear and bending on floor.

There is apparently a contradiction between these figures and actual conditions in the case of several members of the truss as usually built.

The most notable is in the case of member No. 2. In will be remembered that this member is often omitted as an integral part of the truss, in fact more often than not. And yet it is subject to greater stresses under all kinds of loading than any of the other members. Undoubtedly, therefore, the true shape of the truss is maintained by the action of the entire panel or section of roof on the lower slope between trusses, together with the resistance offered by member No. 5 to bending action at the level of the plate. Just how much of No. 2's maximum tensile stress of 40000 pounds is taken by the nail joints of the rafters at plate and purline, and how much of this load is transferred as a bending moment to No. 5 is an indeterminate problem, and must remain so until more specific information is at hand concerning strength of various types of nail joints. For the present it might be wise, in view of the difficulty of making an adequate joint at the plate, to use an iron rod between plate and purline to supplement the nail joints. A rod $1\frac{1}{2}''$ in diameter will take approximately one half the required load which is based on a very high wind load maximum.

No. 3 is similar to No. 2 in action but is subject to less intense stresses. Furthermore, a member is usually included here aside from the rafter which is sufficiently strong and is properly joined to withstand the tensional strain to which it is subjected; although the compressive stress is undoubtedly in this case as in No. 2 taken in part by the roof rafters acting together. (Extra may be omitted when rafters are supported on a ridge board and rafter designed as a tension member.)

No. 4 is subjected to a maximum stress in tension which, as a 2″x10″, it is amply strong to withstand. However, its maximum compressive stress is such that it is quite likely to fail by buckling because of its unusual shape. The fraction representing the relation between its length and least dimension is unusually large, and it therefore should not be expected to take much compressive load without more bracing than it ordinarily is provided with. Probably the chief reason for its not failing is because it has as yet not been subjected to maximum loads such as the above computations are based upon. For ordinary loads it is amply sufficient.

Because it is braced at frequent intervals by lattice work stiffeners, the purline post or No. 5 is able to work under the full values for safe working unit stresses under compression, i. e.,

$$\frac{\text{length in inches}}{\text{least dimension in inches}} \text{ or } \frac{1}{d}$$

is less than 10. It is therefore entirely adequate for its work when composed of 2 pieces of 2″x8″ spaced 2″ apart by the stiffening pieces. It is very often further reinforced by a 2″x6″ nailed on the outside edge from the floor to the point where No. 4 passes through it.

As for No. 11, any member that is strong enough to take the floor loads is also strong enough to take the tension due to internal truss stresses.

As a check on the graphic determination of the direction of stresses in the various members, the model shown in Figure 5 was constructed. It contains all the essential elements of the truss as shown in Figure 2a and is so constructed that all joints are flexible and subject to displacement in any direction a maximum amount of about $\frac{1}{8}$ inch. All vertical members are single, $\frac{1}{2}''$ thick by 1″ wide, and are pierced at the proper points by 8d nails which have had the heads and points taken off, leaving a pin 1″ long, of which $\frac{1}{4}''$ projects on each side of the member. The two rafters, the ties and main peak tie are all double members $\frac{1}{4}''$ thick by 1″ wide, which straddle the single members and are

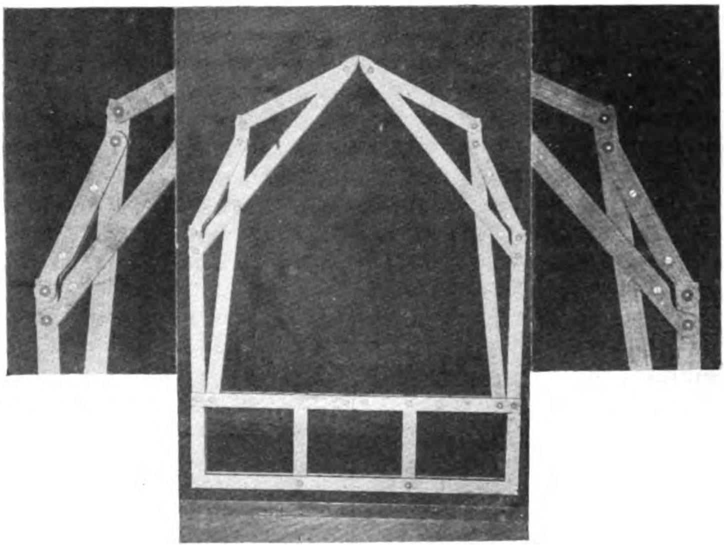


Fig. 5. Flexible joint truss model—unstressed

of such length that the above mentioned steel pins come in the precise center of $\frac{1}{2}''$ diameter holes in their ends when the truss is not subjected to any pressure. The space between the pins and the walls of the $\frac{1}{2}''$ holes is filled with rubber in the form of a washer whose inside and outside diameters conform to the measurement of the pin and hole. The double members are held in place by small $\frac{1}{8}''$ stove bolts, inserted at such points that they do not interfere with the deflection of the members when the truss is under load.

In order to make smooth construction, the upper rafter starts at the purline as a double member straddling the purline post and ends at the peak as a single member between the two sections of the peak tie. This is accomplished by merely splicing two pieces of the $\frac{1}{4}''$ stock to a piece of the $\frac{1}{2}''$ stock, making a lap joint 3″

long, or long enough to withstand any stress to which it may be subjected. There is no joint connecting the two sections of the truss at the peak. This point, therefore, simulates a true hinge joint when taking vertical loads.

A joint is made in the center of the tie member (No. 11) to indicate the direction of the stress to which it is subjected.

The truss is placed on a rigid, rectangular support, which consists of 1"x1" end posts tied across at the bottom by a double member. This bottom member is connected to the ends of two posts by means of flexible joints. The upper ends of the posts are flexibly connected to the truss tie cord (No. 11).

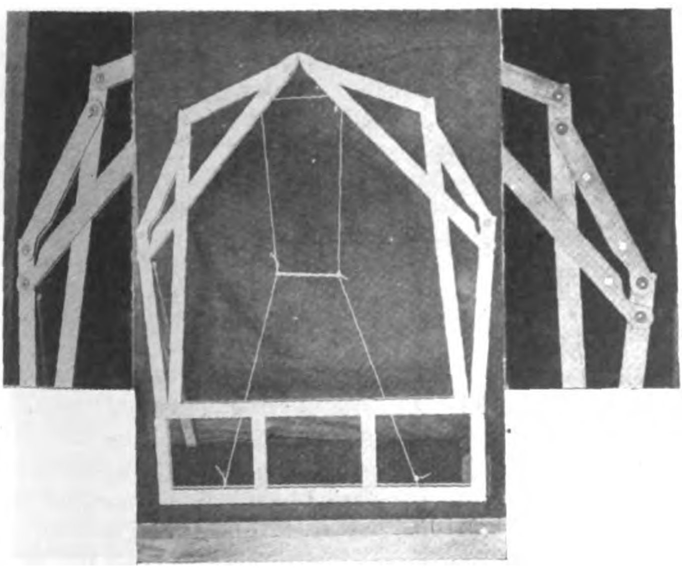


Fig. 6. Flexible joint truss model, loaded to show direction of stresses

In Figure 5 is shown the truss unstressed with enlarged portions to show the construction of the joints.

In Figure 6 the truss is shown loaded by means of a cord stretched from the peak to the lower floor member and constricted at the middle in order to produce maximum strains. The enlarged sections at the sides illustrate very clearly the action of the joints to indicate direction of stress. The distance between the pins in member No. 2 (or lower roof rafter) has increased, thus indicating a tensional strain, whereas the distance between the pins in member No. 4 has decreased, indicating compression. This is also true of No. 5.

The relative amounts of deflection at the joints also check very closely with the amount of stress as determined graphically. Thus, No. 2 has the greatest maximum tensile stress under vertical loading, and the joints holding it in the model show a maximum displacement. The same is true to a less noticeable degree with all the other joints.

CONCLUSIONS

1. In conclusion, it may be said that as ordinarily constructed the Shawver truss is not a true truss in the sense that it is truly rigid. In order to make it so, the lower roof rafter, or member No. 2, must be made an integral part and designed to withstand tensional stresses from vertical loadings—the most usual condition —and compressive stresses from wind loads. This applies in a lesser degree to member No. 3.

2. It is further very apparent that the purline post, or No. 5, should always be heavier than the peak tie, or No. 4. They should ordinarily have relative strengths of 4 to 3.

3. Little of any value can be offered at this time concerning construction of joints because of the dearth of reliable information on the strength of various kinds of nail joints. It is hoped that such information will soon be forthcoming.

4. It is suggested that the type of construction shown in the model here illustrated might well be applied to other similar structures as an aid in teaching agricultural students who ordinarily are not prepared to assimilate the more advanced specialized knowledge necessary to analyze such structures either mathematically or graphically.

DISCUSSION

QUESTION: I should like to ask Mr. Strahan if he has had occasion to investigate the curved roof. In the northwest there has been considerable interest taken in the curved or arched roof made up of 1″ by 8″ pieces. The feet of the rafters are attached to the walls at the plate. The curvature is not seamless at the peak. There is considerable break at that point.

MR. STRAHAN: I haven't studied the details of that type of truss construction from a mathematical standpoint. The arch has a radius equal to about two-thirds of the expanse of the building. This radius is usually 14 feet directly from the floor level. I have seen such a barn built out of 1″ by 12″ pieces and the arch cut right out of the center of that one by twelve.

QUESTION: Do you think that design is more capable of withstanding the heavy wind pressure.

MR. STRAHAN: I think possibly an analysis of that would show a resistance to the wind pressure.

MR. NORMAN:[1] Regarding your sketch of the Flickinger diagram—is the material about the same in the Shawver and the

[1] Department of Agricultural Engineering, Purdue University, Lafayette, Ind.

braced rafter? Isn't there a great deal of difference in the cost of construction between those two types?

MR. STRAHAN: I am not prepared to say, but I should think so. The Shawver truss is built right on the floor and one truss is built right on top of the other.

MR. NORMAN: That is the way they usually build a braced rafter, raise it up in shape. It is so much lighter than the Shawver.

MR. STRAHAN: I have no figures.

PRESIDENT SCOATES: There is room for a lot of work on barn roof trusses. I guess everybody who has designed barns has found that to be true.

MODERN DEVELOPMENTS AND PRACTICAL DETAILS IN THE PRESERVATIVE TREATMENT OF WOOD

KURT C. BARTH,[1] Member Amer. Soc. A. E.

Wood preservation is primarily a conservation measure and an economy of far reaching importance. Although but a minor detail of structural engineering, it is comparable perhaps with the axiom "take care of the pennies and the dollars will take care of themselves."

Popularization of the practice of wood preservation is most desirable, but it is to be achieved only by education. The desire for thrift and economy is an indication of intelligence based on a conception of values, and that must be taught. Ignorance is wasteful.

We are particularly interested in developing efficiency on the American farm; of promoting every effort which will in any way improve conditions, practices, or any phase of agricultural engineering; hence it is not only desirable, but, in fact, obligatory to aid in minimizing the loss due to the ravages of decay and insects which annually destroy millions of dollars worth of lumber, and timber employed on farms. There are various ways in which this can be done. An extremely radical cure that has been advanced, is the entire elimination of wood, excepting for such luxurious purposes as interior trim, furniture, etc., but that is not apt to become a popular remedy, at least during the next 50 years or so. Wood will undoubtedly remain the most available building material for farm structures and uses.

The cause and effect of decay, the activities of the chief destructive agents, fungi and termites (white ants) are well known, and were interestingly referred to in Mr. Thelen's paper published in the 1916 Proceedings of the society. It is, however,

[1] Of the Barrett Company, Chicago, Ill.

necessary to convey to the general public in simple form the fundamental reasons why wood decays. In searching the literature on the subject I found the following to be the most lucid, with all practical explanation of this highly technical matter. I quote from a paper presented by C. J. Humphrey, Pathologist, U. S. Forest Products Laboratory, to the Western Society of Engineers. (Journal W. S. E., February, 1917.)

> "Decay is due almost entirely to the growth of the wood destroying fungi within the tissues of the wood. These fungi are plants just as much as are trees and herbs. They differ merely in their form, lack of green coloring matter, and methods of nutrition. While green plants absorb their food supplies from the soil through their roots, fungi derive their nutriment from the substance of the wood. In the life cycle of a wood destroying fungus there are two distinct stages: (1) The vegetative stage consisting of thread-like, usually much branched, filaments, termed mycelium, which takes on definite form on the surface of the decaying timbers, and serves for the production of spores and hence the propagation of the species. The mycelium is usually confined within the wood substance, the fine, cotton-like filaments ramifying the tissues and filling the pores of the wood and the cells of the pith rays, as well as boring through the walls of the wood elements. It can roughly be compared to the root system of ordinary plants, for its function is the same, namely, that of an absorbing system. In order to render the constituents of the wood available for food they must be reduced to simpler organic compounds which can be absorbed readily through the walls of the mycelium filaments. This is accomplished by the secretion of organized ferments which have the capacity of acting chemically upon the wood and splitting up the complex compounds into their simpler components."

Equally necessary is it to follow lines of least resistance in promoting remedial measures. The public will rather suffer loss than inconvenience; consequently, in introducing preservative treatments, practicability has been the governing motive, and the adaptation of theory and practice to existing circumstances is mandatory. Nevertheless, the most efficient practice must be the goal, and as means of retarding decay find general employment, better methods can be introduced gradually, with some assurance of success.

It is a fact that the preservative treatment of wood is an unknown practice to the average farmer, and that those who have been reached by the educational efforts thus far expended were either discouraged by the apparent technicalities involved, or confined themselves to treating a few fence posts. This is due largely to the lack of confidence which the educators and experts have in the simple methods available, and their failure to recognize that the problem is chiefly one of expediency, requiring adjustment of theory to the practical conditions encountered. In lieu of the factors involved in other industries, such as mining and general structural engineering, the customs and characteristics of the agricultural field must be given careful consideration, to the end that the introduction of preservative treatments shall not create unreasonable obstacles.

The solution of this problem has occupied me for a long time, and it is my belief that it lies largely with the agricultural colleges, and the various associated educational bureaus, to teach the value of wood preservation, not only to the students but also to those now engaged in the practice of agriculture. County

Fig. 1. Demonstration of creosoting posts cut from farmer's wood-lots conducted under auspices of Michigan Agricultural College

agents' organizations promote better farming, and so forth; they could likewise preach more economical building, and aid considerably in the practical application of suitable methods of preservative treatment. The departments of the colleges having in charge the preparation of plans for numerous types of farm structures could advance the practice of this economy by merely indicating the parts and portions which are subject to decay and specifying their treatment with a preservative. Most plans and specifications covering metal, or steel structures and parts, clearly state requirements as to painting or that they shall be galvanized, and the necessity of protection against deterioration is thus emphasized. What I suggest is merely that the same precaution should be exercised in the case of wood construction. Painting necessary to convey to the general public in simple form the fundamental reasons why wood decays. In searching the literature on the subject I found the following to be the most lucid, with all practical explanation of this highly technical matter. I quote from a paper presented by C. J. Humphrey, Pathologist, U. S. Forest Products Laboratory, to the Western Society of Engineers. (Journal W. S. E., February, 1917.)

> "Decay is due almost entirely to the growth of the wood destroying fungi within the tissues of the wood. These fungi are plants just as much as are trees and herbs. They differ merely in their form, lack of green coloring matter, and methods of nutrition. While green plants absorb their food supplies from the soil through their roots, fungi derive their nutriment from the substance of the wood. In the life cycle of a wood destroying fungus there are two distinct stages: (1) The vegetative stage consisting of thread-like, usually much branched, filaments, termed mycelium, which takes on definite form on the surface of the decaying timbers, and serves for the production of spores and hence the propagation of the species. The mycelium is usually confined within the wood substance, the fine, cotton-like filaments ramifying the tissues and filling the pores of the wood and the cells of the pith rays, as well as boring through the walls of the wood elements. It can roughly be compared to the root system of ordinary plants, for its function is the same, namely, that of an absorbing system. In order to render the constituents of the wood available for food they must be reduced to simpler organic compounds which can be absorbed readily through the walls of the mycelium filaments. This is accomplished by the secretion of organized ferments which have the capacity of acting chemically upon the wood and splitting up the complex compounds into their simpler components."

Equally necessary is it to follow lines of least resistance in promoting remedial measures. The public will rather suffer loss than inconvenience; consequently, in introducing preservative treatments, practicability has been the governing motive, and the adaptation of theory and practice to existing circumstances is mandatory. Nevertheless, the most efficient practice must be the goal, and as means of retarding decay find general employment, better methods can be introduced gradually, with some assurance of success.

It is a fact that the preservative treatment of wood is an unknown practice to the average farmer, and that those who have been reached by the educational efforts thus far expended were either discouraged by the apparent technicalities involved, or confined themselves to treating a few fence posts. This is due largely to the lack of confidence which the educators and experts have in the simple methods available, and their failure to recognize that the problem is chiefly one of expediency, requiring adjustment of theory to the practical conditions encountered. In lieu of the factors involved in other industries, such as mining and general structural engineering, the customs and characteristics of the agricultural field must be given careful consideration, to the end that the introduction of preservative treatments shall not create unreasonable obstacles.

The solution of this problem has occupied me for a long time, and it is my belief that it lies largely with the agricultural colleges, and the various associated educational bureaus, to teach the value of wood preservation, not only to the students but also to those now engaged in the practice of agriculture. County

Fig. 1. Demonstration of creosoting posts cut from farmer's wood-lots conducted under auspices of Michigan Agricultural College

agents' organizations promote better farming, and so forth; they could likewise preach more economical building, and aid considerably in the practical application of suitable methods of preservative treatment. The departments of the colleges having in charge the preparation of plans for numerous types of farm structures could advance the practice of this economy by merely indicating the parts and portions which are subject to decay and specifying their treatment with a preservative. Most plans and specifications covering metal, or steel structures and parts, clearly state requirements as to painting or that they shall be galvanized, and the necessity of protection against deterioration is thus emphasized. What I suggest is merely that the same precaution should be exercised in the case of wood construction. Painting or galvanizing a steel fence post is necessary to protect it from rust, creosoting a wooden post is protection against rot; both are a vital detail of proper utilization.

Colleges and experiment stations have done valuable work in connection with the preservation of fence posts. These investigations should be continued and augmented, but there is a larger and more important field, namely, structural wood for general building purposes and farm equipment. It is this latter phase in which I am most interested at present, and I wish to appeal to the engineering department of every agricultural college to not only include wood preservation in their curriculum, but especially to aid in impressing upon the farmer the very considerable saving in material and labor that would result from protecting wood against its chief weakness—decay. White ants also cause the destruction of much building lumber in certain sections of the country, and for this evil preservative treatment likewise is an efficient remedy, as has been discussed in detail by T. E. Snyder, Bureau of Entomology, U. S. Department of Agriculture, Bulletin No. 759.

METHODS OF PRESERVATIVE TREATMENT

The standard methods that have proven satisfactory under conditions where their employment is warranted, are divided into two groups: (1) Pressure processes; (2) Non-pressure processes. These are again divided into methods which, though similar, vary in procedure, which conform to the operating conditions involved.

(1) The Pressure Processes consist of (a) Full cell treatment; (b) Empty cell treatment. In treatment (a) the timber is impregnated with a pre-determinated quantity of preservative per cubic foot, the wood cells remaining filled; and in the treatment (b) a pre-determined quantity of preservative is also injected, but the surplus oil is recovered from the wood cells, leaving merely a coating on the cell walls. Treatment in both cases is applied in large cylinders or retorts under heavy artificial pressure, and commercial coal-tar creosote oil, as well as zinc chloride, or a solution of zinc-creosote, are the standard preservatives.

(2) Non-pressure processes are divided into (a) Open tank process; (b) Surface treatments. The former is strictly an impregnation process, as under proper conditions the timber is impregnated in practically the same manner, excepting that no artificial means other than the heating of the oil is resorted to. Even control is possible with reasonable care. The treatment consists of complete submersion for varying periods in alternate hot and cold baths of refined coal-tar creosote oil. No other preservative is really suitable for this process.

Briefly, impregnation of wood is obtained by the aid of atmospheric pressure, gravity of the preservative, and a slight vacuum resulting from expansion and contraction of air and moisture in the wood cells, caused by the difference in temperature between the hot and cold treatments.

Surface treatments mean any practical method of applying refined coal-tar creosote oil to the surface of wood, surrounding it with an intact film of the preservative. The special feature is to entirely and thoroughly coat the portion, or surface, which it is intended to protect, and to accomplish this it is usually necessary to make two or three successive applications. Surface treatments are distinct from the regular creosoting processes, namely, pressure and open tank treatments. Thus we are confronted, perhaps, with a considerable selection that, judging from experience, is

Fig. 2. The brush treatment

confusing to many, but each and every method has definite limitations, and is fit particularly for certain purposes, so that determination of these effectively eliminates those treatments not suitable to the conditions encountered. As far as the agricultural industry is concerned we may immediately eliminate pressure treatments as unavailable. The exception where farmers are so located as to be able to purchase pressure treated material from commercial creosoting plants, simply proves the rule. Of the one hundred odd pressure treating plants in the United States, but very few are so situated that it is possible for them to supply the general trade. Over 80 percent are contract plants, whose entire production is sold to large industrials such as railroads; for dock, wharf and harbor improvements; and for paving blocks. In the future it may be possible that a number of additional commercial plants will be established, and that these will produce creosoted material ready for the general market, but it is not practical to count thereon at least for a considerable time to come. Consequently, we find that the average consumer—especially the farmer and land owner—must avail himself of non-pressure processes of treatment if he desires to benefit from the practice of wood preservation.

The open tank process may be employed by anyone who is in a position to supply the necessary tanks, and means of heating the preservative. In some cases such simple apparatus will cost $50, in other instances $200, $400, and even perhaps up to $1,000. Thus, the availability of this method is largely dependent upon the quantity of lumber to be treated at one time, or within a reasonably short period. The farmer is again excluded from employing

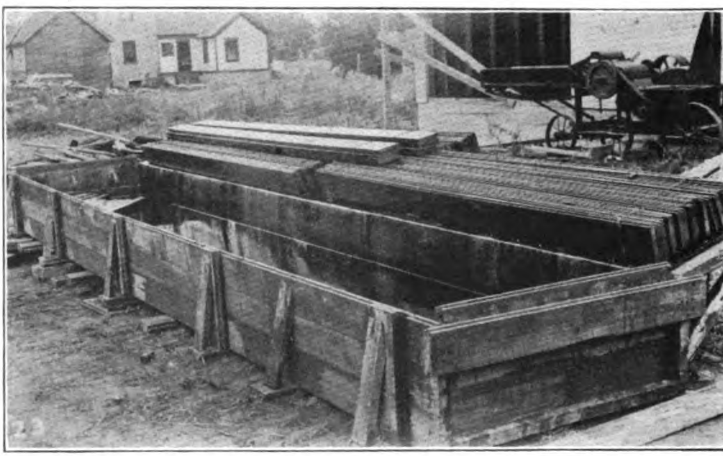


Fig. 3. Close-up of farmer's tank, built of common lumber, lined with sheet iron soldered at all joints

this method, largely because he has not sufficient work at one time to warrant the expense of the necessary equipment, but eventually it must be our object to induce the progressive land owner to so equip himself that he can creosote lumber by the open tank process whenever the occasion for it arises. Naturally, he will not do this at first, but after having used the more simple methods and experienced satisfactory results therefrom, he is more apt to consider favorably the permanent installation required, viewing it in the same spirit with which he perhaps builds a smoke house or some other equipment that is also used only occasionally during the year.

Primarily the introduction of preservative treatment on the American farm is dependent upon the promotion of surface treatments, that is, the application of the preservative with a paint brush, in the same manner as paint, or application of one or more coats with spraying machines, or dipping of the lumber and timbers into creosote for short periods, and without heating during favorable weather.

The only opposition is that of those who believe that these surface treatments are of little or no value, who state that unless a thorough impregnation of the wood with the preservative is obtained the effort is wasted. I wish to state emphatically that such a contention is erroneous. Surface treatments are of value, and do increase the life of timber so treated more than sufficient to warrant the expense and trouble. Admittedly, surface treatments are not as efficient as impregnation processes, and most assuredly where it is possible to employ the latter that should be done; but nevertheless, and in spite of the popular impression that mere painting of the preservative on to the wood is a doubtful makeshift, I seriously recommend to you gentlemen that you devote your entire effort to introducing surface treatments on the farm. After that has been accomplished and when the farmer is thoroughly acquainted with the purposes and simpler practices of wood preservation, we can unitedly endeavor to improve the methods, and eventually, perhaps, induce the consumer to purchase properly creosoted wood from stock, but these are developments which must await the opportunity, and that can only be supplied by the gradual education which must proceed, as previously stated, along the lines of least resistance.

PROPER PRESERVATIVE

There exists sufficient official data on what a proper preservative for non-pressure treatments should be, and it is merely necessary that this be made available and called to your attention. Recently a standard specification for refined coal-tar creosote oil for brush treatments has been issued by the United States Shipping Board Emergency Fleet Corporation; and also by the United States Railroad Administration—both containing identical requirements. A copy of the former is attached as an appendix to this paper as are also recommendations for the application of non-pressure processes. The difference between refined creosote oil and the commercial grades used in pressure processes is largely a physical one. Briefly, a refined oil should be employed, because it presents no obstacles to its use under ordinary working conditions which would be the case if an attempt were made to use the commercial grades; and without going further into this matter permit me to state that practically all responsible authorities are united on this specification. It is the expression of the industry, and as such warrants the confidence of all consumers. Other products may be just as good, but if they do not conform to this standard they naturally represent the minority opinion. It must

Fig. 4. Creosoted cottonwood posts after 9½ years' service

be fully realized that it would be neither practical nor desirable to educate the farmer to buy a preservative on specification, and the only means that suggests itself, which would provide protection for the farmer against the unscrupulous dealer who might, if permitted, foist some inferior but more profitable article upon him, is that the agricultural colleges should act as advisers. The lierature of the college could suggest to the farmer that he can

Fig. 5. White cedar posts after 9½ years' service

obtain information regarding the efficiency of any wood preservative by addressing the respective department and furnishing the name of the product offered. It would be a simple matter for the college to analyze the several preservatives on the market, thus ascertaining whether they conform to the standard specification, and communicate their advice as based on the analysis to their correspondent.

The above suggestion may meet with objections, but the thought in mind is that it would enable rendering a valuable service to the farmer who has no means of determining the value of a preservative which is offered to him as such, and who, if he uses an inefficient product, is worse off than if nothing at all had been done.

In the final analysis the entire problem devolves itself into educating the farmer to understand the cause and effect of decay, and to realize the loss to himself in dollars and cents of permitting the development of decay, and likewise the saving in dollars and cents resulting from the elimination of this loss by the practice of wood preservation. In this effort the agricultural colleges can render a specific service to their constituencies. It will always be a pleasure to collaborate to the fullest extent of my ability.

APPENDIX A

RECOGNIZED AS STANDARD SPECIFICATION FOR REFINED COAL-TAR CREOSOTE OIL

UNITED STATES SHIPPING BOARD EMERGENCY FLEET CORPORATION

Washington, D. C., July 24, 1917 *Specification No. 128*

Supplementing Circular Letter to District Officers No. 10 dated June 24, 1917, and final specifications on wood preservative.

SPECIFICATION FOR CREOSOTE OIL FOR BRUSH TREATING SHIP TIMBERS

The oil shall be obtained from coal-gas or coke-oven tar and shall be free from any tar, including coal-gas tar and coke-oven tar, oil, or residue obtained from petroleum or any other source. It shall comply with the following requirements:

1. It shall be completely liquid at 15° C.
2. It shall contain not more than 2 percent of water.
3. It shall contain not more than 0.5 percent of matter insoluble in benzol.
4. The specific gravity of the oil at 15°/15.5° C. shall not be less than 1.08.
5. The distillate based on water-free oil shall be within the following limits:

Up to 210° C not more than 1 percent
Up to 235° C not more than 10 percent

6. The specific gravity of the fraction between 235° C and 315° C shall not be less than 1.03 at 38°/15.5° C. The specific gravity of the fraction between 315° C and 355° C shall not be less than 1.10 at 38°/15.5° C.
7. The residue above 355° C, if it exceeds 5 percent shall have a float test of not more than 50 seconds at 70° C.
8. The oil shall yield not more than 2 percent coke residue.
9. The foregoing tests shall be made in accordance with the standard methods of the American Wood Preservers Association.

APPENDIX B

RECOMMENDATIONS FOR APPLICATION OF NON-PRESSURE TREATMENTS

SURFACE TREATMENTS

This description applies to any practical method of preservative treatment which coats the surface of the wood and surrounds it with an intact film of the preservative. They are distinctive from the regular creosoting processes, namely, pressure processes and the open tank process, which aim to secure a thorough impregnation. The principal methods that have become standard practice are:

(1) *Brush Treatment:* Application of two paint coats of refined coal tar creosote with a wide wire-bound brush. The oil should be carefully brushed into all crevices and checks, depressions and abrasions. Poles and large timbers are often treated by applying the preservative with a mop or by pouring it over the wood.

(2) . *Spraying.* Application of refined coal tar creosote with spraying machines operated by compressed air or hand pumps. Two applications are usually advisable. This method has many advantages over the brush treatment, chiefly because less labor is required and the preservative can be more readily forced into checks, crevices, bolt holes, etc. Spraying machines must be equipped with properly designed nozzles, otherwise unreasonable waste may occur due to vaporization of the oil.

(3) *Dipping:* Complete immersion of timbers in refined coal tar creosote for short periods As this method requires but one operation it is economical and practical where tanks, mechanical means of handling timber, and steam for heating oil can be provided.

When employed for treating lumber and timbers of species readily impregnated by immersion for varying periods in the hot bath only, this method becomes a modification of the open tank process, and is discussed further in that division.

The preservative should be heated to an average temperature of 150° F. for brush and spraying treatments, and should be maintained at an average temperature of 180° F. (minimum 150° F., maximum 200° F.) in the dipping treatment.[1]

Lumber and timber should be cut to size, bolt holes drilled and completely framed previous to treatment, and protected against abrasion after treatment. If the treated surfaces are injured and the film of preservative broken, exposing untreated wood to attack by fungi, such abrasions should receive an additional treatment of two coats of refined coal tar creosote.

OPEN TANK PROCESS

Impregnation of wood in open tanks, or vats, without artificial means other than heat, by aid of atmospheric pressure, gravity of the preservative and a slight vacuum resulting from the expansion and contraction of air and moisture in the wood cells caused by the difference in temperatures between the hot and cold treatments.

The process is divided into two stages (1) the hot treatment, and (2) the cold treatment.

1. The *hot treatment* consists of submerging the wood for varying periods in refined coal-tar creosote oil which should be maintained at a temperature of not less than 150° F. and not more than 200° F.
2. The *cold treatment* immediately follows the hot treatment and

[1] Note: Exception is allowed when circumstances absolutely preclude heating of oil, but satisfactory results are obtained only when the mean atmospheric temperature is not lower than 60° F.

consists of submerging the wood for varying periods in refined coal-tar creosote oil, which should be maintained at atmospheric temperature, between the minimum and maximum limits of 75° F. and 100° F.

(A) In lieu of the cold treatment above described, the following method may be employed: Upon expiration of the hot treatment, the wood is not removed but remains submerged, heat is shut off and both wood and preservative permitted to cool to atmospheric temperature, within the minimum and maximum limits of 50° F. and 100° F.

(B) Lumber of species that readily absorb creosote, and of small cross-section often is adequately impregnated by the hot treatment only, or short immersions in the heated preservative In that event the dipping method becomes a modification of the open tank process, and should be conducted as described under surface treatments.

Wood to be treated by the open tank process should be thoroughly air-seasoned, or air dry; that is, the moisture content should not exceed 20 percent of the average oven-dry weight of the respective species.

Timber and lumber should be framed, all mortises and tenons cut, bolt holes drilled, and otherwise completely manufactured ready for placing previous to treatment. If abrasions of the treated surfaces occur, or additional framing or drilling become necessary after treatment, a two coat brush application of the preservative at such points is imperative.

DISCUSSION

MR. BARTH: Mr. President: We are contemplating an extensive promotional campaign to bring to the farmer a realization of the advantage of wood preservation. We don't know exactly how that is going to be done. We are thinking about it. What we would appreciate is suggestions from you gentlemen, as to what you think is the best way. Can we cooperate directly through the colleges? We realize that first we have to educate the farmer before we can create a market. The first stage of it is strictly an educational campaign—to teach the farmer that he earns a much larger profit from the use of a preserver than anyone else in the promotional sale. In other words, if the farmer spends $5 to treat a foot of lumber he increases its life from three to five years. You know who gets the advantage—the farmer does.

PRESIDENT SCOATES: Are there any questions you wish to ask Mr. Barth? In our state, Mr. Barth, the best way of reaching the farmer would be through the agricultural engineering department of the college, going through the county agents. Once a year we have all the county agents in the state come into the college for the school in which they are given all the latest developments.

MR. BARTH: When are these meetings held?

PRESIDENT SCOATES: In the summer, usually. These other men can tell you about their own states—whether that would work in their states or not.

MR. BARTH: Is this subject of sufficient importance to the farming community to warrant the cooperation of all of us in promoting it, regardless of the commercial feature?

President Scoates: I think it is a vital subject. I will be glad to cooperate with you down there to get it before our farmers. They are asking about such things. Since the war, lumber is pretty high priced and they are thinking about just such things. Another thing I am doing—pardon my personal reference; in our freshman work one of the laboratory exercises is to have them creosote fence posts. We are also teaching them to build fences.

Mr. Barth: That is very encouraging.

Question: Is it possible to paint over the creosote and get good results?

Mr. Barth: No, sir, creosote will eat through the paint. However, you can put a coat of shellac over the creosote to keep it from eating the paint, but that isn't practical.

Question: What would be the approximate cost?

Mr. Barth: It would cost about 20 cents for a 5-inch post.

Mr. Smith:[1] There are a good many inquiries, but creosote is not in the market in Canada.

Mr. Barth: Due to war conditions we haven't had a large supply, but you will get creosote if you find anybody to buy it.

Question: What is the effect, if the hot treatment is not followed by the cold?

Mr. Barth: Merely to expand the moisture in the cell of the wood and make it more susceptible to decay.

WATER POWER ON THE FARM

By J. S. Fitz,[1] Member Amer. Soc. A. E.

The development and application to useful service of the innumerable little water powers now going to waste on American farms is well worth the attention of every farm engineer. Few improvements will return such substantial benefits in proportion to the time and money expended on them. Water power is especially well suited for farm use since it requires but little attention, and costs practically nothing for operation, or depreciation. Even the original cost of installation need not be large in most cases, since the spare time labor of the farmer and his regular employees will usually take care of most of the work.

In looking for a suitable site for a water power development, there are several points to be considered. The power that it is possible to secure depends upon two factors, namely, the volume of water available and the amount of fall that can be obtained. The fall can easily be measured by means of a hand level if no transit is at hand. The volume of flow can be measured most accurately and conveniently through a weir dam as shown in the illustration attached (Fig. 1). Detailed instructions for the construction of weirs, together with tables showing volume of water passing through at various stages, may be found in any water wheel catalog.

As a practical example of a little stream that would be well worth developing, we will assume that our weir measurement shows a depth of 4 inches through a notch 20 inches wide. This would indicate a volume of 64 cubic feet of water per minute, and on a fall of 10 feet, would be capable of developing 1 horse power for continuous service. If our notch should be 40 inches wide with the water flowing at the same depth, we would have 120 cubic feet of water per minute in our stream and would need only a 5-foot fall to develop 1 horse power.

With 1 horse power, it is possible to drive a dynamo generating sufficient current for from 20 to 25 Tungsten lamps. Since this power is available for constant use, both night and day, without any increased expense, the electric current can be used for driving electric irons, washing machines, churns, etc. Ample power can also be furnished for sawing firewood, etc., and pumping water, but the saw should be driven direct from the water wheel if possible.

If the minimum flow of the stream does not afford sufficient power to do the work desired, a storage dam may be used to accumulate the water during the hours when the full power is not

[1] Department of Agricultural Engineering, Manitoba Agri. College, Winnipeg, Can.

required. A stream having a capacity of 1 horse power continuous service, can be made to yield 3 horse power for 8 hours work per day, by the use of a storage dam, or a larger amount of power for a correspondingly shorter period. The details of dam construction vary so much with the location that no definite statement is possible as to what type is best to use. Sketches of several types which have been found useful are shown here. (Fig. 2.)

Either of the foregoing locations could be utilized at small expense and would afford splendid service. Many power sites

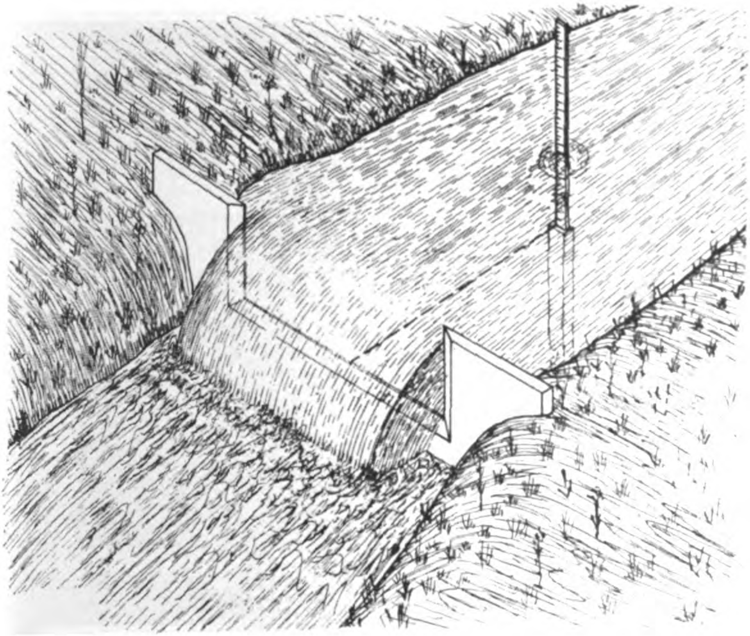


Fig. 1. Weir dam—the top of the stake on which the measurements are taken should be level with the bottom of the notch

like these are available in all parts of the country, but are mostly being ignored by their owners who are looking for something bigger. As a matter of fact, it is these small water power developments that really pay the best returns in proportion to the money expended. Power sites with capacities of 20 horse power or more, are seldom available for farm use, as they are greatly in demand for manufacturing purposes. If a farmer can get his smaller and every day tasks done by water power, he can well afford to run his engine occasionally to do the heavier work, such as driving a threshing machine, etc.

The third important point in a water power development is the choice of the proper type and size of water wheel. Too much

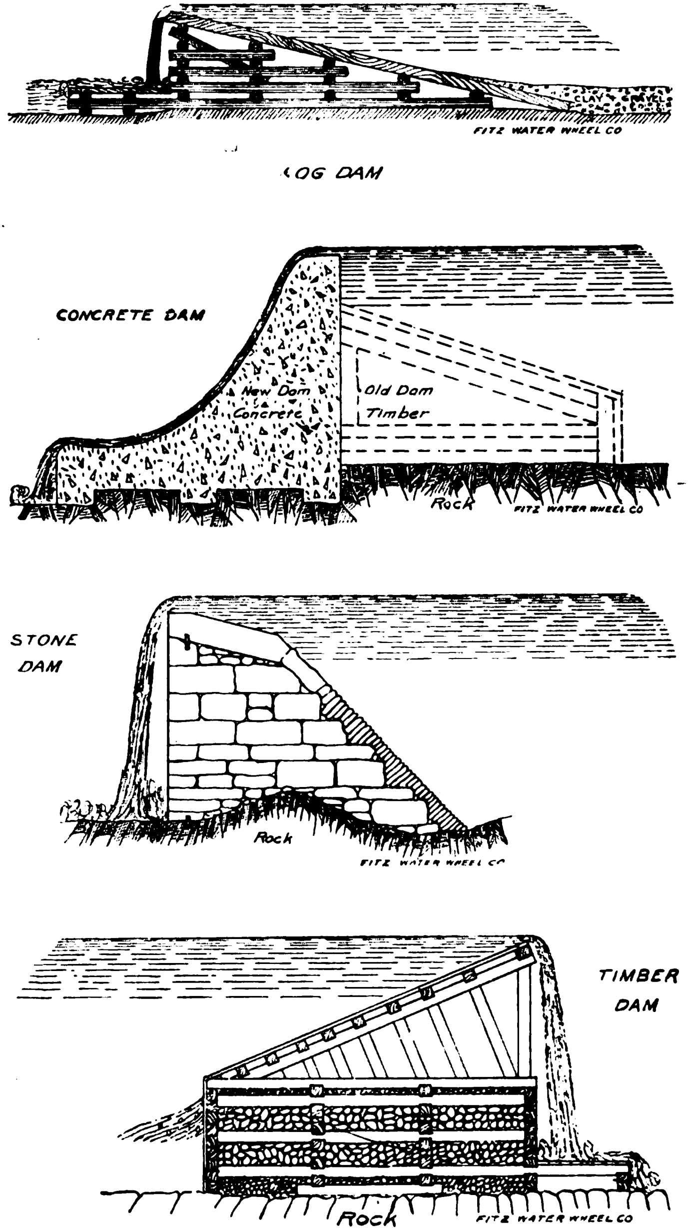


Fig. 2. Four types of dams

care can not be used in its selection. The cost of the best water wheel on the market represents only a small part of the value of the dam, raceway, and water rights which it is to utilize. Through a spirit of false economy, however, or a lack of appreciation of the situation, many otherwise well-planned little powers have been seriously crippled by the installation of wasteful or ill-adapted wheels. There is a great difference in the efficiency of various types of water wheels, and it is not an uncommon thing to see from 60 percent to 80 percent of the power being wasted by the wrong kind of wheel. An error of that kind reduces the earning capacity

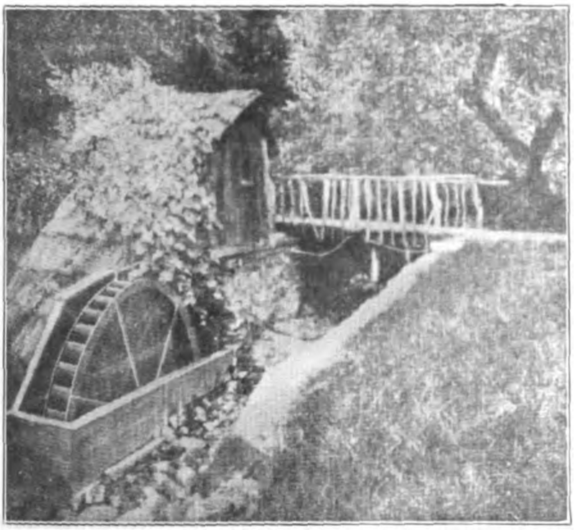


Fig. 3. Steel overshoot water wheel, suitable for small streams

of the plant correspondingly, and consequently is an expensive mistake to make. For the majority of farm water power sites, the modern steel overshoot water wheel will be found most suitable on account of its very high efficiency and its ability to utilize the smallest kinds of streams. This type of wheel (Fig. 3) should be used in practically all cases where the head ranges from 8 to 20 feet and the volume of water available is less than 250 cubic feet per minute. For lower falls and larger streams of water an open flume turbine may be used to good advantage, if set in an open wood or concrete penstock (see Fig. 4). For falls higher than 20 feet, provided there is a sufficient flow of water, an enclosed turbine mounted in a metal case of the globe type affords an exceedingly neat and convenient installation (see Fig. 5). The foregoing recommendations are not to be regarded as hard-and-fast rules, for circumstances may often require something different, but they are in line with the best standard practices.

In the case of extremely small streams it is often preferable to dispense with a storage dam for the water and to use a storage battery instead. This method enables us to store up electric current instead of water during the hours when the power is not required. This is a very convenient method, as the water wheel can then be allowed to run 24 hours per day, charging into the battery continuously. A slow, even charge like this is ideal from a battery standpoint and causes the batteries to last much longer than they will in ordinary service. A brief description of a few typical water power installations may be of interest, as follows:

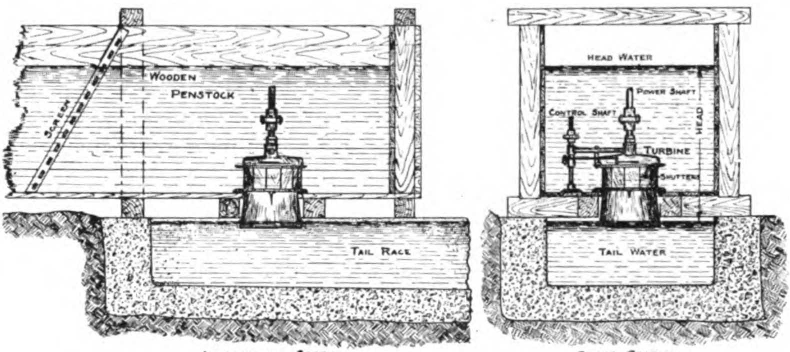


Fig. 4. Open flume turbine, suitable for lower heads and larger streams of water

One of our customers had a lively little brook on his farm. It was 2 feet wide by 6 inches deep. He threw some sticks in the stream and timed their progress between two points so as to find out how rapidly the water travelled. After six or seven tests, he found it took 12 seconds for a chip to travel 20 feet down stream. He found, upon taking some levels, that he could secure a 13-foot fall in 480 feet length of the brook. Upon receiving this information, we advised him to build a wall across the brook about 4 feet high near the head of the rapids, so as to dam the water up enough to take up part of the fall; then to lay 10-inch riveted steel pipe from the dam to a point down towards the foot of the rapids, where he could install a 10-foot diameter wheel.

In order to save as much pipe as possible, the dam was built across the stream at a point 230 feet below the rapids, taking up all the fall which existed in that 230 feet by backing the water up over the rapids. The bed of the stream sloped very rapidly for the first 80 feet down stream from the dam, and then more gradually from that point on. The water was led from the dam thru a riveted steel pipe for a distance of about 80 feet, thus taking up 5 feet more fall below the dam. The wheel was located at this point, a little off to one side of the creek to protect it from floods. The remaining 4 feet fall was taken up by digging a ditch or tailrace with a slant of about 4 inches to 100 feet parallel to the

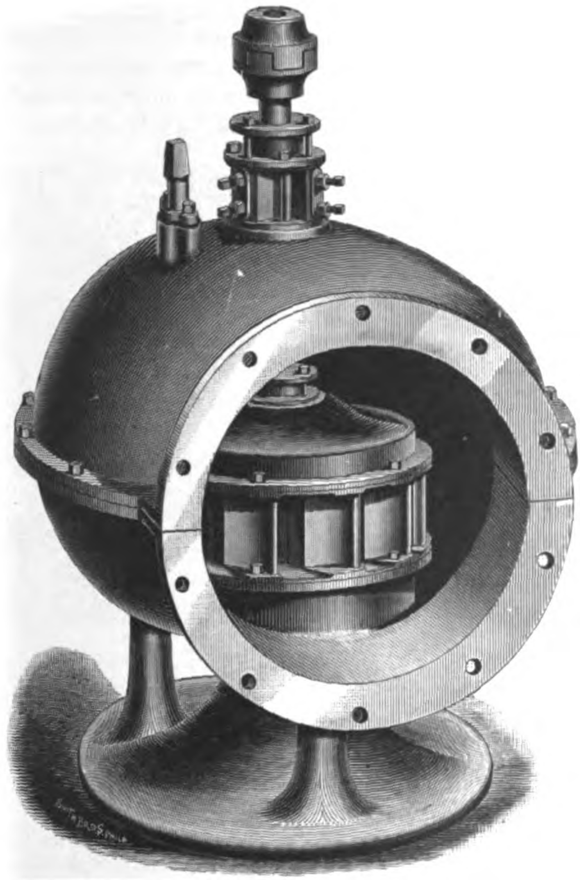


Fig. 5. Turbine water wheel in Globe case ready to bolt to the end of a steel pipe or to the side of a wooden penstock

general direction of the bed of the stream, to a point down stream where the tailrace could join the main stream again on a level.

A complete electric lighting plant was installed, including a 10 foot diameter by 1½ foot face Fitz steel overshoot water wheel and 3 K. W. G. E. direct current dynamo. The customer, with the aid of his two sons, made the installation himself, doing all the work and having all the fun of building the low dam, etc., at odd moments. With this outfit he is driving 140 Tungsten lamps at a time, furnishing light for two smaller farms, in addition to his own. He controls the starting and stopping of the wheel by means of a wire cable, from his house, although the wheel is located at a distance of 600 feet away. Besides having all the light needed for his barn, a cut-off saw for firewood, as well as vacuum cleaner, churn, etc., and numerous small electric cooking utensils, he has a portable motor in his orchard which saves him much money and time in his spraying, etc. The entire plant costs him nothing to run except a little oil occasionally, and a little fuse wire.

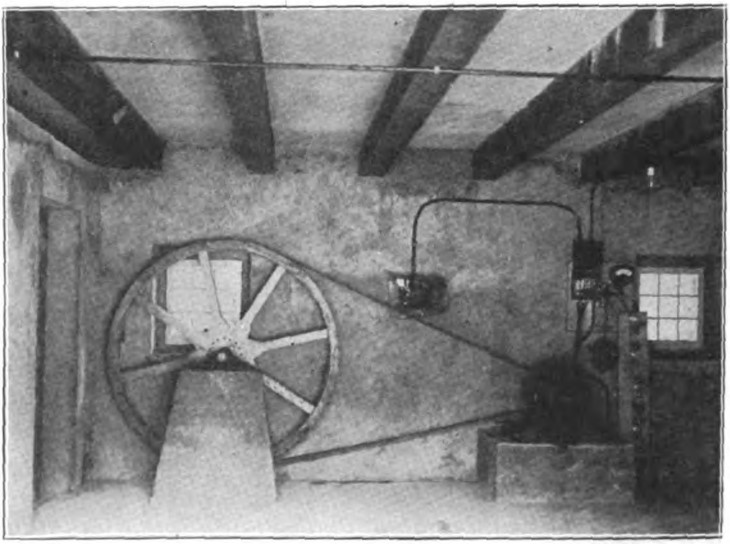


Fig. 6. Large pulley mounted on the jackshaft of the water wheel, belted direct to a slow speed dynamo

At another farm, in Lancaster County, Pa., last year, the owner found that he could secure a fall of about 9 feet on a little stream of water that was then being used to drive a 3 foot diameter wooden overshoot wheel to operate a small pump. Upon measuring the water through a weir board, it showed a depth of 3 inches through a notch 18 inches wide, thus indicating a volume of flow of about 36 cubic inches per minute.

A small concrete wall was thrown across the stream as a dam, and the water was then led through an open canal or ditch to the point down stream where the wheel was to be placed. On account of the exposed situation a good concrete block house was built to house the machinery. In this house a 7½ foot diameter by 2 foot wide Fitz steel overshoot water wheel was installed, driving a slow

Fig. 7. Wheel installed at dam, saving cost of raceway and pipe

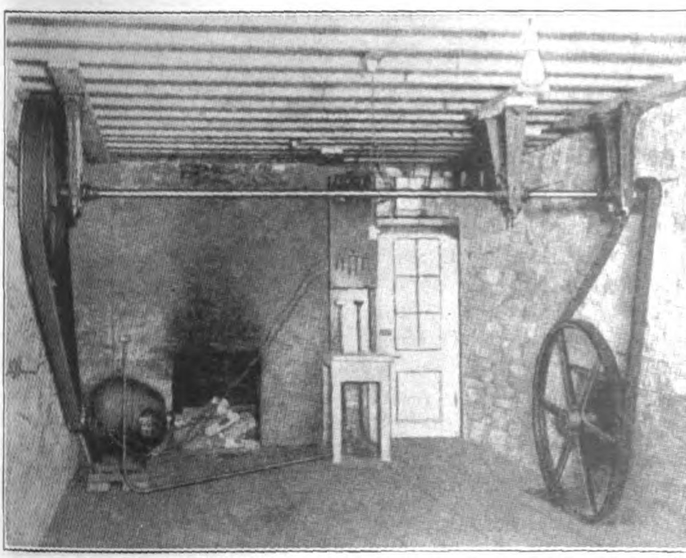


Fig. 8. Morse silent chain drive, used to transmit power from overshoot water wheel to the line shaft

speed 500 watt, 125 volt D. C. generator. This generator is driven direct from a large pulley, mounted on the jack shaft of the water wheel (as shown in Fig. 6). The wheel runs continuously 24 hours a day, charging a 56-cell, 125-volt Electric Storage Battery Company battery from which the current is drawn as needed.

From this plant, Mr. Nolt furnishes electric lights for his own substantial residence, as well as that of his son on an adjoining farm. The large barns, cow stables, dairies, and other buildings on both farms are also supplied with ample light, and there is plenty of current available for ironing at both houses. Although some of the coldest weather ever known in Lancaster County was experienced last winter, the water wheel gathered no ice in its warm little house, and the plant has never caused a cent of expense for upkeep or repairs.

For our last practical example we wish to show an installation on a farm just outside of Trenton, New Jersey (see Fig. 7). In this case an old abandoned water power was restored with the view of retaining its picturesque effect, as well as securing the very practical benefits afforded by its power. The wheel is 10 feet in diameter by 3 feet wide, and was installed right at the dam, thus saving the cost of raceway and pipe. The water wheel shaft was extended inside the building through a hole in the wall, and a large sprocket wheel was mounted on the end of the shaft (see Fig 8). From this sprocket wheel, a Morse silent chain drive is used to the line shaft, which in turn belts to a standard Fairbanks-Morse 5 k. w. generator as shown. The current supplied by this generator operates various machines on the farm in addition to furnishing all the lights that are needed and supplying various cooking devices and conveniences at the house. Since the photo was taken a large centrifugal pump has been installed in the dynamo room, being driven by belt from the overhead line shaft. This pump supplies water for an extensive irrigation system on the farm which is bringing in some very attractive profits.

These instances are only intended to serve as illustrations of what can readily be done on countless other farms where water power is available. A water power plant suffers but little loss from depreciation. If well built, the dam and water ways should last a lifetime, and with reasonable care the machinery will last equally as long. The farmer who puts a water power to work is not only assisting in the great cause of conservation of natural resources, but he is making one of the most satisfactory and profitable investments that any one could want.

AN ANALYSIS TO DISTINGUISH BETWEEN A CRANK AND AN ECCENTRIC AS DRIVING OR DRIVEN ELEMENTS

By H. S. Dickinson.[1]

This analysis was prepared as evidence or proof in presenting an application for patent for a certain invention. For this reason, the author is not at liberty to discuss but one phase of the original case, namely, a device shown in our diagram No. 1 the parts of which are drawn proportionately and throughout the analysis are to be considered of the following dimensions:

Throw of the eccentric or crank, 3″
Diameter of the crank pin, 1″
Diameter of the eccentric boss, $5\frac{7}{8}$″

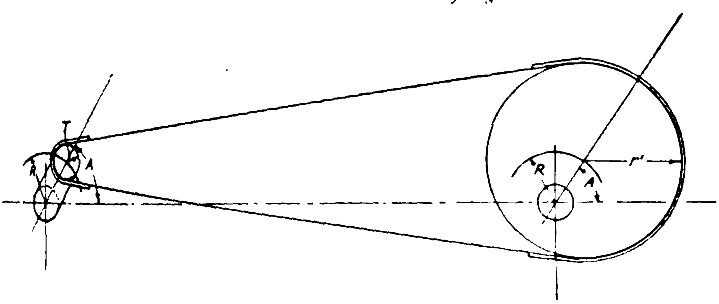


Fig. 1

Neither the distances between the centers of the two shafts nor the diameter of the same, as we shall see later, have any bearing upon the problem.

Throughout this discussion we have abbreviated, using following letters to distinguish corresponding parts:

R=The radius of the crank throw, being understood in our preliminary statement that this is equal to the eccentric throw.

r=The radius of the crank pins.

r'=The radius of the eccentric sheave or boss.

k=The coefficient of friction which we have shown by prints attached as effective in the model in varying quantities from .0005 to 3. which variation of value runs much lower than would be ordinarily possible to find in any construction and also runs much higher than is possible to find in usual constructions.

M=Represents the moment of power which may be applied either at the crank shaft or the eccentric shaft. This can be distinguished as Mef when applied to the eccentric shaft

[1] Experiment Department, Moline Plow Company, Moline, Ill.

or Mcf when applied to the crank shaft, or by Med= resultant moment at the crank shaft when the eccentric is driving, or by Mcd=resultant moment at the eccentric when the crank is driving.

A=The angle formed by the line of centers between the shaft centers and the eccentric axis or the crank arm.

In our calculations, in order to avoid plus and minus signs as largely as possible, and also to simplify the trigonometric equations, we have considered A to vary between 0 and 90 deg.

Diagram No. 1 shows an eccentric and crank of the same proportions as in the model, and employing the above legend.

Let us consider now a given force M applied to the *crank shaft* in order to turn the eccentric. The force transmitted as due to this in a direction parellel to the line of centers and passing through th crank pin and eccentric centers will be equal to LR Sin A, in which L may be termed load on the connecting bar due to the moment applied at the crank shaft, and thus L becomes equal to

$$\frac{M}{R \text{ Sin } A}$$

We find, however, that as soon as, or before, a movement can take place the friction between the connecting rod and the crank pin must be taken into consideration, and we find that this friction at the crank pin amounts to $k\ Lr$. This formulæ is the one usually employed in mechanics (See Kent, 8th Edition, p. 1205) in which the moment of friction for shafts and journals is equal to one-half $f\ W\ d$ in which f is the coefficient of friction; W the weight or load upon the journal and d the diameter of the shaft. From the above formula Mcf, which we have termed the driving moment at the crank shaft, becomes equal to LR Sin A + $k\ Lr$, whence L is equal to

$$\frac{Mcf}{R \text{ Sin } A + kr}$$

Similarly we find that the resultant driving moment at the eccentric shaft derived from the moment Mef applied at the crank shaft, which we can express as Mcd, becomes equal to LR Sin $A + kr'\ L$. Substituting in this formula the value of L as found above Mcd becomes equal to Formula 1

$$Mcd = \frac{Mcf\ R \text{ Sin } A}{R \text{ Sin } A + kr} - \frac{Mcf\ kr'}{R \text{ Sin } A + kr} = \frac{Mcf\ (R \text{ Sin } A - kr')}{R \text{ Sin } A + kr'}$$

From this formula, with a given load or moment applied at the crank shaft, can be found the resultant driving or turning moment at the eccentric shaft, and it will be noted that the resultant moment is dependent upon the following variable and fixed quantities.

R, which is the radius of the throw of either the eccentric or the crank; r, which is the radius of the crank pin and r' which is the radius of the eccentric sheave or boss; the Sin of the angle which the crank and eccentric makes with the line of centers between the axis of the two. Also k, the coefficient of friction.

Conversely it may be shown that when the eccentric is driving the resultant force at the crank shaft, which we may term *Med*, becomes equal to Formula 2

$$Med = \frac{Mef\, R \operatorname{Sin} A}{R \operatorname{Sin} A + kr'} - \frac{Mef\, kr}{R \operatorname{Sin} A + kr'} = \frac{Mef\,(R \operatorname{Sin} A - kr)}{R \operatorname{Sin} A + kr'}$$

in which the same constant and variable quantities enter as when the driving moment is applied at the crank shaft.

It will be seen that the distance between centers does not enter either of these formulæ and hence will have no bearing upon the problem at hand. Let us now assign values to these formulæ. Let *Mef* be equal to 10. As we have stated

$$r = .5''$$
$$r' = 2.937''$$
$$R = 1.5''$$
$$\text{Let } k = .1''$$

When the angle A becomes 90 deg., taking formula No. 1, that is, with the crank driving, we find $Med = 7.78$ and so on

When A is 80	deg.	*Med.*	=	7.75″
" 70	"	"	=	7.65″
" 60	"	"	=	7.45″
" 50	"	"	=	7.13″
" 40	"	"	=	6.61″
" 30	"	"	=	5.69″
" 20	"	"	=	3.89″
" 10	"	"	=	—1.3
" 5	"	"	=	—9.01
" 0	"	"	=	—58.7

It will here be seen that the *resultant* driving moment from a given force must reach 0 somewhere between 10 and 20 deg., and as the angle decreases the quantity becomes negative very rapidly until it reaches the maximum negative at 0 deg.

Now employing the formula with the eccentric driving, using the same values for the constants and variables as above, we find at

90	deg. the	resultant moment	8.12
80	"	"	8.05
70	"	"	7.98
60	"	"	7.84
50	"	"	7.61
40	"	"	7.26
30	"	"	6.68

20	deg. the resultant	moment	5.74
10	"	"	3.79
5	"	"	1.94
0	"	"	—1.7

It will here be seen that the resultant moment becomes 0 somewhere between 0 and 5 deg., a much smaller angle than was found when the crank was driving. It must also be noted that the negative quantity is very much smaller at 0 deg. and that the positive quantities at the same comparative angles are much greater than when the crank is driving. This alone should provide ample proof that an eccentric is not a crank.

Still we wish to go further into the matter and we have assigned varying values for k, the coefficient of friction, in these same formulæ. When k becomes .5 we find, with the crank driving and at the angle 90 deg., that the resultant moment is 1.27. From this small positive quantity as the angle is decreased the quantity will rapidly decrease until at 0 deg. we again reach —58.7. With the same value .5 for k and the eccentric driving we find, at 90 deg., that the resultant moment is 4.21. As the angle is decreased this quantity decreases until it becomes at 0 deg. —1.7. It will here be noted that as the coefficient of friction is increased the resultant moment is decreased and as we shall show later, the angle at which the quantity becomes negative, will also increase. On the other hand if k is decreased to .0005 we find with the crank driving at 90 deg. the resultant moment is 9.963 and at 0 deg. the quantity is again —58.7. Using the same value for k with the eccentric driving the resultant moment at 90 deg. is 9.988 and at 0 deg. is again —1.7. So that it is evident that as the coefficient of friction may be infinitely decreased the resultant driving moment at 90 deg. will approach the initial driving moment. *At 0 deg. the resultant moment remains negative and is of the same value regardless of the magnitude of friction.*

Considering again these formulæ, first with the eccentric driving where we have

$$Med = \frac{Mef\,(R \text{ Sin } A - kr)}{R \text{ Sin } A + kr'}$$

When this resultant moment Med becomes 0 we have

$$Mef\,R \text{ Sin } A - Mef\,kr = 0$$

which may be transposed into the equation,

$$\text{Sin } A = \frac{kr}{R} \qquad \textbf{(Formula 4)}$$

Similarly, when the crank is driving we find that when

$$Mcd \text{ becomes } 0,\ \text{Sin } A = \frac{kr'}{R} \qquad \text{(Formula 5)}$$

By these two formulæ we may find the angle at which the resultant moment becomes 0 for any value of k.

The following is a tabulation of results showing a variation of k from 3.0 to .0005:

	ECCENTRIC DRIVING $\frac{kr}{R} = \text{Sin } A$	CRANK DRIVING $\frac{kr'}{R} = \text{Sin } A$
$k = .005$	$A = 0$ deg. 1′	$A = 0$ deg. 33′ —40″
$k = .1$	$A = 1$ deg. 55′	$A = 11$ deg. 20′
$k = .2$	$A = 3$ deg. 49′	$A = 22$ deg. 54′
$k = .35$	$A = 6$ deg. 40′	$A = 43$ deg. 15′
$k = .5$	$A = 9$ deg. 35′	$A = 78$ deg. 31′
$k = .9$	$A = 17$ deg. 30′	....
$k = 1.5$	$A = 30$ deg. 00′	....
$k = 2.$	$A = 41$ deg. 45′	....
$k = 2.5$	$A = 56$ deg. 30′	....

For convenience let us term these angles the "critical angles" and in order that we may compare them more carefully we have prepared diagram No. 2 in which we have used as abscissa angles from 0 to 90 deg., regularly spaced. As ordinances we have used the coefficient of friction varying from 0 to 3.

For the values as given in the tabulation above we find the curve which represents the critical angles when the cranks are driving to be a regular one, gradually increasing from 0 point until it passes the 90 deg. line at a point which would require about .51 friction, showing that for values of the coefficient of friction greater than .51 it would be impossible for a crank to drive an eccentric, even at the most favorable position, namely, 90 deg.

The second curve upon this same diagram represents the critical angles when the eccentric is driving. It will be noted that this curve rises rapidly from 0, takes a regular form and crosses the 90 deg. line at 3. friction. It should be noted also that this curve passes (.51) the value of the limit for the cranks driving, at about 10 deg. angle, showing an enormous difference between the two arrangements.

Comparing the friction between the crank and eccentric driving in any angular position it will be noted that it requires a very much larger friction to produce the same critical angle when the eccentrics are driving than it does when the cranks are driving. Here again is ample proof that a crank is not an eccentric.

It will be seen in this last formula that the elements upon which this critical angle depend are the coefficient of friction, the radius

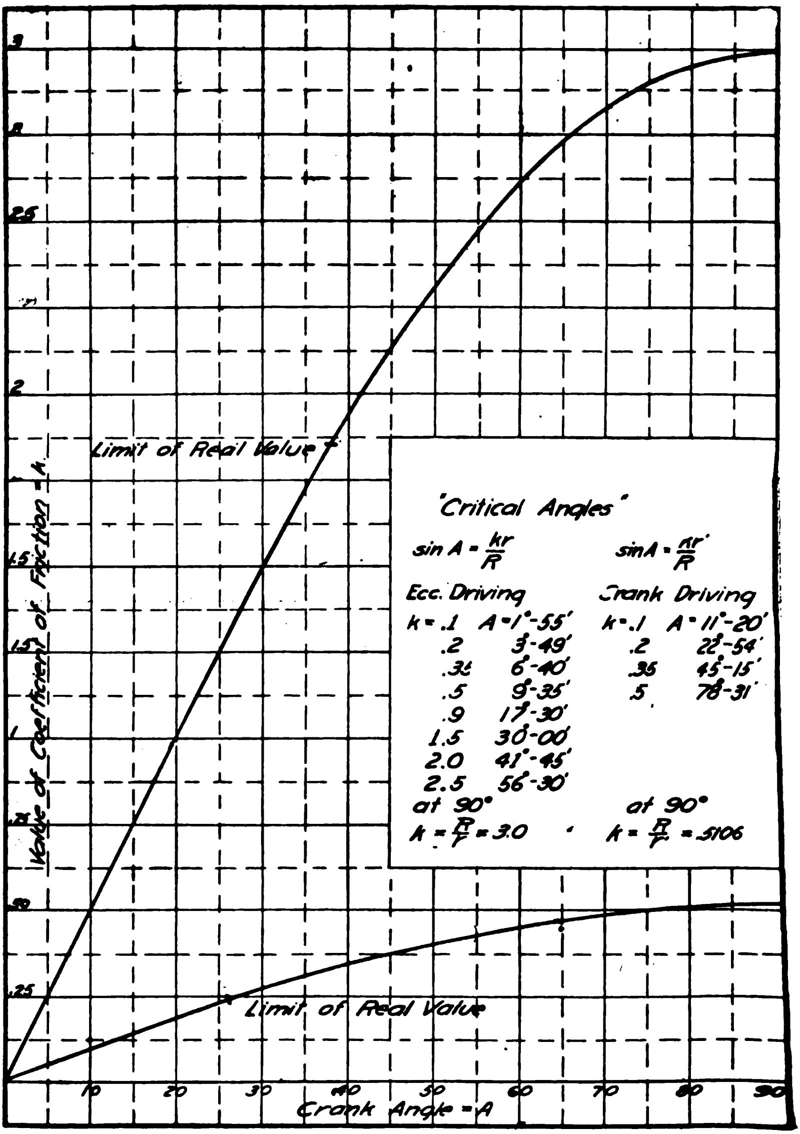


Fig. 2

of the crank pin r, the radius of the throw of the crank R, and the radius of the eccentric sheave or boss r'. It is clearly evident that only when the crank pin becomes equivalent in diameter to the eccentric boss can the unit be driven equally well from either point, and the instant when one becomes an enlarged boss, which is the definition of an eccentric, then at that moment the eccentric ceases to be a crank.

In order that these formulæ may be clearly understood we have prepared diagrams to illustrate the resultant moment, and with varying quantities for the coefficient of friction. In diagram No. 3, in which any point on the circle represents a zero driving moment, and within which the driving moment is negative and

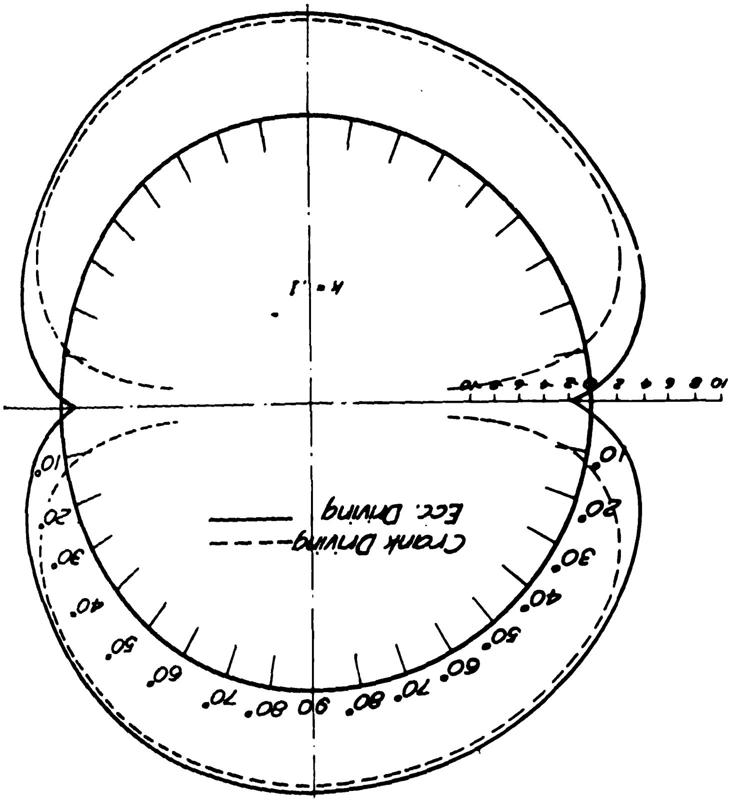


Fig. 3

without which the driving moment is positive, a scale running from 0 to +10 and from 0 to —10 is incorporated. In this diagram the coefficient of friction is taken as .1. The continuous curved line represents graphically the resultant driving moment when the eccentric is driving. It will be noted that at 90 deg. this moment is maximum, and as we have tabulated above, may be assigned the value of 8.12. It will be noted that this quantity decreases as the angle decreases until as we have also tabulated, at 1 deg. 55′ reaches the circle at which point the driving moment becomes 0. From that point, as the angle decreases, the quantity becomes negative, reaching a maximum (at 0 deg.) of —1.7 and, as we have already shown, this is a fixed negative quantity regardless of the variation of the friction. In this same diagram the dotted line shows the resultant driving moment when the crank is driving. At 90 deg. it is maximum and as we have tabulated is 7.78. This quantity decreases until according to the tabulation at 11 deg. 20′ it reaches the circle and becomes 0, from

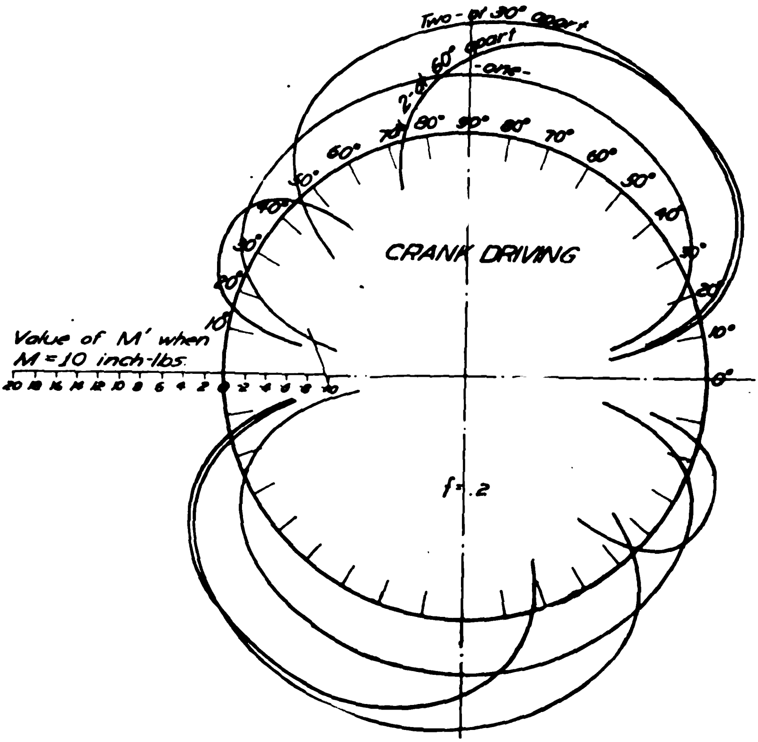


Fig. 4

which point as the angle decreases, rapidly becomes negative, reaching a maximum negative of —58.7 at 0 deg. This negative point, as we have shown, is fixed and is always —58.7 regardless of the variation of the coefficient of friction.

Since the machine under consideration is arranged with two cranks on each shaft, for which reason we have arranged the model with two cranks upon one shaft and two eccentrics upon the other shaft, we are submitting diagrams to show the resultant driving moment from two cranks driving and from two eccentrics driving.

In order that our method of graphical illustration may be entirely clear we refer to diagram No. 4 arranged in the same manner as diagram No. 2 except we have used the value of .2 for the coefficient of friction. One of the curved lines represents a single crank driving marked "one." This shows, as in diagram No. 3, that the resultant driving moment is maximum at 90 deg., decreases as the angle decreases, becomes 0 at 22 deg, 54′, is negative from there on and would reach —58.7 at 0 deg. Now if a second resultant driving moment is imposed upon this same diagram, and the same added to this primary resultant driving moment, when the

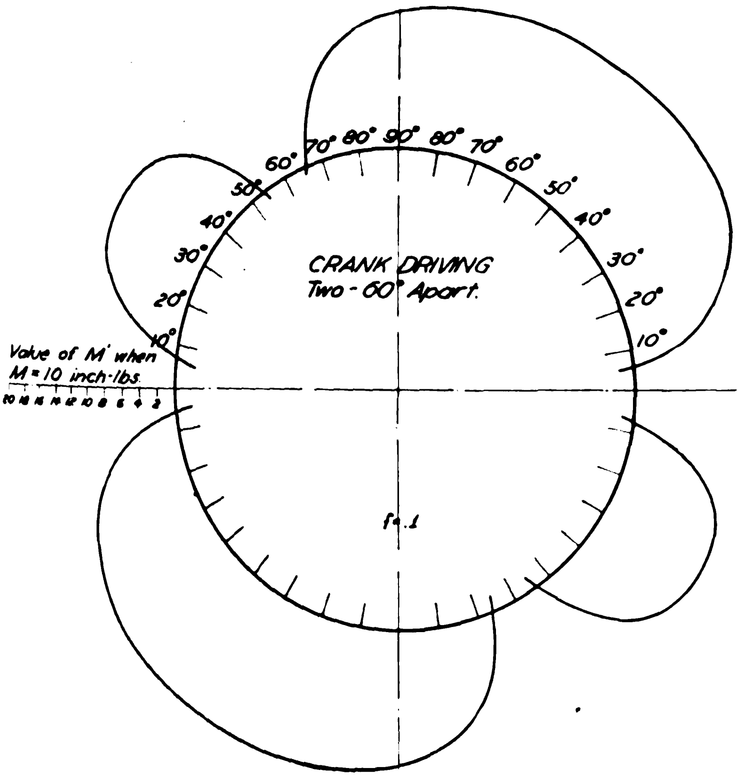


Fig. 5

cranks are 60 deg. apart the total resultant would be represented by a second curved line which is designated by "two, 60 deg. apart," It will be here noted that at 90 deg. the total resultant driving moment is slightly in excess of a single crank; that it reaches a maximum at 60 deg. and again decreases, reaching 0 somewhere between 10 and 20 deg., and from there on rapidly decreases towards, but not reaching, the maximum of the negative —58.7 at 0 deg. It again reaches 0 in turning clockwise at some 20 odd degrees; reaches a second maximum at 30 deg., becomes negative again at about 45 deg., remains negative approaching the maximum —58.7 at 60 deg., becomes 0 again at some 70 odd degrees, reaches a maximum at a point exactly 180 deg. from the first maximum and then repeats, producing what might be termed four "dead points," the first one in the direction of rotation indicated occurring from about 14 deg. before the 0 deg. line to 14 deg. beyond the 0 deg. line, and the second occurring about 14 deg. before reaching 60,

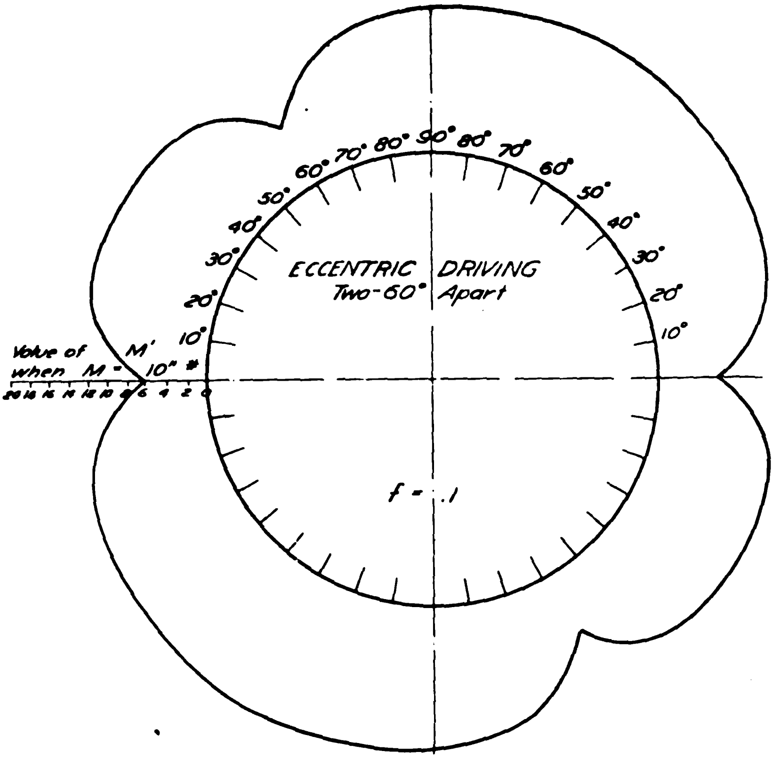


Fig. 6

to 14 deg. after reaching 60, the other two symmetrical with and 180 deg. from these just defined.

On this same diagram No. 3 we have shown a resultant moment with two cranks set 30 deg. apart, and it can readily be understood from the foregoing description how the maximum is reached and how there will be 0 points reached, limiting what we have termed "dead points." It is evident from our discussion that these "dead points" will vary in length depending upon the value of the coefficient of friction and will vary in position according to the angle between the driving cranks.

In order that these variations may be studied and the quantities measured we have prepared further diagrams which include these variations. Diagram No. 5 shows two cranks driving, set at 60 deg. apart, coefficient of friction .1. It will be seen here that there are two large positive maxima and two smaller positive maxima and four dead points, symmetrically arranged.

Diagram No. 6 shows two eccentrics driving, set 60 deg. apart with the coefficient of friction .1. It will be seen here that the

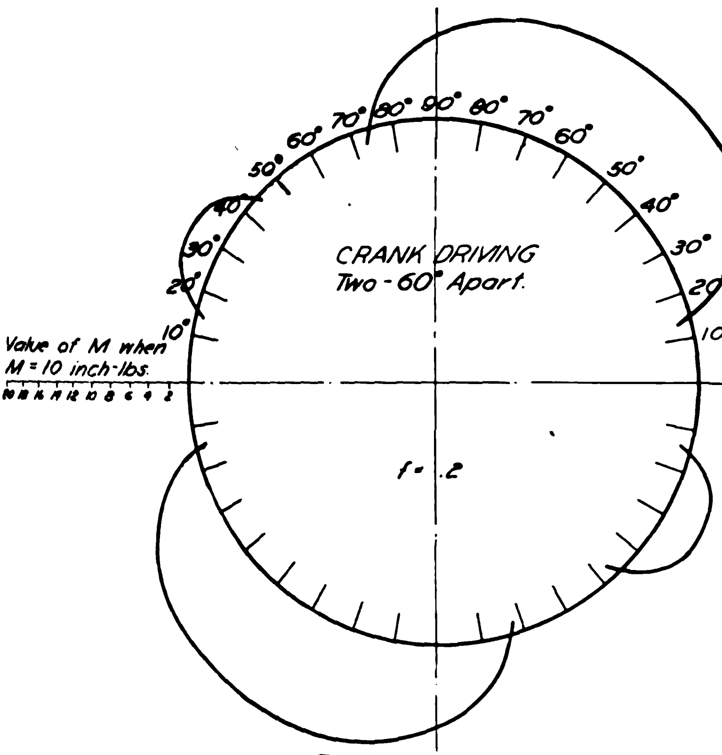


Fig. 7

resultant driving moment is constantly positive, that as in the case of the cranks driving there are two greater maxima and two lesser maxima, and also that the minima never reach the 0 point but are highly positive. It is clearly evident then that two eccentrics may be employed to drive, set 60 deg. apart, and with the coefficient of friction as high as .1, but that it would be impossible, in the same arrangement with the same values, for cranks to drive the eccentrics. Here again we believe we have found positive proof that an eccentric is not a crank.

As further proof we have prepared diagram No. 7 in which two cranks set 60 deg. apart are driving with a coefficient of friction of .2. It will be here seen in comparison with diagram No. 5 that there are two greater maxima and two lesser maxima, that the dead points have become much wider, that all the maxima are much smaller, and that it would be impossible for cranks to be used as driving means under this condition.

Also diagram No. 8 in which two driving eccentrics have been set 60 deg. apart and the coefficient of friction is .2. Here it will be seen by comparison with diagram No. 6 that there are two

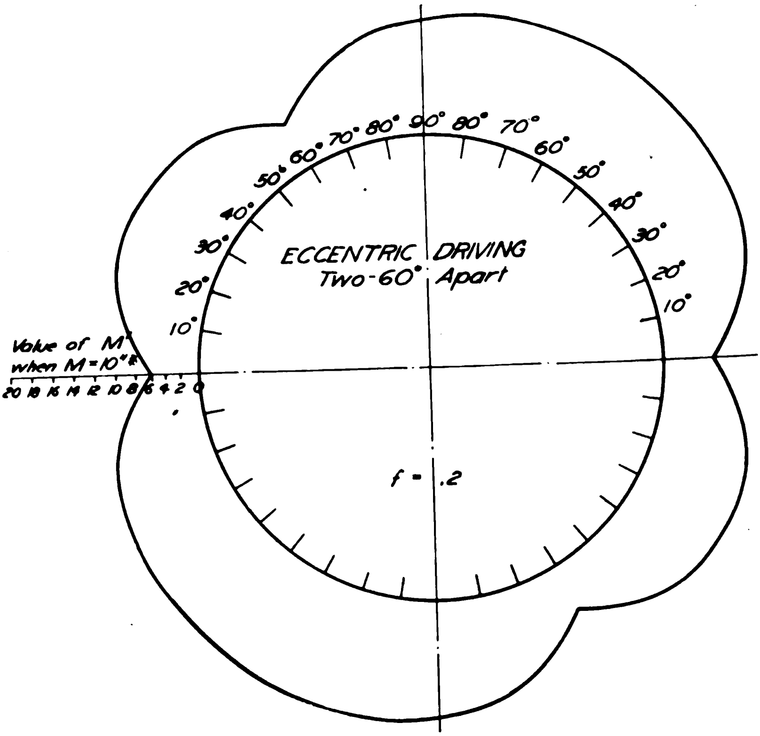


Fig. 8

greater maxima and two lesser maxima somewhat smaller than in No. 6, that the maxima are still positive and are large enough to eliminate any doubt but that the eccentrics would drive. This goes to show further that as the coefficient of friction is increased the efficiency of the device is decreased and that while the critical point of driving for the cranks has been passed, yet it has still not been reached for the eccentrics even for this great value for friction. We have, therefore, further increased the value of the coefficient friction to .5.

Diagram No. 9 with this value .5 of friction and two eccentrics driving, shows that while the maxima have been reduced, yet the minima are still positive, that even with this extraordinary high value of the coefficient of friction, the eccentrics will still drive.

In order to eliminate any doubt as to the effect of the coefficient of friction we have prepared diagram No. 10 in which we have two cranks driving set 60 deg. apart and in which the coefficient of friction has been reduced to .05. Here it will be seen that the maxima are a little greater, yet there remain four dead points reduced in angularity, and the device could not be operated.

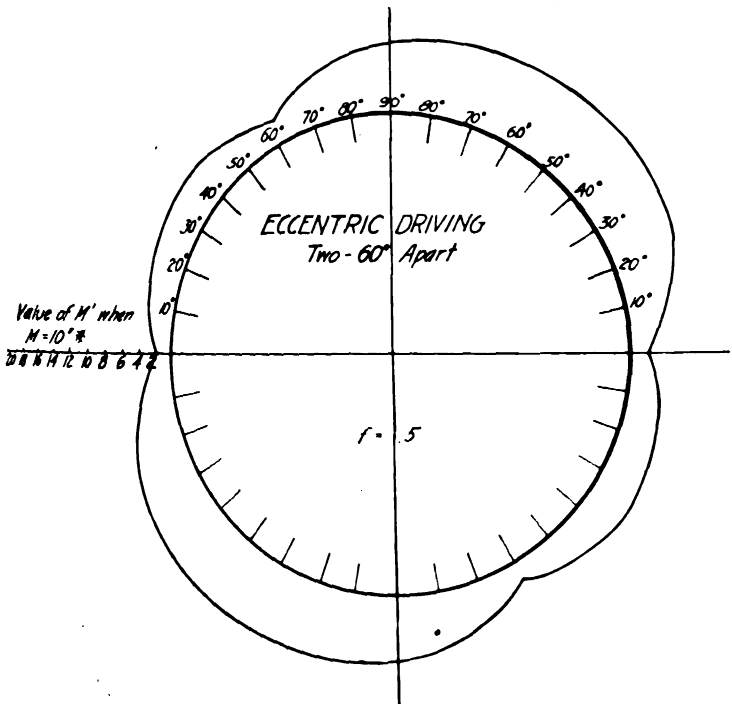


Fig. 9

Diagram No. 11 shows two eccentrics driving set 60 deg. apart with the coefficient of friction .05. It will here be seen that the minima are still all positive and that the maxima have increased showing a fairly efficient driving device throughout.

Diagrams were prepared showing two cranks driving set 90 deg. apart, with the coefficient of friction respectively .1, .2, .05. In these diagrams it was shown that the maxima were symmetrically 90 deg. apart, that these dead points increased in angular width as the coefficient increased, and that in no case could the device be operated. Diagram No. 12 shows the characteristics of this arrangement, with the coefficient of friction .1.

Diagrams were also prepared in which eccentrics were driving and set 90 deg. apart, and in which the coefficients of friction varied respectively from .5, .2, .1 to ..05, showing that with a higher coefficient of friction the maxima were smaller, the minima were smaller and yet all positive, and that with this arrangement the device would operate.

Diagram No. 13 shows one of these diagrams, with the coefficient of friction .5.

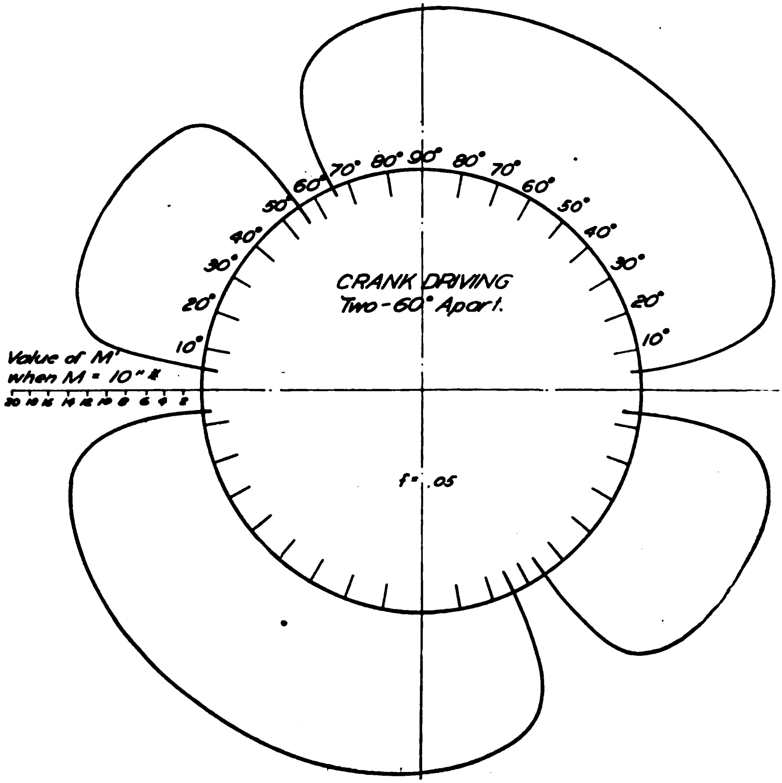


Fig. 10

Here we believe we have ample proof that with two cranks set under most favorable conditions and with two eccentrics to correspond, since with the cranks driving the device is not operative and with the eccentrics driving the device is operative, that it cannot be held that an eccentric is a crank.

That it might be clearly understood just how the angularity between the cranks is effected we prepared another set of diagrams, in the first of which were shown two cranks set 30 deg. apart, and in the second, two eccentrics set 30 deg. apart. These diagrams show the cranks driving set 30 deg. apart, with the coefficient of friction varied, respectively, from .5, .2, .1 to .05.

Diagram No. 14 (coefficient of friction .05) shows the characteristics of this arrangement; two large and wide angular maxima, two smaller and narrow maxima and four dead points; these dead points increased with the larger coefficient; the smaller maxima

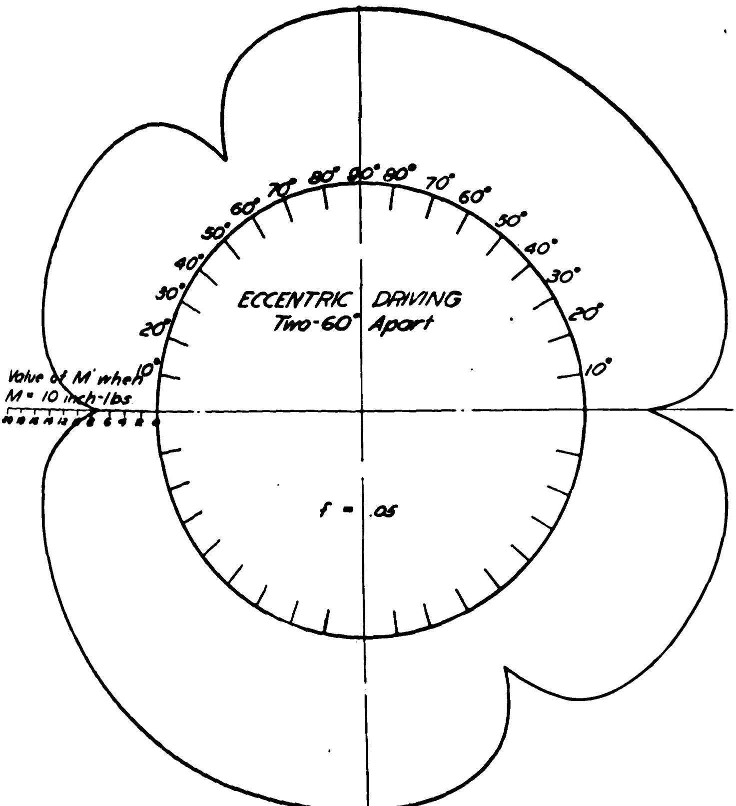


Fig. 11

disappeared when the coefficient of friction became .2, and in fact as the coefficient became .5 the greater maxima appeared only during a comparatively small angularity and became so small as to be almost negligible, showing that in no case can a crank set at 30 deg. apart possibly be used as a driving means.

On the other hand diagrams were prepared showing two eccentrics set 30 deg. apart and driving with coefficients of friction, respectively, .5, .2, .1 and .05.

Diagram No. 15 (coefficient of friction .05) shows the characteristics of this resultant and positive driving moment throughout the revolution, this positive driving moment decreasing as the coefficient of friction increases, but still under these conditions leaving a moderate driving resultant, still further proving that an eccentric cannot be considered a crank.

In order to eliminate any argument that an eccentric is the equivalent of a crank under some particular condition, we have prepared diagrams Nos. 16 and 17. In diagram No. 16 we are showing a number of curves plotted, using as abscissa the angles

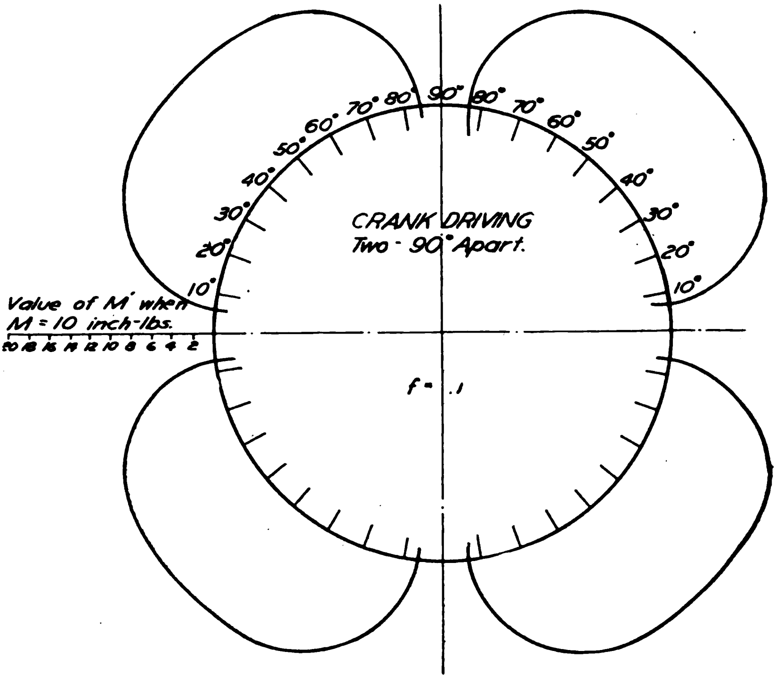


Fig. 12

from 0 to 90 deg. and as ordinates the resultant moments as obtained in the formula No. 2 when eccentrics are driving cranks. Let us consider first that these curves represent the resultant driving moment at any angular position for a single crank and eccentric. We have assigned the same values to the various elements in this curve as we have used throughout this discussion, viz.:

$$R = 1.5$$
$$r = .5$$
$$r' = 2.937$$

The initial driving moment we have taken in these diagrams as

10. The coefficient we have varied as is noted upon the diagrams from .05 to 2.

Diagram No. 17 has been similarly arranged, using the formula No. 1 showing the resultant moment of the values when the cranks are driving. It will be noticed at once the characteristic difference between these resultant moments, and as we have already explained it should be noted that when the eccentrics are driving at 0 deg. the greatest minima is reached. This is uniformly —1.7 in all cases. In the diagrams showing the cranks driving the

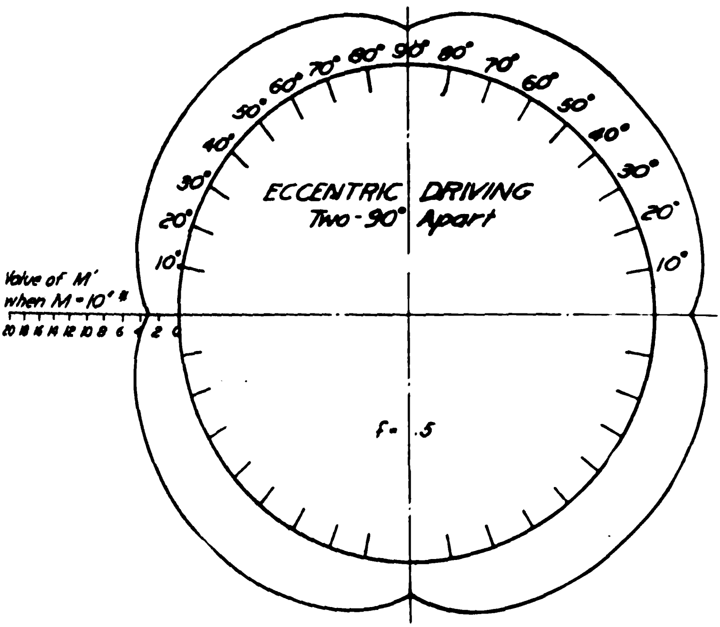


Fig. 13

greatest minima is, as we have explained, at 0 deg. and reaches the uniform point of —58.7. These diagrams can equally well show, as we have stated, the resultant moment as any particular angle for a single crank and eccentric; or they can show the resultant moment of an *infinite number of cranks driving an infinite number* of eccentrics (or the converse). Now if we measure the *area above the 0* on the ordinate line and measure the *area below 0* on the ordinate line, the difference between the same will give the *total resultant driving moment for this same infinite number of eccentrics driving,* or in diagram No. 17 for an *infinite number of cranks driving.* For convenience we have tabulated the results of these measurements as follows:

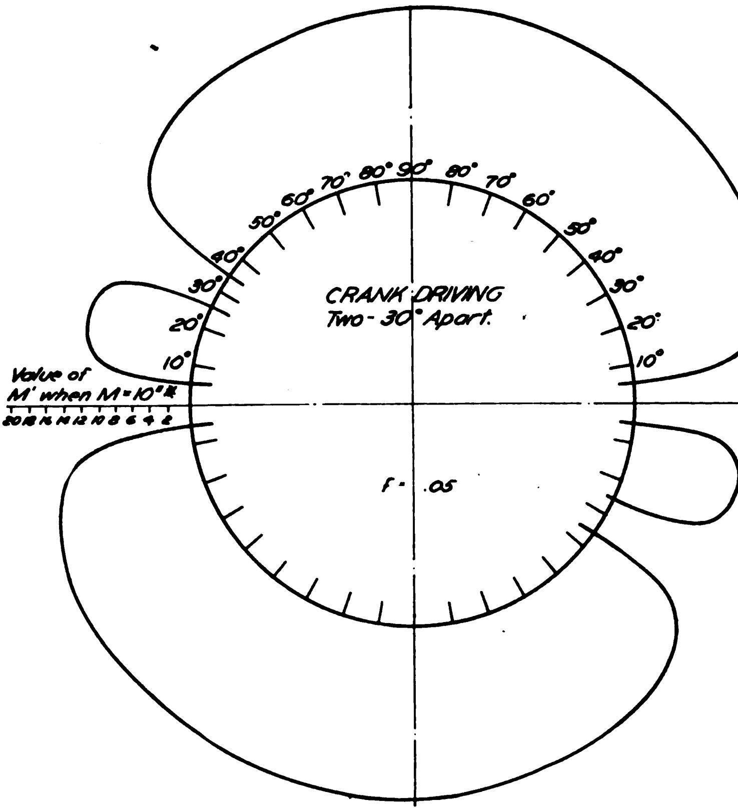


Fig 14

DIAGRAM NO. 16

INFINITE ECCENTRICS DRIVING

	Area	Med.
$K =$ .05	1466–1	8.1
$K =$ .1	1193–3	6.61
$K =$ .2	904–7	4.98
$K =$ .35		
$K =$ .5	472–15	2.65
$K =$ .9	253–25	1.26
$K =$ 1.35	123–37	.86
$K =$ 2.	37–58	–.0116

DIAGRAM NO. 17

Area	Mcd
1351–194	6.4
1008–272	4.03
677–532	.8
195–852	–3.65
5–1491	–8.25

In order that the *Med* and *Mcd* columns of this tabulation may be entirely clear let us explain, taking for instance, where an infinite number of eccentrics are driving in diagram No. 16 and

$K = .05$. Here it will be seen that we have enumerated 1466 as the positive area. This can be verified by counting the number of squares from the particular co-ordinate paper from which this print is made above the abscissa line and below the curve for $K - .05$. As we have counted them there are, as the tabulation shows, 1466. The curve passes the abscissa and leaves, as near as we estimate, one full square below as the tabulation shows.

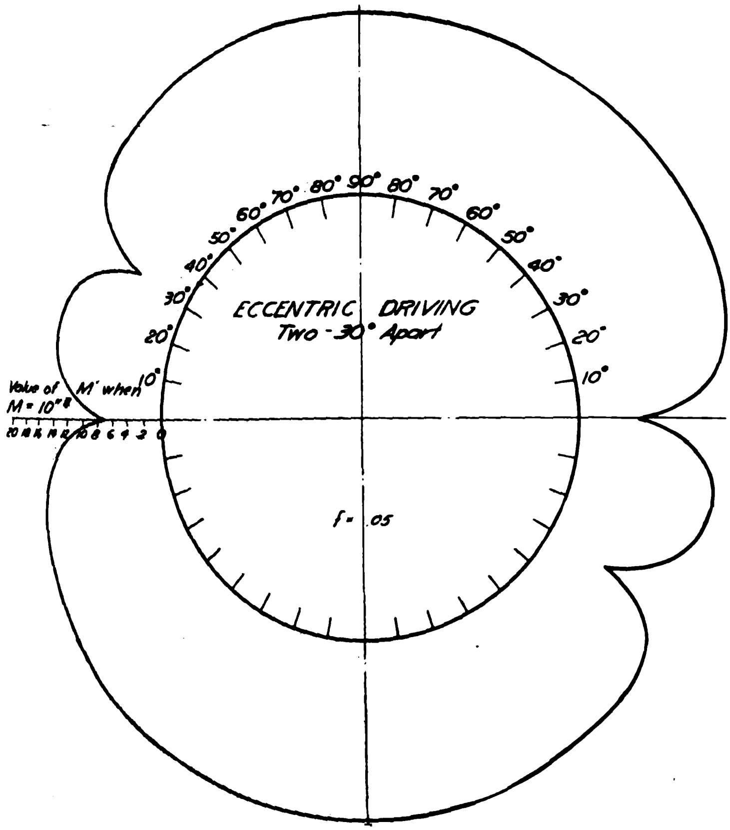
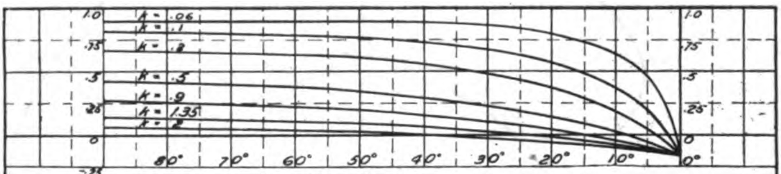


Fig 15

We then have an area of a difference between 1466 and 1, which would be 1465. This divided by the width representing the entire curve or by 90 we would have 16.2 as the average height or the positive area, but as we have taken two squares to represent the ordinate units we must divide this again by 2 which would give us the $Med = 8.1$.

Similarly all of the numbers in the column under the *Med* have been developed, and so have the numbers under the column *Mcd* been developed. This value it will be readily understood represents the resultant driving moment in the first case for an infinite number of eccentrics driving through varying degrees of friction, and in the second case for an infinite number of cranks driving through varying degrees of friction.

The results of this tabulation we have plotted in diagram No. 18 which as abscissa we have taken both positive and negative values for the resultant driving moment. As ordinates we have taken the coefficient of friction varying from 0 deg. to 2. The lower curve represents the resultant driving moment when the cranks are driving. It will be noted that this curve passes the 0 abscissa line somewhere between .2 and .3 friction. This shows



Eccentric Driving

$$Med = \frac{Mef(R\sin A - kr)}{R\sin A + kr'} \qquad Mef = 10,\ R = 1.5,\ r = .5,\ r' = .2937 \qquad \text{(Formula II.)}$$

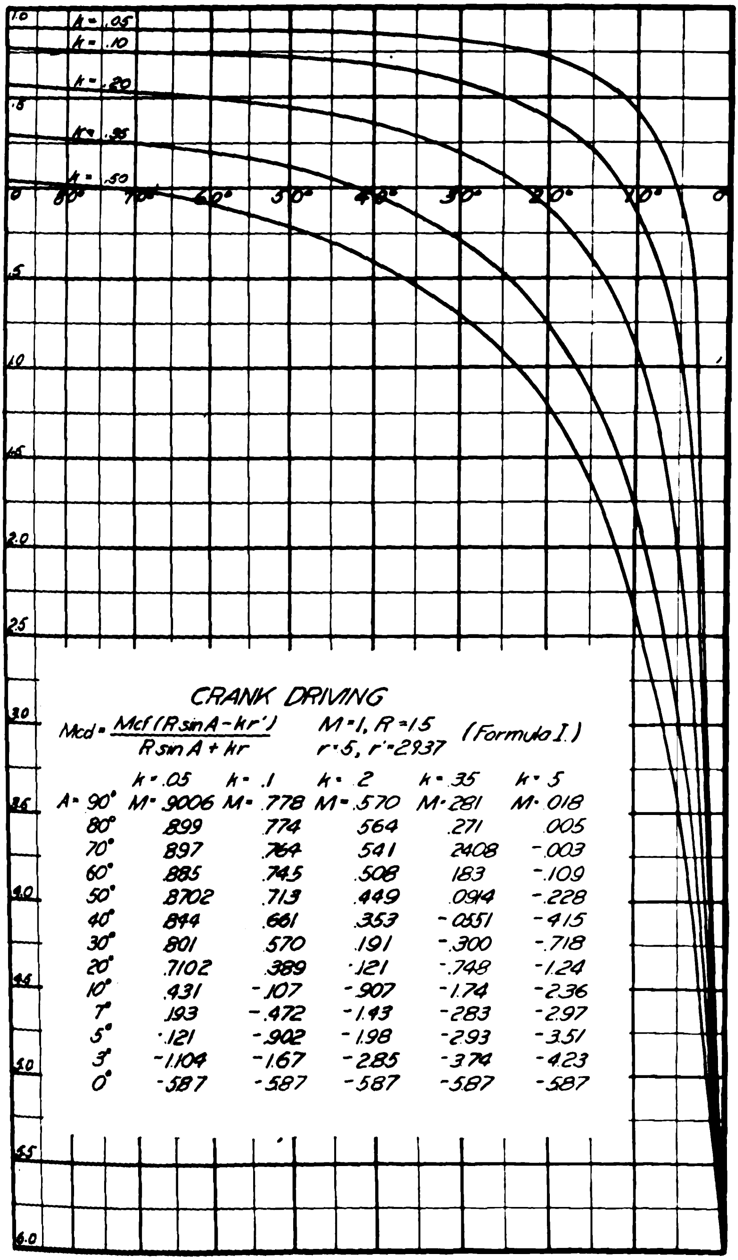
	k = .05	k = .1	k = .2	k = .5	k = .9	k = 1.35	k = 2
A = 90°	M = .909	M = .808	M = .670	M = .420	M = .253	M = .151	M = .067
80°	.908	.805	.667	.416	.243	.147	.0669
70°	.904	.798	.656	.402	.236	.136	.0562
60°	.896	.784	.635	.379	.215	.116	.0416
50°	.884	.761	.604	.343	.184	.0929	.0212
40°	.865	.716	.536	.296	.144	.0586	-.00525
30°	.833	.670	.486	.225	.0834	-.0362	-.0377
20°	.773	.573	.375	.132	.000	-.0187	-.0761
10°	.633	.397	.188	.006	.0608		-1.2
7°	.546	.278	.107	.047			
5°	.461	.190	.042	.074	-1.16		
3°	.337	.076	.037	1.108			
0°	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7	-1.7

Fig. 16

at once that with the cranks driving when friction is increased a little above .2 the total resultant driving moment *Med* becomes 0, and under no condition with the proportions for crank and eccentric as we have set forth could the device be an operative one.

The second curve on this diagram represents similarly the resultant driving moments *Med* when the eccentric is driving and will at once be seen to have an entirely different character from the first curve. It ascends rapidly from where the moment is equal to 10 and the friction is 0, crossing the ordinate at a point of friction somewhere between 1.8 and 2, showing that only when the friction has become impossibly high could a device in which the eccentrics are driving become inoperative. Here we believe we have found the ultimate proof that a crank is not an eccentric.

In order to eliminate any doubt that these measures and plotted calculations may have led us into error, we have employed a calculus formula which gives us at once the total resultant moment



$$Mcd = \frac{Mcf\,(R \sin A - kr')}{R \sin A + kr} \qquad M = 1,\ R = 1.5,\ r = .5,\ r' = .2937 \qquad \text{(Formula I.)}$$

A	k = .05	k = .1	k = .2	k = .35	k = .5
90°	M = .9006	M = .778	M = .570	M = .281	M = .018
80°	.899	.774	.564	.271	.005
70°	.897	.764	.541	.2408	-.003
60°	.885	.745	.508	.183	-.109
50°	.8702	.713	.449	.0914	-.228
40°	.844	.661	.353	-.0551	-.415
30°	.801	.570	.191	-.300	-.718
20°	.7102	.389	.121	-.748	-1.24
10°	.431	-.107	-.907	-1.74	-2.36
7°	.193	-.472	-1.43	-2.83	-2.97
5°	.121	-.902	-1.98	-2.93	-3.51
3°	-1.104	-1.67	-2.85	-3.74	-4.23
0°	-.587	-.587	-.587	-.587	-.587

Fig. 17

when an infinite number of cranks are driving, and a second formula which gives us at once the total resultant moment when an infinite number of eccentrics are driving. For the cranks driving we have taken the original formula in which

$$Mcd = \frac{Mcf\ (R \text{ Sin } A - kr')}{R \text{ Sin } A + kr} \qquad \text{(No. 1)}$$

In order to get this equation into a form which may be integrated we have taken the value for Mcf out of the equation by making it equal to one. We have let $a = kr$ and $b = R$. By inspection we find that a is less than b. We also find that the equation then takes the following integral form (Osborn, pp. 226–7).

$$\int \frac{dx}{a + b\,(\text{Sin } A)} = \frac{1}{\sqrt{b^2 - a^2}} \log \frac{a \text{ Tan } \frac{1}{2}A + b - \sqrt{b^2 - a^2}}{a \text{ Tan } \frac{1}{2}A + b + \sqrt{b^2 - a^2}}$$

Now—Formula No. 1 may be written

$$Y = \frac{R \text{ Sin } A}{R \text{ Sin } A + kr} - \frac{kr'}{R \text{ Sin } A + kr'}$$

$$Y = \int \left(\frac{kr}{R \text{ Sin } A + kr}\right) dx - \int \left(\frac{kr'}{R \text{ Sin } A + kr}\right) dx$$

$$Y = \int dx - k\ (r' - r) \int \frac{dx}{R \text{ Sin } A + kr}$$

Now, substituting the values of $R = b$ and $kr = a$, and integrating, we have

$$Y = \Big|_{0}^{\frac{1}{2}\pi} A - k\ \frac{(r' - r)}{\sqrt{R^2 - k^2\ r^2}} \log \frac{kr \text{ Tan } \frac{1}{2}A + R - \sqrt{R^2 - k^2\ r^2}}{kr \text{ Tan } A + R + \sqrt{R^2 - k^2\ r^2}}$$

Substituting the limits $A = 0$ and $A = \frac{1}{2}\pi$ we have the summation *(Formula No. 5)*

$$Y = \tfrac{1}{2}\pi - \frac{k\ (r' - r)}{\sqrt{R^2 - k^2\ r^2}} \log \frac{kr + R - \sqrt{R^2 - k^2\ r^2}}{kr + R + \sqrt{R^2 - k^2\ r^2}} - 0 -$$

$$\frac{k\ (r' - r)}{\sqrt{R^2 - k^2\ r^2}} \log \frac{R - \sqrt{R^2 - k^2\ r^2}}{R + \sqrt{R^2 - k^2\ r^2}}$$

In diagram No. 18 it is evident that somewhere between .2 and .3 when the cranks are driving the device becomes inoperative.

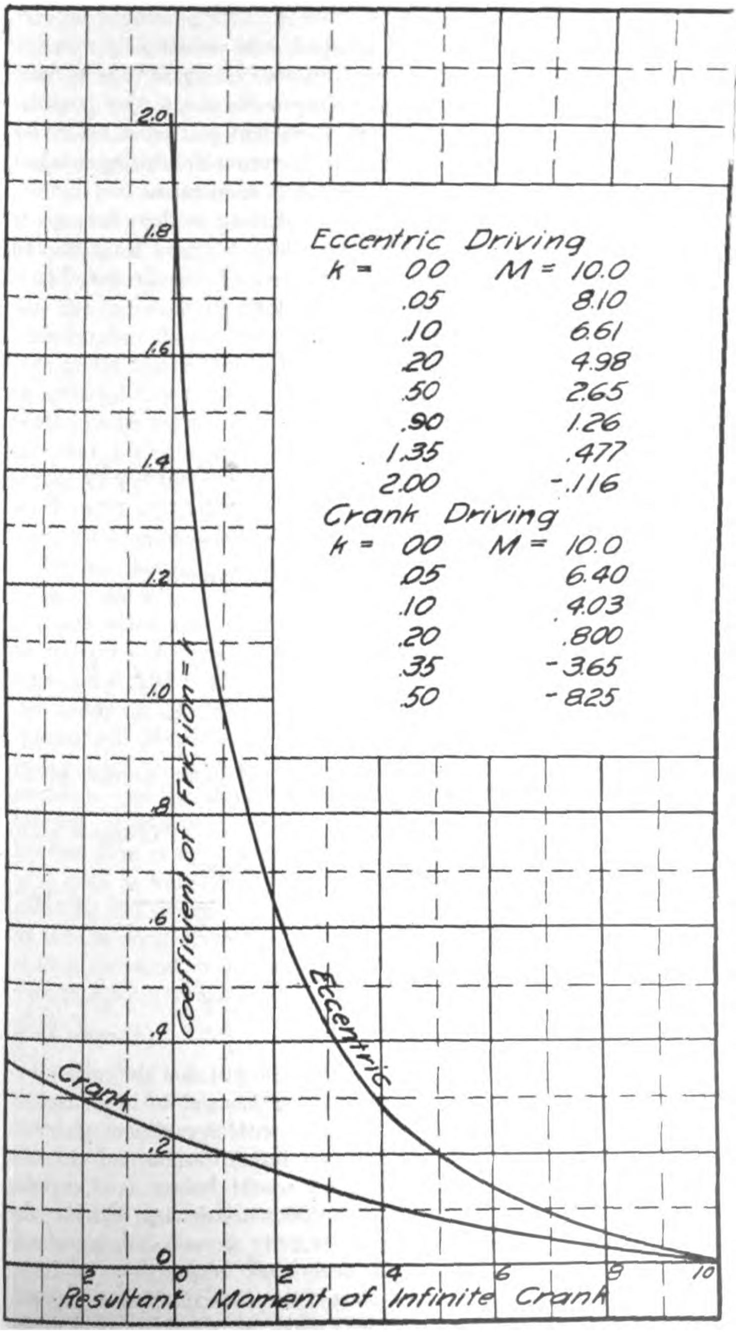

Eccentric Driving
k = 00 M = 10.0
.05 8.10
.10 6.61
.20 4.98
.50 2.65
.90 1.26
1.35 .477
2.00 -.116
Crank Driving
k = 00 M = 10.0
.05 6.40
.10 4.03
.20 .800
.35 -3.65
.50 -8.25
Coefficient of Friction = k
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
Eccentric
Crank
2
0
2
4
6
8
10
Resultant Moment of Infinite Crank

Fig. 18

Using this formula just developed and substituting values as enumerated, after several substitutions we found that by using $k = .221$ the resultant driving moment became 0, thus furnishing a mathematical proof that if the coefficient of friction has the low value .221 when an infinite number of cranks are driving an infinite number of eccentrics the device becomes inoperative.

Similarly when the eccentrics are driving we have been able to find an expression by calculus by which we have found the total resultant driving moment. In this case, a is greater than b. Then the integral takes the following form

$$Y = \int \frac{dx}{a + b \text{ Sin } A}$$

Integrating we have

$$Y = \frac{2}{\sqrt{a^2 - b^2}} \text{ Tan}^{-1} \frac{A \text{ Tan } \frac{1}{2}A + b}{\sqrt{a^2 - b^2}}$$

Now when $a = kr'$, $b = R$, we have the formula

$$Y = \int d\,x - k\ (r' + r)$$

$$\int \frac{2}{\sqrt{k^2\ r^2 - R^2}} \text{ Tan}^{-1} \frac{kr' \text{ Tan } \frac{1}{2}A + R}{\sqrt{k^2\ r^2 - R^2}}$$

Substituting in this formula as we did in the previous one the limits of A between 0 and $\frac{1}{2}\pi$ we have

(Formula No. 6)

$$Y = \frac{1}{2}\pi - \frac{2\ k\ (r' + r)}{\sqrt{k^2\ r'^2 - R^2}} \left\{ \text{Tan}^{-1} \frac{kr' + r}{\sqrt{k^2\ r'^2 - R^2}} - \text{Tan}^{-1} \frac{R}{\sqrt{k^2\ r'^2 - R^2}} \right\}$$

(Formula No. 6)

By investigating, using the value of 1.91 for the coefficient of friction, we find the resultant driving moment to be an angle of 89.7 deg. This would indicate that with a coefficient of friction a trifle higher than this value, an infinite number of eccentrics driving the total resultant moment would become 0. Comparing this value $k = 1.91$ when the eccentrics are driving, with the value obtained with cranks driving ($k = .221$) we see again a true comparison between cranks and eccentrics respectively as driving means, verifying the curves plotted on diagram No. 18, that only a moderate degree of friction will make inoperative a crank driving device having an infinite number of cranks driving, and that only when the impossible limit of $k = 1.91$ is reached would a device with an infinite number of eccentrics driving become inoperative.

Referring to diagram No. 1 it can be understood from the discussion up to this point that with the eccentric driving in a clockwise direction, for instance, there would be a moment in the direction of rotation at the crank pin and due to the friction at the eccentric boss and transmitted to the crank pin end by means of the connecting rod. It can readily be seen that this would produce an assisting increment of moment during the outboard throw of the crank which should be added to the total resultant moment. Also this increment of moment would tend during the outboard throw to reduce the critical angles at that position, but on the other hand, on the inboard throw this increment would oppose and must be subtracted from the total resultant moment at the crank end and would decrease the total resultant driving moment, thus increasing the critical angles as much as they would be decreased by this same moment during the outboard throw. On the other hand it can readily be understood how there will be a similar moment at the eccentric end produced when the cranks are driving, this moment producing an assisting increment during the outboard throw which would be added to the total resultant moment and an opposing increment which must be subtracted during the inboard throw at the eccentric end, producing as in the first case a tendency to decrease the critical angles during the outboard throw and increase them during the inboard throw. It can easily be proven that these moments will be respectively proportionate to the radius of the crank pin and the eccentric boss, and consequently a much greater one will be found at the crank end than at the eccentric end. We have not considered it necessary to develop formulæ that would represent these moments because the increment thus produced would be so small as would be practically negligible in the case we are presenting and the real effect would lie in the causes as we have set forth in our general discussion. However, the careful analysis of these increment moments would tend further to prove that an eccentric is not a crank.

SUMMARY

Formula No. 1 arranged to show the resultant moment when the cranks are driving. This we have compared with formula No. 2, the resultant moments when the eccentrics are driving, and we have found a vast difference between the resultant moments. By means of these formulæ the resultant moments have been carefully analyzed and the results in different positions very clearly shown. We have found at once that these moments are dependent, first upon the coefficient of friction which we have shown varying between reasonable limits. Second, on the radius of the crank pin as compared with the radius of the eccentric sheave or boss;

R, which has been used to represent the throw of the eccentric or cranks, also enters the equation only as a constant.

In formula No. 3 we have been able to show the "critical angles" when the eccentric is driving in various positions.

In formula No. 4 we have similarly shown "critical angles" for a crank driving and we have made a comparison between these critical angles, and the results are very positive, distinguishing very clearly between a crank and an eccentric.

Again these have been dependable upon the same elements as the resultant moment was dependent, namely,

r—crank pin radius
r'—the radius of the eccentric sheave
R—the throw of the crank
k—the coefficient of friction

In a number of diagrams we have shown the compound resultant moment when two cranks were driving two eccentrics, or when two eccentrics were driving two cranks. We have varied the angular relation between the cranks and the eccentrics respectively so as to eliminate any doubt as to the supposition that there might be some angular arrangement whereby a driving device might be produced when the cranks are driving, and we believe that our diagrams and our explanations have been entirely clear to the point that eccentrics cannot be considered cranks.

In diagrams Nos. 16 and 17 we have shown the resultant moment of an infinite number of cranks driving an infinite number of eccentrics, and also for an infinite number of eccentrics driving an infinite number of cranks. In these diagrams we have been able to find a total which is the average resultant moment, and in these diagrams we have varied the coefficient of friction so as to reach the limit of movement in each case. When the eccentrics were driving we found that the coefficient of friction must reach the impossible limit somewhere between 1 and 2 before the device becomes inoperative. On the other hand when the cranks were driving we found that it was only nncessary to increase the coefficient of friction somewhere between .2 and .3 before the limit was reached and the device became inoperative.

Now it is easy to understand that even if an implement could be produced in which an infinite number of cranks could be arranged to drive an infinite number of eccentrics, if the operator became careless and neglected to oil the same, or allowed a little dirt to get into the bearings, or the bearings to get a little out of adjustment, any of which conditions are more than likely to arise, then would the coefficient of friction arise to somewhere above .2 and his machine would stop. In fact .2 is a commonly found measure for the coefficient of friction. On the other hand if eccentrics were driving cranks the machine would run even until the bearings had become almost welded together, or so clogged with dirt and rust that it would almost be impossible for them to turn at all.

To support these diagrams we have produced formula No. 5 in which we have mathematically shown that the coefficient of friction after it has passed .221 would be sufficient to stop the cranks driving the eccentrics, and on the other hand by formula No. 6 we have proven that it would be necessary to increase the friction to the impossible high limit of something over 1.91 before eccentrics driving cranks would become inoperative. We believe that these diagrams and these formulæ are conclusive evidence to sustain the point we have taken.

To further substantiate our theory we wish to quote the following well known authorities:

Unwin—page 183 (Vol. 2):

"The friction of an eccentric is much greater than of a crank."

D. A. Lowe—page 55, Machine Design:

"The crank can be used for converting circular into reciprocating motion or vice versa, while the eccentric can only be used for converting circular into reciprocating motion. This is owing to the great leverage at which the friction of an eccentric acts."

This is exactly what we have shown in our diagrams and what we have substantiated in our formulæ.

Again—

Unwin—Book 2, page 92, Machine Design:

"An eccentric is a modified crank. It is really a crank with a crank pin enlarged so as to include the crank shaft. The friction of the eccentric is much greater than of a crank and it is, therefore, not used where ordinary cranks can be applied."

Again—

Page 98—Paragraph 63 of the same reference:

Friction of an eccentric. Let R be the radius of the eccentric sheave in inches; P be resistance of the slide valve or other part moved by the eccentric, in pounds; N the number of rotations per minute; k the coefficient of friction. Then the frictional resistance at the surface of the sheave is about $k\ P$ pounds and the work expended in friction is

$$\frac{2\ k\ P\ \ R\ M}{12\ x\ 60}$$

foot pounds per second or putting k =to .06 becomes equal to .00052 $P\ R\ M$ foot pounds per second. This is so large that in some cases it amounts to 20 or even 25 percent of the whole work transmitted by the eccentric."

In final conclusion we believe it cannot be denied that a *crank* can equally well *drive* or *be driven.* An eccentric will *drive* fairly well compared with a crank but in no measure can it *be driven* as compared with a crank, and in our particular case *the ordinary* *value of friction which we might expect* would make it *absolutely unsafe* to utilize cranks as driving members to eccentrics on a machine such as has been the subject of this particular analysis, and especially when the number of cranks is limited, as our case has limited them, to two, it is evident that it would be impossible to employ cranks to drive eccentrics even under the most favorable conditions.

EQUALIZERS AND HITCHES

E. A. WHITE,[1] Member Amer. Soc. A. E.

In our present agricultural practice the connection between the prime-mover and the implement (where a tractive unit is used) is designated as an equalizer when horses or mules are used and as a hitch when a tractor is used to generate the required power. Equalizers and hitches must be used. Time need not be spent arguing about the importance of these connections. The problem is to develop a method for making a fundamental mechanical analysis of these units. Fortunately, no problems are presented which cannot be solved by the proper application of well known mechanical principles. There are at the present time numerous devices used as equalizers and hitches. Many claims have been made for certain patent equalizers and hitches, which claims have, in turn, been stoutly refuted. This paper presents a method by which equalizers and hitches may be analyzed, thereby affording a means of making fundamental comparisons and when desired predicting the results which may be expected in a given case.

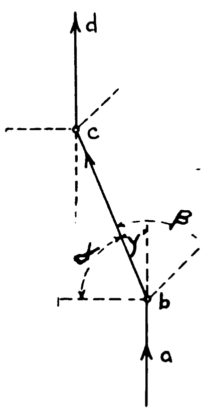


Fig. 1

It is a well known principle of mechanics that one force or one force and a couple may be found which will produce the same effect as a number of forces. In addition to this, due consideration must be given to Newton's Third Law, namely, "Action and reaction are equal and opposite." A proper application of these universally accepted laws, together with other well known principles of statics, furnishes the keys to a thorough understanding of equalizers and hitches, and will clarify many problems which, on the surface, appear to be complicated and perplexing.

As the first general case, take the conditions which are represented in Fig. 1. The load moves in the direction *ab* and the

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prime-mover in the direction *cd*. The hitch is attached to the load at the point *b* and to the prime-mover at the point *c* in such a manner that the drawbar takes the position *bc*. The line *ab* is parallel to the line *cd*, both of which are parallel to the direction of travel. Let the tension in the drawbar *cb* be represented by *F*, and designate the angles which this drawbar makes with the *x*, —*y* and —*z* axis respectively as a, β and γ. The force from the load acts upon the motor in the direction *cb*, and can be resolved as follows:

$$F_x = F \cos a$$
$$F_{-y} = F \cos \beta$$
$$F_{-z} = F \cos \gamma$$

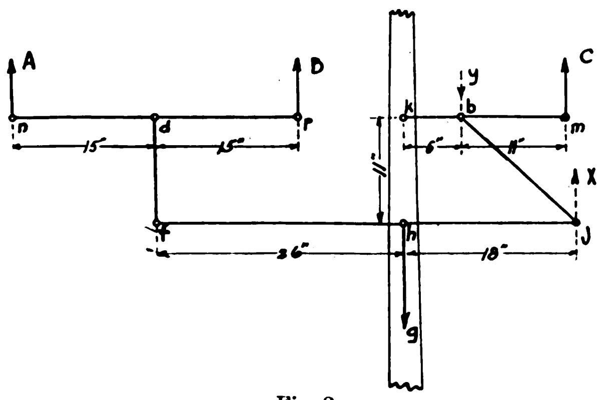

Fig. 2

If a tractor is used, force F_x will tend to pull the rear end of the prime-mover to the right and swing the front end to left. Force F_{-y} will produce a downward pull upon the tractor. The exact manner in which this affects the operation of the tractor will depend upon where the point of attachment *c* is placed with reference to the wheels. The force F_{-z} is the effective force acting opposite to the direction of motion. The effects produced upon the load are equal in magnitude and opposite in direction from those produced upon the prime-mover. F_z is the only force which is effective in the direction of motion and is therefore the only force which should be taken into consideration when computing the drawbar horse power required to move the load. Suppose that this unit moves at the rate of *n* feet per minute, then

$$H.P. = \frac{F \cos \gamma \, . \, n}{33000}$$

Very few hitches, however, are as simple as the general case just considered.

In Fig. 2, an equalizer frequently used in attaching three horses to a wagon with a single tongue, is illustrated.[1] The equalizer is attached to the tongue at points k and h in such a manner as to allow the members to rotate about these points as centers. The attachments at points d, f, j, b, and m are of such a nature as to make them free-moving joints. The load moves parallel to the z — axis in the direction gh and the forces exerted by the horses A, B C and act parallel to the line gh. The member km is to remain parallel to fj.

The first problem is to analyze the distribution of the pull between the draft animals. Let the force exerted by horse A be represented bv F. As $nd = pd$, the force exerted by horse B will also be F. The force applied at point f will then be $2F$. The member fhj can be considered as a lever of the first class with the fulcrum at h and a force of $2F$ applied at point f. From the law of levers:

$$2\,F \cdot 26 = x \,.\, 18$$
$$x = 2.89\,F$$

This force 2.89 F applied at point j must act parallel to fd. The force at point j, however, acts in the direction jb. In order to find the force in this direction the force 2.89 F must be resolved into two forces, one acting in the direction jb and the other in the direction hj. This is possible, but unnecessary for the present, because when lever kbm is considered, the force acting in the direction bj must be resolved into two forces, one acting parallel to the force 2.89 F and the other acting parallel to km which is parallel to hj. Therefore the force 2.89 F will be equal to the force at b, call it y, which acts parallel to the force C. In order to find force C consider kbm as a lever of the second class with the fulcrum at k and the weight y applied at b, then

$$y \cdot 6 = C \cdot 17$$
$$x = y = 2.89\,F$$
$$(2.89\,F)\,6 = C \cdot 17$$
$$C = 1.02\,F$$

Thus it appears that for all practical purposes this device equalizes the pull between the draft animals when used under the conditions illustrated in Fig. 2.

The next problem is to analvze the effects produced by this hitch upon the load. The tension in the unit jb is equal to x sec a;

$$x \sec a = 2.89\,F \cdot \frac{16.28}{11} = 4.28\,F$$

[1] In this paper straight line diagrams will be used. This method simplifies the discussion and introduces no appreciable errors from the standpoint of general analysis.

The component of this force applied at point j which acts in the direction jh is

$$\frac{4.28\,F \cdot 12}{16.28} = 3.15\,F$$

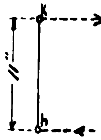
Fig. 3

This same component acts at the point b in the direction kb. Thus we have two equal and parallel forces applied at the points k and h but acting in opposite directions, as illustrated in Fig. 3. This is a couple and produces the condition commonly known as "side draft." The moment of the couple is

$$11 \cdot (3.15\,F) = 34.65\,F$$

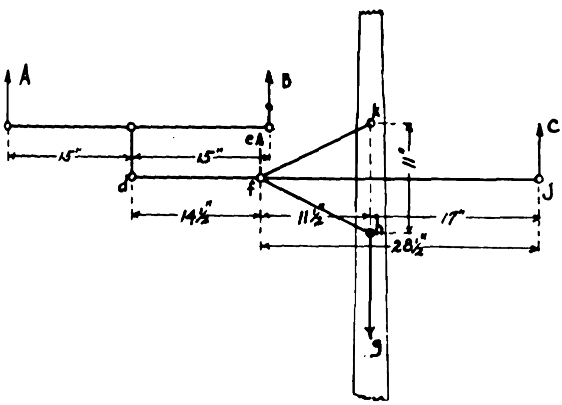

Fig. 4

This couple which tends to rotate the load must be balanced by a force acting about a fulcrum or a couple having the same moment as the couple tending to produce rotation. This will make additional friction which must be overcome in order to move the load in the direction gh. The increase in draft due to this hitch is directly proportional to the moment of the couple which acts on points k and h.

The next problem is to compare the patent hitch illustrated in Fig. 2 with the ordinary 3-horse hitch attached to an offset from the tongue as illustrated in Fig. 4. The horses A, B and C exert the same forces and are placed in the same relative positions as for the hitch illustrated in Fig. 2. The resultant of the forces exerted by the horses A. B and C is applied at f, and is equal to $3.02\,F$. The resistance from the load acts in the direction hg, and, as action and reaction are equal in magnitude, it must equal $3.02\,F$. This condition gives a couple tending to produce "side draft" the moment of which is:

$$(3.02\,F)\,11.5 = 34.7\,F$$

Thus it appears that the hitch illustrated in Fig. 4 produces the same effect upon the load as the patent hitch illustrated in Fig. 2.

Patent hitches have been chiefly developed for the purpose of eliminating "side-draft," on horse-drawn implements when it is desired to use three horses on a single tongued implement or when four or more horses are to be worked abreast on plows. These patent devices all have two points of attachment to or contact with the load so placed that a couple can produce a twisting effect. A careful analysis of a large number of these hitches, of which the case discussed above is a fair sample, shows that they produce exactly the same moment of couple upon the load as would be the case if a simple hitch was used with an offset for the point of attachment.

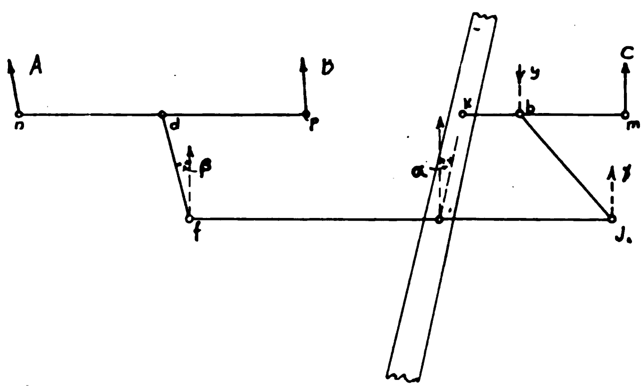

Fig. 5

The results of practical experience in the field with these patent hitches has generally been unsatisfactory. An analysis of these same hitches explains why they are no better than the simpler forms. Occasionally it may be desirable to use these patent hitches in order to secure a more desirable distribution of the strains in the members. Under certain conditions a more substantial hitch may be secured but it should always be remembered that the draft will be increased in direct proportion to the moment of couple produced. When in use the hitch illustrated in Fig. 2 will take a position similar to that shown in Fig. 5. The tongue will make an angle a with the direction of travel and the horses A and B will also work at an angle to the direction of travel, horse A usually making a greater angle than horse B. The resultant of the forces exerted by horses A and B will make an angle β with the line of motion. This resultant has a component which acts perpendicular to the line of motion about an unknown fulcrum whose moment acts in the opposite direction to the moment producing "side draft."

TRACTOR HITCHES

The discussion of tractor hitches will be limited to those ordinarily found upon plows. In general (eliminating a few patent hitches seldom used) tractor-plow hitches are of two classes, differing essentially in the range or horizontal adjustments permitted at the plow. In Fig. 6 a hitch is represented which allows a very wide range of horizontal adjustment in addi-

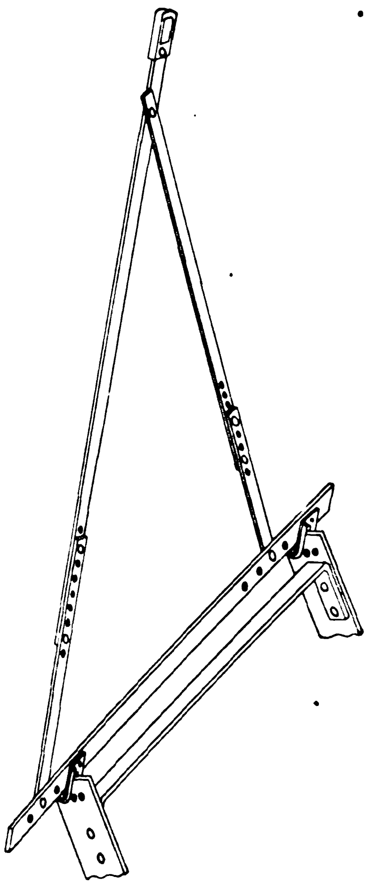

Fig. 6

tion to a vertical adjustment. The hitch illustrated in Fig. 7 has a very desirable vertical adjustment, but the range of the horizontal adjustment is more limited than in the case of the hitch illustrated in Fig. 6. These hitches both contain the same fundamental elements—three bars making a rigid triangle with a single point of attachment for the clevis which makes the connection between the hitch and the tractor. In order to illustrate

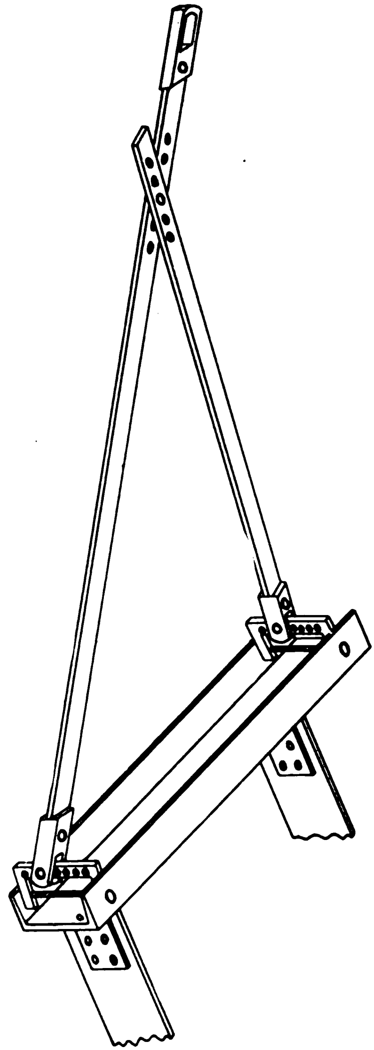

Fig. 7

the method of analyzing these hitches for purpose of comparison a few typical cases will be considered. Unfortunately it is not known whether the forces which resist the motion of a plow can be resolved into a single force or a force and a couple. In either case, however, it is evident that there must be some line in which the resultant of the forces which move the plow should act in order to give a minimum draft and to produce conditions most favorable from the standpoint of operating the plow. In this paper the resultant of the forces resisting the movement of the plow will be represented by a single force. Any error which may be involved in this assumption can easily be taken account of if later investigations prove it to be incorrect. Further, the effects of the vertical angle of hitch are omitted from the discussion.

In Fig. 8 the adjustments are such that the clevis *cb*, connecting the hitch and tractor falls in the line of motion of the center of

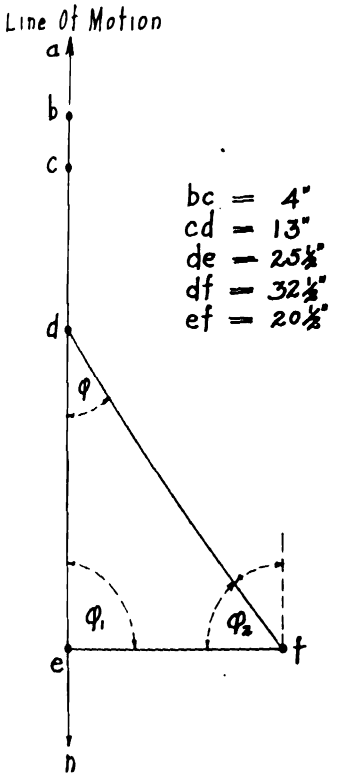

Fig. 8

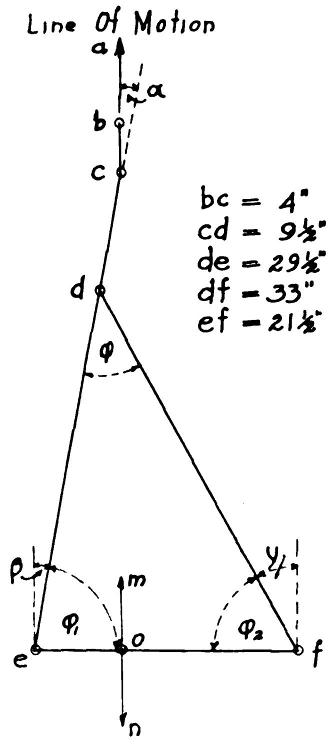

Fig. 9

resistance of the plow, *en*. In this case there is no "side draft" on the plow. If the line of motion of the resultant of the forces tending to move the tractor falls in the line *cb* extended, there will be no "side draft" on the tractor. If, however, this resultant from the forces of the tractor does not fall in the line *bc* extended there will be a tendency to rotate the tractor equal to the moment of the couple produced. In the hitch the entire load is carried on the member *ce*. The member *df* is neither in compression or tension. It is useful on the turns or when the plow strikes an obstruction which tends to force it out of the line of motion.

In Fig. 9 the member *bc* is parallel to the line of motion, and falls in the same line *(on)* as that produced by the motion of the center of resistances of the plow. In this case there is no "side draft" on the plow. The only problem, then, is to analyze the strains produced in the members of the hitch. The method here presented is general and therefore will be given in detail.

Let the tension in the clevis *cb* be F pounds. The tension in *ce* is F_3:

$$F_3 = F \cos a$$

Acting perpendicular to *ce* at the point C is a force F_4:

$$F_4 = F \sin a$$

This force F_4 acts upon *cde* as lever and produces tension in *df*, which will be designated as F_5. From the law of levers

$$F_4\,(39) = F_5\,(29.5) \sin \Phi$$

$$F_5 = F_4 \frac{39}{29.5} \cdot \frac{1}{\sin \Phi}$$

From this lever there will be a reaction at point *e*, (F_6). Taking moments about point *d*:

$$F_4\,(9.5) = F_6\,(29.5)$$

$$F_6 = F_4 \frac{9.5}{29.5}$$

F_6 can be resolved into two forces: F_7 acting parallel to the line of motion but in the opposite direction and F_8 acting perpendicular to the line of motion:

$$F_7 = F_6 \sin \beta$$
$$F_8 = F_6 \cos \beta$$

At point *e*, F_3 can be resolved into two forces, F_9 which acts parallel to the direction of motion, and F_{10} which acts perpen dicular to the line of motion.

Similarly, at point *f* the force F_5 can be resolved into two forces, F_{11} and F_{12} which are respectively parallel and perpendicular to the line of motion.

Then it follows that:

$$F_7 + F_9 + F_{11} = F$$
$$F_8 + F_{10} + F_{12} = 0$$

If the clevis *bc* does not fall in the line of motion of the center of resistance of the plow then the conditions illustrated in Fig. 10 may arise when the hitch shown in Fig. 6 is used. Under these conditions the clevis *bc* will make an angle Φ with the line of motion. Let the tension in the clevis be F pounds. At *b* the point of attachment to the tractor, this force F can be resolved into two forces, namely, $F_1 = F \cos \Phi$ which opposes the motion of the tractor and $F_2 = F \sin \Phi$ which acts perpendicular to the line of motion and tends to rotate the tractor. In hitches of this kind the point of attaching the clevis to the tractor is usually to the right of the line of motion of the resultant of the forces which move the tractor, in which case the moment produced by the force F_2 will act in the opposite direction to the couple tending to rotate the tractor. As a special case these two moments may balance each other. The stresses in the members of the hitch can be analyzed in the same manner as given above for the hitch

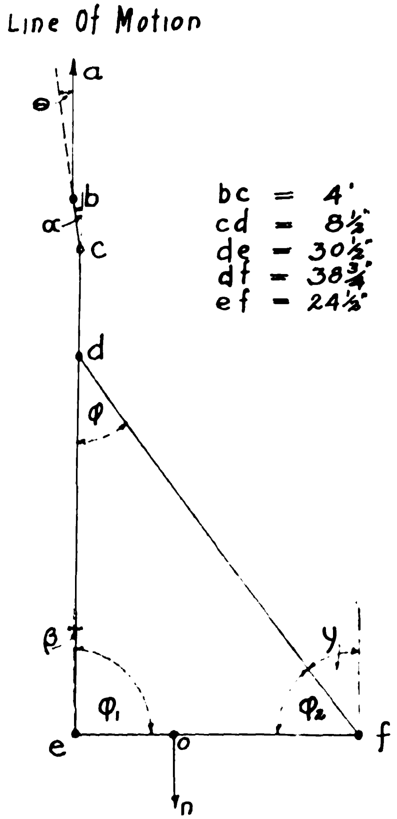

Fig. 10

illustrated in Fig. 9. As the clevis *cb* does not fall on the line *no* extended there will be "side draft" on the plow. At point *C* the force *F* can be resolved into two forces as follows:

$$F_3 = F \cos a$$
$$F_4 = F \sin a$$

The force F_3 applied at point *c* is opposed by an equal force applied at point *o*, which acts parallel and opposite to the direction of motion and consequently to the force F_3. The moment of this couple is F_3 multiplied by the perpendicular distance from the line *no* to the point *c*, and it will tend to rotate the front end of the plow to the right. Opposed to the action of this couple is the moment of the force F_4 applied at point *C* and acting about an unknown fulcrum. The increase in draft due to the hitch is directly proportional to the difference between these two couples.

The conditions represented in Fig. 11 may occur when the hitch

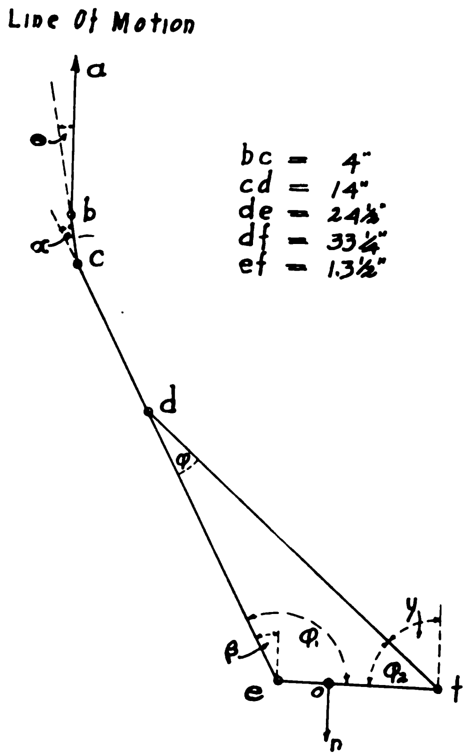

Fig. 11

illustrated in Fig. 7 is used. The chief difference between this case and the one represented in Fig. 10 is that the angle formed by the intersection of the units *ec* and *bc* falls to the left of *bc*. This will cause the unit *ce* to be in tension and the unit *df* to be in compression. In the ultimate analysis the tendency of this hitch to produce "side draft" will be found to be the same as for the hitch illustrated in Fig. 10, but the stresses will have a very different distribution in the various members.

The analysis of equalizers and hitches given in this paper by no means completely covers the field. Many important practical applications have been entirely omitted. The problem is too large to discuss completely in a paper of this length. An attempt has been made, however, to present the fundamental method of attacking the problems presented.

DISCUSSION

PRESIDENT SCOATES: This has been a very interesting paper to all of us on this very vital subject. Are there any questions you would like to ask Mr. White?

MR. SHEDD:[1] I believe the statement was made that the draft was increased in proportion to the size of the couple tending to produce rotation, that is, side draft. I'd like to ask whether that is mathematically correct? It seems to me if you have one force forward, one to the side, the result is an angle you call alpha.

MR. WHITE: (Indicating) Every time you have a center of resistance acting here, over here you have your pull—you have a tendency to rotation that must be overcome. In the case of most of our implements it is overcome by some forces, probably a couple, that makes increased draft to overcome the friction that is thrown in there. If you are not satisfied with those analyses built up, put these equalizers in there and hold them in position. Those forces will very soon tell you where they come, how they act and what they are. We took sub-scales, built big frames and put scales in every joint in such a manner that the equalizer is held in the position it is in the field and put a load on it. That shows that there is a couple produced on all these equalizers. I realize that I am going contrary to what has been, perhaps, considered as correct in literature, in analyzing these equalizers and hitches. I was fully aware of the point Mr. Shedd brought up when I started on this paper. There was a paper put out by Mr. Watson bringing out that the increase in draft would be in proportion to the third side of the triangle. My study of the proposition does not lead me to believe that is correct.

[1] Department of Agricultural Engineering, Iowa State College, Ames, Iowa.

RELATION OF LARGE MACHINE UNITS TO PRODUCTION

By Arnold P. Yerkes.[1]

Other things being equal, it is a self-evident fact that production increases in direct proportion to the size of the machine; a 12-inch plow will plow twice as much ground in a given time, and therefore produce twice as much as a 6-inch plow; a 12-inch two-bottom gang plow will produce twice as much as a 12-inch walking plow, and so on.

This being so evident, rather than to undertake to give figures on acreages, etc., for different sized implements, such as "with a one-row corn cultivator a man can properly care for 40 acres of corn or other tilled crops and with a two-row cultivator he can properly tend 80 acres"; or that "with two horses and a 12-inch walking plow a farmer can plow 2 acres per day under favorable conditions, while with four horses and a 12-inch gang plow he can cover 4 acres in the same time"; or to quote figures similar to the oft-repeated statement that in 1850 one farm family supported only one other family in the city, while in 1910 one farm family produced sufficient foodstuffs to feed two families in the city; which have been stated so often they have become an old story to most of us—I decided it would better in treating the subject I was asked to discuss to deal more largely with the reasons for the continuation of older and less efficient machines and methods on so many farms and the possibilities of hastening the adoption of improved machinery on such farms.

The improvements which have been made in farm equipment and methods during the past century are, of course, universally realized by members of this society. With all due respect to the improvements in methods and equipment in other lines of industry, it is doubtful if any of them have made any greater progress, comparatively, than has agriculture. In a few years it has progressed from the cradle and the flail to the harvester-thresher which permits two men to thresh and clean 20 acres of grain per day. In about the same period it has passed from the wooden plow which turned an indifferent furrow, covering perhaps an acre per day, to immense plowing outfits which will cover from 20 to 30 acres per day. From a bundle of brush, a split log, or a few planks fastened together and drawn over the plowed ground by oxen or horses, covering from 5 to 10 acres daily, it has progressed to different types of scientifically constructed steel harrows, packers, pulverizers, etc., which, when used behind a modern prime mover will cover from 50 to 100 acres, or even more in a day and do

[1] Of the International Harvester Company.

much better work than the earlier makeshifts. From these and a hundred other similar examples which might be mentioned, it certainly seems safe to state that the agricultural industry has at least held its own in the development of efficient labor-saving machines and methods.

COMPARATIVELY FEW USE LABOR-SAVING EQUIPMENT

In view of these improvements and the possibilities which they offer of increasing the output per man on American farms, it might, at first glance, seem remarkable that such equipment is not in almost universal or at least more general use by American farmers. There are many farms in the country even today where grain is still being cut with a cradle and bound by hand; 1-horse walking cultivators and walking plows are predominant in large areas of the country, and so on. Why this state of affairs when such efficient equipment is available? Before attempting to answer this question, I want to say that the farming industry is not alone in not fully utilizing the improved equipment and methods which have been developed and are available to it. A casual observation will convince anyone that only a comparatively small percentage of any industry utilizes the very latest and most efficient methods and equipment available to that industry. Is all city hauling done with motor trucks? Are all manufacturing plants fully equipped with the latest and most efficient machines? Far from it. Take the plants manufacturing automobiles. A few of them are using the latest and most efficient machine tools, turning out the various parts in large quantities and at a minimum expense. Their shops are designed in accord with the very best shop practice so as to keep all the material moving in one direction, no doubling on its track, and no lost motion. Other shops are less efficiently equipped and designed in varying degrees, yet they are all manufacturing a similar product to be sold in a competitive market. So long as the demand is good and prices fairly high, they will all make a profit, though the less efficiently equipped shops will obviously make the smallest profit and when adverse market conditions arise, they will naturally be the first to go to the wall.

There are a number of reasons for this varying degree of efficiency in the equipment of both factories and farms. In the case of a manufacturing concern equipped with old style machinery which is still serviceable. very often its present business is not of sufficient volume to justify the increased investment necessary to install the most up-to-date and efficient equipment, and the men responsible for the directing of the business do not have adequate assurance of a large enough possible increase in the business to justify such an expenditure in the hope of increasing it. In other cases, the location of the plant may be such as to prevent the utilization of the most efficient machinery and equipment; in still others a difference in the raw materials used may have the same effect, and so on. But if you asked business men their reasons for not employing the most up-to-date machines, the great majority of them would doubtless reply truthfully that their business was not large enough to justify it. Many farmers would give the same reason, but I want to point out the fact that it is much easier to enlarge the farm than most other lines of business.

EFFICIENT METHODS MEAN LOWER COST PRODUCTION

It is obvious that the farmer who can make use of the most efficient machines can produce his crops at a lower cost than a farmer who is less fortunately situated and who endeavors to raise the same crops. While it is probably well known to all the members of the American Society of Agricultural Engineers that the farming business is, in the true sense of the word, a competitive one, the impression prevails so generally among people unacquainted with agriculture that there is no competition in farming that it may not be amiss to call attention to the fact that the price on farm products is determined to a considerable extent by the cost of production on those farms on which the bulk of the crop is produced. For example, when the price of wheat falls to say $1 per bushel, those farmers who are well enough posted on the cost of producing wheat on their farms to know that they cannot produce it at a profit for $1 per bushel will, of course, stop raising it unless it is especially desirable in their crop rotation for seeding grass, or serves some other useful purpose which will justify its continuance in the crop rotation when the receipts from the sale of the grain itself will not cover the cost of growing it. The same thing happens as the price falls to other levels; as the price goes down, more farmers must quit raising it, the same as in a manufacturing business. This has the effect of reducing the amount of wheat produced in those sections where conditions are not particularly favorable, and at the same time tends to increase the amount grown in the sections best adapted to its production. As prices increase, the reverse holds true. When the demand is such that the price level ascends to a point where farmers who have not been growing wheat believe that they can make a profit, they will begin planting wheat.

It is obvious that those farmers who are unable to utilize the most efficient machines and methods, or who are located on poor soil, must necessarily be the first to quit growing a crop as prices fall. It is this influence in its broad aspect which determines to a great extent the type of agriculture followed in any community. Soil and climatic conditions, of course, are a primary influence, but as these in turn affect the utilization of certain machinery or methods, it is apparent that the equipment problem is also important.

The desirability of increasing the production per man through the use of the most efficient machinery in all industries is most obvious. It is a generally accepted fact that during the next few years there will be keener competition between the commercial interests of the various nations than ever before. This competition is not going to be restricted entirely to industries other than agriculture. The most fertile and generally desirable farming land in this country has already been settled, and is being tilled to a great extent. Most of this land has a comparatively high value. But there are several other countries where there are still enormous tracts of very fertile, low priced land which has never been put under the plow which will be brought under cultivation during the next few years, and such cultivation will be carried on by means of the most improved American-made farm machinery (or imitations of it). A good idea of what we must expect along this line was given yesterday by the gentleman who spoke regarding the enormous possibilities of undeveloped land in South Africa as a world granary.

In view of these facts, it behooves the people of this country to make use of the most efficient methods in all lines of industry, including agriculture.

I submit that the most important problem which today confronts the agricultural engineers of this country, as well as other organizations for the promotion of agriculture, is to assist in the utilization to a greater extent than ever before of existing improvements in agricultural equipment, in order that the vast majority of American farms may be organized and equipped on a basis which will enable them to compete successfully with those farmers in other countries who will be operating under highly favorable conditions with regard to land values and modern equipment. If this is not done, it will be only a matter of a few years before we are importing large amounts of staple farm products from other countries where American-made machines are being used efficiently under favorable conditions, permitting successful competition with the farmers of this country.

We may well take pride in the progress which has been made in developing improved farm machines in the past and look forward to greater achievements in this direction in the future. But we must not lose sight of the very important fact that only a very small percentage of the farms of this country are today making use of such improved equipment as is available. Of what avail are such machines as the harvester-thresher, the tractor, the motor cultivator, and so on, when only a small percent of the farmers of the country are utilizing them at the present time?

I am sure few people will question the desirability of having every possible effort made to hasten the adoption of improved machines by farmers. Thousands of dollars worth of advertising of all kinds is being turned out every day to accomplish this purpose, and nearly all literature which reaches the farmer's hand contains articles extolling the virtues of modern farm machines, and telling him he should be up to date and make use of all such modern equipment. At the same time there is a dearth of practical suggestions as to how he can use such equipment with profit.

The desired result cannot be accomplished simply by telling the farmers of the country about these large and improved machines, how well built they are, the number of anti-friction bearings they contain, the beautiful shades of paint used on them, etc. Most farmers are already aware of the existence of such equipment and will admit the advantages it possesses. Many who are not now using it would be willing to adopt it on their farms today if they could only see to their own satisfaction how they could utilize it with profit.

MODERN MACHINERY EARNS MONEY FOR THE OWNER

It must be borne in mind that a great many farmers do not require any advice whatever regarding the management of their business—they are entirely competent to conduct it to the best advantage. To influence the others, what is needed, it seems to me, is to point out to them the conditions under which this improved equipment can be utilized to advantage, and then tell them how they can make their conditions meet such requirements. Suggestions must be practical. It would not be practical to suggest to the publisher of a small weekly paper with a circulation of two or three thousand that he should obtain an octuple press such as is used by the publishers of a large metropolitan daily with several hundred thousand circulation. It could be truthfully pointed out that the octuple press turned out papers several times faster than the small one, cost less per copy for operating expense, that the use of such modern equipment was a sign of progressiveness, and that since it would do the work so much faster it would permit of doing a much higher quality of work. Furthermore, that since it would not be kept busy all the time on the small paper it could be used to do outside work. It is not probable that such arguments as these would carry a great deal of weight with most small publishers. The strongest and only really valid argument of those mentioned would doubtless be that relative to doing job printing for others, and in many cases small publishers do install presses of greater capacity than their own needs demand and then keep these presses reasonably busy, and have them earn some money by doing job printing with them. But many publishers do not care to go into the job printing business, and many farmers do not care to get into the business of doing custom work for neighbors.

There is no doubt whatever that the purchase of some of the larger farm machines is an excellent investment for a small farmer who will use such machine for custom work when not needed on the home farm, and thousands of farmers are making money from such work. At the same time, there is a limit to the amount of such custom work which can be done in any community, and the fact that a farmer has time to use a machine for such work is proof that the home farm is not large enough to keep its equipment busy during the working season. While many farmers find such custom work profitable, such machines would usually prove even more profitable where the owner keeps them busy on fields from which he will receive the entire profit from the crop.

The principal reason which will justify the installation of a large octuple press in the case of a publisher is to have a circulation

Modern machinery is enlarging the farms in the states that produce the bulk of our food-stuffs

which will require nearly the full capacity of the machine. And the principal justification for the purchase of most of the improved equipment on farms today is to have a sufficient acreage for it to cover to keep it busy during a large part of the working season. This fact is so obvious and has been so fully demonstrated on thousands of farms in actual practice that it should be unnecessary to even touch upon it before a meeting of this kind. But strange to say, it is the one point which receives very little mention in the reading matter which reaches the farmers of this country, either in the agricultural publications or catalogues and other literature extolling the virtues and capacity of large and improved farm implements.

On the contrary, the farmer is constantly being told that the tendency in this country is toward smaller farms and more intensive cultivation. When he is urged to buy a tractor or other machine which will multiply his efficiency and permit him to do the work on his present acreage in much less time than was required by old methods he is told that he can do a better quality of work and farm more intensively, and so obtain a greater yield per acre which will make such equipment just as valuable to him as to his neighbor who is growing the same crops but who grows a much greater acreage of them, using about the same amount and kind of equipment.

To read some of this sort of advice which is handed out to the farmers one wants to use a popular slang phrase and inquire "where do they get that stuff?" It reminds me of the verse by Lee Shippey as follows:

THEY ALL DO IT

In our little town—ah, sad to tell:—
There's a merchant who doesn't know how to sell,
A lawyer who doesn't know much of law,
A sawyer who doesn't know how to saw.
A teacher who doesn't know how to teach,
A preacher who doesn't know how to preach,
A painter who can't paint very well,
And a printer who doesn't know how to spell,
An odd-jobs man with never a job,
A cobbler who doesn't know how to cob.
A miller who doesn't know how to mill,
A butcher who doesn't know how to kill,
A racer who doesn't know how to race,
A mason who doesn't know how to mace,
A clocksmith who cannot mend a clock,
And a doctor who doesn't know how to doc;
And since none of them are busy men
You'll find them, again and yet again,
Ever, anon and a few times more
Round the stove in Mendelsohn's store,
Each talking freely—and through his hat—
Doing the one thing they're expert at—
Giving advice to the farmers.

A great deal of the advice offered to farmers has all the earmarks of coming from such sources. It is a remarkable fact that a great many people who have had no experience whatever in farming feel perfectly competent to tell farmers how to conduct their business. These same people would not think of offering their advice to men in other businesses or professions with which they were so entirely unacquainted, yet even the moderately successful farmer today must possess fully as much technical knowledge and business ability as men in any other line of business.

But let us analyze the effect of larger machines on the size of farm. As already stated the production increases practically in direct ratio to the size of the machine. This being the case, it is self-evident that to produce a given quantity of foodstuffs the larger the machines used the fewer will be required, and it naturally follows that the fewer machines used the fewer the men needed to operate them. Other things being equal, the acreage required to produce a given amount of foodstuffs will remain the same, therefore the fewer men, the more acres per man. All of which is just another way of saying that larger implements increase the acreage one man can farm.

Is anything more logical than the fact that a man who uses 4-horse implements can do practically twice as much work in a season as one who uses only 2-horse machines? Then cannot the man who uses 4-horse tools farm twice as many acres as the man who uses 2-horse equipment? And the man who uses a tractor which will do more work than four horses, farm still more land? Yet we frequently hear the statement that there is a tendency toward smaller farms in this country. If such were actually the case, then the inventors and manufacturers of labor-saving farm equipment should hang their heads in shame and retire, because if the production of machines which increases the amount of work one man can do and the acreage which he can till is resulting in one man farming fewer acres than in the past, their work would have gone for less than nothing.

CENSUS REPORT ANALYZED

But such is not the case. People who state that we are tending toward smaller farms are, to use the expressive slang term, "kidding themselves." This idea has been formed by many people by glancing at the figures in the 1910 census report as to the total number of farms of different sizes and the increase in the number of each size for the previous decade. These figures show a large increase in the number of so-called farms of less than 20 acres and as small as 2 acres, but if the text accompanying these tables is read carefully, it will be seen that the increase is more apparent than real. Furthermore, if they would stop and think of the thousands of small country homes and estates which are included in this group of so-called farms, they would realize it is not "farming" which is tending in this direction, but that the figures only indicate a natural consequence of the tremendous increase in our total and urban population, since thousands of city workers desire to and do live on small acreages outside of cities near the railroads and trolleys. These "farms" are nothing more than homes with large gardens. They are not supporting the family and are an entirely negligible factor in so far as the food supply of the nation is concerned. They have very little more right to be termed "farms" than has a garden in the back yard of a city home.

But where is this increase in small farms occurring? And what section of the country should be selected as most fairly representing

American agriculture if we want to study any such tendencies? Surely not the South, where the most important crop for the period covered by the census report was cotton. Cotton, as we all know, is one staple which is still being raised largely by hand methods because no wholly successful picker has been developed. This has resulted in it being grown principally in acreages small enough so that one negro family could pick it by hand. In the South, to be sure, there has been a tendency ever since the Civil war to break up the old plantations into smaller farms, and there is a great deal of land leased out to negroes in small plots which the census reports would list as farms, which are really only parts of a large farm which is being managed by a system found most profitable in many sections of the South. Nor would the eastern states or the Pacific coast states be representatives. If you will take Volume 5 of the 1910 Census Report you will find that the twelve states included in the section of the country designated as the East North Central and West North Central groups, including North and South Dakota, Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Michigan, Ohio, and Indiana, raised 56 percent of the total crop production for the year the census was taken. Not so bad for twelve states! And in view of their record, I think they are justly entitled to be considered as representative of our agriculture.

Now what do you find there as to the tendency in the size of farms? In the East North Central group, which includes Wisconsin, Michigan, Illinois, Indiana, and Ohio, there were 12,000 less farms in 1910 than in 1900, or 1.1 percent decrease, with only an increase of 1.4 percent in total acreage in farms. We find there was an increase of 8,000 in the number of so-called farms of less than 20 acres, which was an 8.2 percent increase. However, there were 33,000 less farms in the 20- to 49-acre group, and 9,000 less in the 50- to 99-acre group. Now, it didn't take 8,000 of the larger farms to make that increase of 8,000 under 20 acres, but if it had there would still be 41,000 comparatively small farms missing and these are in the groups which may rightfully be termed small farms, ranging from 20 to 99 acres. Where did they go? Why they, with more land from some of the farms of over 500 acres, helped make an increase of 22,000 farms from 100 to 499 acres. If there is any "tendency" shown by these figures, it is certainly toward the fairly large and efficient sized farm.

Now as to the West North Central states. Here we find an increase of only 4,000 farms of less than 20 acres and this was a 10 percent increase for the size, showing there were not a great many such small farms there before. There was a falling off of 18,000 or 16.9 percent in the 20- to 49-acre farms and 30,000 or 14.5 percent in the 50- to 100-acre group. But there was an *increase* of 13,000 in the 100- to 174-acre farms, and 58,000 in

STATISTICS RELATING TO FARMS IN THE UNITED STATES AS A WHOLE, AND IN THE EAST AND WEST NORTH CENTRAL DIVISIONS, 1900-1910

SIZE	UNITED STATES					East North Central States—Wis., Mich., Illinois, Ohio Indiana			West North Central States—North and South Dakota, Minn., Neb., Iowa, Mo. and Kansas		
	Percent of Increase 1900 to 1910	No. in 1910	Percent of all improved land in farms	Percent of No. of all farms	Value of implements and machinery	Increase[1] in No. of farms	Increase[1] in percent of farms	Increase[1] of all land in farms	Increase[1] in No. of farms	Increase[1] in percent of farms	Increase[1] of all land in farms
All farms	10.9	6,361,000	100.	100.	$1,265,000,000	—12,000	—1.1	1.4	49,000	4.6	15.7
Under 20 acres	24.5	840,000	1.7	13.2	47,000,000	8,000	8.2	3.5	4,000	10.3	2.4
20 to 49 acres	12.5	1,414,000	7.6	22.2	107,000,000	—33,000	—14.4	—15.6	—18,000	—16.9	—19.1
50 to 99 acres	5.3	1,438,000	14.9	22.6	224,000,000	—9,000	—2.7	—2.9	—30,000	—14.5	—14.2
100 to 174 acres	6.6	1,516,000	26.9	23.8	365,000,000	14,000	4.6	4.5	13,000	3.9	3.7
175 to 499 acres	12.7	978,000	33.8	15.4	381,000,000	8,000	5.9	5.9	58,000	20.4	21.8
500 to 999 acres	22.2	125,000	8.5	2.0	80,000,000	—422	—7.6	—7.1	19,000	52,5	51.8
1000 acres and over	6.3	50,135	6.5	.8	59,000,000	—188	—19.8	— 6.4	2,000	21.4	9.7

[1] Minus indicates decrease.

those of from 175 to 499 acres. Nor was this all. There was an increase of 19,000 in the 500- to 999-acre farms, and of 2,000 in those over 1,000 acres. We must note, of course, that there was an increase of 15.7 percent in total acreage in farms, that is, there was this amount of land being farmed in 1910 which had not yet been settled in 1900. But the thing we are interested in just now is the "tendency," and it certainly is not toward smaller farms in this section.

But I am not presenting these figures simply to show that the tendency in our most important agricultural states is toward the larger and most efficient sized farm, where modern equipment can be used to advantage. I also want them to bring to your attention the fact that while a great many of the channels through which the farmer is supposed to receive valuable advice regarding his problems were carrying statements of a tendency toward small farms and intensive tillage, several thousand individual farmers, saw that the solution of their biggest problem was to have enough land to make an efficient sized farm, and they acted accordingly. This throwing together of small farms to make a larger one and the buying or renting of an additional field or two has not been done by farmers on the advice of anybody. Rather, it has been done in spite of contrary advice.

I may add that since 1910, several thousand farmers in these states have bought tractors and an investigation showed that one out of every three of those men increased the size of their farm approximately 100 acres soon after buying this machine which increases a man's efficiency at farm work.

Now it would seem that since so many farmers increase the size of their farms so as to use modern equipment efficiently, in spite of advice to the contrary, this tendency could be accelerated by pointing out to all farmers through the agricultural press, farm equipment advertising literature, and all other channels, the desirability of this action.

INTENSIVE TILLAGE ON LARGE FARMS

And now a few words as to the intensive tillage advice and the "little farm well tilled" fallacy which is still a popular theme among some city people who tell the farmer how to manage his business. It is a very common statement that the farmer who has less than 100 acres is fully as much justified in buying modern machines as his neighbor following the same system of farming but with a greater acreage, since he can make the larger equipment pay because it will cost a little less per acre of work done and he can also do more thorough work and use more "intensive" methods, thus offsetting the other advantages which the owner of the larger farm possesses. Such arguments roll off some people's tongues like butter off a hot knife.

I would like to submit that there is no intensive farming practice which the small farm can use to advantage in the production of staple crops which the larger farm cannot use to even greater advantage. Let us take two corn-belt farms of 80 and 240 acres, respectively, as an illustration. The 80-acre farm has to have just about as many machines as the 240-acre farm, but some of them will be smaller, a 6-foot instead of an 8-foot binder, a two-plow instead of a three-plow tractor, an 8-foot instead of a 10-foot disk, and so on. The total investment for the equipment is only a little less for the 80- than for the 240-acre farm. The investment charge per acre, however, is more than twice as great. Furthermore, the cost for man labor on all operations will be greater because of the smaller size of the machines and the smaller amount of work done per man per day. (And as they both receive the same prices for their products, it doesn't require much figuring to tell who will have the largest income at the end of the year.)

But now as to the intensive methods which the small farm is to employ to offset its handicaps. Is it to be deep plowing? Deep plowing doesn't always or even generally increase the yield, but assuming it did in this particular case, can't the farmer with the 240 acres and a 3-plow tractor plow just about as deep as the other? He will not be hurried in getting his plowing done on a well organized farm of this size if he has a good 3-plow machine, and with his more efficient size of tractor he can do the additional work at a lower cost per acre. Is it to be through the use of manure? The large farm has the advantage in justifying the purchase of a large and efficient sized spreader, while on an 80-acre farm very often the amount of manure to be handled will hardly justify the purchase of a spreader, but at best it will be a small and less efficient one. Is it to be through the use of commercial fertilizers as is frequently suggested? If this is a profitable practice for the small farmer it is just as profitable for the large one. Furthermore, the large farm will buy three times as much, which may give a lower price or permit of carload freight rates as against l.c.l. rates for the small farm. When it comes to distributing it the large farm will justify the use of a large size distributor which will cover an acre for less than the smaller size on the 80-acre farm, and the investment per acre for the machine will also be lower. Is it to be through green manuring and cover crops? The large farm can practice this just as well as the small one and will have the advantage in using more efficient machinery in planting such crops and in turning them under. And so on through the list of intensive farming practices.

Good practices are not confined to the small farm and it is ridiculous to hand out such bunk to farmers to encourage them to buy modern equipment. Furthermore, comparatively few farmers will "fall" for it.

THE REAL ARGUMENT FOR THE FARMER

Why not come right out and say to them: "Here, you are using equipment which will only permit you to crop 100 acres. Now by getting this larger and more efficient machinery, your investment in equipment will be increased only 15 or 20 percent, while you can till 200 acres and not work any more hours per year, as by using this improved equipment you will be able to do twice as much work per day as with what you are now using and you can care for twice as great an acreage."

Isn't that logical? And doesn't it sound better than to say to him: "Now you are using old and out-of-date equipment. We admit you are getting your work done in some fashion, but you are not up-to-date. By buying one of these large machines like farmers use who have double your acreage, you can cut down the expense of operating your farm by several dollars, and while you won't have nearly so much for it to do as they will, you can offset this by doing better work."

In one case he is told how to increase his income in the same manner that any other business depends upon increasing its income, that is, by expanding. In the other he is told to attempt to increase his income by reducing his expenses which, while in itself is a very desirable thing, offers a very limited possibility in the way of increasing an income, and few business men would care to depend entirely upon such a method, much as they try to cut down operating expenses.

Now just stop and think, how many times did you ever see, in reading literature intended for the farmer, arguments to the effect that improved machines would permit increasing the size of the farm, and thus increase the farm income; that many farmers by buying or renting additional land could well afford to adopt larger and more modern equipment, that what the country needs is fewer farms but larger and more efficient ones, and a smaller farming population with a greater productive capacity through the more extensive use of machinery.

I'll venture to say that for every time you have seen such statements you have seen a hundred to the effect that farmers should farm less land and do it better so as to get high yields per acre like European peasants, or bewailing the fact that people were leaving the farms for the cities and proclaiming that something ought to be done to keep the boys on the farms. Some one has very truthfully remarked that the way to keep the boys on the farm is to make farming pay and the way to make farming pay is to have the farm large enough to use modern equipment efficiently. Surely it is not desirable that there should remain on our farms any more boys, or men either, than are necessary to produce an adequate supply of foodstuffs through the use of the most efficient equipment.

The faster labor-saving farm machines can be adopted and the men and boys thus released engaged in some other productive industry, the better for all concerned.

It is not half so bad for the country to have boys replaced on farms by machines as to have them kept there doing work by old, inefficient methods that could be done better by modern machinery.

In conclusion I would like to summarize as follows:

We have made wonderful progress in the development of improved farm machines.

Much of this improved equipment is in use on only a very small percentage of our farms even in sections where natural conditions are favorable to its use.

Efficiency in all industries during the coming years is highly important, but probably more so in agriculture than any other, as our farmers are likely to find themselves competing with men farming new, fertile land in other countries under very favorable conditions.

The greatest problem which today confronts the various organizations for the promotion of agriculture is that of having available improved equipment more fully utilized.

There are several factors which tend to prevent the utilization of such equipment on different farms. Lack of progressiveness on the part of the farmer, while often credited with being largely responsible, is not so much so as eccentric influences and confusing advice.

The principal justification for the adoption of improved farm machinery is a farm of sufficient size to utilize it efficiently. This has not been emphasized in the past, but for the welfare of both farmer and nation it is highly desirable that it should be emphasized in the future.

Let's boost for the farm which is large enough to permit of the efficient use of modern equipment and where a high production per man is obtained through the use of large machine units, the kind of a farm which is most profitable to the farmer and to the country.

DISCUSSION

QUESTION: There is nothing wrong with intensive farming on a big scale?

MR. YERKES: Absolutely no. I have gone through a lot of big farms and they are using intensive farming. They make the little fellow sit up and take notice. Intensive farming can be done just as well and better—cheaper. How can you expect the little fellow to compete with the big farmer under those conditions? Yet, the fellows are telling him he can. How many business men would want to depend on increasing their net income by cutting down expenses? Don't most business men increase their income by expanding? Isn't it logical, then, when a farmer is going to increase his income he is going to do it by expanding?

QUESTION: Is 240 acres considered a big farm?

MR. YERKES: I consider it a big farm when it gets over 500 acres. As I said, the average farm is between 240 and 340 acres. Lots of farmers can farm more land than that, but I am talking of the average farmer. It depends on the type of farming. Fifty acres is a good big truck farm, but we can't all raise truck. It makes me smile about the 10-acre farms for returning soldiers. Ten-acre farms will not pay, except in the best trucking regions where transportation is good, and manure is obtainable.

The farmers in this country haven't been running at full capacity at all. They couldn't. They were taking too much of a chance. Farming is more expensive today that most of the other industries. Farming is very competitive. When the price of wheat went to $2.20, the farmers got into the game. When the price goes down in 2 years from now farmers who are raising it today will have to quit. When it goes to a dollar there will be still more dropping out. They are raising wheat out east now and they can't raise it for $1.00 a bushel. When the price goes down they will quit. That means the farmer with the best facilities is going to raise the bulk of the crop and make the money on it.

QUESTION: What does it cost to raise a bushel of wheat?

MR. YERKES: I don't know. There have been many estimates made. I understand there has been a lot of trouble getting the figures from Hoover, as to the cost of raising wheat. The Senate called upon him for the figures, but he said that the figures obtained were not entirely reliable. I am not in close touch with the latest figures. The cost has practically doubled in most sections, but in normal times the cost of raising wheat was from 75 cents to 95 cents a bushel. In Pennsylvania and New York they wouldn't have raised wheat at all if it hadn't been that they wanted the wheat to seed grass. They were not making a cent on it. Back in the low-lying parts of those states I have seen figures to the effect that they raised wheat for 30 cents a bushel, but that is getting down to rock bottom when labor was cheaper. Fifty bushels to the acre was a fair average. What you can get depends on the kind of machinery you use, the kind of soil adapted to wheat, and the labor price.

QUESTION: I would like to ask Mr. McGregor-Smith what it costs to raise wheat in Canada?

MR. SMITH: It cost us about 60 cents before the war..

STANDARDIZATION OF FARM MACHINERY

A. B. Dinneen[1]

I appear before you as an implement man who has quite closely followed the conservation plan laid down by the Government as it applies to the farm implement industry.

The Government's plan of conservation was to adopt reforms such as have always been known in the implement industry as elimination and standardization. The farm equipment industry has for a number of years given consideration to these matters through the media of the various departments of the National Implement and Vehicle Association.

I think it well to review the progress we have made in standardization and elimination since the United States entered the war. This should cover both the activities of the industry and of the Government. Before an outline is given showing what has been done we should consider the reasons for the activities. What does the industry and the Government hope to accomplish by the standardization of farm equipment and the elimination of the non-essentials in the line?

REASONS FOR STANDARDIZATION

When the industry considered the elimination of left-hand plows a careful analysis was made relative to the benefits and disadvantages to all interested parties of the left-hand plow. For the purpose of analysis a high lift 2-bottom gang plow was considered specifically.

We can give no better argument in favor of these reforms than to give here this analysis:

BENEFITS

To the farmer:

It satisfies the farmer's preference of mind for a left-hand plow and this is all. There is no economic advantage whatsoever from its use.

To the dealer:

No benefits to the dealer.

To the manufacturer:

The manufacturer receives no benefits from the left-hand plow.

To the people and the world at large:

The world receives no benefits because of the left-hand plow.

This sums up fully what we can put on this side of the balance sheet except to add the deficit.

[1] Deere & Company, Moline, Ill.

DISADVANTAGES

To the farmer:

1. It results in a higher cost of the plow whether or not the farmer uses a right- or left-hand gang. If the total production is thrown to one kind it will reduce the cost of the one made in the greatest quantities.

2. The service to the purchaser of the plow on the whole is slower where two articles are concerned than if there is but one article for sale. Possibly when a farmer wishes to purchase a left-hand plow there is none in the dealer's stock, or he may have a right-hand only. In making this statement on these plows I appreciate the trade on each type runs in territories, and the case mentioned may not well apply; but taking manufacture as a whole it does apply—sometimes seriously.

3. The repair service is slower and not so satisfactory for the same reason that the service on the complete implement is not so good.

To the dealer:

1. The difference in the service on complete plows affects the dealer in the same manner as the farmer except to a more marked degree.

2. The dealer is required to carry stock of both plows. The results are:

A—Increasing dealer's investment in stock.
B—Increased stock depreciation.
C—Increased storage requirements and investment in buildings.
D—Increased shopworn and obsolete implements.
E—Increasing handling, clerical work and such other work as is necessary to carry two articles instead of one.

3. Complications in furnishing repairs is doubled because of the two plows. All of the disadvantages mentioned on the complete implement will apply forcibly to repairs—particularly possibilities are increased for repairs becoming entirely obsolete.

To the manufacturer:

The manufacturer is burdened to a greater extent because of these two plows than either the farmer or the dealer. I think it will be well to go somewhat into detail on the manufacturer's problems.

Thirteen steel forgings are used on the left-hand plow that are not common to the right-hand. From the design of these parts to their ultimate manufacture each and every piece must pass through 22 processes - 286 processes in all to make a left-hand gang. We do not refer here to the processes in manufacture, but rather the processes of designing, ordering, recording, etc. In a large organization these processes very nearly represent the number of individuals that must give consideration or work to the piece.

In manufacturing these 13 forgings it is necessary to design, manufacture, record and keep in stock 75 manufacturing tools. Every time a manufacturing run is made on these left-hand gangs 75 tool set-ups are necessary, and 87 operations are performed that are not common to other implements. Consider for a moment the time involved in the designing, preparation and manufacture of these special parts, and also the investment in the manufacturing tools necessary to make them.

Twenty malleable castings are used on a left-hand gang plow that are not common to the right hand. In the designing and furnishing of these castings the same processes on each must be performed as on the steel parts; namely, they must pass through 22 sequences. We have also the outlay in money tied up in the permanent patterns for these castings.

In addition to this, certain special foundry equipment such as matches, flasks, or possibly a machine pattern is necessary. Production is menaced by stopping one pattern in the foundry and starting another. Twenty stops and twenty starts are necessary before left-hand plows can be manufactured.

Against each forging and casting, material is provided and in a great many cases it is special for the part, thus increasing our inventory of raw material, and the possibility of it becoming entirely obsolete.

We must now erect the plows in the factory. This requires special erecting benches, and because of the small quantities an erecting crew must change from a right-hand to left-hand plow. We thus hinder production and increase cost. This procedure increases the finished stocks at the factory, at the branch houses and at the transfer points; and additional entries must be made on records to properly take care of left-hand plows. The same duplication results when shipments are made to dealers.

To the people and the world at large:

The harmful effect to the people lies in the waste of materials that are tied up in patterns, tools, etc., and the waste of time and labor to make them.

You will appreciate that this discussion has applied only to one left-hand plow against one right-hand plow. I think we should follow this matter along further and determine how the effects of making the two plows magnify as we get into our present implement line.

MULTIPLICITY OF TYPES

In computing the number of complete left-hand plows in the line which are manufactured and carried in all stocks, I have not counted plows that are made by any particular manufacturer.

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MULTIPLICITY OF TYPES

In computing the number of complete left-hand plows in the line which are manufactured and carried in all stocks, I have not counted plows that are made by any particular manufacturer.

As a basis I have conservatively estimated the number of left-hand plows that almost any manufacturer will have to duplicate for the left-hand trade.

Walking Plows—Walking plows for the northern trade are ordinarily made in 12″, 13″, 14″, and 16″ sizes, or a total of four sizes. Left-hand plows are made in at least two series or two types, thus if we made four sizes of plows in two series we have eight plows. It will be necessary to make one series of plows with cast shares and we then have four more, or a total of twelve left-hand plows, which is a very conservative number to have in any plow line.

Gang Plows—Gang plows are made in at least three sizes, namely: 12″, 13″, and 14″. They are made in at least two types —the high lift and low lift—thus we have six plows. Left-hand plows are manufactured with at least three kinds of bottoms on each size and type, resulting in eighteen plows. One series of bottoms on both the high and low lift plows must be made with cast shares and we then add six more, which results in a total of twenty-four plows.

Sulky Plows—We will consider sulky plows made in 12″, 14″, and 16″ sizes. Two types, the high and low lift, are manufactured, resulting in six plows. With three kinds of bottoms on each size and type we have eighteen plows, and then adding the cast share bottoms we get six more, or a total of twenty-four sulky plows.

The grand total of the above is sixty plows, which must be designed, made ready for manufacture, manufactured, carried in stock, sold and shipped.

It is evident that we are getting rapidly into complication, and we here begin to see the far-reaching effect of building what we ordinarily term two implements instead of one. When we take into consideration sizes, types and equipment, the number necessary to supply the trade multiplies very rapidly. I have known a demand to arise in a small locality for some special brace or part on a plow which in itself looked very innocent. When this special part was applied to all sizes and to various equipments that were sold in the territory, the result was ten to twelve entirely new articles so far as stock and shipping was concerned.

The advantages to the farmer in making the right-hand plow only are, of course, the reverse of the disadvantages to him in making the left-hand plow. There is also another advantage.

Many plow manufacturers in the United States have never made left-hand plows. They have considered it wise to stay out of the left-hand territories rather than to complicate their line and increase their capital requirements to the extent necessary to manufacture left-hand plows. The elimination of the left-hand plow lays open to such manufacturers the possibilities of trade development in former left-hand territories. Thus competition is stimulated.

ACTIVITY OF THE IMPLEMENT INDUSTRY

As previously stated, the implement industry has always favored the elimination of non-essentials and the standardization of sizes and equipment of the necessary types. Much had been accomplished previous to our entrance into the war in almost all of the lines, but hardly a manufacturer believed that we had gone sufficiently far. I will only refer here to the progress we have made since we entered the world war.

At the annual convention of the National Implement and Vehicle Association on October 19th, 1917, a paper was presented recommending the elimination of the left-hand plow. The idea was accepted with favor by a great many manufacturers with the result that on November 28th manufacturers representing about 90 percent of the total left-hand plows made met in Chicago and signed an agreement to eliminate the left-hand plow. This agreement was then passed among the manufacturers who could not attend the meeting and it was finally signed by every manufacturer of left-hand plows in the United States who had a substantial trade. Other meetings followed and progress was made in the elimination of many types of drills, tillage implements, and further standardization of the farm wagon.

GOVERNMENT ACTIVITY

On February 26, 1918, the National Implement and Vehicle Association received at its offices in Chicago the following telegram:

> In order to assist in carrying out program for husbanding raw material resources utilizing manufacturing equipment to best advantage and reducing amount of capital tied up in manufacturer's and dealer's stocks, this Board would like to receive from you as promptly as possible detailed suggestions of styles and varieties of machines which you believe can be eliminated from your production during war. Board will appreciate your cooperation in working out a thoroughly practical program.
>
> COMMERCIAL ECONOMY BOARD,
> *Council of National Defense.*

The Commercial Economy Board of the Council of National Defense afterwards was changed and given additional powers as the Conservation Division of the War Industries Board headed by Mr. Shaw of Chicago.

Following this telegram meetings of the various departments of the Association were held to consider radical recommendations for standardization and elimination on the suggestion of the Government.

The Plow and Tillage Implement Department met on March 8 and prepared a report in which a radical reduction of the styles and sizes of tillage implements was proposed. This was followed by other meetings representing the various lines of the implement industry.

A combined report of all of this work was submitted to the Conservation Division of the War Industries Board at Washington. This board then issued a questionnaire to every manufacturer of implements in the United States, submitted the proposals as made by the industry, and asked for comments. The Board also referred the proposals to jobbers, a committee representing the Federation of Implement Dealers, and to a committtee of thirty farmers who were appointed to consider such matters in Washington. The farmers' committee represented the entire United States.

After this exhaustive investigation the Conservation Division on July 1st, 1918 issued to all manufacturers a schedule of implements which they might build and this schedule corresponded in practically every detail with the recommendations made by the National Implement and Vehicle Association.

RESULTS OF ELIMINATION

The Government's conservation plan has made some very great changes in the implement business. The changes, however, have been for the good of all interested and harmful to none. Specific reference to a few items may be of interest.

Previous to the war 226 types and sizes of steel walking plows were made and sold by the industry. The elimination program reduced these to 39. Forty-seven types of wheel plows were made and only 15 remain.

Four tractor plows were eliminated, indicating that even the new lines needed attention.

In the combined plants of the industry 788 sizes, types, and equipments of corn and cotton planters were manufactured. The Government now authorizes the manufacture of 31.

So throughout the implement line eliminations were made. Harvesters, drills, hay machinery, wagons, chilled plows, cultivators, and harrows have been considered and the variety of each line greatly reduced. It has been a great work carried out by the Government of the United States with the hearty co-operation of all manufacturers, jobbers, retailers, and farmers.

CARE IN PROCEDURE

Eliminations have been made carefully. When recommendations were considered to discontinue a certain implement, the need for the implement was analyzed carefully. Nothing was cut from the line that in itself had a distinct economic value. The rule followed was to discontinue no implement that could not be replaced in the field with a standard tool that remained in the line. Today and in days to come farmers can and will till their land as well, do the work as economically, and produce as much on each acre as was possible with the great and complicated variety of farm machines existing before the war.

It is not the intention to hinder in any way the vast experimental work carried on by all manufacturers. In fact, the elimination of many sizes and the reduction of the number of patterns should stimulate rather than retard the development of the present machines and the construction of new and better types to take their place.

There is nothing in the conservation program that will prevent any manufacturer from considering suggestions for improvement. As I understand it, yours is an engineering society and you should feel free to promote the improvement and development of farm equipment in the most forceful way you can. What we want is constantly better implements but not greater variety unless there is some farm operation that requires a new kind of implement.

THE FUTURE

Each of us has in mind the conditions as they will maintain after Government control has been released. On November 18, 1918, the following letter was addressed to Mr. Brantingham, Chairman of the Farm Implements Committee:

November 18, 1918.

To: Mr. C. S. Brantingham, Chairman,
War Service Committee of the Implement Industry,
Rockford, Ill.

We have given careful consideration to the conditions in the agricultural implement and vehicle industry at the present time and their relation to the conservation schedules that have been issued by this Division. Inasmuch as manufacturers have already booked their orders and are manufacturing their product in accordance with these schedules, we agree with your committee that it appears essential that the schedules should be continued for the current manufacturing season. The conservation schedules, therefore, for the following branches of the vehicle and implement industry will continue in force for this season:

Portable grain elevators,
Plow and tillage implements,
Grain drills and seeders,
Spring tooth harrows,
Harvesters, mowers and hay rakes,
Ensilage machinery,
Land rollers and pulverizers,
Southern plows and shapes,
Wagons and farm trucks,
Horse drawn spring vehicles.

MELVIN T. COPELAND,
Secretary, Conservation Divison."

Thus manufacturers are instructed to observe the Government requirements throughout the present manufacturing season. After this season the control will be released. There will be no power to maintain the standardized line. Conservation will no longer be necessary from a patriotic point of view. But are we to put a handicap on efficiency? Are we to resort back to a practice that will waste basic materials and man power? I think the good judgment of all parties interested will maintain for the farm implement industry the progress made under Government control.

This society, you gentlemen here, will have a great influence after Government control is suspended. I hope that your influence will be to maintain the standardized line of farm implements. I trust you will frown upon the manufacturer who produces some unnecessary size of plow to gain a temporary advantage in the trade, and that you will discourage the farmer or dealer who demands the specialty which has no economic value.

DISCUSSION

MR. CLARKSON: There is one point that comes to my mind. How does this standardization affect a possible expansion of trade in foreign countries?

MR. DINNEEN: The action of the Government confines the restrictions entirely to the United States. The Government didn't care particularly about what happened to the foreign trade during the war, because the export was controlled through different channels. There have been no restrictions put on implements for foreign business. The foreign implements have never been considered by any of the association's committees.

MR. DICKINSON: Would it not be possible for the Presidents of the organizations of implement manufacturers, in the success they seem to be having working together, to strike this matter from another angle—charge more for these odd sizes? If it would be possible, for instance, to charge more for an odd size or a left-hand size, that would quickly discourage the farmer from using it. Of course that would call for very close cooperation.

Mr. Dinneen: The only thing I can say is that the associations cannot discuss a question of price. They stayed clear away from that and I don't think as an association it could be approached from that angle.

President Scoates: It could be approached through the county agents. They can pass it on.

Mr. Dinneen: After this agreement was made to eliminate the left-hand plows, the implement dealers of the State of Indiana met in Indianapolis just two weeks afterwards, and that was a hotbed of left-hand plow dealers! I was selected to go down there and tell them about the agreement. I went down there quivering, but I explained this matter to them very carefully, went into it even farther than we did this morning, and the result was they passed a resolution to eliminate left-hand plows. That thing turned around so fast with both the dealers and farmers that the manufacturers had to put left-hand plows on the bargain counter to sell them. There are lots of left-hand plows on hand that seem to be hard to move.

Mr. Clarkson: It seems to me it would be wise for this Society to pass a motion that a copy of this paper be sent to each one of the county agent directors, or perhaps to the special agricultural engineering directors in the State. Send him a sufficient number so he can send one to each of the county agents.

President Scoates: Do you make that a motion?

Mr. Clarkson: I make a motion that a sufficient number of copies of this paper be sent to the special agricultural engineering directors in several states, so that they can send one to their county agents.

Motion seconded and carried.

REGULATION OF FARM EQUIPMENT MANUFACTURE AND DISTRIBUTION

JUNIUS F. COOK,[1] Member Amer. Soc. A. E.

An Act of Congress entitled "An Act to provide further for the National security and defense by encouraging the production, conserving the supply, and controlling the distribution of food products and fuel" was approved by the President on the 10th day of August, 1917. This Act provided:

"That by reason of the existence of a state of war, it is essential to the national security and defense, for the successful prosecution of the war, and for the support and maintenance of the Army and Navy, to assure an adequate supply and equitable distribution, and to facilitate the movement of foods, feeds, fuel, including fuel oil and natural gas, and fertilizer and fertilizer ingredients, tools, utensils, implements, machinery, and equipment required for the actual production of foods, feeds, and fuel, hereinafter in this Act called necessaries; to prevent locally or generally, scarcity, monopolization, hoarding, injurious speculation, manipulation, and private controls, affecting such supply, distribution, and movement; and to establish and maintain governmental control of such necessaries during the war."

The President issued a Proclamation on May 14, 1918, in which the Secretary of Agriculture was authorized to carry into effect the provisions of the Act and to supervise and direct the exercise of the powers and authority thereby given to the President, as far as the same apply to the said farm equipment.

Secretary Houston created the Office of Farm Equipment Control to carry out the provisions of the Act under his supervision. The various offices and bureaus of the Department of Agriculture were advised of the creation of the Office of Farm Equipment Control and directed to cooperate fully therewith. Professor E. B. McCormick, Chief of the Division of Rural Engineering, and Mr. Arnold P. Yerkes, Agriculturist of the Office of Farm Management, were specially authorized by the Secretary to give their services to the work of the Office as found necessary, and in conferences, and by their assistance contributed largely to the effectiveness of farm equipment control. When Mr. Yerkes resigned, Mr. H. R. Tolley, Scientific Assistant of the Office of Farm Management, took his place in the work of the Office.

The paramount idea of this Office was to direct activities to secure a greater production of foods and feeds so far as farm equipment would effectively attain such an end. In order to produce larger quantities, the farmer should be placed in a position

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to put his machinery in better repair or to repair machines previously considered obsolete or be more fully equipped with newer and more efficient implements, so that he could raise the same amount of products with less labor or increase his production with the same labor. It was declared essential in the proclamation to license the "importation, manufacture, storage, and distribution of certain necessaries, hereinafter called farm equipment, including attachments and repair parts thereof, required for farm use in the actual production of foods and feeds, as follows: binders, boilers, brooders, bunchers, carriers, carts, cleaners, covers, crushers, cultivators, diggers, distributors, drills, elevators, evaporators, fencing, forges, forks, fountains, gates, graders, grinders, grindstones, harrows, harvesters, headers, hillers, hitches, hullers, huskers, incubators, jacks, listers, loaders, markers, milkers, mills, mowers, pens, pickers, planters, plows, powers, presses, pullers, pulleys, pulverizers, pumps, racks, rakes, rollers, scales, seeders, separators, shellers, shredders, silos, sleds, slings, sorters, sowers, sprayers, spreaders, stalls, stanchions, tanks, tedders, testers, threshers, towers, tractors, trailers, troughs, trucks, wagons, weeders, weighers, windmills, and all other tools, utensils, implements, and machinery, required for farm use in the actual production of foods and feeds." Some farm machines are much more useful in saving labor than others, and while we did not go so far as to distinguish between those that were most effective in labor saving and those which were least effective, we were prepared to do this, had it been justified later on account of scarcity of material. Fortunately, however, no such occasion arose.

The distribution of the equipment most necessary automatically adjusted itself to a very large extent, and I believe quite satisfactorily. The demand of the farmers was the direct regulator and was a far more accurate method than any other that could possibly be devised. There were some distributors and districts that were short of certain equipment, and some over-supplied, but the adjustment was rapid and effective on the whole. As usual, there was the feeling among certain makers that any machine that would save labor be pushed and the farmer induced to buy whether or not it would save the country any labor before the war ended. There were many proposals that in themselves seemed excellent but when one took a broad view and considered what effect they would have in combination with other machines and upon the nation at war, the advantage of pushing them ahead of other equipment was very slight.

Tractors were the most spectacular of any farm equipment and many very patriotic and conscientious people who read some of the articles of how the tractor would win the war thought the one thing to do was to supply every farmer with a tractor and the food question would be solved and the war won. Upon a little consideration and analysis, it was found that to build a tractor from the iron ore in the earth to the finished machine in the hands of the farmer, took from the supply of labor of this country more days of labor than the tractor would save on the average farm in two or three years. It was evident from a national point of view as a labor-saving machine that the tractor was not altogether an overwhelming success.

After looking over the field of the labor-saving features of all farm equipment it was considered very essential to maintain an adequate and continuous supply of all the essential farm equipment throughout the country and see that the farmers were able to purchase it at a reasonable price. The questions of price and supply were naturally bound up in the condition of the raw material and labor market.

The manufacturers and wholesale dealers were put under license and investigations immediately taken in hand. One of the first problems was what could be considered a fair profit for manufacturers and dealers to make. The manufacturers sent in a statement showing their profits were very low in proportion to the steel manufacturers and others, and specially pointed out that certain farm equipment cost less in 1918, in bushels of wheat, corn, or other farm produce, than before the war. The dealers pointed out that the business was so poor for them that a large percentage went out of the business every year presumably as failures. The position during the end of May was that the manufacturers were scarcely satisfied with their prices; the dealers were distinctly not satisfied; and the farmers were much concerned that the prices of their products were being fixed and the prices of many things they required were rising rapidly. Manufacturers were experiencing difficulty in obtaining raw material, their labor was leaving them and their deliveries to their agents very much delayed by the congestion on the railways. The dealers were complaining about not being able to get equipment, and the farmers were also sending in similar complaints. The country seemed to go along about the same, however, and while at first there was needed a good deal of effort in the way of facilitating shipments, thanks to improved service on the railways conditions soon grew better.

At this time we asked the county agents through the States Relations Service to find what the farmers throughout the country were paying for certain selected typical machines and implements; also what they had been paying each year back as far as 1914. We asked the manufacturers for their prices and discounts from 1914 to 1918.

While we at first had very few reliable figures as to what was a reasonable price, the returns from the county agents and the selling prices of the manufacturers gave us a very good idea of the position of the dealers. These figures were not sufficient to base a general statement to the farmers upon but were useful in dealing with individual complaints from farmers and retailers.

The rise in the price of raw material and labor from 1914 to 1918 was a rough guide as to the profits of manufacturers. Although the comparison was too general to base any statement of authority upon, it indicated to us that there would be no very excessive profits on the whole. In special cases of certain companies it was possible their profits would be large but this would also be limited by the excess profits tax. With these conditions taken fully into account we decided to cooperate with the Federal Trade Commission in a comprehensive investigation which they were making in compliance with a Resolution of the Senate. This investigation is nearly completed and will give reliable information that will be of considerable value even now after the war is practically at an end.

There is an interesting point connected with the control of manufacturing profits. The whole farm equipment industry taken together makes year after year an average profit that perhaps may not be as large a return on money invested as Liberty Loans would give. At first thought one would say this is not a sound position and that prices must be raised so that the return would be commensurate with the risk. If one examines any industry such as gold mining, farming, marketing, dry goods, hotels, or any other, he will find that the average profit is low; that is, some concerns are operating at losses or making very low profits while others are making high profits, due to good management with good equipment or favorable location. It is wrong to fix the maximum profit at the average figure as then we kill incentive to good management. It is impossible by fixing the profit higher to make over poor management into good management. A way to determine approximately a fair profit for an industry during a period of stress is to give the industry the same percent of profit on its capital as was earned during a period of years previous to the period of stress. In practice such figures are difficult to obtain but they can be ascertained approximately and are a reliable guide. When an industry during a period of stress is subject to greater risks, owing to exceptionally large fluctuations of prices, materials and completed machines, additional profit should be allowed to cover the greater risk.

There was a question that affected both the manufacturer and dealers and that was the sale at replace values. This was a question that involved the manner the manufacturers and dealers conducted their business. In most cases there was no difficulty in justifying sale at replace values. Instances where larger stocks than usual or than were justified by the demand were bought presumably for speculation came under the description in the Act of Hoarding. By a study of these two classes of stocks it became apparent that if manufacturers and dealers were allowed to sell at replace values they should replace the goods or show in some satisfactory way their intention to do so. The ruling was made and any one not replacing the goods or an equivalent amount (not necessarily the same identical machines) would be guilty of profiteering. There were no complaints that this ruling caused any injustice, so far as we have been able to determine.

During the work some of the larger plants of the manufacturing industry have been visited and have greatly impressed me with their organizations and equipment. They are splendid examples of great factories employing the most up-to-date labor-saving appliances to manufacture the great agricultural labor-saving machinery and equipment that has in the hands of American farmers so largely assisted in winning the war. What would our civilization be if it were not for labor-saving machinery and appliances? The labor-saving quality of farm equipment, thereby allowing work to be done more quickly and therefore more seasonably, is well known. A labor-saving machine may be considered by some a disadvantage if there is not enough work to supply all the workers. For myself, if I must be limited in my production, I am prepared to work a less number of hours with a labor-saving machine on my farm rather than the full number of hours without the labor-saving machine. I have learned from association with agricultural experts that many farmers are located on farms where they can not afford to hire much help, but are compelled to do so at the times when help is very scarce; that is, in planting or harvesting seasons. Labor-saving machines at these times and under these conditions are exceptionally valuable.

There appears to be sufficient capacity to build all the farm equipment required, although there will probably be a large demand after prices have resumed a normal level. It is impossible to say what a normal level after the war will be and perhaps it will be some time before such a level is reached. On the whole there has been a sufficient supply and many farmers have only bought what was clearly necessary, as no doubt they considered the prices too high to buy other than sparingly.

The tractor during the war has been very well advertised and has occupied a good deal of our time in the Office of Farm Equipment Control and I would like, as it vitally concerns the results of equipment control, to give a few figures:

The number of tractors manufactured during the first half of 1918, as ascertained from the tractor questionnaire sent out by the Office of Farm Equipment Control, for various horse power ratings, are as follows: 10 HP to 12 HP inclusive, 2714; 15 to 16, 3716; 18 to 20, 24128; 22 to 26, 20658; 27 to 30, 3172; 35 to 36, 1495; 40 to 50, 1025; 60 to 80, 1049.

The output for the last half of the year was considerably greater than this and a still further increase is planned for the coming year. Some of the older tractors have been improved in some respects and some of the newer models show good engineering features. Some information obtained from tractor users shows in general what parts of the tractor need improvement. From the answers sent in to the Department of Agriculture by 2,179 farmers I found that the question, "What part of your tractor gives you the most trouble?" was answered as follows:

Magnetos	299
Spark plugs	110
Gears	108
Carburetor	104
Bearings	80
Cylinders and pistons	61
Clutch	59
Valves and springs	43
Lubrications	29
Starting	28

This information gives one a good idea of how to start examining a tractor with the view of buying or of studying the machine. It will be seen from this that one can eliminate at once a great many details and concentrate attention upon the above, which may be considered the main points of trouble. The reports of these troubles were from the users, and many of them probably did not know how to use them to the best advantage, but after all it is a good indication as to where to look for trouble. It is interesting to note that more users had troubles with the accessories than with the machines themselves.

Another question that has come prominently before me in connection with this work is the position of the agricultural engineer in the domain of agriculture. Let us look at the work being done upon the farm. Plowing, planting, harrowing, cultivating, harvesting, hauling, trenching, trimming, clearing, fencing, building, feeding, cleaning, cooking, storing, evaporating, supplying water, grinding, hulling, husking, threshing, hatching, packing, sawing, pressing, pumping, rolling, weighing, shelling, shredding, sorting, spraying, spreading, testing, are all mechanical in their nature and the economics of these operations can best be applied by agricultural engineers who must be well acquainted with farming operations to be successful agricultural engineers. The economical size and design of farms are much influenced by the above-mentioned operations. Can all these operations be supervised and the equipment used be best designed, improved, repaired, and adapted to their uses by an agricultural engineer and the farmer or by some one else and the farmer?

There seems to me only one conclusion, and that is that the agricultural engineer does not occupy the position he should, and I do not know of any one but the agricultural engineer who can remedy this condition. He must have not only a thorough knowledge of the principles and practice of engineering, but also of the principles and practice of agriculture, in order effectively to apply his engineering knowledge to the advancement of agriculture. We have seen a great advance in mechanical engineering; is there not as great a chance for advance in agricultural engineering? The field for the agricultural engineer seems large and full of possibilities.

DEVELOPMENT OF RURAL MOTOR EXPRESS LINES

S. A. MILES[1]

The time allotted me is short, but within it I shall endeavor to outline some facts relative to the rural motor express movement in the hope that you will become sufficiently interested to investigate further at your leisure.

In your news letter of November 1 there appeared a quotation from a letter written by Mr. E. R. Jones, who says: "The drained marsh and overflowed lands of the several states should attract the attention of a large number of returning soldiers desiring to settle on farms. Secretary Lane is working on a plan under which the government would buy some of these lands at a rock bottom price, complete their drainage and sell them to settlers, preferably soldiers, at cost and on easy terms. The committee on drainage of the American Society of Agricultural Engineers is desirous of helping Secretary Lane as much as possible in the formation and execution of this plan. To this end an exchange of views on the subject between the agricultural colleges seems advisable."

There *are* millions of acres to be reclaimed, and the suggestion made by Secretary Lane is theoretically excellent, but we contend that a more important work is to bring the farms we already possess up to reasonable efficiency. Whether some of the present methods, and particularly the methods of transportation by which the farms are served, are efficient or not, may be judged from a remark recently made by Mr. Hoover to the effect that of all the produce raised only about 50 percent reaches the market; and by the further fact, based on investigations by the Highways Transport Committee and others, that because of inadequate transportation facilities, a great number, possibly a majority, of our farmers raise only sufficient material for their own use.

To those of you who are familiar with the great farms of the west these statements may seem exaggerations, but the fact is that of our millions of farms only a small minority are of the up-to-date kind and using the best available facilities. A majority, and a

[1] National Automobile Chamber of Commerce.

large majority, are small, inefficiently equipped and conducted, partly because of lack of capital, partly because of lack of education, and partly because of plain neglect.

The conditions by which we are confronted are as follows:

Most of the world is today unproductive. Man power is impaired. Of the nations that have recently been at war England does not produce enough to feed her people, France is war-torn and disorganized, Russia is swept by anarchy, Belgium is ruined, Italy cannot for a long time be considered a source of supply, and Canada, with a population smaller than that of the State of New York, is suffering greatly from reduced man power. Germany and Austria, like Russia, are in a state of anarchy.

In our own country food production is handicapped and costs are high because of the disinclination or inability or both of the farmer to produce up to his full capacity; by the fact that he finds it necessary to spend a great part of his time away from the farm, and by the waste of quantities of food raised but not marketed. (See Hoover, page 21.) All of these conditions are due to transportation problems aggravated by a 20 percent shortage of labor. (See Blakeslee, page 19.)

The railroads cannot now carry, and probably never can carry, all of the short haul material offered them. Hundreds of thousands of farmers are not served by railroads at all, hence the farm owner is as often a teamster driving to town and back as he is a farmer raising crops. As a farmer, or as a carrier, he might succeed. He cannot personally do both things successfully.

The remedy is the rural motor express, which relieves him of every transportation problem, insures quick daily contact with the market, keeps him advised of the market's requirements so that he may benefit by advantageous prices, enables him to devote all of his time to the farm, thereby assuring an increase of his product with the certainty that it will not be wasted, and enables him to obtain supplies from town on the day of order. (For more detailed specifications see Blakeslee, pages 69 and 70.)

The rural motor express movement has the unqualified endorsement of practically every department of the government. The Council of National Defense started a string of endorsements by requesting state authorities to take all necessary steps to facilitate this method of transportation, and to remove any regulations tending to restrict it. Secretary Lane of the Department of the Interior has said that he sees a new America of farming communities and small industrial centers which must be developed and made easy of access by good roads and transportation over them. Mr. Redfield, Secretary of Commerce, has said that a perfect system of transportation must bring goods to every man's door, and that neither the railroad nor the water way can reach its normal place unless linked with motor truck routes, so that the farmer may have his rural motor express which comes to his door, connects him up every morning with all the earth, and brings what he wants of the earth's products back to his door the same night. The Department of Labor has urged farmers to make use of rural motor express lines to release labor for greater production of foods, and has pointed out that one man driving a 5-ton truck can haul to market more than three men with wagons, and cover three times the distance in a given time, which means that the use of the truck would release eight men and sixteen horses to continue work on the farm.

The Railroad Administration, through Mr. Wright, speaking for it at a meeting of the Highways Transport Committee, has given assurance that so far as short hauls are concerned the attitudes of the railroads is and will remain entirely favorable. Even if the rural motor express line were in direct competition with the railroad, over a short distance, the charges of the motor truck would be lower, and the time of delivery quicker than that of the railroad.

In the Post Office Department, with Mr. Blakeslee, Fourth Assistant Postmaster-General, is found an enthusiastic supporter. Mr. Blakeslee speaks from experience, inasmuch as he is already operating a number of experimental routes in the post office service. (For details of a severe test see Blakeslee, pages 19 and 20.)

Mr. Hoover has pointed out that the rural motor express facilitates delivery, conserves labor and foodstuffs, effects delivery of food in good condition, and will dispose of many of the draft animals which now eat the crops of millions of acres. (For further references to horses, see Blakeslee, pages 46 and 47, 75, 76 and 77.)

The Food Administration has interested itself deeply in the formation of rural motor express lines. Mr. Hurley, Chairman of the United States Shipping Board, has said that highways transport facilities at every farmer's gate must make a picture in the farmer's mind of the movement of his products through the distant points of the world, and that highways transport service is the first step in the great system of transportation to the sea, and then on the merchant marine to the far points of the earth.

The origin of rural motor express lines is obscure. They have probably been in operation on a small scale for several years. It was only when the railroads failed, when embargoes became general, and the farmer was obliged to waste a great part of what he had raised, that the subject was earnestly considered by the highways transport committee of the Council of National Defense under the chairmanship of Mr. Roy Chapin. Starting with a committee of five men he and his associates built up an organization of about fifteen thousand persons, every one of them a volunteer, and covering, generally with marked efficiency, every one of our states.

There are certain things, however, which a government committee may not do without stepping on the toes of some other department. The Highways Transport Committee felt obliged to stop short of presenting a definite plan for the organization and operation of routes, the purchase of cars and some other practical details. Hence the formation of the rural motor express committee of the National Automobile Chamber of Commerce which has in its turn appointed representatives with instructions to cooperate with the State Highways Transport Committees. These men were, of course, engaged in the industry, and while actuated largely by a patriotic motive, had an additional commercial incentive. Many of them are not only members, but the very active members, of state highway transport committees.

The Rural Motor Express Committee has issued pamphlets and other printed matter covering every phase of the movement. First, for the purpose of obtaining the assistance of district managers; second, to educate them in the methods of obtaining and organizing other assistants; and third, in instructing them in the details of the steps to be taken in the actual organization of express lines. Into these details we shall not now enter because the pamphlets are available for your use. But a general survey of their contents indicates that they first cover a list of services to be rendered which run all the way from the carriage of hogs to third-class mail matter; details of the method of establishing a scale of charges; how to make a preliminary survey of a route in order to be sure of the condition of roads, safety of bridges, license fees and taxes, the attitude of merchants, factories and farmers, the probable amount of material to be carried, the population within reach of the service, other available methods of transportation and their rates, possible connections with other carriers, and other necessary information. A canvas of prospective customers is suggested, and details of the method of carrying it out are provided. The selection of tracks, the advertising campaign, operating suggestions, and suggestions for dealing with farmers, merchants, bankers and others, with all the necessary forms of letters for the purpose are included.

Of course, the all-important question is, does it pay? It is impossible in this paper to go into great detail, but the answer is, that it certainly does. As one sample of what may be accomplished: There is a man in Maryland who conceived the idea of hauling his produce into Washington by motor truck. He bought a ¾-ton outfit, and disposed of his product and was back at work on his farm before his next-door neighbor got half-way into town. That neighbor made a bargain with him to carry his product also, and as another appealed to him, he added a second truck; then a third, and then a fourth. He set aside 10 cents a mile for overhead expenses, and from the returns from his original truck he bought and paid for the others. Today he is well off, transacts their business for all the farmers within a few miles of him, collects their money, does their shopping, pays their bills, and knows a good deal more about their business than they themselves do.

A farmer at Elmont, L. I., paid for his first truck in a few months, and had $1,400 left. Formerly he left home at 2 o'clock in the afternoon, was in town all night, and got home about 2 the next day. Now he gets back home the same night. He and his man spent ten hours on the road with two teams. The cost for one year was $2,770.50, while by motor truck it was $1,368.34. Many similar cases may be quoted for anyone who is sufficiently interested. (See Blakeslee, pages 32 to 39.)

A contention frequently met with is that our roads are in many cases so bad that the operation of trucks is impossible. This may in a few cases be true during a part of the year; but the greater part of our roads can be traveled, admittedly with some difficulty, all the year round. Practically all of our farm products are ready for the market at times when the roads are at their best. Mr. Gifford, Chairman of the Council of National Defense, very wisely remarks that if we cannot use the roads twelve months in the year, we can use them six, or three, and that to just such extent as we do use them we shall be benefiting our respective communities. If the roads are poor, the demands which will follow the use of motor trucks will serve to improve them. No farmer will be content with a poor road so long as he knows that some other farmer's product is being hauled over a good road. The demand for improved highways will doubtless be assisted by the Postoffice Department, which is already deeply interested. The government has learned through the operation of trucks during the war how necessary an improved system is. The American Automobile Association, with the assistance of other bodies, is striving for an interstate system and other road legislation. Pennsylvania has voted an appropriation of $50,000,000, and Illinois of $60,000,000 for improved roads. In every direction we see indications that road improvement is to be undertaken on a gigantic scale.

I wish it were possible to go further into the woes of the farmer, and into details of how this movement will help him; of the marvelous increase in the value of his property due to the use of the automobile; of the three hundred thousand years saved by our farmers annually as a result of the use of the automobile instead of the horse; of what might be done by the substitution of tractors, and the amount of money that might thus be realized; of the scarcity of farm labor, and the reasons therefor; of the effect of the rural motor express upon the business of merchants and bankers and whole communities; of the possibility of passenger traffic, the opportunities in connection with shore resorts; of more than one-half of our farms of less than 100 acres apiece, and the transportation difficulties under which their owners labor; of the meaning in figures of Mr. Hoover's estimate of the waste of crops; and finally of what might be done if, as suggested in the opening paragraph, all of our farms could be brought up to reasonable efficiency. All of these facts are available for the use of those who care to interest themselves in the subject.

Finally, this subject must not be taken to apply merely to wartime conditions. Rural motor express lines have so definitely shown their value, that they will remain as useful and as completely a part of our national life in peace as in wartimes. We have not been considering a wartime necessity, but a necessity of all times.

KEROSENE AS A FUEL FOR FARM TRACTORS

JOHN A. SECOR,[1] Member Amer. Soc. A. E.

In the early days of the oil engine—more than forty years ago—kerosene was costly and gasoline a by-product. Low-cost gasoline originally created the unprecedented demand for the gasoline engine. Gasoline of 71° Baumé has sold as low as 3 cents to 5 cents per gallon wholesale; although heavier gasoline, say, from 60 to 65° Baumé, was then quoted at a higher price. Even 76° Baumé gasoline has sold as low as 7 cents per gallon. Low grade kerosene at that time was quoted at 20 cents and a better quality at 25 cents per gallon in tank cars. These oils retailed at from 30 to 40 cents per gallon. But the law of supply and demand has reversed the former price relations of gasoline and kerosene. The price of gasoline has increased, until, for many purposes, its cost has become a handicap to the engine.

GASOLINE PRODUCTION:

Crude oil production in America is still increasing, but the increased supply has not included a corresponding, or relative increase in the paraffine crudes from which gasoline is obtained by direct distillation. At the present time these high grade crudes constitute approximately only 4 percent of the world's output. The market price of gasoline would undoubtedly have been much higher than it is, were it not for the fact that each advance in price stimulates an increase in the available supply. It does this in various ways. Under normal conditions, it encourages further prospecting for the paraffine petroleums in the

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old Appalachian field; it also incites increased production of synthetic gasoline by the new processes of dissociation in re-distillation from oil under pressure, and also by compression and condensation of gasoline from natural gas. The available supply of gasoline has been further increased by the inclusion of heavier fractions than in former practice; and also, before the war, by the importation of gasoline to the United States from foreign fields.

Regarding the increased supply which can be obtained by the new "cracking" processes, it should be noted that there are four principal groups of liquid distillates obtainable from crude oil. These include the various lubricants, kerosene, gasoline, and fuel oils; and there must be a certain proportionate, or relative production of each of these to satisfy normal trade requirements. Obviously, the gasoline problem would be simplified, if gasoline were the sole factor to take into account.

SOME OF THE ADVANTAGES AND DISADVANTAGES OF KEROSENE

Under existing conditions, kerosene is the only logical fuel for the farm tractor. Opinions differ widely, however, regarding the respective advantages of gasoline and kerosene as a tractor fuel. It is, of course, conceded that kerosene embodies potential energy in its most compact form. That is to say, it contains more heat and power for its volume, measured in thermal units, than is contained in any equal volume of any other available fuel. As kerosene is practically non-volatile, there is obviously no appreciable loss in quantity nor change in quality from evaporation. Engines operating on kerosene are therefore less affected than gasoline engines by atmospheric changes. In brief, kerosene costs less; is more abundant; is more widely obtainable; contains more power than gasoline; and is safer to handle, transport, and store, than any other available tractor fuel.

Lack of flexibility: On the other hand, it is pointed out that kerosene has certain detracting features as a fuel for internal combustion engines, including the farm tractor. Mr. E. R. Wiggins remarks for example, "Some find their kerosene engines run satisfactorily at full load, but at half, or no load, there is considerable trouble."[1] Regarding this, Mr. H. L. Horning says, "In tractor service when the load remains at over half the full value, kerosene gives reasonable satisfaction."[2] In connection with continuous tractor operation under light load, and varying load, *The Canadian Thresherman and Farmer*, July, 1918, has interesting data from Snyder Brothers, farmers, showing that they operate their engine strictly as a gasoline engine when driving a separator, although they can use kerosene for plowing.

[1] **Power Farming**, August 4. 1915.

[2] The Ultimate Type of Tractor Engine. Address at Annual Meeting of the Society of Automotive Engineers, New York, 1917.

Loss of power: Mr. Horning refers to the effects of vaporizing fuel mixtures as follows: "The loss in volumetric efficiency due to heating the intake charge results in a decrease usually of from 10 to 20 percent in maximum power output."[1] But tractor power tests made by the State Tractor School at Columbus, Ohio, in February, 1918, appear to indicate greater power losses from the oil vaporizer than those stated by Mr. Horning. Tractors of twenty different makes were entered for test, seven of which were gasoline tractors. Of the thirteen oil-burning tractors, three attained their rated power on the first test, but neither of these were tested for reserve power. Four more attained rated power on a subsequent test, leaving six which did not obtain their rated power under oil. One of these obtained its rated power on a third test by simply substituting gasoline for kerosene.

The maximum power developed by the remaining five tractors under oil averaged 77 percent of their rated power. Several recent writers propose to overcome the loss of volumetric efficiency, and reduced power output due to vaporizing devices, by an increase in cylinder diameters.

Fuel efficiency: Inasmuch as the amount of heat liberated by the complete combustion of kerosene exceeds that obtainable from gasoline per unit volume, it is important to ascertain to what extent, if any, this is reflected in the relative fuel consumption of average gasoline and kerosene tractors. Regarding this, the manufacturers of a line of successful oil tractors frankly acknowledge that their tractors use more fuel per horse power when operating on kerosene, than when operating on gasoline. But they are still able to show, notwithstanding the increased fuel consumption, that kerosene affects a substantial saving in operating expenses over gasoline.

In some tractors, however, due to excessive fuel requirements, the cost of kerosene per horse power hour has even exceeded the cost for gasoline. In connection with the relative efficiency of gasoline and oil engines, the *Implement Age* of June 3, 1916, notes that "The ordinary gasoline engine has a compression of from 70 to 80 pounds per square inch. The mixture of air and gasoline will not ignite at this pressure and an electric spark is necessary to explode it. But if a mixture of air and kerosene vapor is subjected to this pressure, pre-ignition is certain to result. As a matter of fact the compression in an oil-burning engine cannot be carried much above 50 to 60 pounds with safety."

Skilled operators a necessity: The *Chilton Tractor Index* issued in February, 1918, states that, "Although most farmers insist upon buying tractors that will burn kerosene, the majority resort to gasoline fuel after they have used kerosene for a short

[1] The Ultimate Type of Tractor Engine. Address at Annual Meeting of the Society of Automotive Engineers, New York, 1917.

time. There are many good kerosene-burning tractors on the market, but unless they are handled intelligently, they will not prove as satisfactory as those which run on gasoline."

INVESTIGATIONS OF DEPARTMENT OF AGRICULTURE

For more than a decade the United States Department of Agriculture has closely followed the development of the farm tractor. Their investigations have included a close economic study of the steam tractor, the gasoline tractor, and the oil-burning tractor operating under diverse conditions in various localities. Bulletin No. 174[1] says: "From the comparison made, it will be seen that the figures are slightly in favor of the kerosene tractor in almost every case, the most important difference being in the estimated life and cost of repairs annually; but the percentage of replies, days used annually, hours lost, horses replaced, and percentage finding custom work profitable, all of which are favorable to the kerosene tractor, are worthy of note. * * * The tractors which have been operated by kerosene show, as a whole, slightly better average results than those operated by gasoline, indicating that the heavier fuels can be burned at least as satisfactorily as the lighter ones. The amount of kerosene used per unit of work, however, is usually slightly more than for gasoline, which would appear to indicate that the combustion of the kerosene is generally not as perfect as that of the gasoline." Bulletin No. 719[2] says, "Gasoline is used as fuel by most of the tractor owners in Illinois. * * * Kerosene is used to some extent, but is not reported to be satisfactory in the majority of small outfits as it was in the larger ones a few years ago. Even where used, the amount consumed for a given amount of work is usually greater than for gasoline, thus tending to offset the difference in price. As a rule, a little more difficulty in operation is experienced where kerosene is used, and slightly more time is lost each day."

Bulletin No. 963[3] notes that "probably the most significant difference between the reports received from tractor owners in 1917-1918 and those received in 1916 is the much larger percentage of men who reported that the tractor had proved a profitable investment. In 1916, less than 80 percent reported that the tractor had proved a profitable investment, whereas in 1917 and 1918, 90 percent or 9 out of 10, made such reports. * * * There is some difference in the fuel consumption between different makes of machines, and also usually a slightly lower consumption in some makes of tractors where gasoline is used instead of kerosene. * * *

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[1] Farmers' Bulletin No. 174, United States Department of Agriculture, April 15, 1915.

[2] Farmers' Bulletin, No. 719. May 5, 1916. United States Department of Agriculture.

[3] Tractor Experience in Illinois, June, 1918, Bulletin No. 963.

"The investigation shows that less difficulty is being encountered by owners of kerosene tractors in burning the lower grade of fuel than was indicated in 1916. Slightly more than 50 percent of the tractors on the Illinois farms reporting are operating on kerosene, and where the machines have been especially designed to burn this fuel the results are apparently very satisfactory, particularly in view of the present price of kerosene as compared with gasoline, the former costing only about one-half as much as gasoline. However, the greater ease in operating on gasoline, and the somewhat greater certainty of steady operation, are sufficient to cause many men to prefer this fuel to kerosene. The fuel consumption, of course, varies considerably, even with the same make of machine, and under practically the same conditions, when driven by different operators. Fuel cost per acre plowed averaged 25 cents with kerosene, and 50 cents where gasoline was used, not making allowance for warming up the kerosene engine with gasoline. But the quantity used for this purpose varies with different makes and different operators."

The results of these investigations may be briefly summarized as follows:

1915—"The figures are slightly in favor of the kerosene tractor in almost every case."

1916—"Kerosene is not reported to be as satisfactory in the majority of small outfits as it was in the larger ones."

1918—"Less difficulty being encountered in burning the lower grade of fuel than was indicated in 1916. More than 50 percent of the tractors reported on Illinois farms are operating on kerosene, and where the machines have been especially designed to burn this fuel, the results are apparently very satisfactory. Greater ease in operating on gasoline and somewhat greater certainty in steady operation are sufficient to cause many to prefer gasoline to kerosene."

In brief, the kerosene tractor is shown to be an important addition to modern equipment and an acknowledged commercial success.

PUBLIC DEMONSTRATIONS

Oil tractors have taken part in all important public tractor contests since the classic Winnipeg trials in 1912, at which the gold medal for general superiority was awarded to an oil tractor.

The four leading gasoline tractors in the contest averaged 11.08 horse power hours per gallon of gasoline, while the prize-winning oil tractor developed 11.2 horse power per gallon of kerosene. This oil tractor showed an advantage of 19 percent in fuel consumption over a high grade gasoline tractor of the same cylinder dimensions.

During the past twelve months kerosene tractors have participated in various public demonstrations; notably, the official state tractor demonstration held at Minot, North Dakota. Five gasoline and twenty-four kerosene tractors took part in the demonstration, and the disparity in the number of each may be considered indicative of the present status of the oil tractor. The fuel consumption for the five gasoline tractors averaged 3.26 gallons per acre, costing 88.2 cents; while the fuel consumption for twenty-three tractors burning kerosene, or a mixture of kerosene and gasoline, averaged 3.77 gallons per acre, costing 66.27 cents. The lowest cost of plowing per acre was shown by the record-holding oil tractor, which used 2.97 gallons of kerosene costing 45 cents, which was nearly one-half the average fuel cost for the gasoline tractors. At the National Tractor Demonstration, held at Salina, Kansas, these low fuel costs for kerosene were duplicated, although no public competitive records were made.

The kerosene motor car contests held in Paris during September, 1918, by the Automobile Club of France, and the 1000-mile fuel road tests conducted by the *New York Herald* in October of the present year, both show remarkable advances in the use of kerosene as a fuel for engines with cylinders as small as 4 inches in diameter. Unquestionably kerosene can be used successfully in tractors of all commercial sizes.

TREND OF IMPROVEMENT

The trend of further improvements will probably be along the following lines:

1. *Fuel Consumption.* Increased average fuel efficiency is both feasible and desirable for the kerosene tractor. A gallon of kerosene should at least plow as much ground as a gallon of gasoline. "The amount of fuel used per unit of work" should not be greater for kerosene than for gasoline.
2. *Power Rating.* The power rating of an oil tractor should be based on its performance when using kerosene; and its maximum power should be equal to that of gasoline tractors having like cylinder dimensions. In order to attain this result the "loss of volumetric efficiency" due to "heating the intake charge should be eliminated."
3. *Flexibility of Power Control.* Power output should readily respond to power demand. Inability to operate under low loads, or inability to maintain rated speed under a fluctuating load, such as occurs when operating a separator, are detracting features which place any oil tractor at a disadvantage. The flexibility of the oil tractor should render it unnecessary to use gasoline, or a mixture of gasoline and kerosene when threshing.
4. *Expert Operators.* Any one who can handle a gasoline

tractor would be able to handle an oil tractor equally well. An oil tractor should be easily regulated, and should require little attention during actual operation. There should be no basis for the claim that there is "greater ease in operation on gasoline and somewhat greater certainty in steady operation."

5. *Performance of Small Oil Tractors.* The large oil tractor was introduced in advance of the small 2-plow oil tractor, and its fuel mixture control is based on longer experience, but there is no inherent reason for less satisfactory results with kerosene in small tractors than in large tractors.

BASIC CONDITIONS OF COMBUSTION

The conditions required for complete combustion are the same in principle for all fuels, namely:

(1) Sufficient air for complete oxidation of the fuel:
(2) Intimate admixture of fuel and air:
(3) Temperature of fuel mixture suitable for the reactions of combustion.

The means for achieving complete combustion in any given case must be adapted for the physical and chemical characteristics of the fuel to be burned; also the means employed must be suitable for the working conditions of the engine.

In other words, internal combustion engines of every type should be designed specifically for the fuel they are intended to burn. While it is a fact that kerosene can be used far more easily at some loads in an ordinary gasoline engine than blast furnace gases can be used in an engine designed for natural gas, nevertheless, the inherent adversities between kerosene and gasoline are too great to permit kerosene to be used successfully in a gasoline engine at all loads by simply adding a vaporizing device and reducing compression.

Oil Combustion Under Constant Conditions. The problem of burning kerosene is presented in its simplest form in the common kerosene lamp. For, in the lamp the controlling factors of oil combustion—density of the air-fuel mixture proportions, and interior temperature during gasification and combustion—are constant.

When a correctly designed lamp is properly adjusted, that is, when the constant controlling factors are regulated in co-ordination, no further attention is required.

Exceedingly simple means are employed for supplying the fuel and the air in the required proportions, and for effecting an intimate commingling of the gasified fuel and air; for maintaining the required temperature of fuel mixture immediately preceding and during combustion; and also for discharging the products of combustion. Due solely to the fact that all the controlling conditions are adjusted in coordination, and that such coordinate adjustment remains constant, the oil lamp operates almost like an instrument of precision. For while the candle-power output is practically constant, the products of combustion are odorless and smokeless.

The kerosene lamp demonstrates that oil is not a refractory fuel when all controlling factors are constants, and when constant factors of combustion mutually cooperate in correlation during combustion.

Oil Combustion Under Inconstant Conditions. The problem of using oil for fuel in the throttle-governed engine is complicated by the fact that the controlling factors of combustion become variables, whenever there is a change in power, or engine speed. And the new conditions of temperature and compression created by each change of load are detrimental to efficient operation.

COMPLEX FUELS

Crude petroleum, and its distillates are chemically complex mixtures of different substances. In respect of relative hydrogen and carbon content, gasoline and kerosene are nearly alike. Twelve samples of gasoline and four samples of kerosene showed the following average proportions:

	Percent *Hydrogen*	Percent *Carbon*	Percent *Oxygen*
Gasoline	14.84	84.65	....
Kerosene	14.37	85.25	.38

Kerosene has usually more carbon, and slightly less hydrogen than gasoline. Nearly the same weight of air per pound is required in either case for complete combustion. In fact, some samples of gasoline and some samples of kerosene required theoretically the same weight of air for complete oxidation of the fuel.[1] In heating value per unit weight of combustion, kerosene and gasoline are also nearly alike; gasoline being a little the higher. The heat liberated by the complete combustion of one pound of motor gasoline will average about 20,400 B.t.u. The U. S. Naval specifications require a minimum of 20,000 B.t.u. for kerosene.

Although kerosene and gasoline contain nearly the same proportions of hydrogen and carbon, and although their potential heat values per unit weight are nearly alike per pound of combustible, nevertheless, they differ materially from each other in the molecular constitution of their respective component substances.

Neither kerosene nor gasoline has a single definite boiling point. Each has a "chain," or series of boiling points, and the distillation temperatures of kerosene are much higher than for like fractions of gasoline.

[1] Bulletin 43, Bureau of Mines.

The respective boiling points differ approximately as follows:

Boiling Points	Initial	20%	45%	90%	Dry Point
Kerosene	365° F.	410° F.	420° F.	500° F.	580° F.
Gasoline	Not over 140° F.	Below 221° F.	Below 275° F.	Below 365° F.	Not over 428° F.

The boiling points named for kerosene are the results of distillation tests of tank car samples from the Whiting Refineries. These samples averaged 41.2° Baumé gravity. As an index of quality, it may, however, be noted that all gravity tests are merely suggestive, rather than conclusive; although this applies more particularly to present day gasoline. The boiling points given for gasoline are quoted from the U. S. Navy Department specifications for motor gasoline adopted September 1, 1917, and later adopted by the Committee on Standardization of Petroleum Specifications at its meeting in Washington October 2, of this year.

Kerosene is further differentiated from gasoline, in that it is heavier, is comparatively non-volatile, and has a higher viscosity coefficient. Its composition also differs from gasoline in being more diverse in respect of the nature and range of substances forming the mixture. Engineering authorities for this reason have assumed that the difficulties encountered in burning kerosene at higher loads "are almost wholly attributable to the heterogeneous nature of the compounds composing kerosene; certain of these compounds are easily broken down to form others, and to free some of the carbon."

TEMPERATURE IN OIL ENGINES

Regarding ignitability of fuel mixtures, rate of flame propagation, pre-ignition, and "cracking," or decomposition of the fuel components, in throttle-governed engines, experience shows that internal temperature conditions which are suitable, or permissible for gasoline are quite impracticable for kerosene. This is especially noticeable when an oil engine is operating under a minimum, or a maximum load. At low loads the temperature must be higher than for gasoline, and per contra, high load temperatures must be lower than for gasoline. Under all working conditions low load temperatures must be hot enough to ensure inflammation of the mixture. Bunsen defines the temperature of ignition as the lowest temperature capable of communicating to the constituent parts of a gaseous mixture the ability to combine abruptly. High load temperatures, on the other hand, must be cool enough to prevent either pre-ignition or "cracking." Under the proper working conditions, the temperature curves of gasoline and kerosene engines of the same size may intersect at approximately two-thirds load.

Density of the Fuel Charge. For many years physicists such as Davy, Bunsen, and Sorel have recognized the effects of compression, and temperature on the fuel to air ratio. Sorel[1] notes that "Pressure as well as temperature, plays a very important part in gaseous reactions, either directly, or indirectly.* * * Pressure directly accelerates the reactions * * * Variations of pressure have the same effect as variations of temperature. With a mixture of given composition, at a constant temperature but under a variable pressure, conditions of equilibrium would be met, next non-explosive reaction, then explosive reaction, * * * Hence with weak mixtures, combustion is likely to be very incomplete. This may be obviated as shown above, by increasing the pressure more and more, in proportion as the mixture is naturally less explosive. * * * The limits of combustion depend upon the pressure, the temperature, and their variations to which a gaseous mixture is submitted, as well as on its initial composition, whether the mixture presents a state of apparent equilibrium, or is the seat of non-explosive reaction, or is explosive."

Coordination of Controlling Conditions. The quality, quantity, compression and temperature of fuel mixtures are controlling factors in the operation of all gas engines. But, in throttle-governed oil engines the regulation of all these factors in coordination demands greater consideration than is necessary for ordinary gasoline or gas engines. This is due to the complex character of kerosene, and the effects of extreme variations of compression and temperature on kerosene fuel mixtures which occur within the power range between "idling" and full load in a variable compression engine. The proportions of kerosene mixtures, and the internal temperature must be adapted for each degree of compression. Inasmuch as the variations in compression are normal, and unavoidable in a throttle-governed engine, therefore the temperature, and the fuel to air ratio, should be correspondingly varied to suit each new set of conditions created by the changing compressions which occur under a variable load.

Temperatures: Temperatures rise or fall with the compressions, but not in accordance with the heat requirements of the complex oil fuel. The lighter fractions of kerosene determine the minimum heat of ignition demanded by an oil engine operating under load compressions. In a gasoline engine, under high load conditions, we have a combination of relatively high compression and high temperatures which would be impracticable in an oil engine. For like conditions cause pre-ignition of kerosene mixtures. This may be avoided, obviously, be reducing the compression, thereby sacrificing thermodynamic efficiency. But such reduction of compression is quite unnecessary. If "variation of

[1] "Carbureting and Combustion in Alcohol Engines." Woodward translation.

pressure has the same effect as variation of temperature," we can retain fuel efficiency and avoid both pre-ignition and "cracking" at the higher loads by lowering the temperature of the combustion chamber and simultaneously reducing the relative proportions of kerosene in the fuel mixtures.

Since compression is both a controlling factor and a variable, the ratio of fuel to air, and the temperature within the combustion chamber must be correspondingly varied in correlation as already shown, so as to maintain the proper working relations between proportions, temperatures and compressions for oil fuel at all loads.

Proportions of Mixtures: The history of the gas engine, as disclosed in several hundred patents, since 1887, and the common practice of manufacturers, as well as the dictum of engineering authorities as stated in technical journals and textbooks show a concensus of opinion that fuel mixtures should be of constant relative proportions regardless of their volume, compression, or temperature. This erroneous assumption is as old as the throttling gas engine, and it has persisted to the present time.

A well known textbook, for example, states that "Mixture composition must be automatically maintained at any desired air gas ratio, irrespective of speed changes, load or weather conditions. Neither accelerating nor idling should change the mixture proportions." This statement is contrary to physical law. In order to achieve the best results no controlling factor should be a constant in a variable compression engine. Gasoline and alcohol, however, differ from kerosene in that their composition permits far greater latitude in temperatures and in the proportions of mixtures, than is feasible for kerosene.

The basis of this fallacy is the well known fact that fuels combine with oxygen in combustion only in certain definite proportions. Products of complete combustion of a chemically complex hydrocarbon fuel mixture are always H_2O for the hydrogen and CO_2 for the carbon. It was, and in many instances still is, incorrectly supposed, therefore, that since the products of complete combustion are thus definitely fixed, the relative proportions of fuel and air in the fuel charges should also be constant.

The theory that constant proportions of fuel charge are practical and desirable ignores the fact that while the combined proportions of fuel and air in complete combustion are constant for standard conditions of barometer and temperature, it is also true that there is a wide range of mixtures for each combustible gas and vapor, within which range the mixture is inflammable and explosive, and other conditions being equal, The (1) degrees of inflammability, (2) rate, or velocity of flame diffusion; and (3) quality of combustion, depend on the qualitative composition of the mixture. Relative proportions of fuel charges should therefore vary in consonance with the varying requirements of compression, internal temperature and piston speed. A constant mixture in a throttling governed gas or gasoline engine cannot be correct for all compressions and temperatures, but in an oil engine, subject to variable load, mixtures of constant proportions are impracticable.

Automatic Readjustments: Furthermore, in an oil engine subject to frequent changes of load, the regulation of internal temperatures and fuel mixture proportions must be absolutely automatic, for the most skillful operator could not possibly readjust temperatures and fuel mixture proportions in an oil tractor while driving a separator. Dynamometer records show that quite abrupt, though momentary, fluctuations of drawbar pull even occur in plowing.

Enlarged Functions of the Governor: The regulation of power, speed fuel mixture proportions, and internal temperatures in automatic coordination with varying compressions, involves an obvious increase in the functions of the throttling governor. In order to satisfy the required conditions, the governor must simultaneously regulate in due correlation the (1) quantity of mixture, (2) proportions of mixture, and (3) the internal temperature; thereby automatically coordinating the regulation of the working conditions at all loads within the capacity of the engine. Subject to such automatic coordinate control, kerosene is more flexibly responsive to a varying load than gasoline.

Use of Water. Experience has demonstrated that water is an efficient and suitable medium for regulating heat conditions in a throttle-governed engine. Water can be used internally as well as in the water jacket. For internal cooling, water may be inhaled with the fuel charge. Prof. C. F. Hirshfeld[1] remarks that "the use of water probably leads to a water gas reaction with the hydrocarbons or with some of the carbon liberated from those hydrocarbons, resulting in the formation of CO_2, CO, and H_2O. This would prevent the deposition of some carbon which would not otherwise be burned and would therefore result in a cleaner engine. These water gas reactions start at a temperature of about 1000° F. and are very active at a temperature of 1800°; they cannot therefore occur to any extent during compression as has been assumed by some. * * * The water serves as a diluent of the combustible mixture just as any other gas or vapor would, and it thus decreases the rate of flame propagation and hence decreases the ultimate maximum pressure. Its action in this way would be particularly noticeable at the higher loads when the velocity of flame propagation in the undiluted mixture would reach its maximum value. * * * It will also be evident that, within limits, the action of the water will be dependent upon its quantity. Too little will give all the troubles with which the engineer is

[1] The Principles of Fuel Oil Engines.

familiar; too much will cause similar troubles. The proper quantity in any engine varies with the load, though not in direct proportion, however."

Both nitrogen and water are diluents. But nitrogen is an inert diluent, while water admitted in proper quantities may even serve as a fuel element, enriching the gas by the addition of hydrogen and oxygen. Hydrogen, within limitations, is a desirable constituent because it increases greatly the calorific value of the fuel and promotes flame propagation. Oxygen combines with carbon to form carbon monoxide.

It is essential, therefore, for the total quantity and relative porportion of water admitted to be regulated by the governor to suit the varying internal temperature requirements incident to a varying load. There should be automatic regulation of water as well as fuel. No water whatever is required when starting, or when operating under low loads which require much higher temperatures than is necessary for gasoline engines. The internal temperatures at the lower loads are increased for kerosene by maintaining a higher temperature of the water jacket than is required for gasoline engine. At higher loads the temperature is reduced as required by inhaling water and regulating the quantity of water inhaled, the quantity increasing more rapidly than the load increases, until it has reached a maximum both in quantity and proportions at maximum load. The statement is sometimes made that "water is taken into the cylinder in proportion to the load on the engine." This is incorrect. The rate of water supply should exceed the rate of increase in load.

THROTTLING GOVERNORS

This paper has considered oil fuel only as it is used in the throttle-governed engine. Engineers are fully aware of the detracting features inherent in the throttling governor. Various other methods of controlling the speed and power of oil engines have been proposed and tested during the past 40 years. Some of these are in present use. But power users now recognize that thermal efficiency is not the controlling factor in the commercial-economy coefficient. Quantity regulation has proven to be the most flexible and best all-around method of governing engines subject to wide, erratic, or frequent changes of load. It is almost universally used at the present time. Common consent has decided that it is highly satisfactory for the farm tractor, and the law of common consent is more powerful than any statute.

CONCLUSIONS

Regarding kerosene as a fuel for the throttle-governed farm tractor, we may deduce the following conclusions:

1. From the strictly commercial, or sales viewpoint, the oil tractor

has already overtaken and passed the gasoline tractor as well as the steam tractor.

2. Now that the disturbing effects of the world-war on the oil trade is passing, it is safe to predict that there will be an adequate supply of kerosene; at least for the requirements of the present generation. And while the price will fluctuate with changes in trade conditions, it will unquestionably be sold at a notable reduction below the prevailing market quotations for gasoline.
3. Before oil engines attained their present stage of development, the kerosene lamp revealed two highly significant facts. The first, that kerosene burns without smoke or odor when all the controlling factors of combustion are in suitable correlation. The second, that under all other possible combinations of combustion conditions, kerosene is a highly refractory fuel. When its combustion is incomplete, the combustion products include free carbon, carbonaceous deposits and highly malodorous gases.
4. The fact that kerosene is practically non-volatile at atmospheric temperatures is advantageous rather than detrimental to its use as a fuel for the farm tractor.
5. Experience with various methods of regulating the speed and power of farm tractors demonstrates that quantity governing has practical advantages over other existing methods of regulation.
6. Density and temperature of the fuel mixture are controlling factors in the combustion of any fuel. But they are vitally decisive factors in the combustion of the non-volatile liquid hydrocarbons, such as kerosene. This is due to the complex character of the fuel and the chain of boiling temperatures. And the so-called problem of burning kerosene in the throttle-governed engine was due to the fact that the controlling factors of combustion became variables under a varying load.
7. It follows that the only feasible method of using kerosene in an engine when controlling factors of combustion are variables, is to readjust the temperature of the combustion chamber and the fuel to air ratio of the fuel mixture to suit each new set of conditions caused by each change in compression.

   In order for the quality, quantity and combustion temperature of the fuel mixtures to be automatically readjusted in coordination under a varying load, these readjustments must be subject to a common unitary control; therefore, ordinary functions of the speed-controlling governor should be increased so as to include such triple automatic coordinate control.
8. The addition of water to the fuel mixture in automatically varying quantities under such governor control is the most efficient means for regulating internal temperatures at the

higher loads. When used in the proper quantities, water is highly beneficial in several directions. It absorbs excess heat, which would cause pre-ignition. It prevents "cracking." It regulates the velocity of flame propagation. It acts as a diluent of the fuel charge. It prevents, or lessens carbonization, and it also acts efficiently as a detergent.

It may be noted, in closing, that the average owner of an oil tractor judges his tractor by gasoline tractor standards, or from the gasoline viewpoint. This is both natural and proper. An oil tractor should certainly possess every advantage of the best gasoline tractor, plus reduced plowing cost. The oil tractor has demonstrated its equality with the gasoline tractor in power output of engines having equal cylinder dimensions, in horse power hours obtained from a gallon of kerosene, in flexibility under a varying load, and in general performance. The past decade may be considered the introductory decade of the oil tractor. Further improvement will be made as suggested by experience. The future will undoubtedly show a greater standardization of sizes and types of tractor than now exists. But efficient standardization must be based on correct underlying principles, and exact data relating to field performance.

DISCUSSION

QUESTION: I would like to ask if the points were taken up as discussed and whether they apply equally to the internal lubricated engine with vertical cylinders as they do to the horizontal with the external lubrication?

MR. SECOR: As everything I said applies, I would say that until I became connected with my present work, my work largely was on marine engines which had to be upright and on stationary engines preferably upright. I never made a gasoline engine in my life until I came to La Porte 10 years ago.

MR. SANDERS:[1] Why do the automobile manufacturers invariably stay with gasoline?

MR. SECOR: You will note in my remarks I said practically nothing about mechanism. I dealt with principles only. Someone may come along and make a better oil engine than the world has ever seen but the underlying principles are either right or wrong. We are dealing with the right principles, we are sure. You will notice I referred to two kerosene tests on automobiles this year—one which occurred in Paris and the other in New York City under the auspices of the *New York Herald*—a 1000-mile test. Both tests were with kerosene. They took up the automobile at every point—the matter of accelerating, retarding, going to the slowest possible speed and then starting up quickly. They did all the stunts and nearly as good as with gasoline. Now the

[1] Newell-Sanders Plow Company, Chattanooga, Tenn.

principles we are speaking of can be applied to the automobile. There is no reason why the automobile should continue to use gasoline. As I said before, and it is a most striking illustration, any properly adjusted kerosene lamp shows better combustion than the best gasoline car. Did you ever enter a country church with six or more kerosene lamps burning, with every door and window shut, and you smelt nothing but people's breaths? If one-quarter that quantity of gasoline had been in there it wouldn't be tolerable.

Question: I think your theories are right if such automatic adjustment can be had, but from experience in the handling of the farm tractor I realize we must give the tractor owners something they can work with every day. Our experience has been they don't get these results when using kerosene. They have difficulties. They don't have proper combustion, and an endless list of difficulties follow. The difference in the cost of the fuel is infinitesimal as compared with buying new engines.

Mr. Secor: Well, the designer of the automobile started out with the idea he wanted to make his fuel mixture as nearly uniform as possible under all working conditions. The designers all agree on that. Now some of the oil engine people have begun to realize that that is quite impractical with oil. The minute you have a constant mixture you have a mixture that is not rich enough for a light load and too rich for a maximum load but so far as I know the automobile men are unanimous and still of the opinion they were 10, 15 or 20 years ago, that full mixture should be constant in proportion. No stream rises higher than its source. They don't claim to get any perfect uniform mixture, but that is the aim. There is certainly no attempt whatever to make a rich mixture at light load, and the richest possible at heavy load. The very minute you do that, and if you carry your temperature at low load high enough to take kerosene, you can use it better. Even under the conditions they are making progress. So far as they are making progress, their practice is far ahead of the theory. When people find the practice has outgrown the theory, they will readjust the theory to suit the practice.

Mr. Dickerson: I should like to ask Mr. Secor if he does not think with the vertical engine there is a movement toward enforced lubrication that will cure some of our troubles?

Mr. Secor: I didn't know that one could run an oil engine either vertical, horizontal, inclined, or V-shaped, without forced lubrication.

Mr. Dickerson: Some are trying to do it.

Mr. Jones:[1] Without presuming to take exception to the statements of a man who is older in years and experience than myself,

[1] Department of Agricultural Engineering, University of Wisconsin, Madison, Wis.

I should like to call attention to one feature of his comparison between the oil lamp and combustion inside the cylinder of the engine. In the case of the oil lamp, nothing comes in contact with the burning gas except air, whereas in the case of the cylinder we have a prepared mixture which is in contact with cold metal. Our flame is propagated from the point of ignition to such a point or to such a distance from the cylinder wall that the cooling effect of that cold metal—comparatively cold—interferes with perfect combustion, and whether it is gasoline or kerosene, there must be some contact with the metal.

With respect to Mr. Sanders' discussion as to the method of lubrication practicable for oil-burning engines as compared with burning gasoline, Mr. Secor has pointed out the necessity for high cylinder walls. You notice the temperatures which he has put there on the blackboard. For example, when 45 percent of the kerosene has boiled away, we have a temperature of 420° F., and that is about as high as the flash temperature of lubricant. Consequently, we run into lubrication difficulties if we attempt to maintain a wall temperature high enough to vaporize. The result is, in a circulating system where the oil is pumped over and over again, the certain amount of kerosene which must condense, or deposit, will become washed down to the crank case and gradually dilute the oil.

Mr. Secor: I fully agree with everything Mr. Jones says.

THE DESIGN, MANUFACTURE, OPERATION AND CARE OF LEAD STORAGE BATTERIES FOR FARM LIGHTING PLANTS

H. M. Beck,[1] Member Amer. Soc. A. E.

About the year 1860, a Frenchman named Plante, while in the course of some experiments with electrolytic cells, placed two pieces of lead in a vessel containing a weak mixture of sulphuric acid and water, connected these in series with a meter and passed current through this circuit from an outside source. After allowing the current to flow for some time, he stopped it, short-circuited the two terminals of the circuit, and was surprised to get a reverse reading of the meter, indicating that the cell was giving back some of the electrical energy applied to it.

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[1] Electric Storage Battery Company, Chicago, Ill.

principles we are speaking of can be applied to the automobile. There is no reason why the automobile should continue to use gasoline. As I said before, and it is a most striking illustration, any properly adjusted kerosene lamp shows better combustion than the best gasoline car. Did you ever enter a country church with six or more kerosene lamps burning, with every door and window shut, and you smelt nothing but people's breaths? If one-quarter that quantity of gasoline had been in there it wouldn't be tolerable.

QUESTION: I think your theories are right if such automatic adjustment can be had, but from experience in the handling of the farm tractor I realize we must give the tractor owners something they can work with every day. Our experience has been they don't get these results when using kerosene. They have difficulties. They don't have proper combustion, and an endless list of difficulties follow. The difference in the cost of the fuel is infinitesimal as compared with buying new engines.

MR. SECOR: Well, the designer of the automobile started out with the idea he wanted to make his fuel mixture as nearly uniform as possible under all working conditions. The designers all agree on that. Now some of the oil engine people have begun to realize that that is quite impractical with oil. The minute you have a constant mixture you have a mixture that is not rich enough for a light load and too rich for a maximum load but so far as I know the automobile men are unanimous and still of the opinion they were 10, 15 or 20 years ago, that full mixture should be constant in proportion. No stream rises higher than its source. They don't claim to get any perfect uniform mixture, but that is the aim. There is certainly no attempt whatever to make a rich mixture at light load, and the richest possible at heavy load. The very minute you do that, and if you carry your temperature at low load high enough to take kerosene, you can use it better. Even under the conditions they are making progress. So far as they are making progress, their practice is far ahead of the theory. When people find the practice has outgrown the theory, they will readjust the theory to suit the practice.

MR. DICKERSON: I should like to ask Mr. Secor if he does not think with the vertical engine there is a movement toward enforced lubrication that will cure some of our troubles?

MR. SECOR: I didn't know that one could run an oil engine either vertical, horizontal, inclined, or V-shaped, without forced lubrication.

MR. DICKERSON: Some are trying to do it.

MR. JONES:[1] Without presuming to take exception to the statements of a man who is older in years and experience than myself,

[1] Department of Agricultural Engineering, University of Wisconsin, Madison, Wis.

I should like to call attention to one feature of his comparison between the oil lamp and combustion inside the cylinder of the engine. In the case of the oil lamp, nothing comes in contact with the burning gas except air, whereas in the case of the cylinder we have a prepared mixture which is in contact with cold metal. Our flame is propagated from the point of ignition to such a point or to such a distance from the cylinder wall that the cooling effect of that cold metal—comparatively cold—interferes with perfect combustion, and whether it is gasoline or kerosene, there must be some contact with the metal.

With respect to Mr. Sanders' discussion as to the method of lubrication practicable for oil-burning engines as compared with burning gasoline, Mr. Secor has pointed out the necessity for high cylinder walls. You notice the temperatures which he has put there on the blackboard. For example, when 45 percent of the kerosene has boiled away, we have a temperature of 420° F., and that is about as high as the flash temperature of lubricant. Consequently, we run into lubrication difficulties if we attempt to maintain a wall temperature high enough to vaporize. The result is, in a circulating system where the oil is pumped over and over again, the certain amount of kerosene which must condense, or deposit, will become washed down to the crank case and gradually dilute the oil.

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each of these pieces of lead into sections and then weld them together in order to get them in a more convenient shape to handle, but they still act as if they were one single piece of lead.

THEORY OF THE STORAGE BATTERY

Why has this simple combination a capacity for storing energy? The chemical theory of the storage battery is very involved and, in fact, has never been completely solved, but, fortunately, it is neither necessary, nor advisable, from an operating standpoint, to go very far into this theory. It is far better to stop with the main facts upon which our operating methods are based, as otherwise there is danger of confusion.

Chemistry teaches us that when different elements, or materials, combine, energy is always either absorbed or released. Where the conditions are right this energy may be made to show itself in the form of an electrical current.

In the case of the storage battery we have two substances: lead and sulphuric acid. During the discharge these combine, forming salt of lead, commonly called sulphate, and the energy released by this combination shows itself in the form of an electrical current. During charge the reverse action takes place. The charging current breaks up the combination and drives the sulphuric acid out of the plates back into the solution, or electrolyte, until the combination is entirely broken up. The cell is then in its original condition, charged and ready for another discharge.

This basic reaction should be borne in mind, not only because it enables us to visualize the reason for the rise and fall in voltage and gravity during charge and discharge, but also because it furnishes the answer to the claim of certain batteries which appear on the market from time to time under the title "Non-Sulphating."

The question naturally arises as to what the current does if the charge is continued after all the sulphate is broken up. When an electrical current is passed through a cell, it will always do the easiest thing first. As long as there is any combination of lead and acid present, this will be broken up first. When this is completed, the next easiest thing is to decompose or break up the water in the electrolyte into its component gases, hydrogen and oxygen, these gases showing themselves in the form of bubbles rising to the surface. This action starts gradually and then increases rapidly, until the electrolyte has the appearance of boiling water. Thus, when a cell begins to gas freely, it is an indication that the plates are nearly charged, as they are not absorbing the current.

DEVELOPMENT AND CONSTRUCTION

A storage battery cell (Figs. 1 and 2) consists essentially of positive and negative plates, separators for insulating and holding

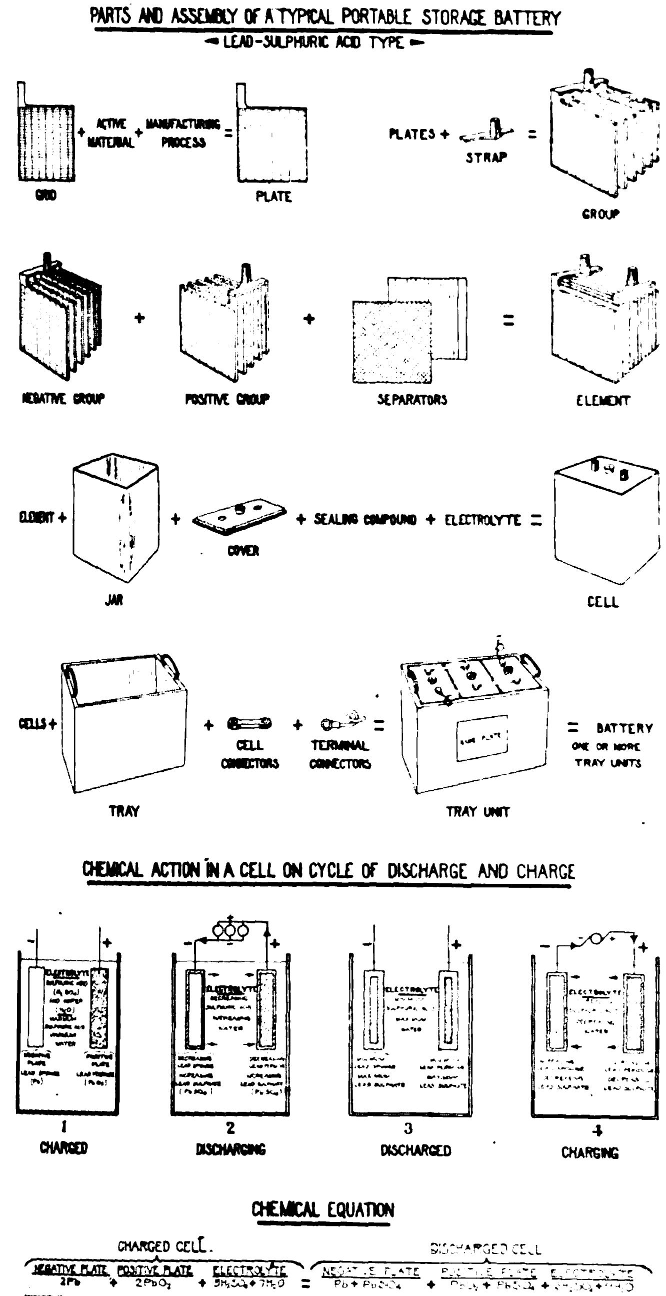
PARTS AND ASSEMBLY OF A TYPICAL PORTABLE STORAGE BATTERY
LEAD-SULPHURIC ACID TYPE
GRID
ACTIVE MATERIAL
MANUFACTURING PROCESS
PLATE
PLATES +
STRAP
GROUP
NEGATIVE GROUP
POSITIVE GROUP
SEPARATORS
ELEMENT
ELEMENT +
JAR
COVER
+ SEALING COMPOUND + ELECTROLYTE =
CELL
CELLS +
TRAY
CELL CONNECTORS
TERMINAL CONNECTORS
TRAY UNIT
= BATTERY
ONE OR MORE TRAY UNITS
CHEMICAL ACTION IN A CELL ON CYCLE OF DISCHARGE AND CHARGE
1
CHARGED
2
DISCHARGING
3
DISCHARGED
4
CHARGING
CHEMICAL EQUATION
CHARGED CELL.
NEGATIVE PLATE
2Pb
POSITIVE PLATE
2PbO2
ELECTROLYTE
DISCHARGED CELL

Fig. 1

these apart, electrolyte, and a jar, or container, for holding the electrolyte and supporting the plates.

Plates—While the simple cell described in Plante's experiment contains the elements of a storage battery, it would have very little capacity, due to the small surface of lead exposed to the electrolyte.

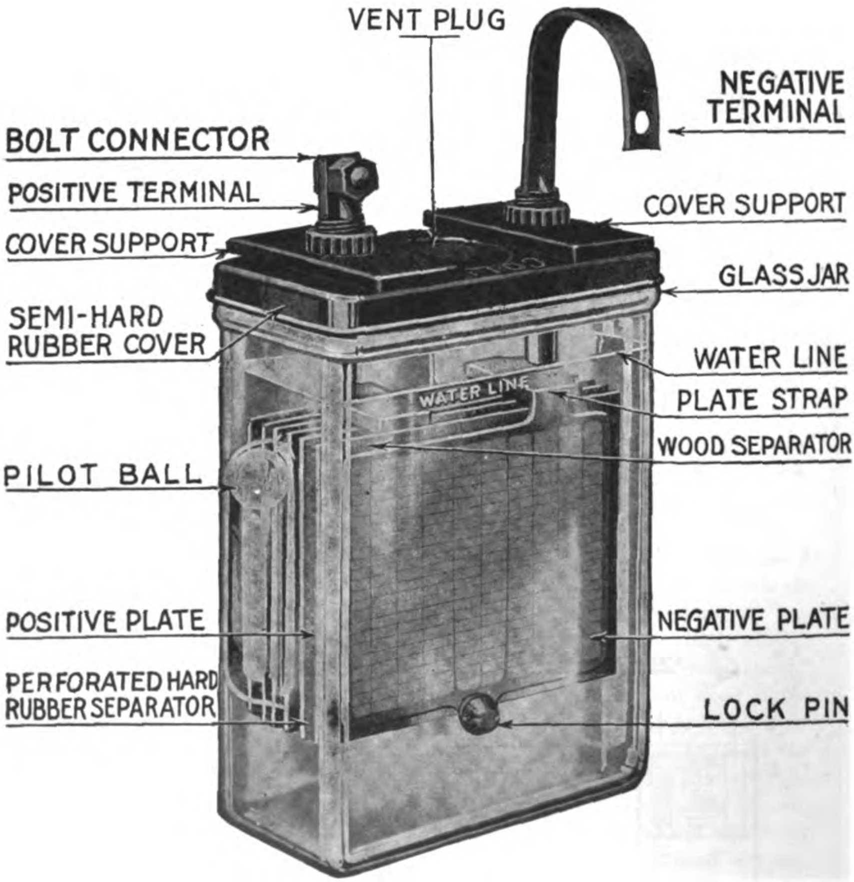

Fig. 2. Typical sealed glass jar cell

Since the discharge is due to the combination of the electrolyte with the lead, naturally the greater the amount of lead surface exposed to the electrolyte, the greater the amount of combination which can take place, and consequently the greater the capacity.

The first step, therefore, in making a commercial cell is to increase the surface of the lead plate and this can be done in a number of ways.

Larger sheets of lead could be used, but we would soon reach dimensions which would be prohibitive even if, as already men-

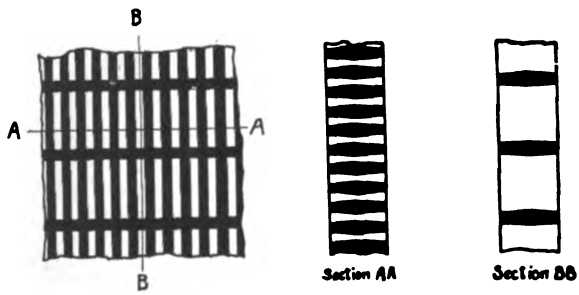

Fig. 3. Cross-section of Tudor positive plate

tioned, these were cut into small sections welded together in order to get them into more convenient shape.

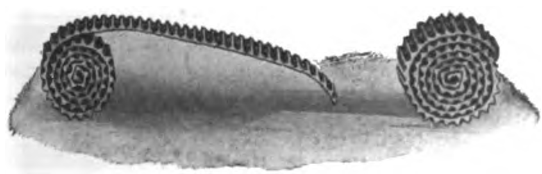
Fig. 4. Manchester button

The exposed surface of a given area of lead can be increased by grooving, corrugating, or casting it in the form of a grid, with openings extending all the way through (Figs. 3, 4 and 5). By this method the effective surface can be increased some eight or ten times and plates of this type, known as Plante plates, are very largely used today in stationary service, or where long life is desired and weight not a serious handicap.


Fig. 5. Section of Manchester plate

A still further increase in surface can be reached by making the plate itself porous, or sponge-like so that it is nearly all surface. This plate represents the limit of surface, and consequently capacity, that we have been able to reach up to the present time; it is probably the most largely used today, and from its method of manufacture is known as the pasted type.

Porous lead has very little mechanical strength and its conduc-

Fig. 6. Pasted plate grid, (exide type)

tivity is not the best, so that it requires some method of mechanical support and this support must also act as a conductor. For this purpose a very light openwork grid of a hard alloy of lead is used (Figs. 6 and 7). The openings of this grid are filled by pasting with a mixture of oxides of lead, of about the consistency of mortar, and when dry this sets hard and becomes practically a unit with the grid, the latter serving as the backbone, or skeleton. These plates when properly charged are very porous, and therefore have a very high capacity in proportion to their weight. (Fig. 8.)

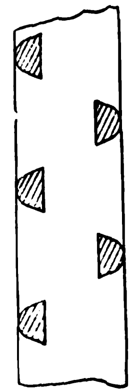

Fig. 7. Cross-section pasted plate grid (exide type)

Fig. 8. Positive pasted plate (exide type)

Finally, in the case of either type of plate, Plante or pasted, it is evident that the exposed plate surface in a container can be increased by making the plates thinner and using more of them. Except within reasonable limits, however, this practice results in short life and mechanical weakness and so is of practical value only where the rates of charge and discharge are extremely high, or lightness and low initial cost are of first importance.

Separators—Next to the plates, the most important part of the cell is probably the separator. The two plates, or groups of plates, must be kept apart and insulated from each other, or a circuit is formed inside of the cell and the capacity lost through internal discharge.

Much study has been given to this subject and many different materials have been used. The ideal separator must be an insulator, but sufficiently porous to allow free action between the plates; must stand the action of the electrolyte and of the active material; and have sufficient mechanical strength to keep the plates apart, even under considerable pressure. The two materials which seem best to meet these specifications, are wood and hard rubber, and as a result, one of these materials, or a combination of the two, is standard.

Hard rubber stands the electrolytic action, is a good insulator and strong mechanically, but it is not porous, so that perforations are necessary in order to allow the action to go on between the plates. In order to keep down the resistance to this action, the perforations must be of considerable size so that there is danger of some of the lead material bridging across between the plates, through the perforations, and causing short circuits. (Fig. 9.)

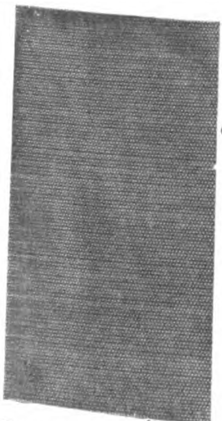

Fig. 9. Perforated rubber separator

A secondary advantage derived from the use of hard rubber is that this material is so resistant to the action of the active material that flat sheets may be placed directly against the surface of the positive plates without danger, and this not only protects the active material from the mechanical action of the gassing, but also holds it in place and thus prolongs the life of the plate.

Wood is naturally porous enough for the action between the plates, and the pores are so small that there is no danger of short circuits forming through them, but only a few kinds of wood are sufficiently strong mechanically when soaked with electrolyte. Also, all kinds of dry or untreated wood contain certain impurities which will ordinarily attack and destroy the plates. On this account wood separators (Fig. 10) should always receive a preliminary chemical treatment, in order to remove these impurities, or the results are likely to be serious. Thus, dry, untreated wood should never be used in a storage battery in any quantity.

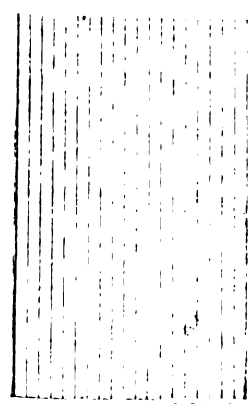

Fig. 10. Grooved wood separator

It is not so generally appreciated that in addition to its mechanical advantages wood, after the proper treatment, still contains certain chemical elements which are beneficial to the plates and tend to prevent loss in capacity, so that this characteristic presents an additional argument in favor of the use of the wood separator. A combination of a wood diaphragm with a perforated sheet of hard rubber (Fig. 11) offers, in many cases, the best solution of

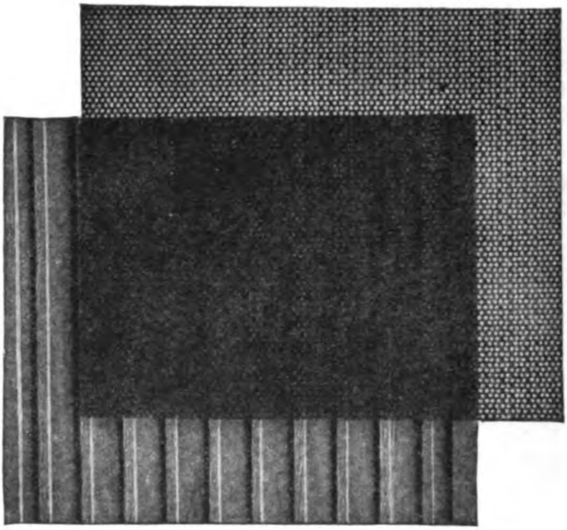

Fig. 11. Combination grooved wood and hard rubber separator

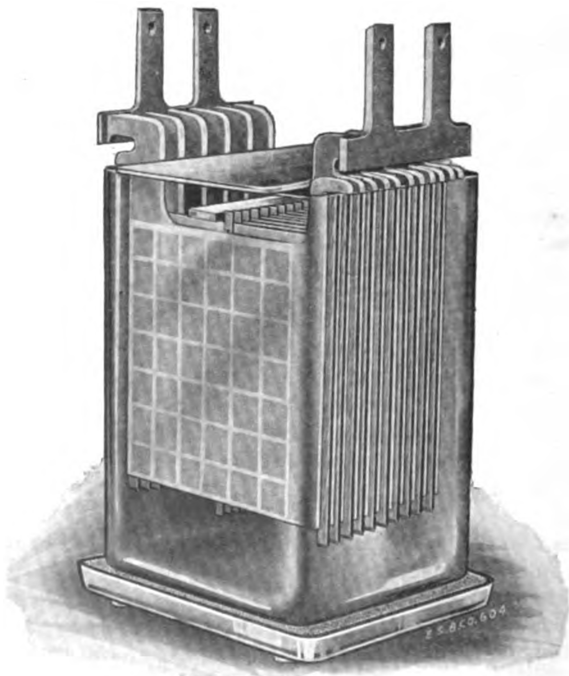

Fig. 12. Stationary cell in glass jar

the separator problem, as we are thus enabled to take advantage of the good points of each material.

Fig. 13. Portable cell in rubber jar

Finally, in order to complete the cell, some sort of a jar is required to hold the electrolyte in which the plates are submerged. For this purpose, glass or hard rubber is most commonly employed for the smaller plants.

Glass jars have the advantage of rendering the inside of the cell visible for inspection, so that they are practically standard for small stationary plants. (Fig. 12.) Where portability is necessary rubber is used on account of its greater freedom from breakage (Fig. 13.)

OPERATION

In the operation of the storage battery, the most important point is the proper charge, and in connection with the charge, the important points are the charging and the cut-off.

The rule governing the proper charging rate can be stated very simply, and in practice, the problem is simply to approach this ideal as nearly as possible. As long as the cells do not gas or heat, it is perfectly safe to use any current rate desired, but the current must never be above normal when the cells are gassing, as this is likely to result in increased depreciation.. Heating should always be avoided by reducing the rate wherever possible.

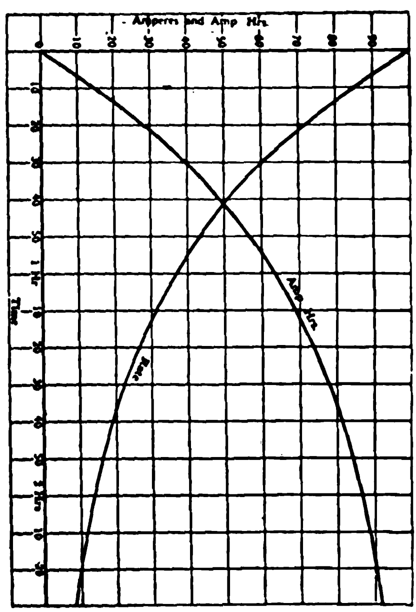

Fig. 14. Curve showing current rate and ampere hour input for quick charge constant potential system

It will be found that many different methods of charging can be worked out which are perfectly safe according to this rule. For example, where there is plenty of time, the normal charging rate may be used from start to finish; on the other hand, if it is desired to hasten the charge, a very high current rate may be used at the start, provided this is gradually reduced as the charge progresses so that there is no gassing until the rate is down to normal. (Fig. 14.) The first method is known as the constant current system and the second as the constant potential system, and in between, there are innumerable combinations of the two. The constant potential system derives its name from the fact that if the proper constant potential is applied to a cell, the charging rate will automatically taper so that gassing is avoided, due to the rise in the cell voltage as the charge progresses.

The determination of the proper point at which to cut off the charge is not quite so simple. According to our theory, during charge the current breaks up the combination of lead and acid, driving the acid back into the electrolyte, and this is indicated by the strength (specific gravity) of the electrolyte increasing, as shown by the hydrometer reading. The voltage of the cell behaves in a similar manner.

This action goes on, that is, the voltage and gravity rise until all the lead sulphate is broken up, when the readings come to a standstill, and cannot show any further increase, no matter how long the charge continues. This, then, is the indication that the charge is complete and should be cut off, namely, that the voltage or gravity has stopped rising.

Then, as already explained, when the charge is nearly completed and the plates will no longer absorb the current, it begins to decompose the water of the electrolyte into its component gases, hydrogen and oxygen, and these gases show themselves at the surface in the form of bubbles commonly referred to as "gassing." This indication of the completion of the charge is very easily used, but unfortunately is not very accurate, so that it should only be employed in conjunction with one of the other methods.

Three methods of determining the end of the charge are thus evident, namely, the voltage or gravity reaching a maximum and the cells gassing freely. (Fig. 15.)

Finally, there is the ampere hour efficiency method, which is very largely used in connection with automatic methods. Experience has shown that under a given set of conditions, the ampere hour efficiency of the storage battery holds quite uniform. In other words, knowing that a certain amount of discharge has been taken out, it can be figured closely how much charge will be required to bring the cells back to a fully charged condition. This method, therefore, depends upon the use of an ampere hour meter, which will measure and indicate the amount of discharge or charge.

It is evident, however, that as the ampere hour meter has no direct connection with the battery, there is a possibility of its getting out of step; for example, indicating that the battery is charged when this is not the case. Thus, where the ampere hour meter is used, it is essential that it be checked by the gravity method at rather frequent intervals, in order to make sure that it is in step.

The discharge is a much simpler matter than the charge, as there is only one point to look out for, namely, not to discharge too far.

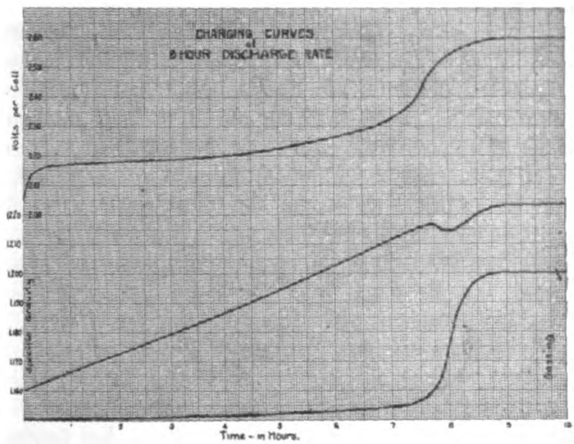

Fig. 15. Curves showing voltage (upper), gravity (middle), and gassing (lower), for constant current charge

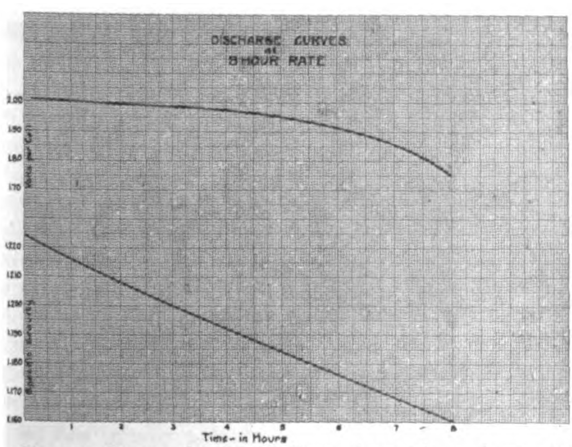

Fig. 16. Curves showing voltage (upper), and gravity (lower), during discharge at a constant rate

As far as injuring the battery is concerned, it makes no difference how high the discharge rates are as long as they are not kept on too long. Just as the gravity and voltage rise during charge they fall during discharge (Fig. 16), and based on experience, certain limits have been placed beyond which it is not safe to go.

The ampere hour meter can be used to indicate the discharge limit where the average discharge rates are not above normal, but where higher rates are used, allowance must be made for the reduction in the capacity of the cells, due to the higher rates.

In addition to the charge and the discharge, there is one other routine operation in connection with the storage battery which must be attended to, namely, replacing the evaporation. It would seem that this ought to be the simplest part of the routine, and yet, due to a quite general misunderstanding, a good deal of trouble occurs at this point. What is actually required is very simple, namely, to put sufficient water of the proper purity into the cells, frequently enough to keep the plates from ever becoming exposed to the air.

By the "proper kind of water" is meant water which does not contain injurious impurities. Distilled water should be, of course, always safe, but many natural waters, including rain water, are also safe and can be used, provided they are first analyzed and approved. This precaution should always be taken where the local water supply is used for this purpose.

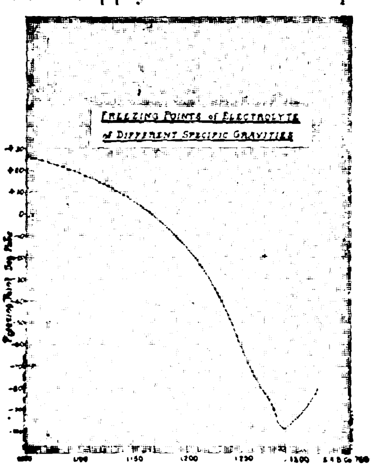

Fig. 17

As we know, water will freeze. On the other hand, except at very low temperatures, electrolyte will not (Fig. 17), and even at very low temperature it does not freeze solid, but forms a sort of slush which will not break jars. Since water is lighter than electrolyte, it will tend to float on top of it when added to replace evaporation, and thus may freeze and cause trouble where a battery is subjected to freezing temperature, unless care is taken to see that it is mixed with electrolyte. Fortunately, this is not difficult, as the gassing at the end of the charge will accomplish the desired result, so that all that is necessary in such cases is to take the precaution only to add water during charge and preferably the latter part of the charge.

The trouble with replacing the evaporation arises from the rather widespread impression that there is a loss of acid as well as water, due to the action of the cell. According to theory, there is no loss of acid. It combines with the lead plates during discharge, but is all driven back again into the electrolyte during charge. Thus, if the proper amount of acid is put into a cell originally, it requires no further attention. This idea that some of the acid is actually used up results in more or less frequent addition of acid to the cells, which eventually results in too strong electrolyte and this is very injurious to the plates.

With use, material from the positive plates gradually loosens and falls to the bottom of the jars in the form of a grayish-brown sediment. A space under the plates is provided for this sediment and in some cases this is deep enough to take care of all the sediment until the plates require renewal. On the other hand, in many batteries where the height of the cells is restricted, this is not the case, so that the amount of sediment requires watching and must be cleaned out before it reaches the plates, as this would result in an internal short circuit and discharge the cells.

The storage battery must be kept clean and free from dirt. In this respect it does not offer any special peculiarities, with the exception that the electrolyte will corrode certain metals if it comes in contact with them. This applies especially to copper, brass or iron; lead is naturally immune. Corrosion is most likely to occur at the connections or terminals and shows itself in the form of a greenish salt.

If connections, etc., are kept well coated with vaseline or some heavy grease, this sheds the acid and prevents corrosion. Where it has occurred, the remedy is to clean the surface thoroughly, neutralizing any acid which may be present with a solution of ammonia or of bi-carbonate (baking) soda and water, and afterwards washing off this solution with plain water. If the surfaces are then thoroughly greased and kept greased, no further trouble from this source will be experienced.

LOCATION

The location of the storage battery has much to do with its successful operation. While it does not require a great deal of attention, that little is vital and it is self-evident that if the cells are inaccessible or poorly lighted, they are bound to be neglected.

A location should be selected where the ventilation is good. If the battery is inside of a cabinet, ventilating openings should be provided so that there is free circulation in order to carry away and prevent the accumulation of battery gases.

Extreme temperatures, either hot or cold, are objectionable. High temperatures, that is, above 110° F. shorten the life. Low temperatures reduce the available capacity and this is apt to occur in winter when the days are short and there is the greatest demand for light. At temperatures below freezing, as already explained, it is further necessary to take precautions when adding water to the cells to replace the evaporation.

ISOLATED PLANT FIELD

The small electric light plant field is from the storage battery standpoint, one of the very best, but until recently, the development has been surprisingly slow, not apparently due to any inherent obstacle, but rather to an insufficient study of the problem so that the real conditions to be met have not been appreciated.

Many attempts have been made to design isolated plants without the use of the storage battery, but judging from the most general practice today, it seems to be admitted that the battery is an essential part of the system. While the use of the battery offers a number of other advantages, its primary object is to render continuous 24-hour service available without the necessity for running the power plant all the time.

It would appear self-evident that an electric lighting plant of this type should be designed as a whole with the various parts properly proportioned to work together, and yet a great deal of trouble in the past has resulted from the neglect of this point. Where a local dealer purchases a standard engine from one manufacturer, a generator or switchboard somewhere else, specifies a battery entirely too small for the work to be done, and finally attempts to assemble the apparatus, the result can hardly escape being a failure. The first essential to success is, therefore, that the plant as a whole be properly designed.

The fact that these plants are so largely sold by non-electrical experts calls for the simplest possible assembly and where there are separate units, provision against improper assembly. In the case of the storage battery, this has produced a demand for cells which can be shipped assembled, sealed and charged, instead of following the earlier practice, which was to assemble them and give them their initial charge after installation. In other words, caution must be taken to see that the plant is properly set up, and turned over to the owner in the best working condition.

It must be appreciated that after installation these plants will be handled by non-experts and further, that the farmer already has his hands full without having to watch his lighting plant. This condition means that as far as practical, the operation of the plant should be automatic in order to reduce the knowledge and supervision required to a minimum, but whether the control is automatic or not, the attention the battery receives is bound to be both crude and irregular, so that from the storage battery standpoint, a very large factor of safety in the form of excess capacity, is required. A central station battery which is handled with the utmost care and accuracy can be counted upon for its full capacity at any time, but not so with the small isolated plant, and experience has shown that the use of too small batteries has been one of the most common mistakes in the past.

Finally, it is essential that the right type of battery be furnished if satisfactory life is to be expected. Other things being equal, the life of the battery depends upon four factors: design, abuse, depreciation due to time, and depreciation due to electrical work, that is, discharge. The problem therefore resolves itself into selecting the type which will give the greatest return per dollar invested.

There are, as given above, two general types from which to choose, Plante and Pasted.

The Plante type is the more rugged, will stand more abuse, and for a given capacity has about double the discharge life. On the other hand, it costs about twice as much and is considerably heavier, which complicates the shipping problem.

The Pasted type has the advantage of lightness and compactness, experience indicates that when properly designed and constructed it is durable under the average conditions encountered in this service and while theoretically its life is less than that of the Plante, the cost is also less, so that greater capacity can be installed at the same cost and will give approximately equal discharge life, that is, the same amount of total ampere hours discharge.

From the standpoint of time life the Plante type has some advantage, but there is no difficulty in designing a pasted plate to stand the depreciation due to time alone (that is, without any discharge) for anything up to a 10 years' life, so that from this standpoint the advantage of the Plante type is theoretical rather than actual.

Summing up the advantages for and against the two types:

1. The cost per ampere hour discharge life is about equal, the Plante showing less than 10 percent advantage.
2. The cost per ampere hour capacity is about two to one in favor of the Pasted type.
3. The Plante is more rugged, but is considerably heavier.
4. The Pasted type is rugged enough and has the advantage of lightness and compactness.

This comparison shows up very decidedly in favor of the adoption of the Pasted type and explains why this type is practically standard for this service.

Individual cases may arise where the discharge is unusually heavy and it may pay to install a different type of plate in order to take advantage of its increased life, but these cases are likely to prove exceptions rather than the rule, and even here a special form of Pasted plate will probably have the preference over the Plante. The comparison, so far, is based upon the flat type of Pasted plate so generally used, whereas there are some other forms which, while more expensive, have a much greater life and will probably show an advantage over the Plante even for heavy discharge work. These special types have not until recently received very much consideration for stationary service, but they are likely to be heard from in the future.

Having selected the Pasted type, we still have the proper design and capacity to settle. Other things being equal, the thicker the plates the longer the life and the more rugged the construction. In fact, experience has shown that certain minimum limits are necessary if a plate is to last a given time, even if it is not discharged at all.

On the other hand, a certain amount of exposed plate surface is required to take care of the charge and discharge rates without dangerous current concentrations. This fixes the minimum plate surface, or, with a plate of a given size, the minimum number of plates which should be furnished.

It goes almost without saying that even the proper plates must be properly assembled. This calls for:

1. A separation which will eliminate the possibility of short circuits.
2. Sediment space which will preferably hold all of the sediment which will be thrown down throughout the life of the plates.
3. Sufficient space over the plates so that evaporation will not have to be replaced too often.
4. Jars which are enclosed, or covered in order to reduce the evaporation and keep out dirt.

Too many attempts have been made to estimate the proper size of battery entirely on the basis of the apparent requirements. This practice has resulted in furnishing too little capacity and, as already explained, this has been one of the most serious mistakes. It is not simply a case of the average requirements, but the maximum requirements which must be met, and the biggest part of the problem is the excess capacity which must be provided to take care of the irregular conditions of operation, provide for future growth and insure a satisfactory life. In other words, it is useless to figure too closely on the load requirements where the factor of safety is the most important part of the problem. Actual experience is probably the best guide in this case, and indicates that for 30-volt plants nothing less than 80 ampere-hour batteries should be furnished, and in most cases they should be considerably larger.

It must not be overlooked that investment in battery capacity is not thrown away, even if not needed at the time, as the battery will give a correspondingly longer life. Furnishing a large enough battery has probably more to do with the success of a plant than any other factor, so that this fact cannot be too strongly emphasized.

DISCUSSION

Mr. Dickinson: Mr. Beck, what is this threaded rubber installation?

Mr. Beck: It is an attempt to artificially produce a substitute for wood. It naturally wouldn't have the chemical advantages of the wood, but if it can be made practical it will have mechanical advantages over the wood.

QUESTION: What is the relative length of the normal life of the positive and negative plates?

MR. BECK: In our large batteries where we have to figure very closely, the negatives will last two or three sets, positives. I have a number of batteries right here in the city which are now on their third set of positives, whereas if you figure closely on the negative and do not allow excess, they have to be renewed in many cases with the positive.

QUESTION: In the regulation of the voltage, do you recommend counter cells?

MR. BECK: It is the most practical method we know of, and there is a development right now which will vastly improve their regulation.

QUESTION: Speaking of the characteristics of the wood separator, doesn't the wood separator tend to render them chemically neutral?

MR. BECK: In some cases, yes. That characteristic has proved immeasurably valuable in some cases. I can't give you the physical facts. The negative plate with age springs and loses surface. If with such a plate you install wood properly treated, it will tend to create an expansive force which will expand that negative and bring its capacity back. That is not theory, it is fact. We have had large central stations down as low as 70 percent of the rating that we have brought back to over 100 percent by this principle,

QUESTION: You think, then, the combination of the wood and perforated rubber plate is likely to prove preferable to the threaded rubber?

MR. BECK: It is a little hard for me to speak of the threaded rubber. Where it is used, that characteristic is not of so much importance, and the threaded rubber will have some advantages when it is perfected but it is a very promising development.

MR. JONES: To what extent is the loss of water due to evaporation?

MR. BECK: That is something that depends on the type of installation. We made some elaborate experiments on a large battery here in town, and step by step we cut the evaporation down in half simply by shielding the cell. Now that would indicate that the biggest part of that evaporation was due to surface evaporation and not gassing. On the other hand, if you have a battery that is not operated directly it is subjected to a great deal of overcharge, and the larger part of the evaporation would be due to gassing. In car and train lighting cells, under the old method of controlling the charge, which really was no control, they were subjected to extreme overcharge. The result was they had to replace the evaporation in anywhere from two weeks to a month. Using the same cells and a modern method of control—either the ampere-hour meter or the constant potential—we cut down that frequency to once in seven months. In that case the loss of order was due to charging. I don't think you can give a general answer to that question.

Mr. Jones: May I ask further if there is any particular reason why in isolated lighting plants the battery should be in close proximity to the generating seat? I have wondered if it wouldn't be desirable to put the generating seat in such a place as a tool room or shop, and put the battery in the basement of the residence where it would have the more uniform temperature?

Mr. Beck: I should think the regulation would be better the nearer the battery is to the center of use.

Mr. Kielholtz:[1] I think the main reason is so there will be very little drop between the plant and battery.

Mr. Beck: Wouldn't you rather have the drop between your battery and lights?

Mr. Kielholtz: They usually put them right together.

Question: Is it advantageous to tie the bottom part of the plates in automobile batteries where there is more or less vibration, and wear the surface apart on the engine?

Mr. Beck: I don't know whether I get your point—as to what kind of service?

Question: In automobile batteries for starting and lighting.

Mr. Beck: I would say for any type of service where there is motion—vibration—the more carefully the plates are anchored, the better it is, other things being equal. We have a case of that right now. We have been developing batteries for tractor service, and on account of the vibration in that service we have had to go to extremes in the direction of anchoring those plates inside the cell in order to avoid that motion which will gradually work through wood.

Question: You speak of the motion of the plates against one another. I meant the motion in the other direction—right angles to the plate.

Mr. Beck: I question whether there would be any in a normal cell if it is assembled right. In regard to the wearing, in our practice those cells fit pretty closely. I don't think you would run into much side motion, but you do sometimes run into vertical motion which causes a wearing of the wood separator. If there is any method of anchoring it more perfectly, it would be a good thing.

Mr. Shedd:[2] I would like to ask Mr. Beck whether, in handling farm lighting plants, he would recommend discharging the battery

[1] Domestic Engineering Company, Dayton, Ohio.

[2] Department of Agricultural Engineering, Iowa State College, Ames, Iowa.

to the normal discharge point before recharging, or if it would be as well or better to discharge at more frequent intervals?

MR. BECK: I will have to answer that with an "if." That depends on your method of control. It used to be considered that the life of the pasted plate was the number of charges irrespective of how complete the discharges had been. That was not strictly true. The fact on which it was based was that those charges were gassing charges, and it is the gassing which largely causes the wear on a paste plate. Now with other methods of control which we are using very extensively, we charge a battery as often as we please, but we don't gas it every time. That makes it possible to charge it often without any injury at all from extra number of charges. In other words, it comes right back to what method of charging is used. If one uses a method of cut-off which results in gassing every charge, then follow the old practice.

MR. DICKINSON: Mr. Beck, did I understand you to say that with the heavy patent we could expect a 10-year life?

MR. BECK: I divided the life into two kinds—time life and working life—and I said it was very easy to make a plate with a grid that would give a time life of 10 years. Actual working life depends on the amount of work, and that is a question of ampere hours. A simple illustration is these little thin plates that are used in automobile starting service. Those plates have such a light grid that even if they were not used at all they would fall to pieces in a few years, on account of being so light. On the other hand, it is possible to make grids that can be used 10 years. So, from the standpoint of time life, there is no handicap to the paste plate.

MR. DICKINSON: What do you think would be a fair assumption as to life?

MR. BECK: That is a good deal like asking the life of a piece of string. We have our own figures which are based on the amount of work the battery does, or I can give you a pretty good general average. Our own figures are based on complete discharges, which you must understand the average farm seldom gets, so these are not altogether definite. If the paste plate were given a complete discharge each day, 365 days a year, we would only figure on between one and two years' life. To increase that life with that plate which has a longer time life, it would be necessary to put in a bigger cell. With paste plates one can put in twice as big a cell as in the other plate. We figure on one discharge per week with that cell at from 3 to 5 years' life.

MR. DICKINSON: A conservative figure would be six hundred complete cycle.

MR. BECK: Four to six hundred complete cycle in ampere hours.

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MR. DICKINSON: A conservative figure would be six hundred complete cycle.

MR. BECK: Four to six hundred complete cycle in ampere hours.

MR. DICKINSON: I have heard the statement made that you might expect a thousand.

MR. BECK: You might probably get a thousand but not if you run them down to the limit. It is quite remarkable how uniformly the cells come out in ampere-hour discharge life.

MR. DICKINSON: Five hundred is an average?

MR. BECK: Yes, complete discharges, equivalent ampere hours.

MR. F. E. HAND:[1] Are the gas cells practically universal in farm lighting service, and is there any reason to think that the rubber battery cell would not be practical?

MR. BECK: The rubber battery cell is perfectly practical. The glass jar's popularity started on account of the fact that it could be assembled, charged and shipped ready for service. They have practically taken the place of the rubber, because rubber is more expensive and is no better. I think today you can practically consider the glass jar as standard.

MR. GILBERT:[2] Regarding a farm lighting system, I should like to ask if it seriously shortens the life of the battery—for example, in a sixteen-cell battery—if you disconnect three of the cells and attach the ordinary storage battery to them, providing the gravity of the lighting battery was down approximately where the storage battery of the automobile was. Could you use it for charging in that way?

MR. BECK: You mean cutting out three of the regular cells and putting the service with the remainder?

MR. GILBERT: How do you charge the three regular cells?

MR. BECK: I wouldn't say it would be very good for those three cells. It has no effect on the rest of the battery.

MR. DICKINSON: I would like to ask one other question. Perhaps Mr. Fowler would be the best man to answer it. What is the attitude of the farmer when you try to sell him a large capacity battery?

MR. FOWLER:[3] I would say that our sales at Rockford run practically 95 percent of the large battery. So far as I am concerned, I will not sell a small battery to the farmer where I know he needs a large one. I would rather lose the sale than have the trouble of satisfying him afterward.

MR. DICKINSON: Does it take much argument?

MR. FOWLER: I say to him, "If you can afford to have the lighting plant, you can afford to have the right one. A difference of $70 in the price of the battery isn't going to prevent him from having the right plant. I never have any trouble at all. When you get down to the point of the close, the matter is left absolutely to the salesman. As a matter of fact, the salesman is the responsi-

[1] Vulcan Plow Company.
[2] Chief Engineer, Rock Island Plow Company, Rock Island, Ill.
[3] Delco Light Company, Rockford, Ill.

ble party. The farmer is at his mercy for the proper installation of a farm lighting battery. The farmer doesn't know how to put those wires in right, or how to set up the battery. To answer Mr. Dickinson's question, I usually draw an analogy—show the farmer that he can build a small fire in a large furnace, but he can't build a large fire in a small furnace. We know absolutely after the man has installed his plant he is going to have a washing machine, water system, milking motor, utility motor or some other thing, so it is only a question of saving yourself trouble in selling the proper sized battery to begin with.

I think a proper sized battery for a farm home should be one which would not have to be charged oftener than 5 days to a week. In our experience we are getting the best results out of that kind of installation.

It is also a matter of properly instructing the user on how to use his plant so as to get the best use out of his battery. For instance, in the use of the Delco system, where it is possible to take your immediate load directly from the generator and store the surplus in the batteries, we recommend that the charging be done on Monday morning, at which time the motor on the washing machine is running and the motor on the automatic electric pump is in operation, so that the load for pumping and operating the washing machine comes directly from the generator, and the surplus which is made goes into the battery. Then we recommend that the engine be stopped at the end of the operation and the charge finished on Tuesday when the ironing is in process. We find in the operation of the electric iron, that the iron is connected about half the time during the ironing process; during the other half, the full charge is going to the battery. Therefore, by taking into consideration efficiency we get 15 percent more out of our kerosene by taking our big loads direct from the generator and save the operating of the battery on our heavy power loads. We have such a case as that where the large sized battery has been in operation now going on the fourth year, and shows very little signs of use.

GOOD ENGINEERING NECESSARY TO SUCCESS OF FARM LIGHTING

EVAN J. EDWARDS,[1] Member Amer. Soc. A. E.

The feasibility of extending the advantages of electric service beyond the reach of the central station lines has been recognized for some years, ever since the tungsten filament lamp became a commercial reality. Long before that time the small individual plant was a possibility, but on account of the large quantity of energy necessary to supply lighting at that time the cost of generating and storing was too high to allow of any considerable development of the business. It is not the high efficiency lamp alone, however, that has brought the modern electric lighting plant to the farm. The attitude of mind of the farmer has considerably changed during the past 10 years, and he has prospered in his business and is able now to buy the things he wants. If any one group of people has more completely adopted the automobile than any other, it is the farmer. This fact indicates that he no longer avoids buying something useful because of a fear of its complication of mechanism. The fact that he has been able to keep an automobile running has naturally given him confidence in the simpler mechanism of the electric lighting plant and his ability to operate it. The present importance of farm lighting, therefore, is the result of engineering development and of changed conditions which happen to be favorable.

Farming, particularly in the middle west, has come to be considered a business worthy of the best business methods and engineering, and expenditures for automobiles, farm lighting plants, and the like are no longer looked upon as luxuries to be indulged in only at the time of unusual prosperity. Such things are now considered as legitimate investments in the business which will render a proper return on the money invested and the cost of operation and maintenance. At the present time there are, no doubt, something like 100,000 of these small lighting plants in use in this country, and these plants, together with wiring and accessories, represent an investment approaching $100,000,000. If this field can be judged by another—the automobile, which seems quite parallel—there exists a potential market for around 3,000,000 plants, or an investment which runs into figures we scarcely even heard of before the time of the great world conflict. I believe the above figures are of interest in this introduction as establishing the importance of good engineering in the design and the installation of the farm lighting plant.

In this field, as in all others, there have been differences of engi-

[1] Electrical Engineer, National Lamp Works of General Electric Co.

neering opinion. Fortunately, the lack of uniformity in the fundamentals of design has not persisted, and already a fair degree of standardization has been accomplished. It has become generally recognized that it is impracticable to attempt to cover all the power requirements as well as lighting, and the plants are designed primarily for the lighting and the smaller power work. Good engineering calls for a plant permanently installed in a fixed position where no other work can interfere with its primary function of supplying charging current for the batteries. It consists of an internal combustion engine, direct current generator, a storage battery of 16 lead cells or 24 nickel iron cells, and suitable switching and control apparatus. In all its electrical essentials it is similar to the electrical equipment of the automobile, but is not hampered by limited space, and does not have to be made to withstand road shocks and dirt.

The average farm place needs around 15,000 candlepower hours per month, or to speak in less well known, but more accurate terms, 150,000 lumen-hours per month. This quantity of light with present day lamps can be produced with about 15 kilowatt hours of electrical energy. A 30-volt 80-ampere hour battery is capable of storing nearly 2½ kilowatt hours, which, according to the above figures, is a several days' supply. Such a battery is not prohibitively expensive to buy or overly burdensome to care for, and the plant capacity necessary to properly charge it can be as little as half a kilowatt.

It might have been concluded from the fact that all the elements of the small electric plant, engines, generators, batteries, and switching apparatus were already at hand at the time of the appearance of the tungsten filament lamp, that this new field would have developed immediately and spontaneously. There was, however, further development to be done on each of the component parts, and many general and engineering features to be determined. The size of units, voltage of operation, detailed method of control, standards to follow in installation, and proper instructions as to care and maintenance were all things which had to be determined, and the progress of electric lighting for the farm has depended, and will depend more than anything else on how well this engineering is done. Considerable credit is due the pioneer enterprises which solved many of the engineering questions, and risked much in painstaking development.

One of the most important engineering points for decision was the voltage. The standard 115 volts of the central station offered many advantages, such as ease of transmission and the availability of 115-volt lamps and other devices. It has the disadvantage of high investment in storage batteries and tedious work in their proper maintenance. These disadvantages were too formidable to accept, and a compromise of 30 volts was reached. That it was a good compromise is evidenced by the fact that there are few engineers now who claim that a lower or higher voltage would have been better. Many individual cases, no doubt, seem to call for lower or higher voltages, but with the present day recognition of the value of exact standardization, the average must determine the selection for the large production plant. A storage battery of 16 lead cells gives an open circuit voltage of 32 volts throughout its normal period of discharge. When delivering current at values within its usual range of use the terminal voltage will range between 30 and 32. In these installations it is entirely feasible to hold the maximum drop in the wiring to two volts. It will be seen, therefore, that the switchboard voltage will range between 30 and 32, depending on the condition of charge of the battery and the rate at which current is being drawn. The nominal voltage is, therefore, usually given as 30, and the incandescent lamps are rated 28-32, meaning that they are designed to operate on these systems, which by their nature may be expected to supply voltage varying within these limits. In this respect we have another similarity to the case of the automobile, where the lamps are rated 6-8 volts for three lead cell generator systems. Standardization of 30 volts for farm lighting has already resulted in availability of standard product lamps in sizes ranging from 5 to 100 watts, as well as practically all other household appliances, such as irons, washing machines, and vacuum cleaners.

It must be admitted that the standards of voltage regulation are based entirely on the performance which can be obtained from the lead battery. With the nickel-iron type of battery it is not possible to meet this standard, at least not without using extra cells and an automatic auxiliary regulating device of some kind. It is sometimes claimed unnecessary to provide a plant on a farm which will give a voltage regulation as close as holding between 28 and 32 volts. In this connection it may be interesting to note the relation between candlepower and voltage as applied to the Mazda lamp, shown in Fig. 1. The best regulation is none too good, provided that it can be obtained without undue cost and the limits given above represent at least the writer's conclusion as to the best compromise between the two opposing factors.

There are two phases of regulation which are sometimes confused. One is holding the range of variation of voltage with load and condition of charge to a proper value, and the other is providing the proper average value to meet a uniform rating for all lamps and other devices. In the first is involved the size and characteristics of the battery and the size of wire to be used in the installation, and in the second the number of cells to be used. At first 15 cells of lead battery were used to supply 30-volt lamps and apparatus, but was found to be unsatisfactory because nothing had been allowed for internal drop in the battery and for drop in the wiring. While 16 cells has practically become standard, there is now and again a manufacturer who resists the established standard and insists on putting out 15-cell equipment.

The higher voltage of a battery under charge has been a question taken perhaps too seriously by manufacturers, and many undesirable methods of controlling the load voltage under charge have appeared. The first method consisted of the use of counter cells which opposed the generator voltage in the load circuit. Considering the small proportion of lamp use during time of charge, the cost, trouble in the care of counter cells and the extra switch-

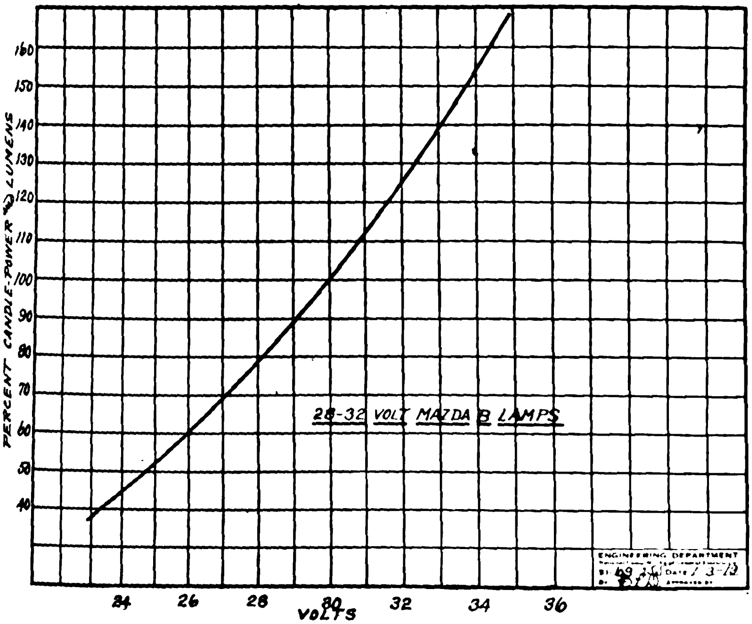


Fig. 1

ing required are certainly not justified in the average case, which is the only one under discussion. Another method at present used is the connecting of the load through a series field winding which opposes the shunt winding on the generator. This seems like poor engineering, for at light loads when voltage reduction is most needed the method is least effective. The relay method of connecting the load across a reduced number of cells during charge can be made to work effectively, but has the disadvantage that complicated switching mechanism is required and that any considerable use of lights during time of charge results in an unbalanced charge condition of the batteries. Here is a case where no solution appears to be the solution for in the average case the load is not on at all unless it is on in sufficient amount to, in itself, hold down the voltage by absorbing the capacity of the generator. The most common case is in the use of a flat iron where it is always best to run the engine if the use is to be continued for more than a very short time.

There are many other features of design which should receive attention from engineers who are in a position to exert an influence on the progress of the business. There seems to be an unnecessary variation in mechanical design, in meter equipment, in methods of control and in general form and appearance. Some variation is, no doubt, necessary and desirable, but those who have observed progress in other lines have noted an inevitable coming together toward a standard not only in fundamental engineering, but also in general appearance. At the present time no automobile manufacturer would adopt a side chain drive or locate a gas engine on the running gear even though he might have an individual opinion favoring these things. Another example in point is the familiar incandescent lamp which now has exactly the same kind of a base and frequently exactly the same form and external appearance for all manufacturers where one time each manufacturer considered it to his advantage to put on his own special base and to depart as far as possible from the general form of lamp produced by another manufacturer.

Not all engineers recognize the value of standard and uniform methods of rating. A case in point which I consider very regrettable is that of plant and battery rating by farm lighting plant manufacturers. The actual number of ampere hours for a given battery are less at higher rates and greater at lower rates and differ somewhat at any given rate, depending on the intermittency of the discharge. These are facts which affect the actual output of the battery depending on the conditions of use. The battery rating should be something for a standard condition of use, and the manufacturer should not be compelled to choose his own basis of rating each one bringing the standard to fit that condition which he considers the nearest approach to the actual in his specialized case and with the natural desire to have an advantageous rating as compared with other manufacturers. Battery capacities can no longer be recognized in the catalogue of the manufacturer. One manufacturer may assume that a given capacity battery will deliver 95 ampere hours under the intermittent service and so rate it; another manufacturer may have a different idea and rate it at 100 ampere-hours; still another may decide that merely in order to go the others one better he will call it 110 ampere-hours. An ampere-hour as a unit means little to the farmer except as he connects it up with lamp and other load operation in his experience in using the plant, and surely the measure which he learns by experience should not depend on an individual manufacturer's idea as to how a battery should be rated. There was more excuse for the situation which resulted in a competition among arc lamp manufacturers years ago when they rated arc lamps up in the thousands of candle-power, because they had no means at hand for measurement, and there were no standards committees of technical societies to establish standard practice in methods and units of rating.

It is desirable to recognize from an engineering standpoint the

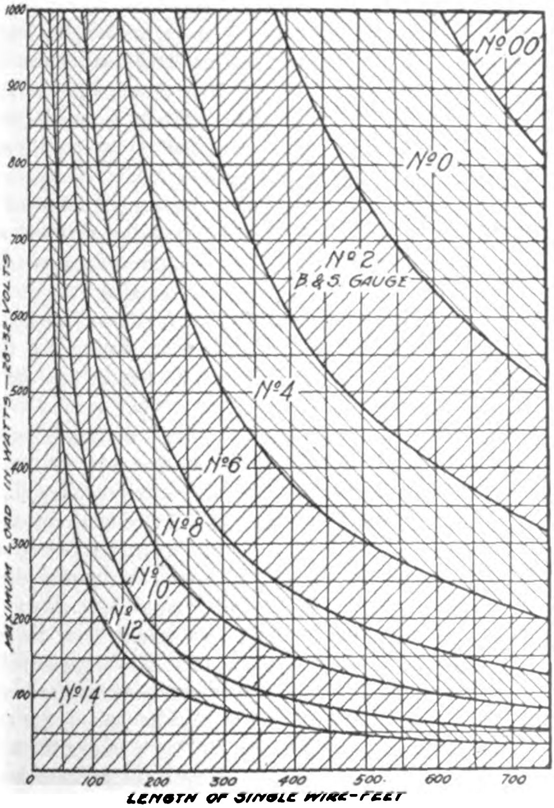


Fig. 2. Chart for obtaining copper wire size (B & S gauge) for 28-32 volt circuits. Wire length to be used is twice the wiring distance between points

proper field for the farm lighting plant. Their plants are usually referred to as lighting and power plants, and sometimes as power and lighting plants. From the standpoint of good engineering they are primarily lighting plants, because they can only be justified on that basis. It is not good engineering to handle the heavy power work of the farm by means of electric motors supplied by generating equipment located on the premises. These plants are most useful for lighting, but are incidentally and to good advantage used for small power work where the consumption of any single motor is a small fraction of output of this plant.

It is often claimed that the farm lighting plant can compete with central station service. It seems clear that the small lighting plant cannot be expected to compete in price with good central station service where the connections can be made without unusual transmission costs, yet the small plant manufacturer often gives the impression that his plant will supply lighting for less money and in showing his figures he neglects to mention a few such items as interest and depreciation and battery and lamp renewal costs. It should, however, not be necessary to compare costs because undoubtedly the convenience of electric lighting is worth considerably more than the central station has to get for it and it is entirely proper that the user of the farm lighting plant should recognize that because of his particular location it is necessary for him to pay more per unit of output for a valuable service than somebody else who is more favorably located. Where comparative costs are under discussion all the items of cost should be included.

There should be a high standard of installation. Good engineering calls for a solid foundation for the machinery and that the batteries be located in a clean place which can be well lighted at times of inspection.

Probably the most important feature of installation is the wiring. Unless the wiring plans have received some engineering attention there is very little chance of avoiding excessive voltage drops in some circuits. The usual wiring tables of current carrying capacity are entirely insufficient for this work. A standard limit for voltage drop should be recognized and the wiring should be put in to meet that requirement. The wiring chart shown in Fig. 2 is an attempt to put in the most convenient form the voltage drop limit requirement of proper wiring for 30-volt systems. This chart is based on a drop of one volt for average load and the assumption that the maximum circuit load is double the average. In other words, the wire size chosen will give under the most unfavorable circumstances a two-volt drop. This chart has been placed in the hands of several thousand people who are connected with the farm lighting business and has proven to be a considerable help in insuring proper wiring. It will readily be seen that for any load up to 1,000 watts and for any length of single wire in the circuit up to 750 feet that the wire size can be read directly. For larger loads and shorter distances or for greater distances and smaller loads the chart can still be used by first taking the product of load and distance and then redividing it into two factors which will bring both on the chart. An example in point would be that of a barn 400 feet from the plant located in the basement of the house, when the maximum expected load would be five 20-watt lamps, 100 watts, allowing for vertical runs at the ends 1000 feet of wire would be required. The "watt feet" product is 100,000. This can be reduced into the factors 100 and 200, which combination according to the chart, calls for No. 6 wire. The drop will not be the maximum allowance of two volts, because it happens that the intersection of abscissa and ordinate lines comes near the left border of the No. 6 area. This means that with No. 8 wire the two volts limit would be only slightly exceeded and with No. 6 the next obtainable size the maximum load drop would be reduced to about 1.5 volts.

A feature of installation of first importance is the application of good illumination engineering to the location of the outlets and the choice of fixtures and glassware. It is a mistake to assume that the farmer will be permanently satisfied with drop cords and key sockets, even though at first he might seem to be. The cheap installation is not good engineering and it is not good business. The farmer will have lasting satisfaction only in an installation fully up to city standards. Unless he is given convenient switches and extra baseboard outlets he cannot enjoy all the benefits which are inherent in electric lighting, and it costs little more as a percentage of the total to do the job right.

Fixtures and glassware are important considerations. The fixtures can be very simple and yet well suited to their work. There should be glassware in the house fixtures and it should be such as to accomplish the elimination of glare and the redistribution of light. The farmer in his experience with coal oil lamps may not recognize the undesirability of having bright sources in the ordinary angles of vision. He may even be inclined to judge the value of a light source by its brightness rather than by the resulting illumination on the objects he desires to see. Nevertheless, if glare in the installation is avoided by proper equipment, he will not be long in recognizing the effectiveness of his investment. In the outbuildings of the farm bare lamps are not particularly objectionable, but certainly in the main rooms of the house reflectors should be provided.

No argument is necessary to establish the necessity of applying good engineering to the farm lighting business. The better the engineering and the more effectively applied, the greater will be the success of the manufacturers and the satisfaction of the user. I suggest that this organization give consideration to the opportunity to render a most useful further service in hastening their efforts toward standardization of this engineering practice and assisting in its application in the field. The manufacturers' part, it seems to me, is to be willing to take common council with other manufacturers, with technical societies such as this, and with the engineers of allied interests, and then to seriously strive through the medium of their instruction books and their men in the field to keep the business going along in accordance with the best established uniform engineering practice.

WHAT CAN THE AGRICULTURAL ENGINEER DO TOWARD THE REEDUCATION OF WOUNDED SOLDIERS?[1]

By J. B. Davidson,[2] Member Amer. Soc. A. E.

1. The great war has emphasized the usefulness of the trained man and revealed his advantage over the untrained man. This is sure to result, first: in an increased demand for training upon the part of the returned soldier, and second: in a call for a revision of courses and methods of training which will give results comparing favorably with those obtained in the intensive war training courses. The war has demonstrated the effectiveness of the thoroughly well trained man. The West Pointer for instance, has been the backbone of our military effort. At the same time, the effectiveness of having men specially trained for special tasks, like those trained in the technical training detachments, has been fully demonstrated. It is to be expected that the demand for training from returned soldiers will likewise be along two general lines, namely, thorough training for the profession, and short intensive training for special tasks or vocations.

2. It is not known at the time of the preparation of this paper how many of these returned soldiers will want an agricultural education. There is a wide difference of opinion in regard to what to expect. There are a number of educators who think that there will be a large number of soldiers who will take this opportunity to heed "the call of the land." They argue that there was a large number of men in business and other industries who have wanted to take up farming but could not arrange to make the change. Now having been drawn into the army, away from their former occupations, they are free to enter into an agricultural pursuit. In addition, the outdoor experience of the soldier will cause him to hesitate to take up sedentary occupations again. There are other educators who do not expect any unusual demands for agricultural training, and such increase in agricultural students will be only that due to the general increase in the total number of students.

3. This paper has to do primarily with the training of wounded soldiers. The United States Congress on June 27, 1918, voted a very liberal policy toward the disabled soldiers and sailors. At that time $2,000,000 was voted for the particular purpose of the training or retraining of disabled soldiers and sailors, and the work was put under the general direction of the Federal Board for Vocational Education. The plans of this Board seem to contemplate

[1] Paper read by C. K. Shedd.
[2] Department of Agricultural Engineering, University of California.

training in almost every conceivable line of work that any disabled soldier may care to enter, and it is the policy of the Federal Board to provide for the entire expense of travel, tuition, board, lodging and all other necessary expenses of those taking the courses of training.

4. A recent publication of the Federal Board of Vocational Education (Monograph No. 4), published since the signing of the armistice estimates the total number of wounded soldiers and sailors at 100,000 men, of which four out of five, or 80,000, will be returned to their former occupations with their wounds fully healed or their disease fully cured. Of the remaining 20,000, one-half, or 10,000, will be unable, because of a serious handicap which injury or disease has brought to them, to follow any occupation with any degree of success, and hence must be considered permanent wards of the nation. The remaining 10,000 will not be able to follow their old occupations and must be trained for a new one. Some pre-vocational training is to be given the disabled soldiers before they are discharged from the hospitals, but this training will be under the direction of the War and Navy Departments.

5. It seems to be the policy of the Federal Board to utilize existing educational institutions as far as possible, both public and private. All manner of methods are to be used, inasmuch as the plans contemplate training in all manner of trades and vocations.

6. The principal interest of the agricultural engineer will no doubt be in the agricultural courses of training, where various agricultural engineering subjects will make up a part of the course. There are, however, several agricultural engineering courses such as gas engine, tractor and farm machinery courses which have been given considerable prominence. The courses which have a considerable amount of practice work connected with them seem to be the best suited, as the wounded men are not able in the majority of cases to concentrate on work requiring close mental application.

7. It will be of interest to determine what other countries are doing along the line of agricultural engineering in the training of wounded soldiers. The following is an extract from Bulletin 15, Federal Board of Vocational Education, concerning conditions in France:

> Farm mechanics, or the use and repair of tractors and other agricultural machinery, is taught in a number of the schools, and probably even greater emphasis will be laid on this work in the future. In order to make up in part for the alarming shortage of hands, the Government is putting forth every effort to turn the French peasant from his old-fashioned methods of farming and to induce him to use modern labor-saving machinery. Large numbers of tractors are being im-

ported from America, and every machine introduced makes a demand for a man who can run and repair it.

The first course in farm mechanics was started by Dr. Bourrillon at the National Institute at Saint-Maurice, when that school was organized in April, 1915. It is now taught in eight agricultural schools in the provinces, and in the Maison du soldat du XIII Arrondissement in Paris. At Saint-Maurice, the course is from five to six months long, and gives to the pupils a thorough understanding of the gasoline and electric motors used in stationary and tractor engines for farm use. It includes some turning, forge work, soldering, etc., in order that men engaged to run such machines in remote country districts shall be able to make all repairs and even to replace parts when necessary. At the Maison du soldat, the course lasts three months, at Ondes two months, Inasmuch as the wages paid to skilled men are much higher than those which ordinary farm laborers receive—equalling, indeed, those in the city industries—there is no difficulty in recruiting pupils for these courses.

8. Canadian schools have been called upon to train wounded soldiers for some time. Professor A. R. Gregg, on November 14th of this year, reported 300 returned soldiers at the University of Saskatchewan, of which 250 were taking instruction in the Department of Agricultural Engineering. In a prospectus, the following courses are described:

Farm Motors	4 months course
Motor Mechanics	6 months course
Farm Machinery	2 months course
Steam Engineering	6 months course
Machine Shop Practice	12 months course

9. The time in the farm motor course is distributed as follows:
Farm Motors (18 weeks)

Mathematics	54 hours
Farm Machinery	54 hours
Electricity and Ignition	108 hours
Gas Engines	108 hours
Practical work	315 hours

The practical work is described as follows:

PRACTICAL WORK ($17\frac{1}{2}$ HOURS PER WEEK)

Practical work is performed every afternoon except Saturday from 1:30 to 5:00 P. M. In addition to the laboratory and field work already outlined, the student gets practical instruction in valve grinding, babbitting, scraping of bearings, renewal of piston rings, soldering, pipe fitting, gaskets and packing renewals, pumps (their care and operation), adjustment of gears, gear ratios, tractor frames, steering gears, road wheels, differential gears, steering and lining up, disking and other field work, belt work and belt horse power trials.

10. Professor Gregg states that the students at Saskatchewan have performed considerable practical work. For instance, "this year the returned soldiers plowed 519 acres, cut with a binder 180 acres, disked 157 acres, graded 20 miles of road and threshed 12,857 bushels of grain." Professor Gregg further writes: "We have had a number of cases of men who have lost an arm or a leg, one case in particular being very successful. The left arm was amputated 4 inches from the shoulder. After completing his 4 months training with us he was given a tractor. On July 1st we put a speedometer on the tractor and since that date it has gone over 800 miles. He made daily about 20 to 25 miles. He is away at the present time getting his artificial arm but at the end of last week he told us that he had run 22 miles on 10 gallons of kerosene."

11. Professor L. J. Smith reports that the Manitoba Agricultural College receives the soldiers discharged from the military hospital in Winnipeg and who elect to take the agricultural courses for their re-educational work. The Manitoba course is a 4-months' course, of which 2 months are devoted almost entirely to agricultural engineering work. Professor Smith states, "the reason for such a large proportion of time is that it was thought that many men who are partially disabled could, by means of learning to operate tractors and farm machinery, be better equipped to go back to the farm or take up farming as their new vocation."

12. Professor Smith makes the following comment on the work: "We find our work with returned soldiers very interesting, but in many ways, rather difficult. In the first place, those admitted have no uniform standard of previous education. This makes our lecture work rather difficult to handle. Then, too, the fact that they are more or less disabled makes attendance rather uncertain. We found it necessary to have more instructors for returned soldiers than for our regular work."

13. It appears that the responsibility of the agricultural engineer in connection with the education of the wounded soldier consists in providing short courses independent of or perhaps more generally in conjunction with other branches of instruction. These courses will be planned to train the soldier to take up some special branch of agricultural work, and no doubt practice with agricultural machinery and equipment will make up the most important. For those returned soldiers who want a long course, no particular change in method or term is required or desired.

Reports of Committees

REPORT OF THE COMMITTEE ON FARM BUILDING EQUIPMENT

M. A. R. KELLEY, Chairman, W. D. JAMES, E. B. MARSH

MR. KELLEY: The work of the Farm Building Committee is divided into three sections, consisting of a uniform standard manger for dairy barns, a rating for litter carriers, and the use of water bowls. The committee investigated the thirty-five barn equipments catalogued very thoroughly, and also corresponded considerably with the various companies.

In regard to the use of water bowls in dairy farms, we sent out 400 circular letters to farmers with a list of questions—about 19 questions. I won't give them all because it is not necessary in the short time we have. They will be included in the report. I will abbreviate them.

I want to take up first the matter of the standard manger.

Acknowledgment must be made to Mr. James for the many good suggestions aiding us to outline the work of the committee. Unfortunately he was unable to continue his work with the committee, due to the stress of war work and the influenza epidemic.

Credit must also be given Mr. Marsh, who assisted in assembling preliminary data on the investigation of sizes of stalls, pens, etc. These data have been tabulated and will assist the committee in completing its investigation on this subject.

We also wish to express our appreciation for the cooperation received from the various manufacturers who furnished us with much information and many good suggestions.

The work of your committee was divided into three parts:

(1.) Study of mangers leading to the standardization of the same. (2.) Study of capacity rating for litter carriers and the need of uniform rating. (3.) Investigation of the use of water bowls in dairy barns.

STANDARD FORMS OF MANGERS

There are now 35 manufacturers of barn equipment in this country and almost as many different manger forms. A few have fairly definite specifications, while some signify their willingness to supply equipment for any manger.

Each manufacturer has endeavored to obtain a manger just a little different from his competitor. This is further augmented by the fact that the Portland Cement Association, lumber associations, Government and experiment station workers, in order to avoid showing partiality, have developed mangers of their own. This results in a large number of unnecessary mangers, which are essentially the same but different in minor details.

Standardization must depend upon its merits and the cooperation of interested parties in order to meet with success. No amount of legislation will be able to force standardization without merits. Legislation has signally failed to force the adoption of the metric system, while on the other hand we need only mention the success which followed the voluntary adoption of standards for automobile parts.

Your committee would hesitate to recommend the adoption of the following, had it not found after a careful study of the existing mangers that the better forms are so nearly alike that there is no real excuse for not adopting a standard.

The proposed manger represents an average of the better forms which have been used successfully for years. It does not represent any one existing manger and contains the points of merit of them all. There is a need for such a standard, and the advantage of its adoption will be pointed out in the following paragraphs.

Successful dairymen seem to agree that in order to get the best results, cows must be fed separately. This necessitates the use of manger divisions. Lack of space will not permit us to discuss the merits of the manger division. There is still room for improvement in these, however, and the standardization of mangers will materially aid in their improvement.

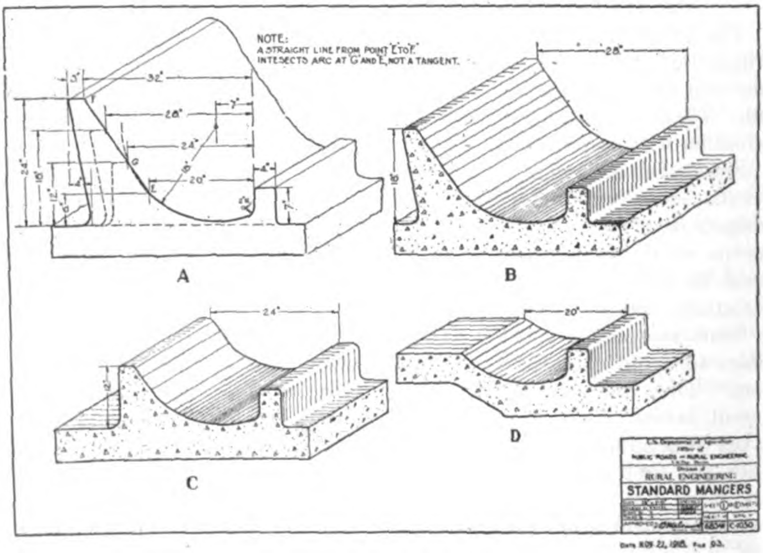
Some companies furnish manger templets to their customers in order to avoid chances of mismeasurement and to aid in construction. They are prepared to furnish templets for each of their different forms of mangers. Shipping clerks have often made mistakes by sending the wrong set. If manger divisions are purchased with the first order the chances of such mistakes are minimized and more easily rectified. If, however, the divisions are purchased in a subsequent order then there is cause for much misunderstanding and in some cases, hard feelings when the divisions don't fit. Such mistakes may cause serious delays in construction. Who pays the freight in making the changes?

The proposed manger forms permit the dairyman to select any of the four sizes of mangers in order to best meet his requirements. The builder is able to build any one of them with one set of manger templets and upon adoption of this standard, he will be able to build barns for any equipment without having special templets for each one. The results are that the contractor is able to use better forms and do better work.

ESSENTIALS OF A GOOD MANGER

1. All corners should be rounded to facilitate cleaning.
2. Should be free from cracks and crevices.
3. Surface of manger should be smooth.

4. Continuous mangers are preferable; easier to clean; easier to construct.
5. Mangers should have drains with sufficient slope to drain well. Slope of 1½″ to 2″ in 100 feet. Drains to clean easily.
6. Concrete manger divisions are not desirable, as there are too many corners to keep clean..
7. Manger divisions removable or hinged to aid in cleaning.
8. Width of manger should not be less than 24″, and preferably 30″ or 32″.
9. Bottom of manger 1″ to 2″ higher than platform on which cow stands.



10. Curb never less than 6″ higher than bottom of manger.
11. Width of curb may be 4″ if not over 7″ high, 5″ or more wide if built up curb is used and 6″ wide when supporting columns come in stanchion line.
12. Footings for wood post should not form corners in mangers.
13. Height of manger front preferably 24″ and never over 30″.
14. Curved manger bottoms concentrate feed and save water when used for watering.

It will readily be seen that the proposed standard manger fulfills all the requirements as stated above. Furthermore, as stated by one manufacturer, "We believe that it ought to meet the requirements of every dairy farmer." Another, upon the examination of a blueprint of the standard manger, stated, "We would recommend the adoption of that standard."

It is not necessary that we discuss at length the construction of this manger, as the accompanying diagram shows clearly how the manger is to be laid out. We wish, however, to call attention to a few points which may be overlooked.

You will note that the front of the manger does not rise perpendicularly, but slopes back 4″ in 24″. This not only saves concrete in construction, but also gives clearance to the wheels of a floor feed truck so that it may run closer to the manger.

Line E F is a straight line, not tangent to the arc of the circle, but intersecting it at points E and G. This gives uniform slope for all mangers, and enables the use of one templet for the different sizes, A B C or D.

The center of the circle describing an arc which forms the bottom of the manger is found by using the point E as a center, and with a radius of 18″ describing an arc intersecting a vertical line drawn 7″ from the inner face of the curb.

Manger D contains the basic curve upon which all the others are formed. The relation of these mangers is shown in Fig. A.

Manger A is the preferable form to use. However, in some cases one of the others may be selected, such as in the remodelling of an old barn. Either the raised or level feed alley may be used as preferred. Mangers C and D should be used with the raised feed alley only.

In submitting this manger the committee has avoided showing any partiality, and has kept uppermost the point of utility and service. This standard manger represents an average of the better forms now in use.

In brief, summation of the advantages in the adoption of such a standard are as follows:

ADVANTAGES TO MANUFACTURERS:

1. Permits the use of one manger templet for all.
2. Eliminates mistakes in sending wrong templets.
3. Diminishes mistakes in construction and lessens misunderstandings.
4. Permits the use of the same manger division in all mangers.
5. Permits the standardization and perfection of manger divisions.
6. Lowering the cost of production of the same.

ADVANTAGES TO FARMERS AND OTHERS

1. Gives definite measurements which are necessary for proper construction.
2. Dairymen still have a choice of mangers to meet conditions.
3. Meets the necessary requirements and eliminates the confusion of large numbers.
4. Enables contractors to use one set of forms and better forms.

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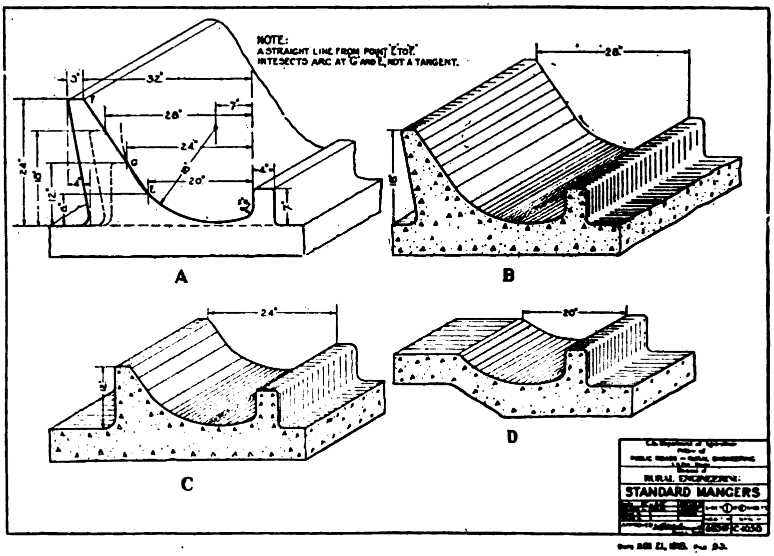

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1. Gives definite measurements which are necessary for proper construction.
2. Dairymen still have a choice of mangers to meet conditions.
3. Meets the necessary requirements and eliminates the confusion of large numbers.
4. Enables contractors to use one set of forms and better forms.

5. Cement and lumber associations, architects and the government can make specifications without discriminating against equipment manufacturers.
6. Aids in the instruction of students in schools and colleges.
7. Ultimately lowers the cost of construction.

We are entering into a period of reconstruction and advanced activities in all manufacturing. Present conditions are in favor of the adoption at this time of such a standard. Stocks are low, hence there will be less loss in this respect. Many manufacturers for various reasons have hesitated to issue new catalogues during the war period, and such changes could be easily incorporated in their new catalogues.

The manufacturers are ready and willing to cooperate with us at this time. As stated by one manufacturer, "The standardization of mangers is a very good thing, and we will assure you of our hearty cooperation along standardization as applied to the installation of our equipment."

Other abstracts of letters from manufacturers read at this time.

DISCUSSION

Mr. Kaiser: I should like to ask Mr. Kelley why he has the curve 7 inches high in the form number?

Mr. Kelley: On that side of 7 inches eventually the drop will make your 8-inch form number. I haven't shown the drop which comes in at all. I tried to cut down the discussion and that is a thing which should be done.

President Scoates: I would like to have a vote on that report. We will consider a motion to adopt that part of the resolution relating to standard forms of mangers.

Mr. Pattie: Mr. President, I am heartily in favor of this and I would therefore move it be adopted as outlined.

Motion seconded and carried.

Mr. Kelley: The next in order is the Uniform Capacity Rating. Owing to lack of time I was not able to take up every factor in this, and I want to secure an opinion on it, not necessarily an adoption, because the work is not entirely finished. We wish to secure the opinion of the men interested as to its value, and have them point out some of the difficulties which we have overlooked.

UNIFORM CAPACITY RATING FOR LITTER CARRIERS

M. A. R. Kelley

Your committee is cognizant of the difficulties of any standardization, and realizes that it is not possible to standardize barn equipment at once. Neither does the committee desire to do this to any undue extent, but believes that the proposed standardizations can be more easily accomplished at this time and will result in a great saving later. Your committee has no "ax to grind" but has based the following recommendations entirely upon the merits of the points in question, and has worked in cooperation with the manufacturers.

There has been an increasing demand for standardization of farm equipment during the past few years, and great progress was made last year. Your committee has found an increasing demand for a uniform rating of litter carriers. One leading agricultural journal very aptly states the situation as follows: "There is but little use in making carriers and boxes an inch or two wider or narrower, or deeper or shallower, of a capacity of a bushel or two more or less, for the sole purpose of having those parts a shade different from every implement made." Manufacturers have seen the need for such a standard, but so far, have been unable to get together and agree upon a common rating. Seventeen manufacturers of litter carriers make 12 different sizes of carriers, ranging from a 4-bushel to a 13-bushel carrier, and no two of these agree in all dimensions for a given capacity. After a careful study of these dimensions we are led to believe that the relation of width to depth and the shape of the carrier are important factors governing the economical construction. There is a certain combination of width and depth which gives the maximum area enclosed within a minimum perimeter. For example: we find that of two boxes each having a perimeter of 60 inches, one 24 inches wide and 22 inches deep has a cross sectional area of 436 square inches, while the other; with dimensions 28 inches by 20 inches, has an area of 480 square inches. Likewise the shape of the box affects the maximum cross sectional area contained within a given perimeter. Your committee did not have sufficient time to investigate this factor hence we are unable to make suggestions in regard to the best size to use for a given capacity. If these dimensions were determined it would lead to the standardization of litter carrier boxes.

We observed in our study that the optimum shape which gives the maximum cross sectional area for a given perimeter is semi-circular in form. It is not, however, a true semi-circle, since the depth of the box is greater than the radius of the circle. The best relation between width and depth is yet to be determined.

On comparison of two carriers of same width and depth, we find that the one with a circular bottom contains 436 square inches of cross sectional area, with a perimeter of 60 inches, while another with a flat bottom has 430 square inches area and a perimeter of 62 inches. Comparing these with a carrier of slightly different width and depth we find that we can secure with the circular form a cross sectional area of 425 square inches with a perimeter of 56 inches. These examples illustrate the possibilities which may be accomplished by a thorough analysis of this factor.

Of the 12 different sizes of carriers manufactured, the sizes range as follows: 4, 4½, 5, 6, 7, 8, 9, 10, 11, 12 and 13 bushels. That there is no need for such a fine graduation of sizes is brought out by the fact that only one manufacturer makes five sizes and the majority make less than three. This shows that all conditions can be met with a fewer number of sizes. One company makes three carriers which vary only one half bushel in capacity. This is clearly added expense which is not necessary. The committee recommends that litter carriers be limited to sizes No. 2, 3, 4, 5, 6 and 7 as shown in accompanying table.

A cable track is limited to a carrier 6 bushels in capacity and provision is made for this in our No. 3 carrier. Our No. 7, of approximately 14 bushels, provides for the maximum sized carrier used on a solid track. It appears that the above six sizes will meet all requirements. While this arrangement provides for the manufacture of six different carriers, it is not necessary for each manufacturer to make this many.

The great need for adopting a uniform rating will be seen in the following table, which shows a variation of 20 percent between the maximum and minimum size of carriers rated at 6 bushels; a variation of 25 percent in the 8-bushel carrier; 32 percent in the 10-bushel size; and 48 percent in the 12-bushel size. The difference shown in cubic inches is only an approximate difference, since it is impossible to secure accurate capacity of carriers without measuring them. However, the percentages shown should be sufficiently accurate for comparison, as all are considered on the same basis.

It is to the credit of the manufacturers that with the exception of one or two cases, carriers as a rule, have been under-rated rather than over-rated. In one case which falls short in capacity, the necessary capacity could easily be obtained by merely changing the form and without the use of additional material, as explained in previous paragraphs.

The need for uniform rating does not lie in the fact that the customer is short weighted, but is due to the wide variation in the sizes for any given capacity. This variation leads to confusion and dissatisfaction.

At the present time manufacturers use six different ways of rating their carriers. Out of the 17 manufacturers, one gives the rating in pounds capacity (700 pounds, 1000 pounds, etc.) This is clearly without merit, as there is too much variation in the weights of various litters. Two companies merely give the dimensions; four state size number (1, 2, 3, etc.) and dimensions; four state size number, dimensions and bushel capacity; and one states size, number and bushel capacity. In summation it will be noted that nine use a size number; fifteen give dimensions; and ten state bushel capacities.

Since the size of litter carrier boxes is not standardized for a given capacity, dimensions should always be given, as they are often very convenient in determining the proper size of doors and width of alleys.

If the size numbers were based on some definite factor in relation to capacity, in place of merely designating relative sizes, it would seem that this would be an ideal method of rating, as uniformity could be easily secured, and once adopted, farmers would soon learn that a certain number designated a definite size. They are accustomed to this method of rating, since wire nails, screws, etc., are all sold according to size number without thought of actual dimensions.

There is no rule in regard to measurement of manure as to whether it shall be considered heaped or stricken measure. The farmer is so familiar with measuring grain in bushels, that when this method is used for rating litter carriers, it leads to confusion. He is accustomed to use 1¼ cubic feet for a bushel of grain, and allows 2½ cubic feet for a bushel of ear corn. Likewise, there is no established rule in regard to whether he shall consider the capacity of his carrier heaped or level. The question then is often one of interpretation.

The densities of litters vary widely, depending upon the amount of bedding used, and no uniform weight per bushel can be established. Hence scales cannot be used as a measure of capacity. There is no standard for heaped bushel, as it varies with the commodities measured and is usually considered 25 percent more than the U. S. standard bushel of dry measure (2150.42 cubic inches.)

Webster defines a bushel as 4 pecks or as 8 gallons. If the gallon measure is used, the capacity will fall short about 14 percent, since the liquid quart (57.75 cubic inches) is less than the dry quart (67.2 cubic inches). There is a need for defining the units to be used, since, as we have seen, there are many interpretations possible. The committee proposes that the level full measurement be used as a basis for rating. If the bushel capacity is desired, then the U. S. bushel of 2150.42 cubic inches should be used. This gives uniformity in size which is very desirable. The following table gives the sizes proposed by your committee which have met with the favor of several companies.

STANDARD RATING FOR LITTER CARRIERS

Size No.	Capacity		Difference		Maximum variation of manufactured carriers	
	Cu. in.	Approx. No. Bu.	Cu. in.	Per Cent	Cu. in.	Percent
2	8000	4 bu. = 8602 cu. in.	600	7.5	......	....
3	12000	6 bu. = 12902 cu. in.	902	7.5	2471	20
4	16000	8 bu. = 17203 cu. in.	1203	7.5	4372	25
5	20000	10 bu. = 21504 cu. in.	1504	7.5	5701	32
6	24000	12 bu. = 25805 cu. in.	1805	7.5	9422	48
7	28000	14 bu. = 30105 cu. in.	2105	7.5	......	....

Column 1 gives the standard size number; column 2, standard capacity in cubic inches; column 3, approximate bushel capacity and cubic inches necessary for full bushel measure; column 4, difference in cubic inches between standard rating and bushel rating; column 5, is the same difference expressed in percent, and shows a remarkable coincidence in that the difference is the same in every case; columns 6 and 7 show maximum variation in capacities between minimum and maximum size of boxes for a given rated capacity as now manufactured.

You will note that there is a constant factor of variation in every case. This is very convenient, inasmuch as the size number may be multiplied by the factor 4000, and the rated capacity in cubic inches secured. The size number may be reduced to approximate bushel capacity by multiplying by 2.

When we consider the slight variation in the dimensions of the carrier necessary to make a difference of 7½ percent, it does not seem unreasonable to allow the carrier to be made this much larger if necessary, in order to use the material economically. This would give us a very uniform rating and within the limit of a reasonable error.

The proposed rating permits the manufacturer to use the bushel capacity rating if he thinks it necessary. However, the committee recommends that its use be discontinued, as it leads to confusion and many misunderstandings. That the farmers do not consider it necessary is shown by the replies received from forty users of carriers. When asked what sized carriers they used, only 25 percent replied in terms of bushel capacity.

Carriers might be rated in cubic feet. For example, carrier No. 4 contains 4 cubic feet, No. 6, 6 cubic feet and carrier No. 14, 14 cubic feet, etc. Such a rating is commendable for its simplicity and accuracy, and would give a uniform rating. However, we believe that its adoption would lead to more or less confusion with the present rating. There would be a tendency for farmers to consider a No. 12 carrier as a 12-bushel carrier and this would be more than its actual capacity. On the other hand, with the rating previously described, the size numbers would not be confusing and the farmer would soon learn their meaning and relation to capacity.

The committee recommends the first method as a means of eliminating the present confusion. The proposed rating would be standard and uniform and its adoption would be beneficial to all.

Several companies are in favor of the adoption of this rating, and others recognize the need of such a standard. This will be shown by abstracts from letters received from various manufacturers.

ABSTRACTS FROM LETTERS OF MANUFACTURERS

"We contemplate some changes in our litter carriers before another season, and will be glad to change the sizes of the tubs or buckets to conform with standard rating."

"One thing is certain; we will never go back to rating litter carriers by the bushel, for there is no such thing as a bushel of manure, and farmers in various states will rate their carriers according to their idea of what their bushel means, and we have had more trouble from this source than from all the other troubles of carriers put together."

"I cannot see why we should make a measure for the bushel in order to use the bushel as a measure for a carrier. Why not use the cubic measure as a standard and make all boxes so many cubic feet or cubic inches; then there could be no conflict or quibble arising in the matter.

"I would suggest, therefore, that the word 'bushel' be abolished and cubical contents be adopted instead, and that there be four or possibly five different size boxes made to conform to the regular galvanized sheets, and that no other size boxes be made."

"With regard to carriers. There is absolutely no need for manufacturing more than two sizes. I would say that three would be the limit. I believe in standardizing the carriers and that is what we have aimed to do. We have taken into consideration first the kind of track on which the carrier would operate; we have then carefully figured out the load that the carrier would carry satisfactorily, and on that basis we have designed our carriers to meet the requirements as nearly as possible.

"For rod track use the carrier of between 4 and 5 bushels is O. K. The next size should be between 10 and 12 bushels, and with these two sizes most conditions could be met.

"The farmers are making a practice of using so much bedding in connection with stalling of cattle that a carrier of from 10 to 12 bushels is just as practical in a dairy barn as it is in a horse barn. If at any time the herdsman should feel that the manure he is handling is too heavy to fill a 12-bushel carrier it is a simple matter to cut down his load. Experience has proved with us that a 10 to 12-bushel size is the most practical on heavy track and the carrier for which there seems to be the greatest demand.

"Your letter of November 20 contains some mighty valuable suggestions, and you have solved the problem in a most practical way.

"We like the way you are going about this work very much and feel sure that the result will be most satisfactory."

"We are in receipt of yours of the 21st inst., and wish to advise that we can see no particular advantage in standardizing the size of litter carriers, because they are not used to measure anything.

Even if your standard were used we doubt very much whether a farmer would be able to select a carrier from the figures given and know any more than he does now that he would be ordering the size that he wanted.

"Nevertheless, we can see no harm in adopting your suggestions and will be willing to adopt it if the majority of barn manufacturers think it advisable. We shall in that case be pleased to be notified as early as possible so that we can use it in our next catalogue, which we hope to issue some time during the latter part of 1919.

"We do, however, agree with you that a uniform system of rating such as you suggest could be adopted by the various manufacturers and that this would be beneficial."

"We arrive at the capacity of litter carrier tubs by dividing the cubic contents by 2150.42 which we understand is the U. S. standard measure. If all manufacturers would do this then the term "bushel" could be used by all with a clear understanding. It seems to us that it is necessary to rate according to bushel capacity, as capacity indicated in cubic inches would not be understood by the average farmer."

"We are perfectly willing to adopt any new standards, but would not be able to do so with the carriers immediately, as we have a large stock on hand at the present time, but would be able to give you our assurance by the first of year, when we will make a new stock."

DISCUSSION

Question: I'd like to ask why you chose the unit 4000 to multiply your size number by.

Mr. Kelley: That is a convenience. I have tried all possible combinations in order to arrive at a definite conclusion—that is, to get uniformity. For instance, one could use 5000, but I did not care to vary too greatly from existing sizes, for the reason that it would be likely to cause confusion in the mind of the farmer. With the sizes which we have used, we avoid that confusion, and it is merely a matter of convenience, that is all.

Question: Why not take 4300 for your factor to multiply by?

Mr. Kelley: Well, that would be very good. It would still give us uniformity. That would cut it down to a narrow limit.

Question: I don't see why the carriers couldn't vary seven percent from the standard just as easily.

Mr. Kelley: Well, you brought up a very good point there.

Question: Will the size of your sheets permit that?

Mr. Kelley: That is a point the committee did not have time to investigate. This is not a set thing; it is merely a preliminary report on which I want to secure the opinions of as many of the men interested as possible in order to finally arrive at something that will have a definite merit that will be satisfactory to all of us What is the opinion of most of you in regard to the point Professor Shedd brought up? Should we make the size there a limit, definitely multiply by 4300?

QUESTION: What is the principal object of the standardization?

MR. KELLEY: The principal object is to secure uniformity.

QUESTION: You also want to save metal, don't you? Why not start in, then, and obtain the sizes you can make by the size of the sheets?

MR. KELLEY: That is a point which can be secured very satisfactorily because we have relations with the present manufacturers of carriers.

QUESTION: Are the sizes made to conform to the size of the sheets? The point isn't worth much, because you are making so many different sizes. If the present sizes are based on an economical sheet it isn't hard to get a size which will be economical.

MR. KELLEY: They can secure a greater capacity by using the same material and merely changing the form.

QUESTION: There is no effort to standardize dimensions; the effort is to standardize capacity?

MR. KELLEY: It is eventually a circular form, that it, not a flat bottom. We do not know definitely the combination between the width and depth. You may have 24″ wide, 20″ deep; the next 22″ wide, and 20″ deep. The one may give you a larger capacity than the other. We didn't have time to investigate that.

QUESTION: Mr. President, I am like Mr. Shedd, I don't see the advantage of using 4000, because this is something the farmer will not use.

MR. KELLEY: It is essentially an arbitrary figure.

MR. KAISER: Wouldn't it be possible to rate it in cubic feet, call the small size four, five; the second size eight, ten; and so on?

MR. KELLEY: Yes, that is possible, too. That possibly is the only difficulty I see. As I said before, the close similarity between the existing numbers and the one proposed form, may lead to confusion. That point may be over-emphasized; it may not be as confusing as we think.

USE OF WATER BOWLS IN DAIRY BARNS

M. A. R. KELLEY

The rapid increase in the use of water bowls and the shortage of farm labor made it desirable for your committee to ascertain the best methods of installation and to learn the value of water bowls as a labor saving device.

Twelve manufacturers sent us names of dairymen using water bowls. Four hundred names were selected from the lists received. and a circular letter and questionnaire were sent to each one of these. Returns were secured from 120 letters, 102 of which contained data of value. Some were returned on account of improper address; others had not yet installed the bowls purchased, so could not give data. Replies were received from fifteen different states, which rank as follows: Wisconsin, 38; New York, 21; Minnesota, 8; Illinois, 7; Michigan, 5; Iowa, Pennsylvania, Connecticut and Virginia, 3; Nebraska, and Indiana, 2; Maine, Maryland, and Massachusetts, 1 each.

It is not necessary for us to dwell at length on the importance of an abundance of pure water for the dairy cow. It is well known that milk is approximately 87 percent water, and that a cow requires 8 gallons of water to produce 10 gallons of milk, besides the water she needs to keep up her body. A dairy cow requires water in proportion to the amount of milk given, the rate being about 2½ pounds of water for each pound of milk produced. It does not pay to use high priced feed to increase milk production, and neglect to provide an abundance of pure water.

In this report gravity bowls are those where the water level in several bowls is controlled by a master float valve. Bowls are considered automatic when the supply of water is controlled by a lever valve operated by the cow. Detachable bowls are easily and quickly detached without the use of tools. They are automatically operated and are a comparatively recent invention. Gravity and automatic bowls have been successfully used a number of years. However, it is said that with the automatic, it is easier to control disease in the herd as each cow has an individual bowl.

The gravity bowls coming first have been in use 12 years, and the automatic, 8 years. The recently improved detachable bowls have been used 2 years.

The following is an abbreviated copy of the questionnaire which was sent to each dairyman. Each question is numbered and will be discussed in order of its rotation. Paragraph numbers correspond to question number.

QUESTIONNAIRE

1. How many cows do you milk?
2. Are bowls automatic or gravity type?
3. Do drinking cups save time?
4. Did cups increase milk yield How much? Estimate or records?
5. Was the water consumption increased?
6. Do water bowls have separate drains? If so, do they give trouble in clogging?
7. Do cups have lids? Are they necessary?
8. Are bowls detachable? Do you think this of much advantage?
9. Do you experience any trouble in using water bowls in pens?

10. What disadvantages have you experienced in using water bowls?
11. What type of water bowl would you buy if you were to make a new purchase?
12. Did you use a tank heater? How much labor and fuel did you save by not using?
13. What size litter carrier do you use and how much time do you save?

(1) It may be of interest to know the number of cows milked in the herds investigated; 37 herds ranged from 8 to 16 cows; 21 herds, 17 to 20 cows; 14, 21 to 35 cows; 11, 26 to 30 cows; 13, 32 to 44 cows; 5, 50 to 80 cows; and one herd had 142 cows. This shows that water bowls are successfully used in the small herds as well as the large.

(2) It is interesting to note that a farmer who has used his bowls for 12 years states, "I would not be without them under any consideration." He states that in purchasing new bowls, he would prefer the automatic type. There has been an increasing demand for the automatics within the last 3 years. The replies show that out of 32 purchases last year, 22 were automatic.

(3) The saving in time affected will necessarily depend upon the method of watering used prior to the installation of water bowls. As the conditions vary in each case, no true average can be obtained. It was quite a common practice to water cows twice a day. Sixty-five replies stated that there was a saving of time ranging from ½ hour to 5 hours. An approximate average of these would be about 1½ hours, depending upon the size of the herd and previous convenience in watering. Four stated there was no appreciable saving in their case. In order to find the true saving in time in using water bowls, the time saved in caring for the tank heater must be added to that of driving the cows to water.

(4) Prof. Larsen of the North Dakota Experiment Station, says, "The amount of milk given is affected to some extent by frequency of watering, but not so much as would naturally be expected. When supplied only one half the amount of water, there was a daily decrease in amount of milk of 4.2 pounds, or a decrease of about one-fourth."

(N. D. Expt. Sta. Bul. 175, "Role of Water in a Dairy Cow's Ration.)

A good dairy cow requires more water than any other farm animal. She cannot be expected to give a maximum production if she is not supplied with an abundance of water and at the right temperature. Cows will not drink icy cold water and produce the maximum milk yield.

Whether the use of water bowls will give an increase in milk yield will depend on several factors and the previous method of watering, amount and temperature of water, and frequency of watering. The milk yield of high producing cows shows a greater variation than that of low producing cows. The convenience of this method will be most appreciated during cold weather and the greatest variation in milk production will naturally occur at this time.

In the replies received not all were of the same opinion. However, the general view was that there was an increased milk yield. Four stated that bowls did not seem to affect the yield, while seven stated that they did not know. Fifty-seven answered yes. Six estimated an increase of amounts from 1 to 5 pounds per cow per day, with average of 2½ pounds. Three others estimated the increase at 10 percent.

Replies from 19 dairymen who kept records were as follows: Two answered, did not increase appreciably; 2 answered yes; 12 stated increase of 1 to 6 pounds per cow, with an average of 2½ pounds; 1 gave 7 percent increase, another 10 per cent. One gave the following interesting facts.

"My cows are purebred Guernseys, and it so happened that I had several cows on official test this last year. All milk was weighed and recorded, and butterfat tests were made regularly. We found that our cows drank about two-thirds of their water at night, which was indicated by the scale on the side of the tank. It so happened that the pump froze during the winter, and for about one week it was necessary to water the cows in the daytime by pouring water into the bowls. I regret that I am unable to give you at this time the exact figures, but I remember that the cows fell off about one-fifth in milk flow, their butterfat tests remaining the same. At the end of the week repairs were received for the pump, the system was put in order, and cows returned to original flow of milk."[1]

(5) The increase in water consumption was most noticeable during cold weather. The cows drank when they wished and did not become chilled by drinking large amounts of water at one time. Forty-two dairymen were of the opinion that there was an increase in the water consumption, but did not have any way to measure it; individuals answered, 10, 20, 25 and 33 percent increase. Eight answered that cows consumed twice as much water. Eight others gave increased amounts varying from 1 to 5 gallons per cow per day, with an average of 2 gallons. In this connection it should be remembered that the water consumption will also vary with the amount of dry feed consumed and according to milk production.

(6) With a few of the older designs some difficulty was experienced in keeping the drains clean and six reported trouble. The frequency of drains clogging is summed up by one dairyman,

[1] (Here, as elsewhere, the total number of answers do not always total up the same total number of replies. All questions were not answered in some cases.)

who uses 150 bowls and states that not more than 2 per month give trouble in clogging. With the automatic detachable bowls this difficulty is eliminated.

(7) The principal advantage expressed in having lids is that it keeps dirt out and prevents cows from lapping water out of the bowl into the manger. Twenty-nine chose lids, while 67 preferred them without; 5 of the 29 did not use lids, and 13 of the 67 used lids. The majority of both gravity and automatic bowl users preferred them without lids. It is not known how many of the latter were detachable. With this type of bowl, however, lids are not necessary except perhaps when used in pens.

(8) The replies to this question were not definite, as many considered bowls detachable if fitted with a union which could be detached with a wrench. This is not the meaning of the word as now considered in connection with the latest improved bowls. Many expressed themselves in favor of detachable bowls, since it aided in cleaning, and when used in hospital stalls can be easily sterilized and the water supply controlled.

(9) Twenty-five dairymen did not use bowls in pens, and 16 did not answer. Fifty-three used bowls in pens and experienced no difficulty and only 8 reported trouble. The deposit of droppings in the bowl was the principal source of trouble. Most dairymen preferred to use covers on bowls in pens in order to avoid this trouble. Some difficulty was also experienced in bull pens, as the bull bunts or rubs the bowl, causing it to leak at the joints. We are of the opinion that bowls in bull pens should be provided with guards or placed outside the pen. Water bowls are successfully used in calf pens, and the calves seem to do better when they are supplied with an abundance of pure water.

(10) It is the opinion of most dairymen in this investigation that water bowls occupy a predominant position among the essential items of barn equipment. They have given almost universal satisfaction and the disadvantages experienced may be said to be caused by faulty design rather than of the system.

There were two principal disadvantages expressed; that of keeping the bowls clean and pipes from freezing. Six mentioned difficulties in keeping bowls clean and seven reported trouble from freezing. The invention of the latest types of automatic detachable bowls greatly mitigated the first trouble, and the second trouble emphasizes the need of precaution in installation where severe cold weather is experienced. Another disadvantage expressed was the tendency to neglect giving the cows proper exercise. One dairyman stated that when cows were not turned out they were not noticed in heat. These factors are not the fault of the water system, but rather neglect on the part of the herdsman.

(11) Thirteen replies stated that gravity bowls were giving satisfaction and 15 users of gravity bowls expressed a preference

for the automatic. Five, in making a new purchase, would secure bowls with covers. There were 38 satisfied users of automatic bowls, and only one farmer who had both, preferred the gravity. In this case he had used city water pressure and experienced trouble in operating the automatic valves. He states that the pressure should not be over 20 pounds per square inch.

(12) Twenty former users of tank heaters stated that there was a saving of ½ to 1 ton of coal, or 1 to 3 cords of wood per winter and a saving of ½ to 2 hours of labor per day. This, of course, will vary with the individuals. The use of unprotected tank heaters also greatly increases the fire risks.

(13) While this question does not relate to the use of water bowls, it is included here, since the replies contain data of interest and value. There did not seem to be any correlation in the size of litter carriers used with the size of the herd. There are many variable factors which control the selection of litter carriers. It was noticeable in some cases that the size of carrier used was too small, and that a greater saving of time could be secured in using a larger size. No average can be given for the saving of time, as this also varies according to size of herd, amount of bedding, size of carrier, and the individual. However, it was noted that in herds of size from 8 to 16 cows, the saving varied from ¼ to 1 hour; 17 to 20 cows, ½ to 1 hour; 21 to 26 cows, ½ to 1½ hours; 26 to 30 hours, ½ to 3 hours; and 32 to 40 cows, 1 to 2 hours. In calculating size of litter carriers allowance of 1 to 1½ bushels of manure per cow per day may be used. This, of course, will vary with the amount of bedding used.

The committee hesitates to express an opinion in regard to the value of water bowls, for fear it may be construed as propaganda in increasing their sale. However, on the basis of our investigation we cannot refrain from saying that we believe the true worth of the bowl is not generally known. The past 2 years has shown remarkable improvement in water bowls, and we expect to see an increase in their use and further improvement in their design.

Many voluntary remarks were included in the replies, all of which are of interest. They are too numerous to be included in this report, and only those which can be classified are included. Five users state that cups pay for themselves in one year. Six others said that cows like water after every feed, and drink much more in the evening up to midnight or when they get up. Six were of the opinion that when cows have water accessible at all times, they drink oftener and do not become cold or chilled by drinking large amounts. Although it is very difficult to determine what relation bowls have to the health of cows, two volunteered that the general health of the herd was better. Two asserted that the milk flow was more uniform during cold weather. Twenty-four consider them a good investment and indispensable to dairymen producing winter milk. Only three expressed adverse criticism, one because of difficulty of freezing and two because of difficulties experienced in using old style bowls, now discarded.

In conclusion we will mention a few notes on installation which were brought out in the investigation. Briefly they are as follows:

1. Light covers should be used, as cows will not lift heavy covers which hurt their nose.
2. Use pressure-reducing valves when water supply pressure is over 20 pounds per square inch.
3. Bowls should be provided with double feed, so that either bottom or top supply pipe may be used.
4. Detachable bowls should be substantially and firmly fixed, yet easily released by hand.
5. Water should be supplied to cows at the rate of 2½ to 3 gallons per minute.
6. Bowls should be placed so as not to interfere with manger divisions.
7. Water supply storage should be based on production needs. (See answer to question 5.)
8. Bowls in bull pens should be protected.
9. Covers are preferred on bowls used in pens.
10. Non-corroding metal should be used in valve construction, and in detachable parts where necessary.
11. Where cold weather is experienced, provision should be made for draining both ends of pipe line and frost proof hydrants provided.
12. Detachable bowls are more sanitary.

Mr. E. A. White: Mr. President and members of the Society: I think that as agricultural engineers we could gain much by reviewing some foreign works on scientific development of agricultural machines. Strange as it may seem, America has produced more machinery but far more scientific study has been done abroad than in America.

REPORT OF THE COMMITTEE ON RESEARCH

E. A. White, Chairman, H. E. Horton

Your committee begs to submit the following report:

A list of the more important works relating to the plow has been compiled. This list does not contain all the works on the subject, it being our belief the members of the society will find a selected list for reference more useful.

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Vormfelde, Karl. Das Streichflech des Pfluges. Ans dem Buche über Pflüge des Prof. W. Gorjatschim. Moscow.
Verband Landwirtschaftl Maschinen-Prufungs-Anstalten. 1909.

White, E. A. A Study of the Plow Bottom—Its Action Upon the Furrow Slice. Journal of Agricultural Research, Vol. XII, No. 4, 1918.

The following are references to very complete bibliographies on the subject of plows:

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Translations have been made of many of these articles, and it is hoped that at some future time it will be possible to present a brief review of these works.

REPORT OF COMMITTEE ON STANDARDS FOR ISOLATED POWER PLANTS

E. W. Lehman, Chairman, H. F. Good, A. H. Hoffman, I. W. Dickerson

Your special committee on Standards for Isolated Electric and Power Plants for the past year has completed little work of consequence. Correspondence has been carried on with a number of men engaged in this line of work to determine the best practices that are being followed. We beg leave to report on the following points with recommendations:

1. Due to the fact that standards have been adopted by the National Board of Fire Underwriters covering electric wiring of all voltages, we recommend that all installation of farm lighting and power plants be made in accordance with these standards. Copies can be secured from the Underwriters Laboratories, Inc., 207 E. Ohio Street, Chicago, Ill.

2. In regard to the matter of ratings and specifications for low voltage isolated electric light and power plants, we recommend that the recommended practice adopted as such December 28, 1916, be adopted as standard practice with the elimination of the rating of the output of storage batteries based on 72 hour intermittent discharge. It is the belief of the committee that the above method of rating a storage battery tends to encourage overrating, and should not be recognized by this society.

3. Your committee, in recognizing the jurisdiction of the American Institute of Electrical Engineers and the Electric Power Club in the field of electrical engineering, and their work of preparing technical and commercial operating standards of electric equipment, recommends that this society accept the recommendation for all general electrical equipment provided by these organizations.

DISCUSSION

MR. DICKERSON: This report was prepared by Professor Lehman. I haven't talked to the other members of the committee, but we have had a little correspondence, especially in regard to this matter of rating for low voltage lighting plants. The committee (at least Mr. Lehman and myself) are of the opinion that the standard as it is now, is not satisfactory. It is not definite. It is either up to the society to make this rating definite or eliminate it, and personally, I believe that it should be eliminated. This is the objection I have to it. I think the policy of all of the electric battery people is to induce the farmer to buy the larger storage battery. It is cheaper fo him to have a large storage battery—if gives longer life and more reserve power for sudden calls for lighting or equipment work.

Now there has grown up a sort of idea in the farmer's mind that the 60 ampere-hour battery is fairly good and a good many of them want to buy it. We all believe a 20 ampere-hour battery is cheaper in the long run.

It is really working against this idea of inducing the farmer to buy a larger battery, and there is only one argument that I know of for the intermittent grading, I presume that will be discussed a little more in detail. It may be that you will not want to adopt this recommendation of the committee. If you would prefer to keep the 72 ampere hour rating it should be made definite, a certain definite ampere output—a certain number of hours discharge and a certain number of hours rest.

QUESTION: I'd like to ask the chairman of the Committee on Standards a question. He said he changed the standard of rating batteries. I would like to ask Mr. Dickerson where that standard was adopted, and who authorized that adoption of standard rating of any kind of a battery.

MR. DICKERSON: I am not chairman of the committee, but so far as I know, this society is the only society which has adopted the 72 hour rating as standard. I don't know what the American Institute of Electrical Engineers have done in this regard. Possibly Mr. Beck or Mr. Keilholtz can give more information.

MR. KEILHOLTZ: The American Institute of Electrical Engineers have not standardized. The Society of Automotive Engineers have standardized it for use on automobiles. There have been quite a few smaller battery companies and one or two of the larger ones who have used the 8-hour continuous discharge to some extent, but there is no society standardized on any rating. The Domestic Engineers use an intermittent dicharge rating. It was because we wanted a rating that would be approximately what the farmer really got out of his battery in acutal service that there was no rating adopted at the time. Since Mr. Dickerson made the statement that the intermittent rating encouraged the thick plate substantial battery, instead of the flimsy thin plate battery, if you take a thick plate battery and cut the plates in two, you could get a much higher rating of 8 hours continuous discharge but what a farmer wants is a thick, substantial plate battery.

MR. BECK: Perhaps a word or two from the manufacturer's standpoint might be of interest. In other lines of work it has been a pretty generally accepted practice to rate a battery according to the use to which it is going to be put. We, at least, as one firm of battery manufacturers, have felt that the object of rating a battery was to tell the customer or give him as good an idea as possible as to what he would get out of the battery under his condition of service, and on that basis, batteries in various classes of service have been rated on a very different time basis, and this has been standard practice for a number of years. For example, in electrical vehicle service the nearest average rate to the rate that will be used in service is about the 4-hour rating and, therefore, you will find that automobile vehicle batteries are rated on the basis of approximately a 4-hour rate, and this is known as the normal rate of that battery. In other words, the term normal doesn't necessarily mean 8-hour rate. In our large power batteries that are used on peak work where the time of discharge is very short—anywhere from 20 minutes to 2 hours—the batteries are rated at a higher rate, very often at the hour rating, and this is their contract rating because that is the way they are going to be used, and it indicates to the customer what he will get under his condition of use.

We have batteries used in signal service on steam railroads to operate semophore signals. In that service practically all the batteries are rated on what is known as the intermittent rate, a similar rating to this isolated plant rating. In automobile ignition service we again have the intermittent rate, because the batteries are used on intermittent basis. This has practically been established over a number of years, and on that basis we feel that it would be in line with past practice, and in line with telling the farmer what his plant will do for him under his conditions of service, to rate the battery on the intermittent basis. If any other basis is adopted it will be to a certain extent a departure from precedent.

President Scoates: Any other discussion?

Mr. Dickerson: How do you want this report adopted, in sections or as a whole? I think probably there will be no question about accepting the second part. You had better take the other two parts of the report separately.

President Scoates: I will entertain a motion to that effect.

Mr. Dickerson: I move the first and third sections of the report be adopted.

(The Chairman reads parts of the report to be adopted.)

Mr. Dickerson: I think there are some representatives here of the National Board of Fire Underwriters who might have something to say.

Mr. Glover: I might say no action has been taken, so far as I am aware, in regard to low voltage systems, it having generally been considered that the rules and requirements for light, heat, and power applied equally well to any voltage, including the 32- or 30-volt standards. I came to your meeting this evening to learn, and to get any ideas that might be expressed as to the necessity of special rules for these special equipments.

Mr. Dickerson: Do you have special rulings, Mr. Glover, in regard to electric irons and other fixtures requiring a high current rate?

Mr. Glover: None whatever aside from existing rules, sizes of wires, current capacity, installation, etc.

Mr. Dickerson: While no doubt we can agree with all the specifications that the National Board of Fire Underwriters have worked out, we will probably need some additional ones due to special conditions. The committee is not ready to recommend that plan now.

President Scoates: Do you still recommend this as it stands? Motion is seconded.

MR. SHEDD: It seems to me, in view of what Mr. Glover said, that the report should be revised a little.

MR. GLOVER: In reply to Professor Shedd I will say that the National Electrical Company has a classification for low potential systems which really covers anything, 550 volts or less. The problem of carrying capacity, the current carried over the wire for low voltage equipments, etc., is fully covered if you simply apply existing rules and specify the size of wire required to carry the increased current. The conditions are all plain in the existing rules. The only point that perhaps is not entirely clear is that any rules that would apply to any low voltage system are considered as applying to an equal extent with the 32-volt system included under that general title of low potential systems.

PRESIDENT SCOATES: Does that answer your question, Mr. Shedd?

MR. SHEDD: Yes, it overthrows my objection.

Motion carried.

PRESIDENT SCOATES: Do you want to take this second section up and discuss it?

MR. DICKERSON: I hardly know whether we are ready for discussion on this or not.

PRESIDENT SCOATES: What do you recommend, that the committee take it up next year and thrash it out?

MR. DICKERSON: Mr. Kielholtz, did I understand you to say the American Institute of Electrical Engineers were working on specifications?

MR. KIELHOLTZ: I have letters from them and from the Society of Automotive Engineers both saying they were working on the standardization of batteries, and in the coming meeting they expect to take this up.

MR. DICKERSON: In view of that information, Mr. President, I move this section be referred to the new committee.

Motion seconded and carried.

REPORT OF THE COMMITTEE ON STANDARDS

F. N. G. KRANICH, Chairman, J. F. MAT PATITZ, JOHN C. BOHMKER, E. M. MERVINE, E. B. MCCORMICK, I. W. DICKERSON, L. F. SEATON

The magnitude of the work necessary from a committee of this kind makes much tangible evidence in a report almost impossible. It seems to be largely a question of working out plans and a program for the work that should be done subsequently, instead of really trying to do any one thing.

The conditions due to the war have also made anything of any tangible nature almost impossible, because conditions were so difficult among manufacturers, as best, without burdening them with other work along this line.

Making plans is, perhaps, as big a part of this work as actually trying to do it, since no one committee can accomplish much in one year.

TRACTORS

One of the most urgent needs is a standard or uniform method of rating these machines, both for belt power and drawbar work. There are several ways in which this might be done. The most common, of course, would be to make tests of these machines and have a standard form to follow so that when this work is done, it will be comparable. We at present have only the nominal rating of the individual manufacturer, which varies as the ideas of men vary.

The same thing will apply to tests conducted at demonstrations where some of this work will be, in a measure, carried out.

There are several schemes on this score that now have been worked out and will be presented at this meeting. This has been divided into a series of three types of rules for conducting demonstrations and tests.

The Society of Automotive Engineers have adopted a standard for the height of drawbar on the tractor for hitching drawn machines.

This height of 17 inches for a drawbar hitch is a feature that needs a good deal of consideration. The height varies, depending on whether the tractor runs in the furrow or on the unplowed ground, and this has not, apparently, been considered by them. An adjustable drawbar will probably be found feasible and receive more recognition by manufacturers than the 17-inch which has been adopted.

It is very unwise to our way of thinking to arbitrarily adopt standards for tractors without first considering the present manufacturers of tractors, many of whom have been in the business for years. They have gone through the pioneering phase of the tractor business in manufacturing and in the field. They deserve consideration since the standards adopted must benefit them as well as the purchasers.

Another thing, the standards adopted must be such that the implements that go with the tractor shall have some consideration. The tractor alone is as useless as the chassis of an automobile without the body. To really get good sound standards adopted, it becomes necessary to consider the manufacturers and also the implements that go with the tractor and necessarily perform an important part of the work that the farmer does.

The adoption of a 2600-foot belt speed by the Society of Automotive Engineers so far, means little for two reasons. First, because most manufacturers will find it impossible to abide by the figures owing to the individuality in design and construction of each manufacturer's tractor; and in the second place, the figure is too low to be practical for belt power machinery that is now used with tractors.

It is useless, in any case, to formulate standards unless they are logical and can be adopted by manufacturers. It is needless to establish standards, which will never accomplish much unless they can be applicable to tractors and to the goods that are manufactured.

BELT POWER MACHINERY

The work of rating these machines is also a part of this committee work that must be taken up. Threshing machinery, for instançe, is not at all properly rated today. They speak about the number of bushels a machine will thresh. The same is true of corn shellers, corn shredders, silo fillers, etc. All have capacities in figures that can never be accomplished as a standard. All depends on the yield of these various grains or the straw or stalks which govern the figures that must be accounted for. This can best be worked out by getting it down on a basis of capacity. Their capacity is best determined on the volume of material that can be put through them, rather than on the amount of grain that comes from them.

A standard form for conducting tests would perhaps solve this better than any other one thing, and that is a part of the work that this committee is working on.

The belt speeds of these machines is another thing that can get some consideration, and it should be worked out in connection with the belt speeds that are most suitable for tractors. At present, tractors are running at higher speed than formerly, and consequently at 2600 f. P. M. (which was the old steam tractor belt speed) the pulleys become so small that belt power cannot be transmitted, since belt speeds are not relatively high enough.

DRAWN MACHINERY

Standards of all this machinery with reference to rating, must be established, either a horse power rating or a pound pull rating, whichever is decided should be adopted for all implements.

The most logical way that this can be done, it seems, would be to make up a standard form for testing them, and each individual or the various institutions that do this work would then have comparable data which would ultimately lead to standards in this line that could be adopted if found feasible.

MISCELLANEOUS

There is an endless variety of things that might be standardized in our line that go on tractors and farm machines. One of the things that might be mentioned is sprocket teeth. The chain belting is perhaps as big a part of the agricultural implement as a whole, as any other one thing, and at present no standard is followed where the design and shape of teeth for this chain is considered, and it is an important part and causes much bother to the farmer and ultimate user of these machines. Keyways are another item that need standardization with reference to agricultural implements. We find at present $\frac{1}{4}''$ keys using shafts all the way from $\frac{3}{4}''$ to $1\frac{3}{4}''$. Set screws, too, are used from $\frac{1}{2}''$ diameter on $\frac{3}{4}''$ shaft and in $3''$ shaft. All these things need careful consideration by a committee and something along this line on the parts that go with farm machines and tractors should receive consideration with reference to standards.

CONCLUSION

It seems to this committee that the most logical thing to do would be to prepare a data sheet on which would be the questions and all information necessary to conduct a test on any farm machine to establish various facts and features about it, to ultimately determine the ratings with a view to standardizing machines of this sort.

Various agricultural colleges and even individuals could then make tests, and get data which would ultimately become comparable, and this seems to us the most logical step and the one that would prove most valuable to the industry, as a whole, with a view of standardizing parts and ratings on machines.

It is absolutely necessary that there be something definitely done along this line, since no two machines are rated alike. The biggest factor enters into the power required to drive them, and the capacity of these machines. There is a variation in threshing machines of about 160 per cent in the power required to drive the same machine from the present figures published by manufacturers. The difference in silo fillers, corn shellers, shredders, feed mills and various other machines is just as great, and often greater, and the urgency of this is more apparent when we realize what this really means to the farmer who must select these machines to go with his tractor from catalogs where a mess of figures are given which are not at all comparable. It leads to confusion among the manufacturers as well as the farmer and we believe that they would welcome a uniform rating on these machines, as well as on the tractor. The means for doing this is the big problem and deserves very much thoughtful consideration.

DISCUSSION

Mr. Kranich: I wish to say that this committee had worked out some special forms, copies of which are not yet available, for conducting tests on silo fillers, threshing machines and various other machines. We hoped to have these printed and sent to various people so that all the data necessary could be compiled in some form, and we might ultimately determine our standards for rating this various machinery. These standards have not been finished. The committee did not have a meeting. It hopes that by the next meeting data sheets will be available so we can all get a better understanding of what this means. There is another thing with reference to testing tractors, and the chairman has seen fit to appoint to work with him a committee composed of men who live close by, so this work could be done hurriedly and quickly. The manufacturers of tractors, through the National Association of the Tractor and Thresher Manufacturers, have realized the importance of getting something along this line to enable various agricultural colleges, county agents and other people to conduct a test—the importance of getting some form in shape so this could be done in a uniform way. At present each county agent who conducted a county demonstration did it to suit his own ideas. The result has led to a good deal of confusion. This committee has had meetings every week for the last 6 weeks to work this thing over, and we have some little data at hand now which might be brought up here. We have worked out this little table which shows the need or the purpose of these rules for conducting demonstrations and tests. There are, as you will see, three classes—Class A, B and C—which indicates the different rules that should be compiled for conducting tests of this sort. I think that is self-explanatory, and I will try to explain what the different classes are.

Class A is perhaps the one that will be used most for public tractor tests to be run by county agents, agricultural institutions, dealers and manufacturers. These tests are very common, and to give them something so that they could get all this data in shape we have worked out a little four-sheet folder similar to this, which is supposed to be the dummy. It represents the Class A rules. Class B will be more complicated because it will be for national demonstrations—manufacturers' organizations, agricultural colleges, etc., and will include drawbar tests. Class A is very simple and contains but twelve rules. I might read here the object that we have printed on the front page of Class A. (Reads object.)

This sheet contains twelve rules and a sheet of explanation which modifies these rules. On the back of that we propose printing an illustration of how a field should be laid out, together with a depth gauge that had been used for successfully measuring the depth of plowing to get an average depth. This same thing has been worked out in the Class B and Class C rules, and the manufacturers, realizing the need for it, have signified their willingness to adopt something of this sort for work this coming season. If, with the permission of the president, we can ask for some discussion on this, I would like to make a motion that the report of this committee with reference to these rules be adopted, since the manufacturers have a meeting early next month. At that time this will be taken up with them. I would like to make that a motion at this time. (Motion seconded.)

PRESIDENT SCOATES: State the motion again.

MR. KRANICH: That this report be adopted as official from this society, so that when it is presented to this manufacturers' association it will be an official A. S. A. E. report.

PRESIDENT SCOATES: These three sets of data sheets you are going to get up are now compiled but not in shape for presentation?

MR. KRANICH: As a matter of fact the latter part of it was only worked out this afternoon. We haven't had an opportunity to work it out, to get slides made, and present the thing in good shape.

MR. DICKERSON: Wouldn't it be wise to put in that motion that the committee be allowed to make such small changes as appear desirable in view of the discussion you will have with the manufacturers? There will be some changes then they will want to make. The committee should have power to make those minor changes.

MR. KRANICH: I think that is a good suggestion. This may have to be altered in part to conform to the ideas of the manufacturers, since they, of course, are the men who are putting on the show and will pay the bills. They should have a little to say as to what should be incorporated in it. Still, they know of it; it has been presented to them in a general way, and they have agreed to accept whatever this society does in this line.

MR. WOOD: I have been connected with several demonstrations in the past year and I recall a certain county agent who put on a tractor demonstration contrary to the recommendations of the men in charge. He wanted a test to show farmers in that section of the state who were very much interested in the kerosene consumption, oil consumption, time necessary, cost of plowing, etc. We made it a positive rule to have no such tests made at our other demonstrations. Our other demonstrations were very successful from the standpoint of the manufacturer, dealer and farmer. That one demonstration in which tests were made on the machines was a failure, and it seems to me will always be a failure if it is conducted under the management of the county agent. You can take six, eight, ten or twelve tractors and put them in a field. The men at the disposal of the county agent are not likely to be trained agricultural engineers. There is no possibility of the men at the disposal of the county agent being able to keep an account of the work done with these machines. You may work out your rules as carefully as possible, they still cannot keep up with the representatives of the manufacturers if they want to do things that should not be done. That has happened so many times that I think we can rest assured that the salesmen will do all in their power to make a good showing for their machines.

Another thing, too, is any test fair in which the tractor is used for only 2 or 3 hours—possibly 4 hours—in a field where the soil conditions may vary a great deal? We can take a series of demonstrations in one section of the county or state and if we take one operator and keep him on a certain machine throughout the series of demonstrations we will find that machine winning out time after time. It means nothing as far as the work of that machine is concerned. The data obtained from the owners of tractors as to their experience is worth ten times what we can get from any demonstration put on for 2, 3 or even 4 hours.

MR. KRANICH: I think there is a great deal in what Mr. Wirt says, but wouldn't it answer your objection if instead of over there—we have Class A under the publicities—we had those last demonstrations? You wouldn't rule out a tractor demonstration under the direction of the county agent?

MR. WIRT: Absolutely no.

MR. KRANICH: Well now, wouldn't it answer your purpose if it was put under Class A? We have had two mighty successful demonstrations pulled off by the county agents. One was merely a demonstration, and in the other they injected a fuel consumption test which caused the trouble, so I think there is a big field for the demonstration. I am inclined to agree with Mr. Wirt.

MR. WIRT: Don't think I want to discourage the county agents from putting on an economy test.

PRESIDENT SCOATES: The committee has thrashed all that out. While Class A sounds like a test it is merely a demonstration. From what I have seen of those tests, they have taken it all into consideration.

MR. KRANICH: Thirteen of the county agents reported that they intended to arrange tests or demonstrations in their states next year. These tests will be conducted by the dealers. The dealers are conducting shows in almost every little county seat. Sometimes they pull off a little demonstration of their own. Perhaps they include a little fuel economy. It seems to me the dealers might make these tests if they had some standard to follow—that is, if all of the fields were laid out alike, uniformly, and official blanks furnished on which to collect data.

MR. WIRT: I think it is a very good plan to have an outline, but I dislike to see up there, "public tractor tests" and at the head, "County agents." My work is solely with the county agents. They are men of ability or they would not hold the positions that they do. The county agent does not have the facilities for conducting an accurate test, so why go to the trouble of getting that information? Let us discourage that, but let us have the county agent put on demonstrations, not start off with the county agent making the test.

PRESIDENT SCOATES: Is there any more discussion?

MR. KRANICH: As I say, there are just twelve little rules worked out. Nothing but a question of plotting a little piece of land.

Mr. Wirt: It's all well enough to have the demonstration, but I think the society is making a mistake in trying to get figures showing 2 or 3 hours' work at a small demonstration where you do not have trained agricultural engineers in charge. What the farmers are interested in are the figures obtained in actual use, and they certainly differ a great deal from any figures obtained during tests. It is not because of lack of ability but because the farmers have adverse conditions to meet with. We have some figures obtained from about 250 tractor owners on gasoline consumption, kerosene consumption, fuel consumption, average per hour, etc. Those figures looked pretty poor when compared with figures obtained under the management of agricultural engineers. My own experience has led me to the opinion that we should not ask the county agents to put on such tests. I always discourage it myself. If they go ahead I help them all I can, but I think the extension men should have a great deal to do with that.

Mr. Sjogren:[1] I agree with Mr. Kranich in that the county agents will put on these tests regardless of rules or no rules, and if we have simple rules laid out for them, I think it is going to make the work easier, going to bring better results. As Mr. Wirt just said, the farmers are interested in what they can do. I think in these demonstrations the farmers will operate the machine—the majority, at least—and why not have a test if they wish it and the farmers can put on the demonstration?

In regard to rules for national demonstrations, I have been connected with two demonstrations. Last time I had charge of these tests was the national demonstration at Salina, and I am sure the work would have been much easier from the official standpoint if we had some rules to guide us, and the official blanks prepared such as the committee has prepared now. At the Fremont demonstration 2 years ago we conducted some tests, both before the demonstration and after. We had absolutely nothing to back us. We went at it blindly, so to speak, and it was surprising we got the results we did. I feel the rules outlined by the committee would be a splendid help to the men in charge of the tests. They want to put the tests on a comparable basis for all machines, operating under identical conditions, regardless of where they may be made or of what machine.

President Scoates: Are you ready for the question?

(Motion carried.)

Professor Shedd: Are these forms going out labeled as standard forms of the American Society of Agricultural Engineers?

Mr. Kranich: Perhaps I can answer that by reading what we

[1] Agricultural Engineering Department, University of Nebraska.

have here. "Rules for tractor demonstrations by the American Society of Agricultural Engineers, Class A." These will be printed up in quantities, and we will send them to directors of county agents, who will distribute them in whatever quantities they require, but it will be official A. S. A. E. data sheet.

Mr. Macgregor Smith:[1] I'd like to ask one question. I'm not acquainted with demonstrations in this county. National demonstrations seem entirely different. The last demonstration at Salina gave us no information for use in Canada. The demonstrations held in Winnipeg were published broadcast, and as far as tests were concerned you could eliminate any differences in the soil. I understand the committee that conducts these national demonstrations is entirely independent so to speak, not cooperating with the manufacturers. What is the object of having demonstrations if the manufacturers are not willing? The big companies are evidently against spending $10,000 every year on demonstrations, and I understand they are a thing of the past.

President Scoates: If there had been prepared a standard form that the manufacturers themselves could use, probably it would have been adopted in those tests.

Mr. Smith: I think it is a good plan. The agricultural engineer himself might be a county agent. If the colleges are giving the agricultural students a course worth the name they ought to be able to conduct a small demonstration of six tractors, and I believe the other gentlemen said farmers will be running the machines anyhow. I know with us up in Winnipeg last year there were forty-four machines. They would go up and down the field, some of them fast and some slow; some of them never got started at all.

Mr. White: We all know there will undoubtedly be some tractor demonstrations held next year, and we will also have a committee on this tractor test, so it seems to me the entire society should empower the incoming president with the authority to appoint this committee with power to act for the society. I make that as a motion.

President Scoates: This committee has that power.

Mr. White: If it is understood this committee has the power to act, I will withdraw the motion.

Mr. Sjogren: I would suggest that instead of sending these rules to director of county agents, they be sent to the specialists in agricultural engineering. A further word in regard to the Salina test; the reason no data were published was because the manufacturers' rules specifically stated that the results were the property of the manufacturers. The officials in charge were not allowed even to keep a copy of the results. I understand now the manu-

[1] Department of Agricultural Engineering, University of Saskatchewan, Canada.

facturers are practically unanimous in favor of making the results public, and in that event these rules will be just the thing we want.

PRESIDENT SCOATES: I think Mr. Sjogren brought out a good point there. It seems to me that business men—manufacturers—do not understand our educational institutions. The manufacturers are always talking about going to the county agent. I think you will get better results if you will work through your agricultural engineering extension specialists in the colleges, in those states where there are colleges.

MR. NORMAN: I might say my personal opinion would be it would save a lot of paper if these rules are not sent to the directors. I am satisfied it will never reach the county agents, because those men are not engineers of any kind, and they are not apt to be interested in that kind of literature. If the agricultural engineer gets that information he is more likely to keep it or see that it gets to the right place.

MR. KRANICH: I think Mr. Sjogren's suggestion of sending it to the agricultural engineer and then let him get it out, is good.

REPORT OF THE COMMITTEE ON DATA

C. K. SHEDD, Chairman, W. F. MCGREGOR, W. G. KAISER

We recommend:

1. That the Society start publication of a looseleaf handbook.
2. That the handbook sheet shall be $4\frac{1}{4}$ inches x $7\frac{1}{4}$ inches, with rounded corners; the sheet to have three holes 3/16 inches or 7/32 inches in diameter, punched so that the center of the holes will be 5/16 inches from the left edge of the sheet, the holes to be $2\frac{3}{4}$ inches on centers and the middle hole midway between the top and bottom of the sheet. This is the size sheet used by the National Gas Engineering Association, and also by the Society of Automotive Engineers for their data books. Covers to fit may be purchased at retail stores in cities in all parts of the country.
3. That an agricultural engineering classification be published as the first sheets of the handbook. This can be printed on tinted paper to serve as an index to the handbook. Data sheets as issued thereafter may be numbered with a compound number, the first part of which will be the subject number according to the classification, and the second part of which will be the page number under that subject.
4. The following classification is submitted by the committee as suitable for the first sheets of the handbook:

AGRICULTURAL ENGINEERING CLASSIFICATION

Of Literature On Agricultural Engineering and Related Sciences. From U. S. D. A., O. E. S. Circular 23 (Revised) and Davidson's Classification of Agricultural Engineering (Revised.)

1. General Sciences
   - .1 Physics
   - .2 Chemistry
   - .3 Mineralogy, Geology
   - .4 Botany
   - .5 Fermentation, Bacteriology
   - .6 Meteorology, Climatology
2. Farm Management and Agricultural Economics
3. Soils
4. Fertilizers
5. Plants
   - .1 Field crops
   - .2 Horticulture
   - .3 Forestry
   - .5 Weeds
   - .6 Plant diseases
6. Foods
7. Animals
8. Entomology
9. Dairying
10. General Engineering
    - .1 Mechanics of engineering. Graphic statics
    - 2. Hydraulics. Hydrology
    - .3 Thermodynamics and heat
    - .4 Civil, structural, and architectural engineering (except subjects under 11)
    - .5 Electrical engineering (except subjects under 11)
    - .6 Mechanical engineering, machine design, machinery, (except subjects under 11)
    - .7 Manufactories
    - .8 Standard commercial sizes and practices
    - .9 Miscellaneous
11. Agricultural Engineering
    - .1 *Materials.* Manufacture, tests, strength, preservation, etc.
      - .10 General
      - .11 Wood
      - .12 Natural stone
      - .13 Ceramic products
      - .14 Concrete, cement, sand, gravel
      - .15 Lime and plasters
      - .16 Metals
      - .17 Building and roofing papers, shingles, etc.
      - .18 Glass, paints, waterproofing compounds, etc.
      - .19 Miscellaneous
    - .2 Drainage
      - .20 General
      - .21 Preliminary investigations

.22 Drainage design
.221 Tile drains
.222 Surface drains
.223 Flood control
.224 Pumping plants (see also .4124)
.225 Vertical drains
.226 Irrigated lands
.227 Structures
.23 Drainage construction (see also .45)
.231 Tile drainage construction
.232 Open ditch and levee construction
.2321 Dry land excavation
.2322 Dredging
.233 Drainage structures
.24 Drainage administration
.241 Individual
.242 Mutual or corporation
.243 District
.244 Government
.25 Drainage laws, contracts, specifications
.26 Soil erosion
.29 Miscellaneous
.3 *Irrigation*
.30 General
.31 Irrigation engineering
.311 Hydraulics of irrigation (also see 10.2)
.312 Conveyance of water (canals, canal linings, seepage losses, tunnels, flumes, pipes and inverted syphons)
.313 Irrigation structures (dams, diversion works, spillways, check gates, measuring devices)
.314 Irrigation by pumping. (See also .4124)
.32 Irrigation practice
.321 Measurement of water
.322 Preparation of land
.323 Duty of water
.324 Irrigation of special crops
.33 Storage
.34 Irrigation laws
.39 Miscellaneous
.4 Farm machinery. Farm motors. Farm tools. Excavating and grading machinery
.41 Farm machinery
.411 Farm field machinery (drawbar)
.4111 Tillage machinery
.41111 Plows
.41112 Harrows and rollers

- .41113 Cultivators
- .4112 Seeding machinery
  - .41121 Grain seeders and drills
  - .41122 Corn planter and listers
  - .41123 Potato planters
  - .41124 Garden seeders
- .4113 Harvesting and haying machinery
  - .41131 Grain binders, headers, reapers
  - .41132 Corn harvesters
  - .41133 Mowers
  - .41134 Hay rakes, loaders, stackers, etc.
  - .41135 Potato machinery
- .4114 Fertilizer machinery
- .4115 Vehicles
- .4119 Miscellaneous
- .412 Farm power machinery (belt, hand, etc.)
  - .4121 Threshers, hullers and shellers
    - .41211 Threshers and hullers
    - .41212 Corn shellers
  - .4122 Grain graders, cleaners and seed preparing machinery
  - .4123 Feed and food preparing machinery
    - .41231 Feed and ensilage cutters
    - .41232 Feed mills and flour mills
    - .41233 Shredders and huskers
    - .41234 Hay presses
    - .41235 Sorghum mills
  - .4124 Pumping, spraying and well machinery
    - .41241 Pumps
    - .41242 Well construction
    - .41243 Well digging and repairing machinery and tools
    - .41244 Spraying machinery
  - .4125 Elevators
  - .4126 Concrete machinery
  - .4127 Wood working machinery
  - .4128 Land clearing machinery
  - .4129 Miscellaneous
    - .41291 Milking machines
- .42 Farm motors
  - .421 Horses. Horse powers. Hitches
  - .422 Windmills
  - .423 Air engines. Air compressors
  - .424 Steam engines and boilers
    - .4241 Engines
    - .4242 Boilers
    - .4243 Fuels

.425 Gas engines and automotive applications
.4251 Engines
.4252 Tractors
.4253 Trucks
.4254 Automobiles
.4255 Fuels and carburetion
.4256 Ignition, starting and lighting
.4257 Other accessories
.4258 Tractor hitches and guides
.426 Electric motors
.427 Water motors
.43 Power transmission
.431 Bearings, hangers and shafting
.432 Belts, rope and pulleys
.433 Gearing
.434 Chains and sprockets
.435 Friction transmission
.436 Lubricants and lubrication
.44 Farm tools and minor equipment
.441 Agricultural tools (spades, forks, etc.)
.442 Farm hardware. Tackle blocks. Jacks
.443 Forge and machinists' tools
.444 Carpentry tools
.445 Ice tools
.446 Scales
.45 Excavating and grading machinery
.451 Trenching machinery
.452 Dry land excavating machinery
.4521 Scrapers, blade graders, levellers
.4522 Elevating graders
.4523 Power excavators
.453 Dredges
.5 *Roads and bridges*
.50 General
.51 Earth roads
.52 Gravel roads
.53 Crushed stone roads
.54 Paved roads
.55 Road laws
.56 Bridges and culverts
.59 Miscellaneous
.6 Educational and experimental
.60 General
.61 Courses of study
.611 Materials. Concrete construction
.612 Drainage
.613 Irrigation

.614 Farm machinery and farm motors
.615 Roads
.617 Farm buildings
.618 Farm sanitation
.619 Surveying, drawing, etc.
.62 Engineering societies
.63 Experimental work
.64 Public demonstrations and tests
.65 Scientific apparatus
.651 Dynamometers
.652 Measuring and recording instruments for temperature, pressure, time and speed
.653 Laboratory apparatus
.654 Electrical measuring instruments
.655 Kodaks and supplies. Photography
.66 Office equipment
.651 Furniture and filing devices
.652 Office supplies
.653 Typewriters, duplicating machines, computing machines, etc.
.7 *Farm buildings and fences*
.70 General
.701 Building codes
.702 Specifications
.703 Estimating and cost data
.704 Contracts
.705 Framing
.706 Fireproofing
.71 Dwelling houses
.72 Buildings for housing farm animals
.721 General purpose barns
.722 Horse barns
.723 Dairy cattle barns
.724 Beef cattle barns
.725 Sheep barns
.726 Hog houses
.727 Poultry houses
.73 Buildings for housing farm products
.731 Hay barns and sheds
.7311 Measuring hay in barns and stacks
.732 Corn cribs, granaries and seed rooms
.733 Silos
.734 Dairy houses and creameries
.735 Root and fruit storage buildings
.736 Smoke houses
.74 Buildings for housing machinery, equipment and supplies

.741 Machine sheds and garages
.742 Shops
.743 Fuel houses
.745 Ice houses
.746 Manure pits
.75 Fences
.76 Farmsteads
77. Live stock equipment and farm conveniences
.771 Watering tanks, troughs, and tank heaters
.772 Self feeders (grain and condiments)
.773 Feed racks
.774 Feeding floors
.775 Dipping vats and hog oilers
.776 Crates and chutes
.777 Poultry incubators and brooders
.778 Vegetable dryers. Canning equipment
.78 Farm buildings equipment
.781 Lighting
.7811 Electric light plants
.7812 Acetylene light plants
.7813 Blaugas light plants
.7814 Gasoline, kerosene and alcohol lighting
.782 Heating
.783 Ventilation
.784 Plumbing
.785 Refrigeration and creamery and dairy machinery and appliances
.786 Household machinery
.787 Barn equipment
.788 Builders' hardware. Lightning rods
.79 Miscellaneous
.791 School houses, churches and community centers
.792 Green houses, cold frames and hot beds
.8 Sanitation and water supply
.81 Sewage disposal
.811 Sewers
.812 Septic tanks and filters
.813 Cess pools
.814 Privies
.82 Garbage disposal
.83 Fly, vermin and rodent eradication
.84 Laws and regulations on sanitation
.85 Disinfection, sterilization, and general conditions of sanitation
.87 Water supply
.871 Sources of supply
.872 Filters. Purification. Softening

.873 Storage tanks, cisterns, and pressure systems

.9 *Miscellaneous*

.91 Blasting

.92 Rope knots and splices. Harness. Saddlery

.93 Farm labor efficiency

.94 Land surveying and agricultural drawing

.941 Surveying instruments

.942 Drawing instruments and supplies

99. Bibliography and classification of agricultural engineering literature

12. EXPERIMENT STATIONS AND COLLEGES—STATISTICS AND POLICIES

DISCUSSION

MR. SHEDD: That is the framework. Mr. Kaiser has worked up a table on the quantities of material required for concrete and various mixtures, which would make, I think, one suitable table to handle.

PRESIDENT SCOATES: Do I hear a motion to adopt this report?

MR. KELLEY: I move that the report be adopted.

(Motion seconded and carried.)

PARTIAL REPORT OF THE COMMITTEE ON DRAINAGE

E. R. JONES, Chairman, C. D. KINSMAN, H. E. MURDOCK, CHAS. E. SEITZ

Along with inquiries concerning courses offered in the educational institutions of the country, it was deemed advisable to secure data on the oportunities offered for securing educational work along drainage lines. A questionnaire was sent to each of the colleges in the country and replies have been received from almost all of them offering such work.

The following were the questions asked:

1. Courses covering the question of draining land.
2. Courses covering laws concerning drainage.
3. Extension work given along drainage lines.
4. Farmers' institute and Farmers' Week work on drainage topics.
5. Any opportunity offered for research work on drainage.

Many of the colleges give a general course on drainage which takes up the laws, practice, fundamental principles, economics, etc., without going thoroughly into each of the questions involved, while others offer several courses in which a pretty thorough training may be obtained. Most of those not giving specialized courses touch upon the question incidentally in connection with other courses such as agronomy, soils, sewage disposal, etc.

Opportunity is offered for investigational and research work at some of the institutions through the experiment stations.

The following is a brief summary of the drainage courses as obtained from the replies from the colleges. Those not giving special courses on the subject are not included.

The University of Arkansas gives a practical course in land drainage.

The Colorado State Agricultural College offers a 2-hour general course in drainage which deals with the laws, as well as the principles and engineering work.

The University of Florida gives a 3-hour general course in irrigation and drainage.

The University of Illinois offers a 3-hour course and a 5-hour course on the engineering phase of drainage.

The Iowa State College offers a 3-hour course in drainage engineering; a 2-hour course in drainage and irrigation engineering; and opportunity for advanced work.

Courses in drainage are offered to engineering students and agricultural students in the Kansas State Agricultural College. Both classes use C. G. Elliott's "Engineering for Land Drainage." In addition, an effort is made to have a few lectures on Kansas conditions and laws presented by the engineers of the Extension Division. The Engineering Office of the Extension Division assists farmers in laying out drainage systems and also supervises the formation of drainage districts and the construction work done in such districts. The Extension Division maintains an office of Irrigation and Drainage Engineering, employing two men, who give such assistance as is practicable to farmers applying for help.

The University of Maine offers a 3-hour course dealing in part with an economic study of drainage.

Drainage problems are usually discussed at Farmers' Week programs and institute lectures are also given on drainage lines.

The Massachusetts Agricultural College gives a 5-hour course in irrigation and drainage in which the greater part of the time is spent in drainage. It deals mostly with the engineering features.

The Michigan Agricultural College has one course given in the agricultural department on practical farm drainage which is developed with the idea of applying to the individual farm. The agricultural student is also given work in civil engineering on the engineering phases of drainage work. The agricultural course in drainage consists of one lecture and four laboratory hours per week and in the course in engineering, the course consists of five lectures per week. Brief mention in the above course is made of the laws concerning drainage. The Farmers' One Week School which is given under supervision of County Agents, includes considerable work in drainage. This work is conducted by an extension specialist who devotes practically two-thirds of his time to drainage work. Some lectures have been given during Farmers' Week on drainage topics at various times.

The Mississippi Agricultural and Mechanical College offers a course in drainage and surveying, and one in agricultural engineering in which the drainage laws are considered.

The University of Missouri offers a 3-hour course in farm drainage dealing with the general question, and a 3-hour course in drainage and roads. A little extension work is done, and Farmers' Week lectures are given.

The Montana State College offers a 2-hour course on irrigation and drainage which deals with the general question of drainage. Extension work is given to farmers in determining on methods of draining lands, the location of drains, and the formation of draining districts. Farmers' Week programs usually contain drainage lectures.

The University of Nebraska offers two general courses in irrigation and drainage. One is for engineering students and the other is for non-engineering students. Extension work is also done.

In the University of Nevada a 5-hour course is offered in irrigation and drainage in which drainage is dealt with in connection with irrigation.

The New Hampshire College offers a 3-hour course in agricultural engineering, about one-third of which is spent on drainage.

The North Carolina State College of Agriculture and Engineering has a 3-hour course in farm drainage in which the principles and practice of drainage are covered.

The North Dakota Agricultural College offers a course in concrete and drainage in which open ditches and tile drains are taken up.

The Ohio State University offers a 3-hour course in drainage in which the subject is covered in a general way and practical work is done.

One man devotes a large part of his time to extension work in drainage. Some lectures are given at institutes.

The Oregon State Agricultural College offers a 3-hour course in drainage and irrigation dealing with engineering features of the subjects. A 3-hour course in history, installation and operation of land drainage systems is given. Also opportunity for advanced work is offered. Extension work is given in demonstration, surveys and construction; formation of districts.

Purdue University offers two agronomy courses which deal incidentally with drainage, and one 3-hour course dealing with the engineering phase of drainage. A little extension and farmers' institute work is also offered.

The Agricultural and Mechanical College of Texas offers a 4-hour course in drainage which deals with the design and location of drainage systems and with the Texas district law.

The Utah Agricultural College offers a general course in drainage that deals with drainage laws, practice, etc. Extension work is also done in drainage.

The University of Wisconsin has a 3-hour course in land drainage dealing with the engineering principles. Another 3-hour advanced course on observations, design, etc. Extension work is conducted in demonstration and field examinations for proposed districts and for individual land owners. At Farmers' Week and institutes drainage lectures are given, and special meetings are held. Opportunity for investigations along drainage lines is offered on the College farm.

The University of Wyoming has a 2- and 3-hour course on drainage. Farmers' institute lectures and demonstrations are given.

DISCUSSION

MR. JONES: Mr. Murdock has gone into detail in comparing courses in drainage given at the agricultural colleges throughout the United States. He finds there are twenty-three of the agricultural colleges giving courses in land drainage. He has summarized here very concisely and pointed out some interesting details, but the hour is getting so late it will be sufficient, I believe, to have them appear in our annual report. That is one feature.

The second feature of our report deals with Secretary Lane's proposition to induce soldiers to settle on the undeveloped lands in all of the states, including the irrigated lands of the west, the lands of the north, to some extent those in the south, and the wet and overflowed lands that need draining. In his letter last June to the President he made a simple recommendation. It set us to thinking as to what part in this program the development of our wet lands could play, and I got in touch with as many of the agricultural colleges as I could in the middle west and consulted what records were available. I have here five conclusions that are brief but so far as I am able to size up the question, summarizes the situation.

First, that wet and overflowed lands offer unusual opportunities for developing settlements.

Second, that any plan of settlement offered by the Federal Government be not limited to soldier settlement, but be open to all who desire to make homes on new lands.

Now that may be a delicate point to discuss because on the surface it is made to appear that this whole movement is to help the returned soldier. My feeling is that any plan of settlement that will help the returned soldier is also good for any soldier seeking home on new lands, and I believe the object of this movement is to open up homes to everybody wanting one, so I believe we ought to say it instead of camouflaging it behind a movement to get soldiers to go on undeveloped land.

Third, that there are three distinct types of wet land that lend themselves to development. First, the large areas of the south—50,000 acres sometimes in a single unit that must be developed as a unit or you can't do anything with it. Those are 5-year projects and even longer. They are not capable of immediate settlement. However, they should be developed in time and are mighty good projects. The second class are the northern areas where the marshes generally are less than 5,000 acres in extent, each one of which is a unit provided with an outlet, supplementary drains and that can be developed so that in from 2 to 3 years they are open to settlement. It looks as if those projects lend themselves better to immediate development and should require immediate attention, for that reason, along with these bigger projects.

Now class number three. It consists of the land in drainage districts—chiefly in Wisconsin and Minnesota—land now organized with the outlets and ditches constructed, but where those lands are but little more productive than they were before the outlet drainage was put in. Half the job was done in those districts. Those were merely the supplemental drains. By year after next at the latest they should be ready for crops.

Now it appears that those lands, if there is a demand for immediate settlement, and I believe there is, are the ones that seem to lend themselves to the movement better than any of the other two classes which I have mentioned. I can speak from personal knowledge of about 400,000 acres of marsh lands in drainage districts in Wisconsin that are in a half developed state. Why haven't they been developed? For two reasons: first, where the wet land is a part of a farm and there is 60 acres of high land, 40 acres of low land, the labor situation is acute.

There is another class of lands that has been bought up for from $10 to $20 an acre by promoters organizing drainage districts, where the holding companies haven't money enough to swing the deal. If they sold to settlers they would have to demand such a big initial payment the settlers wouldn't have the money to complete the development. The result is those lands are standing still.

Now I should say some plan should be devised by which the Government supply in a limited way, at a rock bottom price, complete the draining under the direction of competent engineers, thereby insuring economy, and selling to settlers at actual cost on easy terms. In other words, the Government would merely step in and finance the settlements.

That leads to the fourth conclusion, that better financing is needed in draining districts, and the Federal Government can aid in this respect, first by actually buying at a rock bottom price some of the marsh lands for immediate settlement, completing the drainage at settlement cost; and the second would be, in the districts not now organized, for the Government to loan money to those districts just as it does to irrigation projects in the west—not giving money, merely loaning it at 3 and 3½ percent interest, the settler to pay in full before he gets a clear title to his land.

We want to be careful that we don't get over-paternalistic. The fifth recommendation would be that the settler be made to stand on his own feet and the Government merely help him to help himself. That summarizes the situation that I present.

PRESIDENT SCOATES: Any discussion on that question? Professor Jones, did you want any action taken on that?

MR. JONES: I don't know that any action is necessary. I mean to boil down those five points. I have merely summarized them.

REPORT OF THE COMMITTEE ON IRRIGATION

O. W. ISRAELSEN, Chairman, H. E. MURDOCK, F. L. BIXBY. and P. A. WELTY

INSTRUCTION IN IRRIGATION OFFERED BY AMERICAN COLLEGES

H. E. MURDOCK

The report of this committee for last year brought out the necessity for the dissemination of knowledge in irrigation. This year it was deemed advisable to present a summary of the educational work which is offered by the educational institutions of the country. A letter was written to each of the colleges asking for a summary on the following points:

1. Courses aiming at engineering features in getting water to the farms.
2. Courses aiming at engineering features in applying water to the land.
3. Courses in which the laws concerning irrigation are considered.
4. Courses dealing with the operation and maintenance of irrigation systems.
5. Outline of extension work done along irrigation lines.
6. Outline of Farmers' Institute or Farmers' Week work in irrigation.
7. Opportunities offered for research work in irrigation.

Replies have been received from most of the institutions offering work in irrigation. Many give drainage work, but touch irrigation only incidentally with agronomy, soils surveying, water supply, sewage, etc. Some of the eastern colleges consider irrigation by spraying, and the use of supplemental irrigation.

Some of the institutions offer opportunity for research work in connection with the agricultural experiment stations.

Courses are offered in some of the colleges giving a general idea of the subject of irrigation dealing with methods, practice, laws, and operation.

Some of the institutions offer two courses which are similar with respect to subject matter but differ in that one is designed for regular college students and the other, more elementary in character, for practical students below college grade.

A summary of the work as submitted by the various institutions giving irrigation work follows:

The University of Arizona gives a 4-hour course dealing with the engineering features, and maintenance and operation of irrigation systems, a 3-hour course dealing with irrigation laws and a 3-hour course in surveying touching upon the application of water to the land.

The Colorado State Agricultural College offers a 3-hour course in irrigation engineering which deals with the engineering features of getting the water to farms and applying it. Another 2-hour course on canal surveying is also given on engineering. A 3-hour course on irrigation farming deals with applying water to the land. A 2-hour course in irrigation law is given. A 2-hour course in canal management deals with operation and maintenance.

The University of Florida offers a 3-hour course in irrigation and drainage.

The University of Illinois offers courses on the engineering features of irrigation.

The Iowa State College gives a 2-hour course on irrigation dealing in a general way with the subject; a 2-hour course in drainage and irrigation engineering; and opportunity for advanced work.

The Kansas State Agricultural College offers two courses in irrigation, one for engineering students and one for agriculture students. The Extension Division maintains an office of Irrigation and Drainage Engineering, employing two men. This office gives such assistance as it practicable to farmers applying for help.

The office mentioned above generally has a limited part on the program of our Farmers' Week, and in addition is sponsor for a State Irrigation Congress which holds a 2- or 3-day session annually.

Montana State College offers three courses dealing with the engineering features of securing water and conducting it to the land. These include canal surveying, irrigation engineering and pumping for irrigation; a total of 9 credit-hours. One of these courses deals a little with irrigation management. One course of 3 hours deals with the history of irrigation and a 3-hour course on canal management is given.

There is a 2-hour course on irrigation and drainage dealing with the application of water to the land.

Some extension work is done in assisting farmers in pumping lines and in applying water to the land.

Farmers' Week programs usually contain lectures on irrigation.

The University of Nebraska is giving two courses in irrigation and drainage. One of these courses is primarily for engineering students and takes up briefly all phases of irrigation and drainage engineering, and the other course is primarily for the non-engineering students. Opportunity is given for the students to conduct research work along these lines.

An irrigation school has also been established at Scottsbluff, at which school it is the aim to give a rather practical course in irrigation matters.

The University of Nevada has a 5-hour course in irrigation and drainage dealing with the engineering side. The drainage relates to irrigated lands. A 3-hour course is given in the history of irrigation.

The Oregon Agricultural College offers a 3-hour course in irrigation farming dealing with the laws, handling water, and crops, and another 3-hour course on the same subject dealing with the engineering side. A 2-hour course is given on the institutions and laws. Opportunity is offered for selective work in a 2-hour course in irrigation farming, in a 1- to 3-hour course in field practice, a 1-hour course in management and also other advanced work.

The Rhode Island State College provides a 3-hour course on irrigation engineering.

The Agricultural and Mechanical College of Texas offers a 4-hour course in irrigation dealing with the questions involved in a general course.

A course on irrigation and drainage is also given to secondary students in use of instruments.

The Utah Agricultural College offers one 5-hour and one 10-hour course aiming at the engineering features in getting water to farms, two 5-hour courses concerning the application of water to the land, and one 3-hour course on irrigation law.

An extension specialist in irrigation and drainage handles the extension work.

Farmers' Week and Farmers' Institutes devote some time to this question.

The State College of Washington offers a course in irrigation engineering covering the general engineering questions concerned with delivering water to the land; another course covering the laws is also given.

The University of Wyoming has a 2-hour course covering the laws of irrigation, a 2- or 3-hour course dealing with the application of water and getting the water to the land, and a 2-hour course on irrigation structures.

Lectures are given at farmers' institutes.

REPORT OF THE COMMITTEE ON SANITATION

H. H. Musselman, Chairman, X. Caverno, H. W. Riley

Mr. Musselman: Mr. President, I will have to report we haven't made any progress this year. I haven't any recommendations to make on that work. Something of a survey has been made of sanitation and reported at previous meetings of the Society. We haven't been able to get anything that is particularly new along this line so we will simply report in that way.

REPORT OF COMMITTEE ON FARM POWER

E. R. Gross, Chairman, R. A. Andree, G. W. McCuen, E. V. Collins

TRACTOR AND GAS ENGINE COURSES FOR FARMERS

By E. R. Gross,[1] Member Amer. Soc. A. E.

The committee begs to submit the following brief report of its activities. A canvas of the 48 land grant colleges was made to ascertain number of farmers' short courses in Gas Engines and Tractors held during the past year (July 1917-July 1918) also the nature of instruction and general success of the work.

Labor conditions due to the stress of war times were and are still so acute that it seems of the greatest importance to do all possible farm operations by mechanical power. Hence the decision of the committee to investigate the means of educating the agricultural public in farm power.

The work in the colleges presents a very creditable showing. The writer is aware that an even better showing could have been made if more time could have been spared to pursue the collecting of data. The reports received gave to some extent regular college work in gas engines. This was not desired. It has been eliminated from the figures given here.

A few of the most outstanding figures are:

Number of colleges canvassed	48
Number responding	29
Number reporting schools	19
Total number of schools held	54
Total attendance	2660
Average attendance	49
Number of 6-day schools	30
Number of all other lengths	24
Number of girls in attendance	42
Total number of days schools were held	379
Average length of schools *in days*	7
Number of schools held at college campus	29
Number of schools held out in state	25

School varied in length from 3 to 36 days. Six-day schools were most common. Schools reported as one week have been counted as 6-day schools. Probably only 5 days were actually used in some cases. No conclusion could be reached as to best length of school. We notice that the average length (7 days)

[1] Extension Specialist in Agricultural Engineering, Mississippi Agricultural and Mechanical College, Agricultural College, Miss.

holds close to the 6-day schools of which there were the greatest number, showing that the wide departure from this length is unusual. There is considerable demand for 10-day or 2-week schools, several reports show prospective schools of 4 weeks and several of 2 weeks, but the greater number seem to hold to 1-week schools. We report several here because a definite number of schools was not stated in many cases. For example a report reads, "Will hold a 2-weeks' course at each Agricultural High School in state."

The tendency is toward holding more schools out in the state as against holding them at the college campus. The greatest number held by one state was 20 in New York. Nebraska and Mississippi are second with 5.

The number of people to be reached is unlimited. Over 2660 were reached this year. This figure does not include all, since several schools did not report attendance. The average attendance was 49. This is especially mentioned because some reports indicate a lack of instructional help. It may be necessary and desirable, therefore, to hold many small schools instead of a few large ones. The advantage in small schools is that the school may be brought to the farmer instead of the farmer to the school.

Forty-two girls attended schools. In many cases they were allowed to register, but none did. The general attitude seems to be to open the work to women. It may or may not be necessary to urge girls to do much work. Surely there can be no harm in leaving the work open to them.

Whether tuition is charged or not seems to be of little general importance. From $1 to $5 was charged in 10 of the 54 schools.

Other work than gas engine and tractor instruction was given in a large majority of the schools of more than 6 days. The following work is mentioned in the reports; babbitting, pipe fitting, soldering, belt lacing, rope splicing, knot tieing, tractor implements, machine shop, forge work.

The principal work of the schools was given very nearly the same in all reports, varying only in the amount of detail given. The work may be outlined as follows:

Gas Engines.

1. Principle.
    - The engine cycle
    - Two cycle and Four cycle
    - Ignition
        - Make and break (low tension)
        - Jump spark (high tension)
        - Magnetos
    - Carburetors
        - Types
        - Fuels
    - Governors

2. Construction.
   - Valves
   - Rings
   - Mufflers
3. Operation
   - Cooling
   - Lubrication
   - Power
   - Trouble

Tractors

1. Construction
   - Transmission
   - Gear shift
   - Clutch
   - Differential
   - Engine types
   - Types of frames
   - Types of traction
2. Operation
   - Hitches
   - Power
   - Trouble

The success of the schools very clearly depends upon two factors: A sufficient number of instructors and an ample supply of equipment.

Attendance seems to be the smallest worry. True a few schools reported very small attendance, but they were also reported satisfactory. According to our reports the two above named factors and weather conditions are the only obstacles in the way of satisfactory conduct of the schools. No school reports a discontinuance of the work. Three do not give any information on future plans.

The winter months are unanimously reported the best time for holding these schools. This is due to the farmers' freedom from the rush of work.

A canvass was also made of seventy-three farm papers and magazines to ascertain what material they had been printing along this line. Results were not very satisfactory. Eight reported having printed a definite course of study or similar articles. This information from magazines was collected by Mr. Robert E. Bosque of Texas Agricultural and Mechanical College.

REPORT OF COMMITTEE ON FARM STRUCTURES

H. H. Niemann, Chairman, W. A. Etherton, Rolf Thelen, A. H. Connolly, R. S. Kellogg, W. G. Kaiser

The work undertaken by the Farm Structures Committee this year consists in selecting a few designs of barn arrangements, which may be considered typical of the farmer's needs, together with designs of construction which most efficiently lend themselves to the average barn requirements.

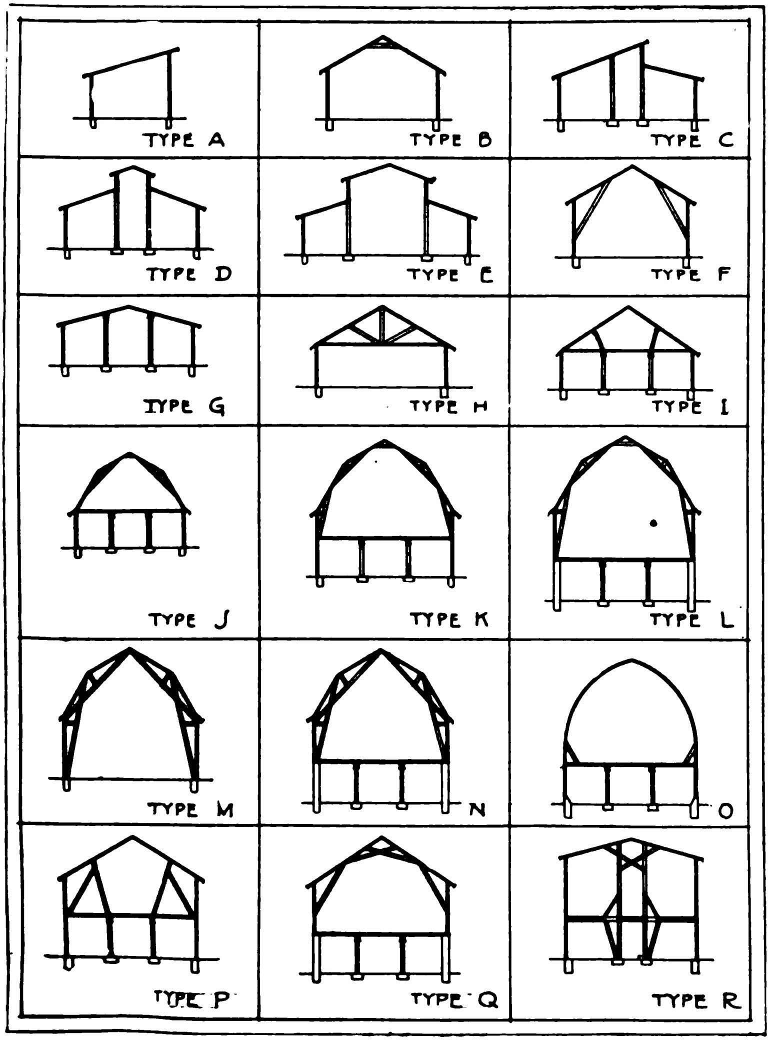


Fig. 1. Types of Barn Construction

These designs of barn construction and arrangements are presented to the society as a nucleus from which future committees may work out a set of standards for the construction and arrangements of barns for the American farmer.

In selecting these designs it has been our aim to procure designs that would be the most flexible as to the kinds of building materials suitable for their construction, and arrangements suitable for various farming conditions.

As this report covers two distinct, yet closely related problems, namely, Construction and Arrangement, we will take them up separately and in their respective order.

CONSTRUCTION

From a large number of designs, representing almost every conceivable type of building construction, a few outlines have been selected, representing eighteen kinds of construction which can be applied efficiently to meet nearly all the needs of the farmers in various climates.

For convenience these eighteen outlines or types of construction have been lettered in alphabetical order from type A to type R inclusive, as illustrated in Fig. 1.

Next, we have worked out a set of plates illustrating the various sizes and proportions for each type, and each of these plates also shows the size of the material required for its various members.

These plates are indexed by giving the letter of the type represented, followed by the height of the side walls or studding in feet, followed by the width of the building in feet. For example, a barn of the gambrel roof, braced rafter type, having 12 ft. studding and being 36 ft. wide, is indexed as K-12-36.

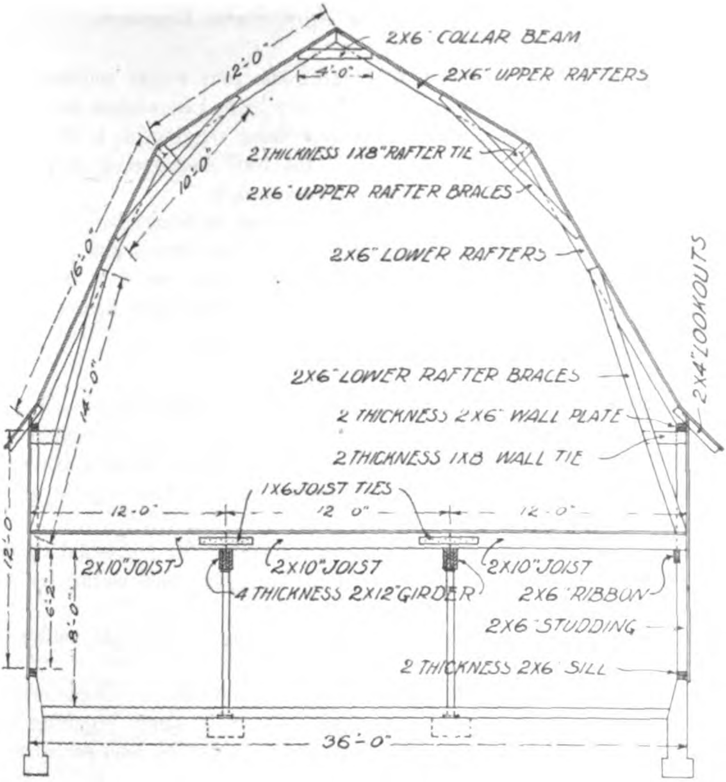
Lack of time has prevented the committee from completing drawings and tables covering all the various details and capacities for the eighteen types illustrated in Fig. 1. Only a few have been developed by the committee, which are as follows:

TYPE K

Type K refers to the gambrel roof, braced rafter type of construction which is particularly recommended for general purpose and dairy barns, for western states, where it is not neecssary to drive into the mow for threshing or for the storage of grain previous to threshing.

The particular size illustrated by cross section K-12-36 is for a barn 36 ft. wide and side walls made of studding 12-ft. long. Upon examining this particular plate, you will notice that it gives the length and size of each rafter, brace, studding, joist, girder, etc., all property proportioned for greatest efficiency, best appearing contour, and of the correct strength to safely resist all dead and live loads they will be subject to, under ordinary conditions.

The advantage of this type of construction is that it requires no timber larger than will be found in stock at the average lumber yard, saving time of ordering special sizes, and these also require less heavy lifting.



CROSS SECTION OF CONSTRUCTION. TYPE "K-12-36"

BARN CONSTRUCTION - TYPE "K"

TABLE OF TIMBER SIZES, FRAMING LUMBER REQUIRED & LOOSE HAY CAPACITIES PER 2 FT. BENT.

TYPE INDEX	SIDEWALL FRAMING				MOW FLOOR FRAMING					ROOF FRAMING								TOTAL FEET OF LUMBER	TONS OF LOOSE HAY
	SILLS	STUDDING	PLATES	RIBBONS	GIRDER	OUTER JOIST	CENTER JOIST	JOIST SPLICES	BRIDGING	LOWER RAFTERS	UPPER RAFTERS	LOWER BRACES	UPPER BRACES	RAFTER TIES	WALL TIES	COLLAR BEAM	LOOKOUTS		
K-12-32	2X6-8	2X6-12	2X6-8	2X6-4	2X12-16	2X10-10	2X10-12	1X6-6	1X4-12	2X6-14	2X6-10	2X6-12	2X6-8	1X8-4	1X8-6	2X6-4	2X4-3	239	1.87
K-14-32	2X6-8	2X6-14	2X6-8	2X6-4	2X12-16	2X10-10	2X10-12	1X6-6	1X4-12	2X6-14	2X6-10	2X6-12	2X6-10	1X8-6	1X8-6	2X6-5	2X4-3	250	2.00
K-16-32	2X6-8	2X6-16	2X6-8	2X6-4	2X12-16	2X10-10	2X10-12	1X6-6	1X4-12	2X6-14	2X6-10	2X6-14	2X6-12	1X8-6	1X8-8	2X6-5	2X4-3	263	2.18
K-18-32	2X6-8	2X6-18	2X6-8	2X6-4	2X12-16	2X10-10	2X10-12	1X6-6	1X4-12	2X6-14	2X6-10	2X6-16	2X6-12	1X8-6	1X8-8	2X6-6	2X4-4	273	2.42
K-20-32	2X6-8	2X6-20	2X6-8	2X6-4	2X12-16	2X10-10	2X10-12	1X6-6	1X4-12	2X6-14	2X6-10	2X6-16	2X6-12	1X8-6	1X8-8	2X6-6	2X4-4	277	2.68
K-12-34	2X6-8	2X6-12	2X6-8	2X6-4	2X12-16	2X10-12	2X10-12	---	1X4-12	2X6-14	2X6-12	2X6-12	2X6-10	1X8-6	1X8-6	2X6-4	2X4-3	252	2.00
K-14-34	2X6-8	2X6-14	2X6-8	2X6-4	2X12-16	2X10-12	2X10-12	---	1X4-12	2X6-14	2X6-12	2X6-14	2X6-12	1X8-6	1X8-8	2X6-5	2X4-3	267	2.56
K-16-34	2X6-8	2X6-16	2X6-8	2X6-4	2X12-16	2X10-12	2X10-12	---	1X4-12	2X6-14	2X6-12	2X6-16	2X6-12	1X8-6	1X8-8	2X6-5	2X4-3	275	2.44
K-18-34	2X6-8	2X6-18	2X6-8	2X6-4	2X12-16	2X10-12	2X10-12	---	1X4-12	2X6-14	2X6-12	2X6-18	2X6-12	1X8-6	1X8-8	2X6-6	2X4-4	285	2.70
K-20-34	2X6-8	2X6-20	2X6-8	2X6-4	2X12-16	2X10-12	2X10-12	---	1X4-12	2X6-14	2X6-12	2X6-18	2X6-14	1X8-8	1X8-8	2X6-6	2X4-4	294	2.98
K-12-36	2X6-8	2X6-12	2X6-8	2X6-4	2X12-16	2X10-12	2X10-12	1X6-6	1X4-12	2X6-16	2X6-12	2X6-14	2X6-10	1X8-6	1X8-6	2X6-5	2X4-3	263	2.22
K-14-36	2X6-8	2X6-14	2X6-8	2X6-4	2X12-16	2X10-12	2X10-12	1X6-6	1X4-12	2X6-16	2X6-12	2X6-16	2X6-12	1X8-6	1X8-8	2X6-6	2X4-3	278	2.52
K-16-36	2X6-8	2X6-16	2X6-8	2X6-4	2X12-16	2X10-12	2X10-12	1X6-6	1X4-12	2X6-16	2X6-12	2X6-16	2X6-12	1X8-8	1X8-8	2X6-6	2X4-3	283	2.80
K-18-36	2X6-8	2X6-18	2X6-8	2X6-4	2X12-16	2X12-12	2X12-12	1X6-6	1X4-12	2X6-16	2X6-12	2X6-18	2X6-14	1X8-8	1X8-8	2X6-6	2X4-4	296	3.10
K-20-36	2X6-8	2X6-20	2X6-8	2X6-4	2X12-16	2X12-12	2X12-12	1X6-6	1X4-12	2X6-16	2X6-12	2X6-18	2X6-14	1X8-8	1X8-8	2X6-7	2X4-4	301	3.38
K-12-38	2X6-8	2X6-12	2X6-8	2X6-4	2X12-16	2X12-12	2X12-14	2X6-6	1X4-12	2X6-14	2X6-14	2X6-12	2X6-12	1X10-6	1X10-6	2X6-5	2X4-3	284	2.38
K-14-38	2X6-8	2X6-14	2X6-8	2X6-4	2X12-16	2X12-12	2X12-14	2X6-6	1X4-12	2X6-14	2X6-14	2X6-14	2X6-12	1X10-6	1X10-6	2X6-6	2X4-3	293	2.64
K-16-38	2X6-8	2X6-16	2X6-8	2X6-4	2X12-16	2X12-12	2X12-14	2X6-6	1X4-12	2X6-14	2X6-14	2X6-16	2X6-12	1X10-6	1X10-8	2X6-6	2X4-3	303	2.94
K-18-38	2X6-8	2X6-18	2X6-8	2X6-4	2X12-16	2X12-12	2X12-14	2X6-6	1X4-12	2X6-14	2X6-14	2X6-18	2X6-14	1X10-8	1X10-8	2X6-7	2X4-4	318	3.24
K-20-38	2X6-8	2X6-20	2X6-8	2X6-4	2X12-16	2X12-12	2X12-14	2X6-6	1X4-12	2X6-14	2X6-14	2X6-20	2X6-12	1X10-8	1X10-8	2X6-7	2X4-4	322	3.56
K-12-40	2X6-8	2X6-12	2X6-8	2X6-4	2X12-16	2X12-14	2X12-14	---	1X4-12	2X6-16	2X6-14	2X6-12	2X6-14	1X10-8	1X10-8	2X6-6	2X4-4	298	2.50
K-14-40	2X6-8	2X6-14	2X6-8	2X6-4	2X12-16	2X12-14	2X12-14	---	1X4-12	2X6-16	2X6-14	2X6-14	2X6-14	1X10-8	1X10-8	2X6-6	2X4-4	306	2.82
K-16-40	2X6-8	2X6-16	2X6-8	2X6-4	2X12-16	2X12-14	2X12-14	---	1X4-12	2X6-16	2X6-14	2X6-16	2X6-14	1X10-8	1X10-8	2X6-6	2X4-4	314	3.14
K-18-40	2X6-8	2X6-18	2X6-8	2X6-4	2X12-16	2X12-14	2X12-14	---	1X4-12	2X6-16	2X6-14	2X6-18	2X6-14	1X10-8	1X10-8	2X6-7	2X4-4	322	3.46
K-20-40	2X6-8	2X6-20	2X6-8	2X6-4	2X12-16	2X12-14	2X12-14	---	1X4-12	2X6-16	2X6-14	2X6-20	2X6-14	1X10-8	1X10-8	2X6-7	2X4-4	331	3.78

With the roof arches transferring the roof weight uniformly on all the studding, this gives a uniformly loaded foundation wall.

This type also prevents the roof from sagging, as is often experienced with barns having a light roof construction supported by heavy trusses spaced some distance apart.

The following table gives the size of each member, the total amount of framing lumber required for its construction per 2 ft. bent, and the loose hay capacity of the mow per 2 ft. bent, for the various sizes of barns as indicated by the index figures in the left hand column.

TYPE L

Type L refers to the gambrel roof, braced rafter type used as a superstructure on a masonry or frame basement, and is particularly recommended for general purpose or dairy barns where a driveway is required into the mow for threshing, or the storage of grain previous to threshing.

This type of construction is most suitable for horizontal siding, because the 24″ spacing of the studding gives good nailing for the horizontal siding.

This type of construction distributes the roof weight uniformly over the foundation, the same as type K.

This type is not recommended for a northern climate where winters are long and the pasture season is short, requiring the barn to have a hay storage capacity exceeding 2½ tons per animal, because in this case it would require the superstructure to have high side walls built of long timbers, making it expensive construction by having the long studding and roof braces spaced so close together.

The one size illustrated by cross section L-12-36 is for a barn having a superstructure with sidewalls made of 12 ft. studding and of 36 ft. width.

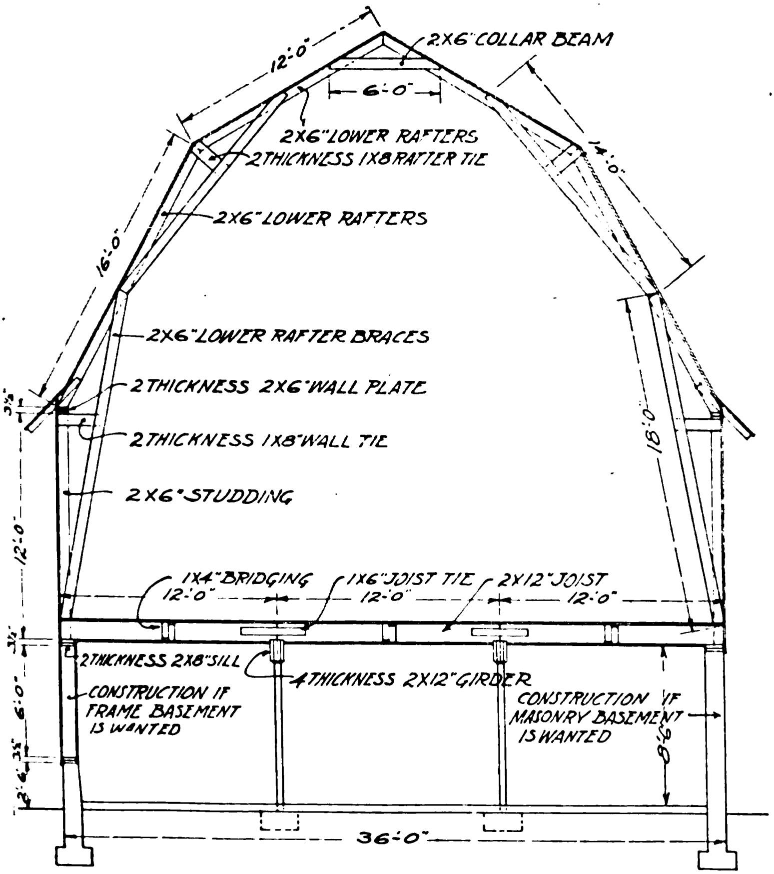
TYPE M

Type M refers to a one-story structure of a plank truss, gambrel roof construction, consisting of trusses made of plank, spaced 12 to 16 ft. apart, forming a clear span roof support by means of braced purlines spanning from one truss to the next which in turn support the rafters.

This type of construction is particularly recommended for hay storage sheds, requiring an economical structure free of posts or beams which would interfere with the handling of the hay.

It is best adapted for vertical siding, as it does not require many studding between the trusses and the horizontal nailing girts required for the vertical siding also act as tie beams for the trusses.

When used as a hay shed or implement shed, it is most economical to place the trusses on substantial masonry piers and build thin walls between the piers to keep out vermin and moisture.



CROSS SECTION OF CONSTRUCTION, TYPE "L-12-36"

BARN CONSTRUCTION TYPE "L"

TABLE OF TIMBER SIZES, FRAMING LUMBER REQUIRED & LOOSE HAY CAPACITIES PER 2 FT. BENT

TYPE INDEX	SIDEWALL FRAMING				MOW FLOOR FRAMING					ROOF FRAMING							TOTAL FEET OF LUMBER	TONS OF LOOSE HAY
	SILLS	STUDDING	PLATES	WALL BRACES	GIRDER	OUTER JOIST	CENTER JOIST	JOIST SPLICES	BRIDGING	LOWER RAFTERS	UPPER RAFTERS	LOWER BRACES	UPPER BRACES	ALL BRACE TIES	COLLAR BEAMS	LOOKOUTS		
L-12-32	2X8-8	2X6-12	2X6-8	- - -	2X12-16	2X10-10	2X10-12	1X6-8	1X4-12	2X6-14	2X6-10	2X6-18	2X6 12	1X8-16	2X6-5	2X4-4	265	2.60
L-14-32	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X10-10	2X10-12	1X6-8	1X4-12	2X6-14	2X6-10	2X6-18	2X6-14	1X8-18	2X6-5	2X4-4	285	2.86
L-16-32	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X10-10	2X10-12	1X6-8	1X4-12	2X6-14	2X6-10	2X6-18	2X6-14	1X8-20	2X6-5	2X4-4	295	3.12
L-12-34	2X8-8	2X6-12	2X6-8	- - -	2X12-16	2X10-12	2X10-12	- - -	1X4-12	2X6-14	2X6-12	2X6-18	2X6-12	1X8-16	2X6-5	2X4-4	275	2.78
L-14-34	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X12-12	2X12-12	- - -	1X4-12	2X6-14	2X6-12	2X6-18	2X6-14	1X8-18	2X6-5	2X4-4	304	3.06
L-16-34	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X12-12	2X12-12	- - -	1X4-12	2X6-14	2X6-12	2X6-18	2X6-14	1X8-20	2X6-5	2X4-4	313	3.32
L-12-36	2X8-8	2X6-12	2X6-8	- - -	2X12-16	2X12-12	2X12-12	1X6-8	1X4-12	2X6-16	2X6-12	2X6-18	2X6-14	1X8-18	2X6-6	2X4-4	290	3.14
L-14-36	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X12-12	2X12-12	1X6-8	1X4-12	2X6-16	2X6-12	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	314	3.44
L-16-36	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X12-12	2X12-12	1X6-8	1X4-12	2X6-16	2X6-12	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	322	3.72
L-12-38	2X8-8	2X6-12	2X6-8	- - -	2X12-16	2X12-12	2X12-14	1X6-8	1X4-12	2X6-14	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	303	3.20
L-14-38	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X12-12	2X12-14	1X6-8	1X4-12	2X6-14	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	318	3.50
L-16-38	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X12-12	2X12-14	1X6-8	1X4-12	2X6-14	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	326	3.80
L-12-40	2X8-8	2X6-12	2X6-8	- - -	2X12-16	2X12-14	2X12-14	- - -	1X4-12	2X6-16	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	309	3.54
L-14-40	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X12-14	2X12-14	- - -	1X4-12	2X6-16	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	324	3.66
L-16-40	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X12-14	2X12-14	- - -	1X4-12	2X6-16	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	343	4.18

With the roof arches transferring the roof weight uniformly on all the studding, this gives a uniformly loaded foundation wall.

This type also prevents the roof from sagging, as is often experienced with barns having a light roof construction supported by heavy trusses spaced some distance apart.

The following table gives the size of each member, the total amount of framing lumber required for its construction per 2 ft. bent, and the loose hay capacity of the mow per 2 ft. bent, for the various sizes of barns as indicated by the index figures in the left hand column.

TYPE L

Type L refers to the gambrel roof, braced rafter type used as a superstructure on a masonry or frame basement, and is particularly recommended for general purpose or dairy barns where a driveway is required into the mow for threshing, or the storage of grain previous to threshing.

This type of construction is most suitable for horizontal siding, because the 24″ spacing of the studding gives good nailing for the horizontal siding.

This type of construction distributes the roof weight uniformly over the foundation, the same as type K.

This type is not recommended for a northern climate where winters are long and the pasture season is short, requiring the barn to have a hay storage capacity exceeding 2½ tons per animal, because in this case it would require the superstructure to have high side walls built of long timbers, making it expensive construction by having the long studding and roof braces spaced so close together.

The one size illustrated by cross section L-12-36 is for a barn having a superstructure with sidewalls made of 12 ft. studding and of 36 ft. width.

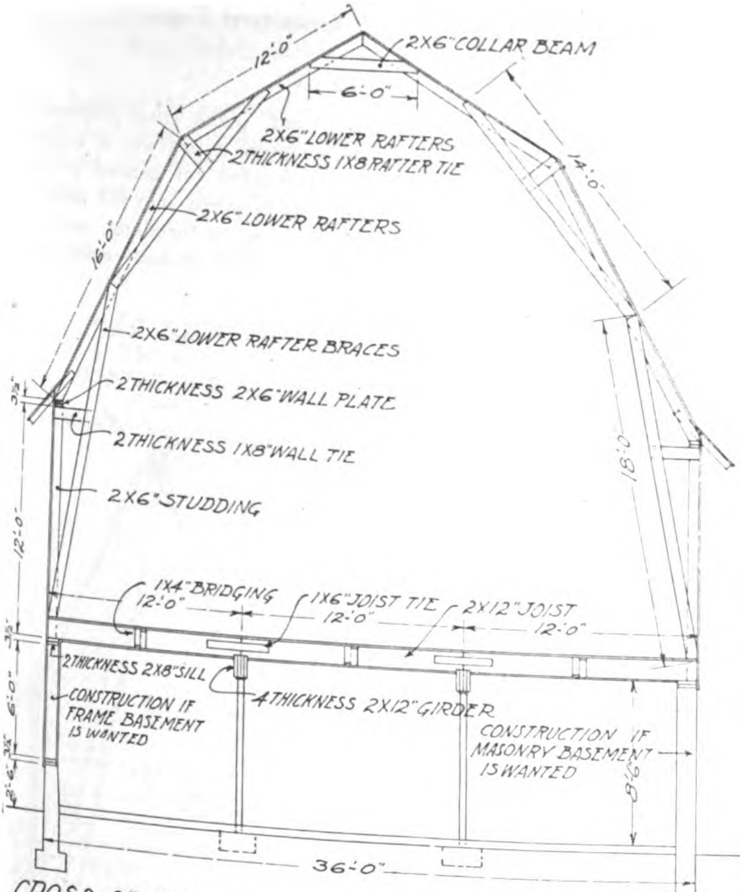
TYPE M

Type M refers to a one-story structure of a plank truss, gambrel roof construction, consisting of trusses made of plank, spaced 12 to 16 ft. apart, forming a clear span roof support by means of braced purlines spanning from one truss to the next which in turn support the rafters.

This type of construction is particularly recommended for hay storage sheds, requiring an economical structure free of posts or beams which would interfere with the handling of the hay.

It is best adapted for vertical siding, as it does not require many studding between the trusses and the horizontal nailing girts required for the vertical siding also act as tie beams for the trusses.

When used as a hay shed or implement shed, it is most economical to place the trusses on substantial masonry piers and build thin walls between the piers to keep out vermin and moisture.



CROSS SECTION OF CONSTRUCTION, TYPE "L-12-36"

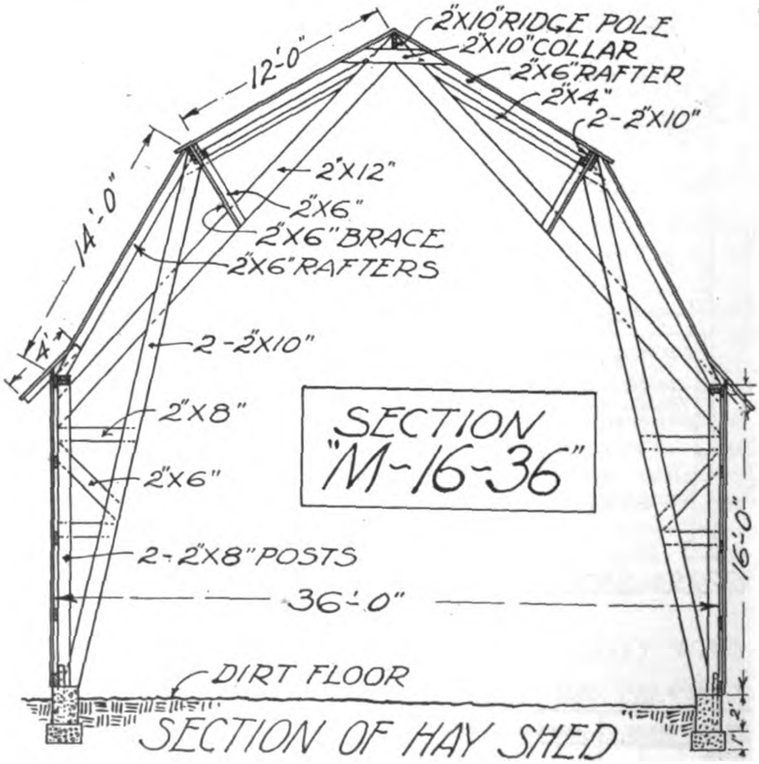
BARN CONSTRUCTION TYPE "L"

TABLE OF TIMBER SIZES, FRAMING LUMBER REQUIRED & LOOSE HAY CAPACITIES PER 2 FT. BENT

TYPE INDEX	SIDEWALL FRAMING				MOW FLOOR FRAMING					ROOF FRAMING							TOTAL FEET OF LUMBER	TONS OF LOOSE HAY
	SILLS	STUDDING	PLATES	WALL BRACES	GIRDER	OUTER JOIST	CENTER JOIST	JOIST SPLICES	BRIDGING	LOWER RAFTERS	UPPER RAFTERS	LOWER BRACES	UPPER BRACES	ALL BRACE TIES	COLLAR BEAMS	LOOKOUTS		
L-12-32	2X8-8	2X6-12	2X6-8	---	2X12-16	2X10-10	2X10-12	1X6-8	1X4-12	2X6-14	2X6-10	2X6-18	2X6-12	1X8-16	2X6-5	2X4-4	265	2.60
L-14-32	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X10-10	2X10-12	1X6-8	1X4-12	2X6-14	2X6-10	2X6-18	2X6-14	1X8-18	2X6-5	2X4-4	285	2.86
L-16-32	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X10-10	2X10-12	1X6-8	1X4-12	2X6-14	2X6-10	2X6-18	2X6-14	1X8-20	2X6-5	2X4-4	295	3.12
L-12-34	2X8-8	2X6-12	2X6-8	---	2X12-16	2X10-12	2X10-12	---	1X4-12	2X6-14	2X6-12	2X6-18	2X6-12	1X8-16	2X6-5	2X4-4	275	2.78
L-14-34	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X12-12	2X12-12	---	1X4-12	2X6-14	2X6-12	2X6-18	2X6-14	1X8-18	2X6-5	2X4-4	304	3.06
L-16-34	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X12-12	2X12-12	---	1X4-12	2X6-14	2X6-12	2X6-18	2X6-14	1X8-20	2X6-5	2X4-4	313	3.32
L-12-36	2X8-8	2X6-12	2X6-8	---	2X12-16	2X12-12	2X12-12	1X6-8	1X4-12	2X6-16	2X6-12	2X6-18	2X6-14	1X8-18	2X6-6	2X4-4	298	3.14
L-14-36	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X12-12	2X12-12	1X6-8	1X4-12	2X6-16	2X6-12	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	314	3.44
L-16-36	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X12-12	2X12-12	1X6-8	1X4-12	2X6-16	2X6-12	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	322	3.72
L-12-38	2X8-8	2X6-12	2X6-8	---	2X12-16	2X12-12	2X12-14	1X6-8	1X4-12	2X6-14	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	303	3.20
L-14-38	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X12-12	2X12-14	1X6-8	1X4-12	2X6-14	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	318	3.50
L-16-38	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X12-12	2X12-14	1X6-8	1X4-12	2X6-14	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	326	3.80
L-12-40	2X8-8	2X6-12	2X6-8	---	2X12-16	2X12-14	2X12-14	---	1X4-12	2X6-16	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	309	3.54
L-14-40	2X8-8	2X6-14	2X6-8	2X8-8	2X12-16	2X12-14	2X12-14	---	1X4-12	2X6-16	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	324	3.86
L-16-40	2X8-8	2X6-16	2X6-8	2X10-9	2X12-16	2X12-14	2X12-14	---	1X4-12	2X6-16	2X6-14	2X6-18	2X6-14	1X8-20	2X6-6	2X4-4	343	4.18

TYPE N

Type N refers to the gambrel roof, plank truss construction similar to type M, used as a superstructure on a frame or masonry basement, and is particularly recommended for general purpose and dairy barns where a driveway is required into the mow for threshing or the storage of grain previous to threshing, and most especially for a northern climate where a large hay capacity per animal is essential.



It is best adapted for vertical siding as explained for type M, and is preferred for very large and wide barns, requiring a large hay mow without posts. The trusses require heavy plank and some of their members are quite long, but may be built up out of several lengths of plank spliced with gusset plates.

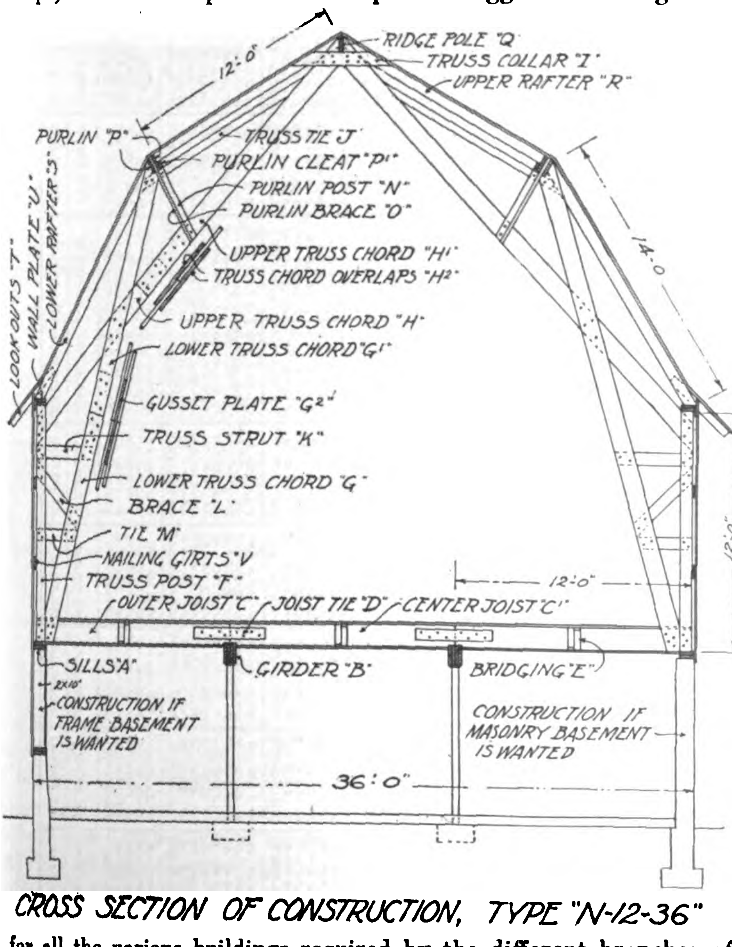
This type is not recommended for barns requiring a hay storage capacity of less than 2½ tons per animal, where Type K would be most suitable. Its efficiency may be compared with Type L by comparing the amount of framing lumber required to build a 14 ft. bent of a given size, with the amount required to build seven

2 ft. bents of the same size of Type L, as shown by the tables giving the framing lumber and hay capacities.

The one size illustrated by cross section N-12-36 is for a barn having a superstructure with 12 ft. side walls and of 36 ft, width.

ARRANGEMENT

As the work undertaken by the committee covers such a wide scope, it will not be possible to complete a suggestive arrangement



CROSS SECTION OF CONSTRUCTION, TYPE "N-12-36"

for all the various buildings required by the different branches of farming, and we will therefore give our first attention to the arrangement for general purpose and dairy barns, because these are the most important structures on the farm, outside of the residence itself.

For each kind of building a general scheme of arrangement has been worked out, based on the average requirements as brought

BARN CONSTRUCTION TYPE "N"

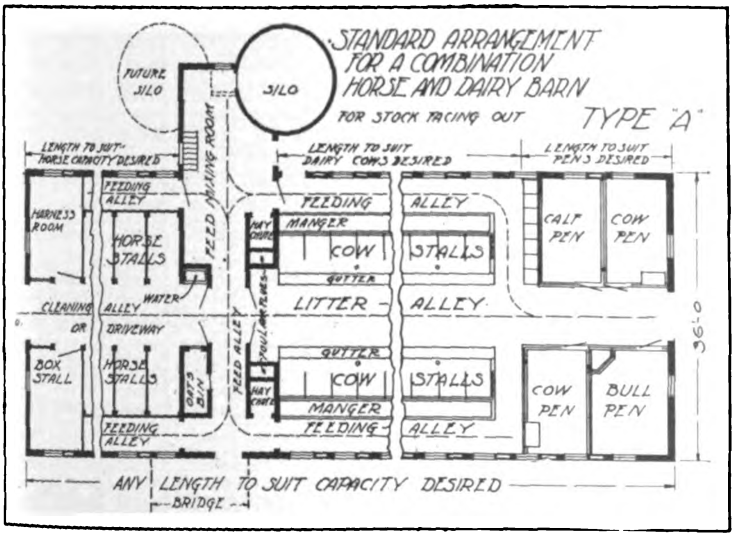
TABLE OF TIMBER SIZES, FRAMING LUMBER REQUIRED & LOOSE HAY CAPACITIES PER 14 FT. BENT.

INDEX		N-12-34	N-14-34	N-16-34	N-18-34	N-12-36	N-14-36	N-16-36	N-18-36	N-12-38	N-14-38	N-16-38	N-18-38
MOW FLOOR CONSTR'N.	A	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14
	B	8-2X12-14	8-2X12-14	8-2X12-14	8-2X12-14	8-2X12-14	8-2X12-14	8-2X12-14	8-2X12-14	8-2X12-14	8-2X12-14	8-2X12-14	8-2X12-14
	C	14-2X12-12	14-2X12-12	14-2X12-12	14-2X12-12	14-2X12-12	14-2X12-12	14-2X12-12	14-2X12-12	14-2X12-14	14-2X12-14	14-2X12-14	14-2X12-14
	C'	7-2X12-12	7-2X12-12	7-2X12-12	7-2X12-12	7-2X12-12	7-2X12-12	7-2X12-12	7-2X12-12	7-2X12-14	7-2X12-14	7-2X12-14	7-2X12-14
	D	—	—	—	—	14-2X8-4	14-2X8-4	14-2X8-4	14-2X8-4	—	—	—	—
	E	14-1X4-12	14-1X4-12	14-1X4-12	14-1X4-12	14-1X4-12	14-1X4-12	14-1X4-12	14-1X4-12	14-1X4-12	14-1X4-12	14-1X4-12	14-1X4-12
		877⅓' LUMBR.	877⅓' LUMBER.	877⅓' LUMB'R.	877⅓' LUMB'R.	952' LUMBER	952' LUMBER	952' LUMBER	952' LUMBER	961⅓' LUMB'R.	961⅓' LUMB'R.	961⅓' LUMB'R.	961⅓' LUMB'R.
MATERIALS FOR ONE PLANK TRUSS	F	4-2X8-12	4-2X8-14	4-2X8-16	4-2X8-18	4-2X8-12	4-2X8-14	4-2X8-16	4-2X8-18	4-2X8-12	4-2X8-14	4-2X8-16	4-2X8-18
	G	4-2X10-12	4-2X10-14	4-2X10-16	4-2X10-14	4-2X10-12	4-2X10-14	4-2X10-16	4-2X10-14	4-2X10-12	4-2X10-14	4-2X10-16	4-2X10-18
	G'	4-2X10-12	4-2X10-12	4-2X10-12	4-2X10-16	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-18	4-2X10-16	4-2X10-16	4-2X10-16	4-2X10-16
	G²	2-2X10-4	2-2X10-4	2-2X10-4	2-2X10-4	2-2X10-4	2-2X10-4	2-2X10-4	2-2X10-4	2-2X10-4	2-2X10-4	2-2X10-4	2-2X10-4
	H	2-2X12-16	2-2X12-16	2-2X12-16	2-2X12-16	2-2X12-12	2-2X12-12	2-2X12-12	2-2X12-12	2-2X12-14	2-2X12-14	2-2X12-14	2-2X12-14
	H'	2-2X12-10	2-2X12-10	2-2X12-10	2-2X12-10	2-2X12-16	2-2X12-16	2-2X12-16	2-2X12-16	2-2X12-16	2-2X12-16	2-2X12-16	2-2X12-16
	H²	4-2X12-5	4-2X12-5	4-2X12-5	4-2X12-5	4-2X12-5	4-2X12-5	4-2X12-5	4-2X12-5	4-2X12-6	4-2X12-6	4-2X12-6	4-2X12-6
	I	2-2X10-6	2-2X10-6	2-2X10-6	2-2X10-6	2-2X10-6	2-2X10-6	2-2X10-6	2-2X10-6	2-2X10-6	2-2X10-6	2-2X10-6	2-2X10-6
	J	2-2X4-12	2-2X4-12	2-2X4-12	2-2X4-12	2-2X4-12	2-2X4-12	2-2X4-12	2-2X4-12	2-2X4-12	2-2X4-12	2-2X4-12	2-2X4-12
	K	2-2X8-4	2-2X8-4½	2-2X8-4½	2-2X8-5	2-2X8-4½	2-2X8-4½	2-2X8-4½	2-2X8-5	2-2X8-4½	2-2X8-4½	2-2X8-5	2-2X8-5
	L	2-2X6-6	2-2X6-6½	2-2X6-7	2-2X6-7	2-2X6-4½	2-2X6-5	2-2X6-5½	2-2X6-6	2-2X6-6	2-2X6-6½	2-2X6-7	2-2X6-8
	M	2-2X6-2	2-2X6-2½	2-2X6-3	2-2X6-3	2-2X6-3	2-2X6-3½	2-2X6-3½	2-2X6-4	2-2X6-2½	2-2X6-3	2-2X6-3½	2-2X6-3½
	N	4-2X6-4	4-2X6-4	4-2X6-4	4-2X6-4	4-2X6-4	4-2X6-4	4-2X6-4	4-2X6-4	4-2X6-4½	4-2X6-4½	4-2X6-4½	4-2X6-4½
		444' LUMBER.	450' LUMBER.	513⅓' LUMB'R.	538⅔' L'BR.	481⅔' L'BR.	507⅔' LUMB'R.	532⅔' LUMB'R.	560' LUMBER.	515' LUMBER	541' LUMBER	568' L'BR	594⅓' L'BR.
ROOF MATERIAL	O	4-2X6-8	4-2X6-8	4-2X6-8	4-2X6-8	4-2X6-8	4-2X6-8	4-2X6-8	4-2X6-8	4-2X6-8	4-2X6-8	4-2X6-8	4-2X6-8
	P	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14	4-2X10-14
	P'	2-2X4-14	2-2X4-14	2-2X4-14	2-2X4-14	2-2X4-14	2-2X4-14	2-2X4-14	2-2X4-14	2-2X4-14	2-2X4-14	2-2X4-14	2-2X4-14
	Q	1-2X8-14	1-2X8-14	1-2X8-14	1-2X8-14	1-2X8-14	1-2X8-14	1-2X8-14	1-2X8-14	1-2X8-14	1-2X8-14	1-2X8-14	1-2X8-14
	R	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12
	S	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-12	14-2X6-14	14-2X6-14	14-2X6-14	14-2X6-14	14-2X6-16	14-2X6-16	14-2X6-16	14-2X6-16
	T	14-2X4-4	14-2X4-4	14-2X4-4	14-2X4-4	14-2X4-4	14-2X4-4	14-2X4-4	14-2X4-4	14-2X4-4	14-2X4-4	14-2X4-4	14-2X4-4
		536' LUMBER	536' LUMBER	536' LUMBER	536' LUMBER	564' LUMBER	564' LUMBER	564' LUMBER	564' LUMBER	592' LUMBER	592' LUMBER	592' LUMBER	592' LUMBER
SIDE WALLS	U	4-2X8-14	4-2X8-14	4-2X8-14	4-2X8-14	4-2X8-14	4-2X8-14	4-2X8-14	4-2X8-14	4-2X8-14	4-2X8-14	4-2X8-14	4-2X8-14
	V	8-2X6-14	8-2X6-14	8-2X6-14	8-2X6-14	8-2X6-14	8-2X6-14	8-2X6-14	8-2X6-14	8-2X6-14	8-2X6-14	8-2X6-14	8-2X6-14
	F'	2-2X8-12	2-2X8-14	2-2X8-16	2-2X8-18	2-2X8-12	2-2X8-14	2-2X8-16	2-2X8-18	2-2X8-12	2-2X8-14	2-2X8-16	2-2X8-18
	F2	4-2X8-14	4-2X8-16	4-2X8-18	4-2X8-20	4-2X8-14	4-2X8-16	4-2X8-18	4-2X8-20	4-2X8-14	4-2X8-14	4-2X8-18	4-2X8-20
		295⅓' LBR.	309⅓' LBR	325⅓' LBR.	341⅓' LBR	295⅓' LBR.	309⅓' LBR.	325⅓' LBR.	341⅓' LBR	295⅓' LBR.	309⅓' LBR.	325⅓' LBR.	341⅓' LBR.
TOTAL FEET OF LUMBER		2152⅔ FT.	2172⅔ FT.	2252 FT.	2293⅓ FT.	2293 FT.	2333 FT.	2374 FT.	2417⅓ FT.	2363⅓ FT.	2403⅓ FT.	2446⅔ FT.	2489 FT.
LOOSE HAY CAPACITY		19.09 TONS	21.00 TONS	22.90 TONS	24.80 TONS	20.83 TONS	22.85 TONS	24.86 TONS	26.88 TONS	23.46 TONS	25.59 TONS	27.72 TONS	29.84 TONS.

out by comparing about 10,000 plans made up in accordance with the requirements of as many farmers.

The numerous ideas brought out by this large number of plans, have been "boiled down," so to speak, into simple plans, eliminating all individuality, but keeping the arrangement so elastic that any required capacity, or size of barn, may be made from the typical plans which follow.

The first typical plan worked out is that of a combination horse and dairy barn, for stock facing out, this plan was indexed "Arrangement, Type A."



ARRANGEMENT, TYPE A

Upon examining this plan it will be noticed that the feed room is centrally located for convenience to all stock. It extends crosswise of the barn, making it accessible from all mangers. One end of the feed room extends out beyond one side of the barn, so as to connect up with one or two silos, as the case may require. The feed room in this location places two solid partitions between the horses and the milking room, making the latter more sanitary.

Hay chutes extend to the floor, have dust-tight doors, and are located at the ends of the cow mangers for convenience. Foul air flues follow the hay chutes through the hay mow and extend up through the roof, and have air outtake openings at the ends of the cow stall gutters.

The silos located at the side of the barn leave the ends clear for future extensions, and with the feed room permanently located near the center of the barn, the established feeding scheme will not be disturbed by any future extension on either end of the barn.

TABLE GIVING LENGTHS REQUIRED FOR VARIOUS LIVE STOCK CAPACITIES OF STANDARDIZED ARRANGEMENTS FOR COMBINATION HORSE & DAIRY BARNS, TYPE "A"

NUMBER OF HORSE STALLS REQUIRED		NUMBER OF COW STALLS REQUIRED: 50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12	10
24	INDEX NUMBER	A-50-24	A-48-24	A-46-24	A-44-24	A-42-24	A-40-24	A-38-24	A-36-24	A-34-24	A-32-24	A-30-24	A-28-24	A-26-24	A-24-24	A-22-24	A-20-24	A-18-24	A-16-24	A-14-24	A-12-24	A-10-24
	LENGTH OF HORSE DIVISION	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"	75'-0"
	LENGTH OF FEED DIVISION	16'-0"	16'-0"	16'-0"	16'-0"	16'-0"	16'-0"	16'-0"	16'-0"	16'-0"	16'-0"	16'-0"	14'-0"	14'-0"	14'-0"	14'-0"	14'-0"	14'-0"	14'-0"	14'-0"	14'-0"	14'-0"
	LENGTH OF COW STALL DIV.	92'-0"	89'-0"	85'-0"	82'-0"	78'-0"	75'-0"	71'-0"	68'-0"	64'-0"	61'-0"	57'-0"	54'-0"	50'-0"	47'-0"	43'-0"	40'-0"	36'-0"	33'-0"	29'-0"	26'-0"	22'-0"
	LENGTH OF PEN DIVISION	38'-0"	38'-0"	38'-0"	38'-0"	38'-0"	38'-0"	38'-0"	30'-0"	30'-0"	30'-0"	30'-0"	30'-0"	30'-0"	30'-0"	20'-0"	20'-0"	20'-0"	20'-0"	20'-0"	20'-0"	20'-0"
	TOTAL LENGTH OF BARN	221'-0"	218'-0"	214-0	211-0	207-0	204-0	200-0	189'-0"	185-0	182-0	178-0	173-0	169-0	166-0	152-0	149-0	145-0	142-0	138-0	135-0	131-0
22	INDEX NUMBER	A-50-22	A-48-22	A-46-22	A-44-22	A-42-22	A-40-22	A-38-22	A-36-22	A-34-22	A-32-22	A-30-22	A-28-22	A-26-22	A-24-22	A-22-22	A-20-22	A-18-22	A-16-22	A-14-22	A-12-22	A-10-22
	LENGTH OF HORSE DIVISION	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"	70-0	70'-0"	70-0	70'-0"	70'-0"	70'-0"	70'-0"	70'-0"
	LENGTH OF FEED DIVISION	16'-0"	16-0	16-0	16-0	16-0	16-0	16-0	16-0	16-0	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	216-0	213-0	209-0	206-0	202-0	199-0	195-0	184-0	180-0	177-0	171-0	168-0	164-0	161-0	147-0	144-0	140-0	137-0	133-0	130-0	126-0
20	INDEX NUMBER	A-50-20	A-48-20	A-46-20	A-44-20	A-42-20	A-40-20	A-38-20	A-36-20	A-34-20	A-32-20	A-30-20	A-28-20	A-26-20	A-24-20	A-22-20	A-20-20	A-18-20	A-16-20	A-14-20	A-12-20	A-10-20
	LENGTH OF HORSE DIVISION	60'-0"	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0	60-0
	LENGTH OF FEED DIVISION	16-0	16-0	16-0	16-0	16-0	16-0	16-0	16-0	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	206-0	203-0	199-0	196-0	192-0	189-0	185-0	174-0	170-0	165-0	161-0	158	154-0	151-0	137-0	134-0	130-0	127-0	123-0	120-0	116-0
18	INDEX NUMBER	A-50-18	A-48-18	A-46-18	A-44-18	A-42-18	A-40-18	A-38-18	A-36-18	A-34-18	A-32-18	A-30-18	A-28-18	A-26-18	A-24-18	A-22-18	A-20-18	A-18-18	A-16-18	A-14-18	A-12-18	A-10-18
	LENGTH OF HORSE DIVISION	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0	55-0
	LENGTH OF FEED DIVISION	16-0	16-0	16-0	16-0	16-0	16-0	16-0	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14'-0"	12'-0"
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	201-0	198-0	194-0	191-0	187-0	184-0	180-0	169-0	163-0	160-0	156-0	153-0	149-0	146-0	132-0	129-0	125-0	122-0	118-0	115-0	109-0
16	INDEX NUMBER	A-50-16	A-48-16	A-46-16	A-44-16	A-42-16	A-40-18	A-38-16	A-36-16	A-34-16	A-32-16	A-30-16	A-28-16	A-26-16	A-24-16	A-22-16	A-20-18	A-18-16	A-16-16	A-14-16	A-12-16	A-10-16
	LENGTH OF HORSE DIVISION	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0	50-0
	LENGTH OF FEED DIVISION	16-0	16-0	16-0	16-0	16-0	16-0	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	12'-0"	12'-0"
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	196-0	193-0	189-0	186-0	182-0	179-0	175-0	162-0	158-0	155-0	151-0	148-0	144-0	141-0	127-0	124-0	120-0	117-0	113-0	108-0	104-0
14	INDEX NUMBER	A-50-14	A-48-14	A-46-14	A-44-14	A-42-14	A-40-14	A-38-14	A-36-14	A-34-14	A-32-14	A-30-14	A-28-14	A-26-14	A-24-14	A-22-14	A-20-14	A-18-14	A-16-14	A-14-14	A-12-14	A-10-14
	LENGTH OF HORSE DIVISION	45'-0"	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0	45-0
	LENGTH OF FEED DIVISION	16'-0"	16-0	16-0	16-0	16-0	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14'-0"	14-0	14-0	14-0	12'-0"	12-0	12-0
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	191-0	188-0	184-0	181-0	177-0	174-0	168-0	157-0	153-0	150-0	146-0	143-0	139-0	136-0	122-0	119-0	115-0	112-0	106-0	103-0	99-0
12	INDEX NUMBER	A-50-12	A-48-12	A-46-12	A-44-12	A-42-12	A-40-12	A-38-12	A-36-12	A-34-12	A-32-12	A-30-12	A-28-12	A-26-12	A-24-12	A-22-12	A-20-12	A-18-12	A-16-12	A-14-12	A-12-12	A-10-12
	LENGTH OF HORSE DIVISION	40'-0"	40-0	40-0	40-0	40-0	40-0	40-0	40-0	40-0	40'-0"	40-0	40-0	40-0	40-0	40-0	40-0	40-0	40-0	40-0	40-0	40-0
	LENGTH OF FEED DIVISION	16-0	16-0	16-0	16-0	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	12'-0"	12-0	12-0	12-0
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	186-0	183-0	179-0	176-0	172-0	167	163	152-0	148-0	145-0	141-0	138-0	134-0	131-0	117-0	114-0	110-0	105-0	101-0	98-0	94-0
10	INDEX NUMBER	A-50-10	A-48-10	A-46-10	A-44-10	A-42-10	A-40-10	A-38-10	A-36-10	A-34-10	A-32-10	A-30-10	A-28-10	A-26-10	A-24-10	A-22-10	A-20-10	A-18-10	A-16-10	A-14-10	A-12-10	A-10-10
	LENGTH OF HORSE DIVISION	35'-0"	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0	35-0
	LENGTH OF FEED DIVISION	16-0	16-0	16-0	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	12'-0"	12-0	12-0	12-0	12-0
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	181-0	178-0	174	171-0	165-0	162-0	158-0	147-0	143-0	140-0	136-0	133-0	129-0	126-0	112-0	109-0	103-0	100-0	96-0	93-0	89-0
8	INDEX NUMBER	A-50-8	A-48-8	A-46-8	A-44-8	A-42-8	A-40-8	A-38-8	A-36-8	A-34-8	A-32-8	A-30-8	A-28-8	A-26-8	A-24-8	A-22-8	A-20-8	A-18-8	A-16-8	A-14-8	A-12-8	A-10-8
	LENGTH OF HORSE DIVISION	30'-0"	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0
	LENGTH OF FEED DIVISION	16-0	16-0	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	12'-0"	12-0	12-0	12-0	12-0	12-0
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	176-0	173-0	169-0	164-0	160-0	157-0	153-0	142-0	139-0	135-0	131-0	128-0	124-0	121-0	107-0	102-0	98-0	95-0	91-0	88-0	84-0
6	INDEX NUMBER	A-50-6	A-48-6	A-46-6	A-44-6	A-42-6	A-40-6	A-38-6	A-36-6	A-34-6	A-32-6	A-30-6	A-28-6	A-26-6	A-24-6	A-22-6	A-20-6	A-18-6	A-16-6	A-14-6	A-12-6	A-10-6
	LENGTH OF HORSE DIVISION	25'-0"	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0	25-0
	LENGTH OF FEED DIVISION	16-0	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	12'-0"	12-0	12-0	12-0	12-0	12-0	12-0
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	171-0	168-0	162-0	159-0	155-0	152-0	148-0	137-0	133-0	130-0	126-0	123-0	119-0	116-0	100-0	97-0	93-0	90-0	86-0	83-0	79
4	INDEX NUMBER	A-50-4	A-48-4	A-46-4	A-44-4	A-42-4	A-40-4	A-38-4	A-36-4	A-34-4	A-32-4	A-30-4	A-28-4	A-26-4	A-24-4	A-22-4	A-20-4	A-18-4	A-16-4	A-14-4	A-12-4	A-10-4
	LENGTH OF HORSE DIVISION	20'-0"	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	LENGTH OF FEED DIVISION	16'-0"	14'-0"	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	14-0	12'-0"	12-0	12-0	12-0	12-0	12-0	12-0	12-0
	LENGTH OF COW STALL DIV.	92-0	89-0	85-0	82-0	78-0	75-0	71-0	68-0	64-0	61-0	57-0	54-0	50-0	47-0	43-0	40-0	36-0	33-0	29-0	26-0	22-0
	LENGTH OF PEN DIVISION	38-0	38-0	38-0	38-0	38-0	38-0	38-0	30-0	30-0	30-0	30-0	30-0	30-0	30-0	20-0	20-0	20-0	20-0	20-0	20-0	20-0
	TOTAL LENGTH OF BARN	166-0	161-0	157-0	154-0	150-0	147-0	143-0	132-0	128-0	125-0	121-0	118-0	114-0	107-0	95'-0"	92-0	88-0	85-0	81-0	78-0	74-0

Pens for dry cattle and young stock may be placed at the end of the milking room, either in the same room or divided by a partition as desired.

In case the climatic or topographical location of the barn calls for a driveway into the mow floor, for the storage of grain or threshing, a driveway or bridge to the floor may be located where indicated by the dotted lines on the opposite side of the barn from the silo. This brings the driveway in the second story, over the feed room of the lower story, so feed can be dumped from a wagon in the second story, through a trap door, directly into the feed bin below, which is marked "Oats bin" on the plan.

This places the hay chutes along one side of the driveway, and these will serve to keep the hay from falling down into the driveway when the mow is filled. The end of the driveway would have a stairway leading down to the silo end of the feed room below.

A barn of this arrangement could be executed out of any kind of building material desired.

The following table has been carefully worked out to show the size of buildings required for various capacities. The length required for each division of the design has been given separately, so that any one division that may not be wanted at the time the barn is first built, can be deducted fro mthe total length mentioned in the table.

The next typical plan worked out, was that of a combination horse and dairy barn, for stock facing in. This plan was indexed "Arrangement, Type B."

ARRANGEMENT, TYPE B

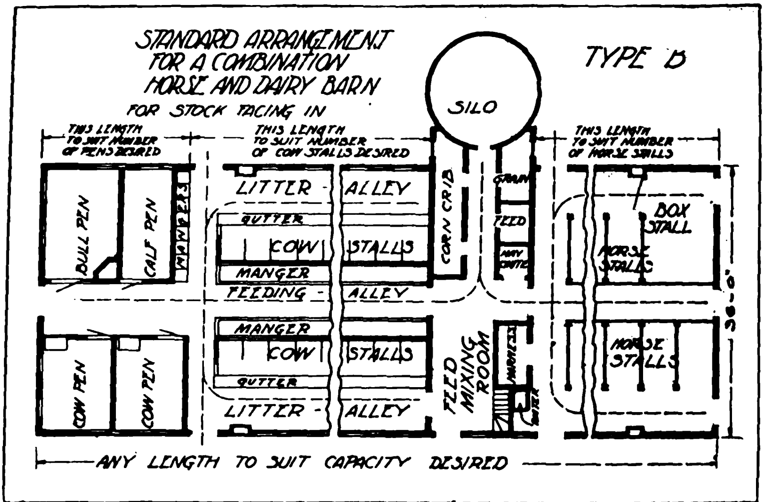
This typical plan was made for a combination horse and dairy barn, for stock facing in. Upon examining this plan it will be seen that about all the features embodied in arrangement Type A are also taken care of with this arrangement.

The feed is distributed from the central part of the barn; bins, hay chutes, stairway, etc., are conveniently located. Foul air flues are shifted to the side walls directly back of the stock. This type will also adapt itself to a driveway into the upper story as explained for Type A.

The location of the feed room makes it possible to keep the dust and odors of the horses away from the milking room, and this also admits of separate ventilation for each room, so the temperature in one room can be controlled independently from that of the other.

Future extensions can be made to either the horse division or cow division without interfering with the established feeding routine.

As shown by the broken lines, this arrangement may be used for a barn of any desired capacity and the table of barn lengths required as worked out for arrangement Type A will also apply to this Type B.



Thirty-six feet is recommended for the width, but thirty-eight or forty feet could be used if so desired.

ARRANGEMENT, TYPE C

The floor plan illustrating this arrangement shows a simple and practical arrangement for a dairy barn consisting of two rows of stalls, placed so the cows face a central feed alley.

The dimensions given are for average conditions and for average sized stock, and may be changed to suit local conditions and size of stock to be housed.

It is preferred to place the barn with the ends to the north and

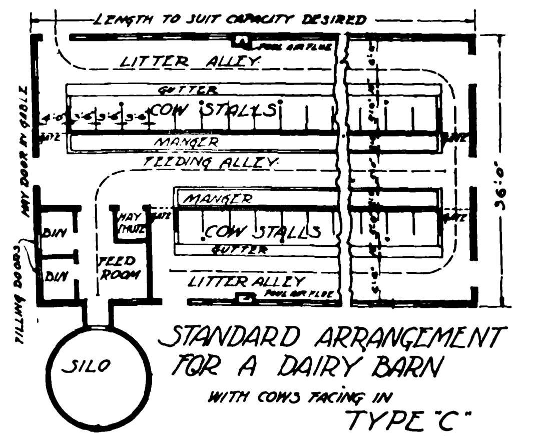


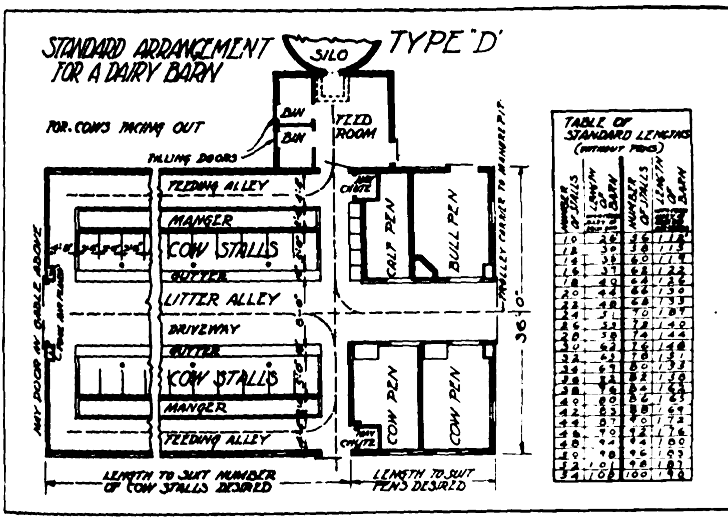
TABLE OF STANDARD LENGTHS

NUMBER OF STALLS	LENGTH OF BARN	NUMBER OF STALLS	LENGTH OF BARN
10	33	56	119
12	37	58	123
14	40	60	126
16	44	62	130
18	48	64	134
20	51	66	137
22	55	68	141
24	58	70	144
26	62	72	148
28	65	74	152
30	69	76	155
32	72	78	159
34	76	80	162
36	80	82	166
38	83	84	169
40	87	86	173
42	90	88	176
44	94	90	180
46	98	92	184
48	101	94	188
50	105	96	191
52	108	98	194
54	112	100	198

south, so the morning sunshine will reach the windows of one side and the afternoon sunshine, those of the other side.

The silo is located at the side in preference to the end of the barn, so the end remains unobstructed for hoisting hay into the gable end hay door, and also leaving both ends clear for future extensions.

An extension may be built on one end for calf and dry stock pens, similar to that shown in plan for Type D, for any number of pens desired, and the other end left for the extension of future cow stalls required as the herd grows.



The table of standard lengths given in connection with the floor plan, shows the length of barn required for various capacities from 10 to 100 head, exclusive of any pens.

It is preferred to place the silo near the north end so as to avoid its casting a shadow which would eliminate sunshine from any window.

Windows are so located in each sidewalk to give at least 4 square feet of glass surface per head, and fresh air intake flues are located between the windows for equal distribution of air, and foul air flues placed centrally behind the cows, using one foul air flue for every 8 to 12 cows.

Hay chutes should run to floor and be provided with tight-fitting door to avoid all unnecessary dust. The height of ceiling should be so regulated that the room will not contain less than 500 cubic feet of air space per head, nor over 600 cubic feet for northern states having severe winters.

ARRANGEMENT, TYPE D

All the conditions mentioned for the arrangement of Type C are also covered by Type D except that this plan is arranged for the stock facing out, and because the feed alleys are located along the side walls, the feed room is not extended in towards the center of the barn as in Type C, but is built between the main barn and the silos.

For large barns requiring a more extensive feeding plant, the feed room could be extended through the entire width of the barn, between the stall division and the pen division, very similar to the horse and cow division of arrangements Type A and Type B.

COMMITTEE ON FARM BUILDING VENTILATION

W. B. Clarkson, Chairman, L. J. Smith, F. W. Ives

Your committee is able to report progress in spite of the war handicaps.

Leaving home early in December, 1917, we first traveled into northwest Canada, and then into several of the states to the south of that district, taking with us a trunk filled with apparatus with which to make tests of barns enroute.

The barns selected were different in character and represented several popular northwestern designs.

Each of these barns was ventilated in a different way and represented, with certain modifications, two well known and much discussed types of ventilating systems.

The first type, which will hereafter be designated as Type "X," is that system which draws the foul air from the floor and delivers the fresh air into the room at the ceiling.

The second type, which will hereafter be designated as Type "Y," is that system which draws the foul air away from the room at the ceiling and delivers the fresh air at, or near, the floor.

Canadian farmers, particularly in the three provinces of Manitoba, Saskatchewan and Alberta, in the past few years have been erecting modern buildings to properly house their rapidly increasing herds.

On account of the low temperature in winter, they see and feel the necessity for scientific ventilation in their farm buildings and in view of the conflicting opinions relative to the proper type that will best serve their needs they are impatient for a settlement of this mooted question.

THE MANITOBA AGRICULTURAL COLLEGE BARN

The first test was conducted in the dairy barn on the grounds of the Manitoba Agricultural College. This ventilating system is Type "Y." See Exhibit A, a record of that test, and Exhibit B, a photograph of the barn.

The record shows that at 4 P. M. December 10, 1917, the be-

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EXHIBIT "A"

Winnipeg, Man. Dec. 10 191 9

Barn Ventilation Test

Owner MANITOBA AGRICULTURAL COLLEGE — Present / Absent

Manager PROF. L. J. SMITH AGRL. DEPT. — Present / Absent

Visitors TEST CONDUCTED BY L. C. SMITH AND W. B. CLARKSON

Barn Location ON THE COLLEGE GROUNDS

Statement of Ideal Ventilated Conditions

According to our best information, a room where animals are housed should never contain more than a certain per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 50 cubic feet per minute per cow in order that the standard of air purity shall approximate 99.7 per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is 32 Cows in stanclons, Calves No, Yearlings No, Horses No, Yearlings No, Colts.

Total Cubic Space to Ventilate 29260 cubic feet. Therefore, the volume of air moving in and out should total 1600 Cubic Feet through the ventilating system per minute.

Description of System. See Plans Inside.

Total Foul Air Flues 4 Size at Bottom 15"x15½" Size at Top 18"x18"

Height Above Floor start at ceiling joined to cupolas

How made 1" two ply lumber, paper, air space [illegible] of lath.

Dimension at Smallest Place 15"x15½" Where is this located at ceiling

Total Intakes see plans Outside Opening see plans Inside Opening see plan

How far below ceiling see plan Total length see plan Dimension see plan

How made space between studs and openings covered with registers faces at each opening outside & inside

How many ventilators 2 What made Wood Size not measured

How constructed wood cupolas with louvers (see plans)

REMARKS: At 8:20 P. M. Dec. 10th, we closed foul air flues dampers #2 and 4, (numbered on plans) the ceiling at 10 P.M. was dry, also walls at north end. The walls at south end were [illegible] frosty, fairly thick.

At time of test the stock room contained only 22 cows 2 young bulls and 4 yearling heifers, estimating young stock at one half the full grown cows, the volume of air then to be moved per minute would be only 14?00 cubic feet to maintain the above stated theoretical standard of air purity in the stock room.

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Temperature of Outside Atmosphere

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at 4 P.M. Dec. 10th 191 9 as marked in No. 1 space.

Readings Taken Every Hour

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
8B	10B	10B	[illegible]	14B	12B	10½B	[illegible]	[illegible]	[illegible]	[illegible]			10B	4B	[illegible]	[illegible]		2B	2B	1B	1B	1B	1B

Inside Temperature and Relative Humidity

Dry	39 38 38	39 38 37				37½	38	39	40	
Wet	36 36½	37 36 35				36	36	36½	36½	
R.H.	83 83 79	83 83 83					83	79	83	NONE Taken

Wind Velocity at Ground in Open Space

Time Taken	12/10 4:30 P.M.	8 P.M.	11 P.M.	9 A.M. 12/11		2 P.M.
Feet Per Minute	165	325	415	420		482

Wind Velocity at Peak of Roof ? Feet Elevation

Time Taken					
Feet Per Minute	This was not taken				

Air Flow Thru the Ventilators on Roof

Time Taken	No opportunity to take this test.
Feet Per Minute	could not get into the cupolas.

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks
1	10P.M. 12/10	Feed Alley	middle	near ceiling	all
2	"	"	"	near floor	stoppers
3	9A.M. 12/11	"	North end	near ceiling	in sample
4	"	"	"	floor	air holders
5	"	"	South end	5' above floor	sealed with parafin

RELATIVE HUMIDITY AT CEILING & FLOOR

	10 PM 12/10		6 AM 12/11		7AM 12/11		10 AM 12/11		11AM 12/11		3PM 12/11	
	FLOOR	CEILING	FLOOR	CEILING	FLOOR	CEILING	FLOOR	CEILING	FLOOR	CEILING	FLOOR	CEILING
Dry	35	39	32	39½	37	39½	36	41	39	42	47	41
Wet	33½	36½	31	36	35	37	36	39	37	39	44	38½
R.H.	86	79	89	83	83	79	83	84	83	77	79	80

Outside Sample

The above tests made in center of the feeding alley.

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Air Movement Thru Fresh Air Intakes

Time	8:30 P.M. 12/10			6 A.M. 12/11-1919		
1	In S.E. cor. 135 feet per minute			160 feet per minute		
2	The next north 130	"	"	100	"	"
3	" " one 135	"	"	75	"	"
4	" " " 76	"	"	110	"	"
5	In S. E. Cor. 136	"	"	252	"	"
6	The next north 157	"	"	174	"	"
7	The next one none			none		
8	" " 130	"	"	80	"	"
9	Total leakage 897	"	"	981	"	"

All of the registers on these fresh air intakes were closed as tight as possible during the entire test and the above figures show the rate of air leakage thru those openings. The volume flow thru out taken shows total air leakage thru other openings.

Air Movement Thru Foul Air Flues

Time	Dec. 10-19 5:30 PM	8 PM	10 PM	Dec. 11-1919 5:45 A.M.	7 A.M.	
1	331	440	370	560	468	478
2	356	430	404	closed	closed	closed
3	368	458	425	537	473	475
4	321	490	430	closed	closed	closed
	1376	1818	1642	1097	931	953

Time	9:40 AM 12/11	11AM	2 P.M.
1	452	486	535
2	closed	closed	closed
3	413	530	632
4	closed	closed	closed
	865	1016	1167

The theoretical volume of air taken out of the room thru the foul air flues therefor, is as follows; Examples: 15" x 15½" = 232 Sq. inches. 232 Sq. In. = 1.61 Sq. ft.

Volume flow thru outtakes

1376x1.61 = 2216 cubic feet — 981 x 1.61 = 1580 cubic ft.
1818x1.61 = 2926 " " — 865 x 1.61 = 1393 " "
1642x1.61 = 2643 " " — 1016x 1.61 = 1640 " "
1097x1.61 = 1767 " " — 1167 x 1.61 = 1880 " "
931x1.61 = 1500 " "

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Carbon Dioxide Determinations

Samples	Marks	Amount CO_2 in 10000 Parts of Air	CO_2 Expressed in Volume Per Cent
No. 1	Center ceiling 11 part in 10000 or .011		
No. 2	1' above floor 23 " " " " .023		
No. 3	One cock open in bottle-not analyzed		
No. 4	Middle near floor 18 part in 10000 or .018		

Outside Air Sample

Remarks:

1. Dimensions — 40'-4" x 66'-0" inside measurement.
2. Basement — None
3. Wall — Brick veneer, ship lap, 2x6 studding and sheeting.
4. Thickness — Brick 4", Air space 1", ship lap & Paper 1".
5. Height — Floor to ceiling 10'-0". Studding 6" sheeting 1"
6. Material — See above 12" total
7. Sheeting —
8. Ceiling — 1" D & M boards
9. Outside Wall — See above
10. Studding — 2" x 6" set 24" O. C.
11. Plate — See plans
12. Purlins — See plans
13. Peak — See plans
14. Hay Track — Yes
15. Floor Joists — Under loft floor 2"x12" set 24" O. C.
16. Girders — 6"x6" Set below ceiling over stanclons.
17. Frame — See plans.
18. Windows — 6 10"x14" lights with transom 10"x16" light see plan
19. Doors — 6-12"x14" lights storm sash cover all windows
20. Driveway — NONE
21. How old — "
22. Photograph — "
23. Dead air space — SEE ABOVE
24. Wind proofing — "

Exhibit A

ginning of the test, the outside temperature was 8 degrees below zero and at 8 P. M. the thermometer dropped to its lowest point during the entire test, (14 degrees below zero). At 5 A. M. the next morning the thermometer registered 10 degrees below zero. At the conclusion of the test, (3 P. M., the second day) the thermometer registered 1 degree below zero.

During the test the wind was very light, in the beginning the velocity was 2 miles per hour, and gradually increasing to 6 miles per hour at the end of the test.

Inside of the stock room the temperature averaged about 38 degrees above zero the first day up to about 10 P. M., when it started to cool down and we closed two of the foul air ducts to

Exhibit B

maintain control of the temperature of the room; this held the temperature about steady all night.

The two foul air ducts were kept closed all through the test.

The relative humidity of the air in the stock room remained steady at about 83 percent during the entire test; these readings were made in the feed alley about the center of the room.

A study of the relative humidity taken at floor and ceiling will be of interest, in view of the fact that, with but two exceptions, they show a higher percentage at the floor in spite of the lower temperature at that point.

The change in the relative humidity readings at 10 A. M. and at 3 P. M. is accounted for by the fact that at both periods the barn doors were open and the men were cleaning out.

The atmospheric conditions outside were ideal to produce a steady suction upward through the foul air ducts; the barn men admitted, when questioned, that occasionally it became necessary to close dampers in the foul aid flues to stop back-drafting, probably caused by the wind blowing into the wooden cupolas and downward through the flues, overcoming the upward air pressure caused by the higher temperature in the room.

All of the intakes remained closed during the entire test, so that the amount of air leakage through the intakes and other openings is probably represented by the volume of air flow through the foul air ducts.

The stock housed in this room at the time of the test equaled 25 full grown cows, and by dividing the cubic dimensions of this room by the number of cows, we find that each cow was called upon to heat about 1170 cubic feet of air. This is fully twice as much as an average 1000-pound cow should be expected to heat in a properly ventilated barn: i. e., where the barn is well built and a ventilating system is moving the air fast enough to keep the air in the stock room reasonably pure.

The ceiling was dry during the test, also, the north, west and east walls were dry where they are protected by the other parts of the building, but where the walls were not protected the inside surface was wet and frosty.

This ventilating system, on the whole, was found to be the best demonstration of the ventilated results produced by this type we saw on our trip.

Both members of your committee who conducted this test agree that this system can be improved in several particulars.

The record shows that the movement of air through the foul air ducts approximated the ideal of 1888 cubic feet per minute during the time the first three readings were made, but in the later periods, when the two foul air ducts closed to maintain the temperature of the room, the flow of air fell considerably below the required amount.

THE KENASTON BARN

On January 19, 1918, Prof. L. J. Smith reported the result of a test he made of a ventilating system in the barn of F. E. Kenaston, Headingly, Manitoba. Prof. Smith's letter is as follows:

WINNIPEG, MAN., January 19, 1918.

Mr. W. B. Clarkson, Owatonna, Minn.

Dear Mr. Clarkson: I am sending you under separate cover the results of a barn ventilation test made on the evening of January 11 and the morning of January 12, 1918. I was very fortunate in getting into the country in one of our coldest spells of weather. I think I neglected to say in the data sheet that the minimum temperature was 22 degrees below zero. I have also just learned from our Physics Department that the average wind velocity on that

Exhibit "C" Pg. 1

January 11 1918.

Barn Ventilation Test

Owner F. E. KENASTON MINNEAPOLIS MINN. Absent

Manager WM. INNES Present

Visitors

TEST MADE BY L. J. SMITH Agr'l Eng. Dept. Agr. College Winnipeg

Barn Location 4½ Miles due North of Headingly Man.

Statement of Ideal Ventilated Conditions

According to our best information, a room where animals are housed should never contain over 3.3 per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 59 cubic feet per minute per cow in order that the standard of air purity shall approximate 96.7 per cent, which is the ideal standard in a dairy barn. for 95% purity/39 Cubic ft. per mile.

In this barn the total capacity is 122 Cows 10 Calves Yearlings Horses Yearlings Colts

Total Cubic Space to Ventilate 61,600 Cubic Feet. Therefore, the volume of air moving in and out should total Cubic Feet through the ventilating system. 122 cows in barn at time of test, 505' per cow

Description of System, See Plans Inside.

Total Foul Air Flues 14 Size at Bottom 16½"x19" Size at Top 2'x2'

Height Above Floor Both flues of ceiling or 1770 sq. ft. Where does top of flue end In cupolas, in pairs

How made Two ply shiplap with bldg. paper between Material

Dimension at Smallest Place 16½x19 Where is this located Ceiling

Total Intakes 14 Outside Opening Inside Opening

How far below ceiling 12" Total length Dimension 5½"x22"

How made between studs Material used

How many ventilators What make Size

How constructed

REMARKS: Both out-take flues has slide control at ceiling King intake " " " inside and outside

505 Cubic Feet per cow, barn capacity.

Evening of January 11th, no dripping, no frost on ceiling, or on walls except at doors and intake flues. Morning of Jan. 12th, no dripping, frost at S. door and at ceiling and walls near same. Door in loft leaked air badly, all loft doors wide open. Loft floor well covered in most places. Would have been better had loft doors been closed. Several O. T. flues needed repairing.

Pg.2

Temperature of Outside Atmosphere

Readings Taken Every Hour

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at M. 191 as marked in No. 1 space.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Friday, January 11, 1918
8:30 P.M. 15 B.
9:30 P.M. 14 B.
10:30 P.M. 15 B.

Saturday Jan. 12, 1918
4:15 A.M. 22 B.
6:15 A.M. 20 B.
8:00 A.M. 18 B
Minimum Temperature

Inside Temperature and Relative Humidity

Dry																								
Wet																								
R.H.																								

Wind Velocity at Ground in Open Space

Time Taken						
Feet Per Minute						

Wind Velocity at Peak of Roof — Barn Elevation

Time Taken						
Feet Per Minute						

Air Flow Thru the Ventilators on Roof

Time Taken						
Feet Per Minute						

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks

Note I took temperature at ceiling and at floor in center of Barn at "T". I found them 32' and 42' respectively. This was due to air leakage at E. door. Receiving thermometer was at T. with bulb about 4' from floor.

Outside Sample

Pg.3

Air Movement Thru Fresh Air Intakes

Only one intake flue open (W.) and this only part time. Very little air leakage at intake flues.

AIR MOVEMENT FOUL AIR FLUES JAN. 11th, P. M.

Time	Flue No.		No. 2		No. 5		No. 6		No. 10	
7:30	262'	238	360	364	525	335	185	185	270	
8:00	255	245	535	303	412	424	120	150	444	
8:30	190	225	394	335	450	468	124	128	120	
9:00	176	292	446	338	515	420	154	120	S.D. badly, had to close	
9:30	297	185	313	460	570	519	100	90	No. 6 B.D. occasionaly	
10:00	191	171	448	384	272	406	[illegible]	[illegible]	later part of evening	
	1211	1136	2496	2184	2814	2572	1006	721		

1211 / 2496 / 2814 / 1006

12)2347 12)4680 12)5386 12)1727

212 / 390 / 449 / 144

+7 / -1 / +15

219 / 390 / 448 / 159

Note: Out-take flues had 2x12 floor joist passing thru nearly at center, I therefore took reading on both sides one directly after the other.

448
390
219
Total 1213 — 2640 Cu. Ft. movement per minute.

Only above flues could be used, others B. D.

Air Movement Thru Foul Air Flues

Time	No. 1		No. 2		No. 5		No. 6		Jan. 12. AM.
4:30	380	412	462	616	616	444	369	433	Find N.T. & M. by
5:00	424	477	367	635	518	428	485	374	morning, and flues
5:30	471	388	382	610	268	430	415	429	worked much better
6:00	419	416	278	580	605	386	339	387	on account of wind
6:30	454	451	394	644	497	456	416	483	striking cupolas at an
	2148	2147	2283	3085	2804	2144	1984	2105	angle.

10)4295 10)[illegible] 10)4948 10)4089

Av. 429 / 637 / 495 / 409

Correction / -1

494 / 535 / 429

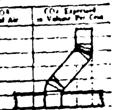
Barn could have stood more Total, 1867 — 4,064.5 Cu. Ft. per Min — 60 — 243870.0 Hr. or 3.95 changes of air per hour.

Flues were but most back drafted

Pg.4

Carbon Dioxide Determinations

Samples	Marks	Amount CO2 in 10000 Parts of Air	CO2 Expressed in Volume Per Cent



Took airvels here

Out-take flues originally came straight but dripped sometimes on cows back so were off set as shown to a point over gutter.

Outside Air Sample

Remainders	
1. Dimensions	BArn T shaped see floor plan
2. Basement	None
3. Wall	
4. Thickness	
5. Height	Stable has 8' ceiling.
6. Material	
7. Sheeting	
8. Ceiling	8" T. & G Ceiling does not trouble with swelling two ply boarding with 2 ply paper outside and one sheathing inside studs, studs 2x6", 24" center.
9. Outside Wall	
10. Bedding	
11. Plate	
12. Purline	
13. Peak	
14. Hay Track	
15. Floor Joists	
16. Girders	
17. Frame	
18. Windows 40	Has storm windows no storm doors. Small 4' high fills between studs.
19. Doors 4	1'.3" swing and 3 driveway doors
20. Driveway	
21. How old	Part three years, part five years.
22. Photograph	
23. Dead air space	
24. Wind proofing	

Cupolas have louvers which should be taken out, cause back drafting.

Exhibit C

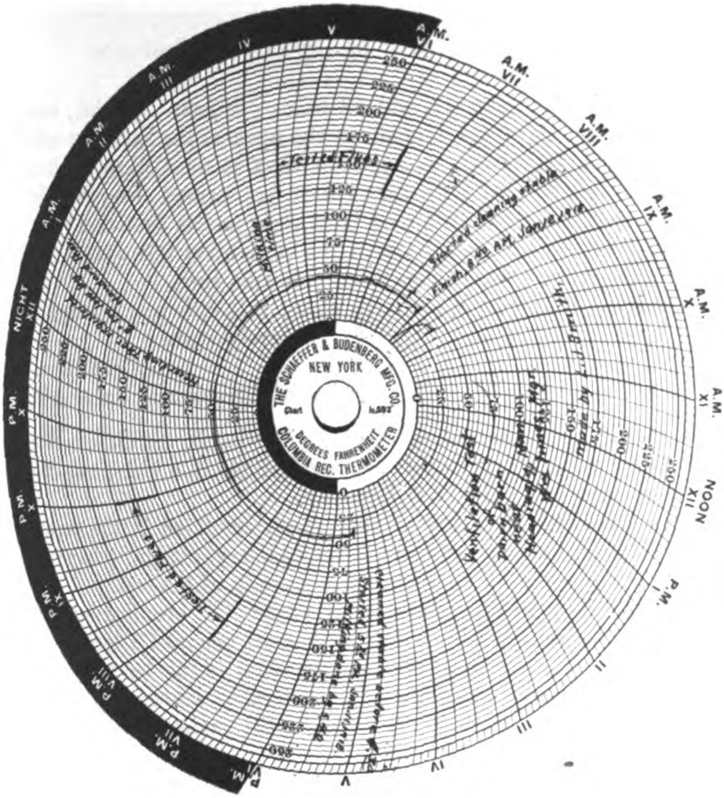


Exhibit D

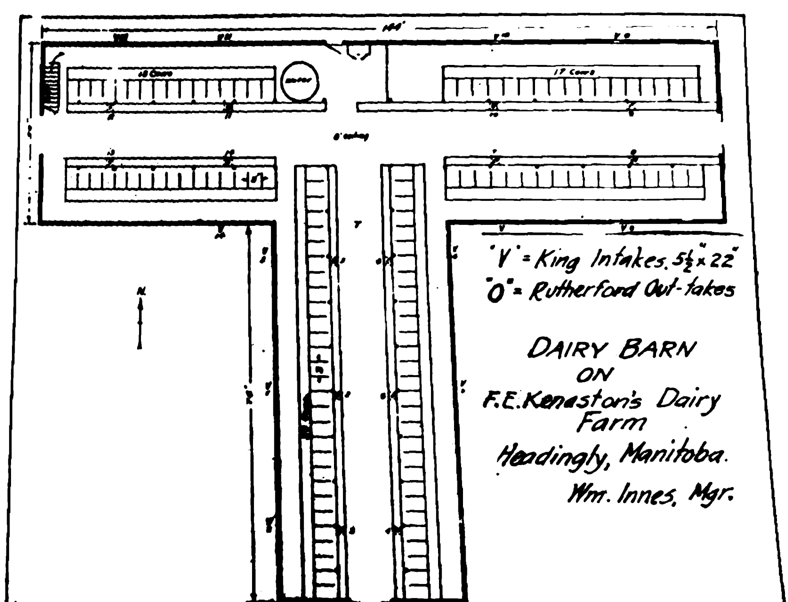


Exhibit E

night was between 17 and 18 miles per hour. I think, however, from the tests I made in the open at the barn, the wind velocity at the barn was greater than at the College. I take this to be the best data that I have yet secured along this line, because it is a well planned barn right in this Province.

I want to use this data at the convention this winter, as I think I mentioned to you when you were here.

Trusting that you are getting along well with your testing, I am,

Sincerely yours,

L. J. Smith,

Department of Agricultural Engineering.

Exhibit C, the record of the test, Exhibit D, the dial sheet from the self-recording thermometer, and Exhibit E, a blue print of floor plan of barn, are submitted herewith.

Prof. Smith's analysis of this sheet, as stated in the record, is so clear that further comment is unnecessary, except perhaps to call attention to some of its features in a study of the test.

1st. This ventilating system is a type "Y" installed by the carpenters who built the barn, the intakes are modified Type "X" style.

2nd. The capacity of the heating plant in this barn (the cattle) was great enough to admit of considerable wastage of heat units through the ventilating ducts and still maintain a comfortable temperature in the stock room.

3rd. If we take the ideal standard of 59 cubic feet per minute as the gauge of air flow necessary in this barn, the record shows the following:

Capacity 122 cows and 10 calves, or equal to about 125 full grown cows. Multiply 125 cows by 59 cubic feet per cow totals 7375 cubic feet, as the total amount of air flow per minute through the foul air ducts.

Judged by that standard the actual air movement through the foul air ducts is less than half the amount required to meet the ideal standard.

On the record sheet, Prof. Smith comments, "Barn could have stood more flues open, but rest back-drafted." This again emphasizes the fact that the foul air ducts must be under perfect control of properly designed ventilators elevated above the peak of the roof.

THE SWETMAN BARN

The ventilating system in this barn is "X" type. Exhibit F is a record of the test, and Exhibit G is a photograph of the barn.

The full capacity of this barn is 25 horses, but at the time of the test we found only 16 medium sized horses and 6 colts in the barn.

The outside temperature was 30 degrees below zero, and the temperature of the stock room 16 degrees above zero. The dampers in foul air ducts were opened full and the intakes about half open.

Page 1

Exhibit "F" Zealandia, Sask. Jan. 1918 28-29

Barn Ventilation Test

Owner Mr. A. E. Sterman Present / Absent

Manager Mr. Whitman Karr Present / Absent

Visitors Messrs. Wm. Burton, James & Fields McPaune, (farmers) — J. Cronin, local contractor, Ernest Wlech, farmer, J. Craig of Carberry, Man. in pure bred horse and cattle business.

Barn Location Just outside the limits of Zealandia, Sask.

Statement of Ideal Ventilated Conditions

According to our best information, a room where animals are housed should never contain more than 3 per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 30 cubic feet per minute per cow in order that the standard of air purity shall approximate 97 per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is No ___ Cows No ___ Calves ___ Yearlings 21 Horses in stall ... & 4 ... box stalls

Total Cubic Space to Ventilate 79'x39' 8" x9" = 27486 Cu. Ft. Therefore the volume of air moving in and out should total 1475 Cubic Feet through the ventilating system per minute if figured at same ideal standard for a dairy barn.

Description of System, See Plans Inside

Total Foul Air Flues 4 Size at Bottom 10½ sq. Size at Top 10½" sq and

Height Above Floor 1' Where does top of flue end in base of aerator

How made square to loft thence round to top Material gal. metal

Dimension at Smallest Place 10½ round Where is this located in the loft

Total Intakes 10 Outside Opening 11x13" Inside Opening 9x13"

How far below ceiling 4" Total length 7' Dimension 2x3x22"

How made space between joists Material used metal screen, damper & door

How many ventilators 2 What make King Size 36" flue

How constructed see catalog of King Ventilating Co. Ltd. Moose Jaw, Sask.

REMARKS At beginning of test the barn contained 16 medium sized horses and 6 colts.

Time	Inside the Room North Wall	South Wall	Center of Room Ceiling	Floor	Outside Air North Wall	South Wall
4 P.M.	19 Above	22 Above	22 Above	18 Above	25 Below	24 Above

The sun shining against south wall of the barn accounted for the difference of temperature as indicated in above reading.

Page 2.

Temperature of Outside Atmosphere

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at ______ M. ______ 191__ as marked in No. 1 space.

Readings Taken Every Hour

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

See page 4 for this record and comments

Inside Temperature and Relative Humidity

Dry / Wet / R.H.: This barn room was never warm enough at any time during the test to take the relative humidity of the atmosphere.

1918-1/28 Wind Velocity at Ground in Open Space 1/29

Time Taken	2 P.M.	7 A.M.	11 A.M.	3 P.M.
Feet Per Minute	Slight Breeze		423 ft.	524 ft.

Wind Velocity at Peak of Roof 40 ft. Feet Elevation

Time Taken	2 P.M.	7 A.M.	11 A.M.	3 P.M.
Mi. per hour	4½ Mi.	4 1/10	5 1/6	8 1/2

Air Flow Thru the Ventilators on Roof

Time Taken	
Feet Per Minute	This was not taken.

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks
A	7:40AM	1/28	Taken at ceiling about 10' from south end.		
B	7:55AM	1/28	" " floor (1') " " " " "		
C	8:00AM	"	" " " " " " " north "		
D	8:10AM	"	" " ceiling " " " " "		
E	8:15AM	"	" " " in the middle		
F	8:20AM	"	" " floor " " "		
G	noon	1/29	" " ceiling about 10' from southend		
H	"	"	" At floor " " " " "		
I	"	"	" " " " " " north "		
J	"	"	" " ceiling " " " " "		
K	"	"	" " " in the middle of room.		
L	"	"	" " floor " " " " "		
M	Is a sample of the fresh air out of doors well away from the barn.				

Outside Sample

Page 3

Wind blowing from north west.

Air Movement Thru Fresh Air Intakes

Time	Jan. 29th		Opening size		Size opening	
1	11 AM 182 ft.		3"x13"		216 ft.	1"x13"
2	161 "		"		217 ft.	1"x13"
3	234 "		"		239 "	"
4					271 "	"
5	246 "		"		329 "	"
6	240 "		"			
7	140 "				200 "	"
8	320 "		"		400 "	"
9	closed in harness room.				250	"
10	182 ft.		3"x13"		215 "	"
11						
12						

Beginning of the test of ventilating system. Temp. during day was as follows;

	Inside the Stock Room North Wall	S. Wall	Ceiling	Floor	Outside N. Wall	S. Wall
7:30 AM	24 above	24 above	28above	20above	47 below	46 below
8:30 AM	21 "	23 "	24 "	19 "	44 "	26 "
10:30 AM	14 "	17 "	19 "	16 "	40 "	25 "
11:30 AM	16 "	22 "	22 "	18 "	32 "	14 "
3 P.M.	17 "	25 "	22 "	18 "	28 "	8 "
4:30 P.M.	12 "	19 "	14 "	15 "	30 "	12 "

At 7:30 AM the temperature reading was taken before the system was opened and working just as the barn was arranged for the night. The system was then arranged with all dampers in the foul air pipes wide open and nine intakes were opened each 3 inches as that space for intake air was 3x13". The intake in harness room closed. The readings at 8:30 AM were taken with stock room and system in this condition. After the 8:30 reading the intakes were closed down to 1x13" openings, except the tenth intake in harness room, and the balance of the readings were taken with the system set at this point. The stock was let out of the barn just after 3PM and the 4:30 temp. reading accounts for change in temperature of the room caused by opening the doors. See comments on the foul air pipe readings.

Air Movement Thru Foul Air Flues

1/28/18 2 PM						
1	607ft.			190 ft.	166'	147'
2	582ft.			198 "	205'	148'
3				215 "	163'	110'
4	360ft. 450ft.			228 "	207'	113'
5	174 ft. lineal ft. flow			831 "	741ft.	518 ft.
6	510 Cubic Foot Flow.			1454 "	1373 "	1101
7						
8	Remember, intakes all					
9	slightly closed			Intakes open 3 "s		Intakes open 1 inch.
10						
11						
12						
13						
14						
15						

Page 4

The analysis of the air samples is furnished by the chemistry division of the University of Sask.

Carbon Dioxide Determinations

Samples	Marks	Amount CO_2 in 10000 Parts of Air	CO_2 Expressed in Volume Per Cent	
A. taken at ceiling 10' from south end		34	.034	
B. taken at floor 10' from south end		44	.044	
C. taken at floor 10' from north end		41	.041	
D. taken at ceiling 10' from north end		29	.029	Container leaking
E. taken at ceiling center of room		63	.063	Container leaking
F. taken at floor center of room		19	.019	
G. taken at ceiling 10' from south end		22	.022	
H. taken at floor 10' from south end		20	.020	
I. taken at floor 10' north end		26	.026	
J. taken at ceiling 10' from north end		35	.035	
K. taken at ceiling center of room		27	.027	
L. taken at floor center of room		nil	.000	

Outside Air Sample

Reminders

1. Dimensions	40' x 80' outside.
2. Basement	No basement. Concrete floor and footing 6" high
3. Wall	Double boards and paper outside studs, matched.
4. Thickness	Boards and paper, inside, total thickness 8"
5. Height	Total height to peak over 40 feet.
6. Material	All lumber except stock room floor.
7. Sheeting	Clear B.C. Fir matched boards.
8. Ceiling	Same
9. Outside Wall	Drop siding, paper and shiplap.
10. Studding	2" x 6" set 24" on center.
11. Plate	2" x 6" double.
12. Purline	Framed
13. Peak	1" board.
14. Hay Track	Runs full length of roof under peak.
15. Floor Joists	2" x10" set 24" on center.
16. Girders	Framed & boxed running lengthwise at 4 positions, over inside line of mangers & back line of stalls
17. Frame	
18. Windows	24 windows, 8 lights each 10" x 12" lights.
19. Doors	9'x7' at E. & S. ends 4'x7' in middle each side.
20. Driveway	North to South between stalls.
21. How old	New in 1917
22. Photograph	Yes
23. Dead air space	No
24. Wind proofing	Very good, except doors & windows.

Exhibit F

The north wall and the north half of the west wall was frosty.

The ceiling was dry where the floor over it was covered with the feed in the loft; otherwise the ceiling was covered with a light coating of frost.

We then added to the stock in the barn, 3 milch cows, 2 heifers and 4 calves; this was all the stock on the place and filled the barn about three-fourths full.

At 2:00 P. M. the inside thermometer registered 23 degrees above at the ceiling and 18 above at the floor.

We then closed all the intakes, leaving foul air ducts open, and at 4 P. M. the temperature was the same as above.

We then closed up the entire system and shut the barn up tight, leaving it that way all night, and at 7 A. M. the next morning the thermometers registered 28 degrees above zero at the ceiling and 24 degrees at the floor, but in this connection it must be noted that the outside temperature during the night had dropped to 47 degrees below zero.

At 7:30 A. M. the fresh air intakes were opened 3 inches, the dampers in the foul air ducts fully opened, and at 8:30 A. M. the temperature at the ceiling had dropped four degrees and the floor about the same.

After the 8:30 A. M. readings the intakes were closed up to a 1-inch opening and the system remained at this regulation until the test was finished, the stock room temperature held steady from 8:30 A. M. and until the end of the test. The cattle were turned out just after the 4:30 P. M. test, which accounts for the drop in the barn temperature after that time. No. 5.

This barn is one of the best built we visited last winter, but storm doors and windows had not yet been provided for it, and the 2 P. M. test on January 28, which was taken with foul air ducts open and all intakes fully closed, shows the amount of air leakage through the walls and opening of the barn.

The north double doors and both side doors were sealed up to keep out the cold. The openings in loft floor are well fitted with doors and kept closed except when in use.

The ventilating system in this barn is large enough to match the total capacity of the stock room, and is arranged to keep the movement of air under proper control. If the room had been filled with stock we have no doubt the temperature of the room could have been held above 32 degrees even in the coldest weather.

We tried opening the heat doors in the foul air ducts, situated just below the ceiling, and found that the room cooled down very fast, but when they were closed and all the air drawn through the bottom of the ducts the temperature of the room could be held steady and a sufficient amount of air moved through the ducts to maintain a good ventilated condition.

Another very interesting feature of this test was at 7 A. M. on

January 29, the ceiling temperature was 29 degrees above and the outside air 47 degrees below zero, a diffrence of 75 degrees. At that time the system was entirely closed and had been in that condition all night.

The system was opened immediately after 7 A. M. and at 8:30 A. M. the difference between the temperature of outside and inside air was 60 degrees, and this difference remained stationary up to 11:30 A. M., while the system was operating.

Another interesting and almost unbelievable difference between the thermometer readings was the two situated on the north and south outside walls, the temperature at 11:30 A. M. showed 32 degrees below on the north and 14 degrees above zero on the south wall.

Exhibit G

As this barn is situated as far north perhaps, as any barn in which a good ventilating system is in operation, it furnishes some good evidence of the possibilities of good barn construction and ventilation.

MC FAULD BROTHERS BARN

This barn has a type "Y" system installed by carpenters. Exhibit H is a record of this test.

This barn can be classed above the average in its construction, and it has two well constructed wooden cupolas on the roof at the head of the ventilating system, with louvers set at an angle of about 45 degrees.

The cupolas were back-drafting during our entire visit. The airmeter held about 12 feet below one of the cupolas registered a downward pressure of 143 feet per minute. Under the other cupola the loft floor was bare, which made it impossible to gauge the downward flow of the air, but the current of air from that point could be plainly felt and it seemed to be as strong as from the other cupola.

The foul air ducts starting at the ceiling, the heat pressure caused a rapid flow of the air from the stock room to pass up through the ducts, and as the ducts extended only to the edge of the roof under the cupolas, the back-draft from the cupolas carried the moisture down under the roof and all over the hay in loft. At some spots on the hay the frost was quite thick and also under the roof.

On the other hand, we believe that if the roof had been closed under the cupolas, and the flues extended through the roof into them, the ducts would then have back-drafted and overcome the heat pressure from the room.

Exhibit "H"

Zealandia, Sask. Jan. 30 1918

Barn Ventilation Test

Owner James & Field McFaulds Present ~~Absent~~

Manager The McFaulds are managing owners. Present Absent

Visitors Whitman Karr, Wm. Burton & J. Cronin of Zealandia. The latter is the contractor who built the barn.

Barn Location Three miles south of Zealandia.

Statement of Ideal Ventilated Conditions

According to our best information, a room where animals are housed should never contain over 3.3 per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 59 cubic feet per minute per cow in order that the standard of air purity shall approximate 96.7 per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is holds 33 head of stock, and at this time contained 2 cows Horses 20 horses ~~Yearlings~~ 8 Colts

Total Cubic Space to Ventilate 42'x68'x8'6" = 24276 Cu. Ft. Therefore, the volume of air moving in and out should total 1949 Cubic Feet through the ventilating system.

Description of System, See Plans Inside.

Total Foul Air Flues 2 Size at Bottom 11x18" Size at Top 11x18"

Height Above Floor ceiling flues Where does top of flue end cupolas on roof

How made single boards & paper inside Material 2x11 spds. 1x8 [illegible]

Dimension at Smallest Place 11x18" Where is this located full length of flue

Total Intakes 6 Outside Opening 3x12 Inside Opening 3x12"

How far below ceiling just a few [illegible] the sill [illegible] made of galv. [illegible]

How made Material used [illegible]

How many ventilators 2 What make wood Size

How constructed Two wooden cupolas with louvres set at 45 degrees angle, with an open space between edge of roof and top louvre about 6 to 8".

REMARKS

Exhibit H

It was impossible to test the relative humidity of the stock room, as the temperature was below freezing and the moisture covering the wet bulb would freeze.

Mr. McFauld stated that he keeps the intakes closed during low temperature because the barn gets too cold.

The ceiling under the hay in the loft was dry, but where the loft floor was bare the ceiling was frosty, and frost had gathered on the walls of the stock room. The barn is sheeted inside the studding, but has no ceiling under loft floor joists.

The owners said the temperature of the barn was satisfactory to them, but in cold weather it cannot be kept above freezing unless the ventilating system is closed.

THE WILLIAM J. F. WARREN BARN

This barn has a Type X system installed with metal foul air ducts and ventilators made by a Canadian manufacturing concern.

Exhibit I is a record of the test in the cattle room and Exhibit J a record of the test in the horse room. This is one barn, but separated into two rooms by a tight partition with two connecting doors in this partition. This made it necessary to conduct two tests, one in each room.

The roof under the ventilators was closed, making it impossible to test the ventilators. The roof is made of corrugated galvanized iron, and it was covered with ice and snow, Frost had gathered

Exhibit "I"

Page 1

Balbeck, Sask., Feb. 1 1918.

Cow Barn Room

Barn Ventilation Test

Owner — Mr. J. P. Warren

Employees / Manager — Jesse Hagstrom & Louis Russell, both were Present

Visitors — Jesse Hagstrom assisted with the test.

Barn Location — near Balbeck, Sask.

Statement of Ideal Ventilated Conditions

According to our best information, a room in which animals are housed should never contain over 3 1/3 per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 59 cubic feet per minute per cow in order that the standard of air purity shall approximate 96.7 per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is 12 Cows 8 box stalls Calves and the barn at the time had 8 cows, 1 bull, 7 calves, 2 hogs

Total Cubic Space to Ventilate 41' 8" x 41' 6" x 8' 10" = 15380 Therefore the volume of air moving in and out should total 1180 Cubic Feet through the ventilating system per minute to meet ideal standard.

Description of System. See Plans Inside

Total Foul Air Flues 2 Size at Bottom 6 1/2x12ins. Size at Top 12" round

Height Above Floor 3' to top of opening. Where does top of flue end in vents above roof

How high between studs to 4' below plate tooted Material Galv. steel

In partition 12" flue, insulated, located between studding. The studding space is lined with metal, and not insulated.

Total Intakes — Outside Opening (size) 12x12 — Inside opening 4" x 24"

How far below ceiling in ceiling Total length ... Dimensions ... Space between very leaky boards of shiplap flooring ... no insulation ... joist

How many ventilators ... What make Dummelow Size 30" flues

How constructed See Dummelow Catalog.

REMARKS

Temperature in Cow Barn

Date	Time	Position Center of Room	Ceiling	Floor
2/1/18	5 PM	" " "	38 Above	30 Below
"	7.30PM	" " "	41 "	34 "
2/2/18	9.30PM	" " "	43 "	38 "
"	8.00AM	" " "	40 "	36 "
"	11. AM	" " "	36 "	32 "
"	2. PM	" " "	33 "	38 "

Page 2

The horse barn was empty at 5 o'clock PM on the First day.

Temperature of Outside Atmosphere

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at 5 PM M. Feb. 1 1918 as marked in No. 1 space.

Readings Taken Every Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	See the temperature readings on Page 2																							

Inside Temperature and Relative Humidity

	5 PM	7.30PM	9.30 PM	Feb. 2	8 AM	Air of room before & afterwards
Dry	38'	41'	42'		36'	
Wet	38'	40'	41'		34'	
R.H.	91%	92%	92%		92%	
Feb. 1						

Wind Velocity at Ground in Open Space — Feb. 2, 1918

Time Taken	5 PM	7.30 PM	9.30PM	8 AM	11 AM	2 PM
Feet Per Minute	575'	313'	230'	1090'	1243'	1423'

Wind Velocity at Peak of Roof — Feet Elevation

Time Taken	5 PM	7.30 PM	9.30PM	8 AM	11 AM	2 PM
Miles per hour	13 Mi	6½ Mi.	7 Mi.	18 Mi.	1243 Ft.	1423 Ft

Air Flow Thru the Ventilators on Roof

Time Taken	
Feet Per Minute	The roof was closed under the ventilators so it was impossible to take this reading.

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks
	10 AM	In center of feed alley just below ceiling.	"	"	
Samples	#1 & 2 were taken in horse barn room.			above floor 1	
	These samples have been sent to the Saskatoon University for analysis.				

Outside Sample

Page 3

Air Movement Thru Fresh Air Intakes

Time	5 PM	7.30 PM	9.30 PM	8 AM	11 AM	2 PM
	All the intakes are closed at this time.	All north intakes are closed and all the south intakes are open. There is no air moving in any of these intakes.	Same as previous reading	Same as previous reading.	During these two readings all of the south intakes are back drafting strongly. The average readings of this back draft are as per the following figures. South #1 502 ft. North #2 850 ft. South #3 506 ft. North #4 722 ft. North #6 579 ft. These are numbered from west to east.	

Air Movement Thru Foul Air Flues

Time	5 PM	7.30 PM	9.30 PM	8 AM	11 AM	2 PM
South	407 ft.	270 ft.	260 ft.	346 ft.	269 ft.	228 ft.
North	302 ft.	209 ft.	234 ft.	324 ft.	193 ft.	69 backdraft.

Page 4

Carbon Dioxide Determinations

Samples	Marks	Amount CO2 in ... Parts of Air	CO2 Expressed in Volume Per Cent

The samples of air were sent to Mr. Wm. J. P. Warren who was there at the University of Sask. so he could get the Chemistry Dept. to make the analysis of these samples; after repeated efforts we have been unable to get a report, nor have we yet had our air collecting bottles returned to us.

Outside Air Sample

Reminders

1. Dimensions
2. Basement
3. Wall
4. Thickness
5. Height
6. Material
7. Sheeting
8. Ceiling
9. Outside Wall
10. Bedding
11. Plate
12. Purlins
13. Posts
14. Hay Track
15. Floor Joists
16. Girders
17. Frame
18. Windows
19. Doors
20. Manure
21. How old
22. Photograph
23. Dead air space
24. Wind proofing

These questions are answered on the report of the horse barn room, except questions that are directly related to this room.

4 in this room on each side 8"x10".8 lights

In west end wall, 1 door 4'x8' 4" with transom 8 lights, 1 door with transom 8 8"x10" lts. Rec'd 1917

No

Yes liatrine between matched boards on the inside of stud; and ... lining ... will dry if barn air is moved rapidly enough to remove C.O.2

Exhibit I

Exhibit "J" Page 1

Balbeck, Sask. Feb. 1 1918.

Horse Barn Room.

Barn Ventilation Test

Owner — Mr. J. P. Warren — Absent
Employees
Manager — James Magowan & Louis Russell — Present
Mr. Magowan assisted me with the test.

Barn Location Near Balbeck, Sask.

Statement of Ideal Ventilated Conditions

According to our best information, a room where animals are housed should never contain over 3.3 per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 55 cubic feet per minute per cow in order that the standard of air purity shall approximate 96.7 per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is — Cows — Calves — Yearlings 24 Horses — Yearlings — Colts

Total Cubic Space to Ventilate 47'x42' 8" x8' 10" = 21401 Cu. Ft. Therefore, the volume of air moving in and out should total 1416 Cubic Feet through the ventilating system per minute to approximate the ideal standard.

Description of System. See Plans Inside.

Total Foul Air Flues 4 Size at Bottom 4½"x18" Size at Top 12" round

Height Above Floor 3' to top of opening Height above top of flue end in Vent above roof.

How made same as in the cow barn room. Material same

Dimension at Smallest Place same Where is this located same as in cow barn room.

Total Intakes — these particulars Outside Opening same Inside Opening —

How far below ceiling — Total length — Dimension —

How made same Material used same

How many ventilators 2 What make Townsley Size 30" flues

How constructed See Townsley Catalog.

REMARKS Record of Temperature

	North Wall Inside	North Wall Outside	South Wall Inside	South Wall Outside	Ceiling	Floor
5 PM	14 Above	Zero	33 Above	4 Above	24 Above	20 Above
7.30 PM	32 "	"	32 "	Zero	32 "	25 "
9.30 PM	34 "	"	33 "	"	35 "	30 "
8.00 AM	26 "	6 Below	30 "	2 Below	28 "	26 "
11 AM	28 "	2 "	32 "	4 Above	28 "	26 "
2 PM	30 "	9 "	34 "	2 Below	26 "	24 "

The horses were turned out after the 2 PM reading.

Page 2

The horse barn was empty at 6 P M on the first day.

Temperature of Outside Atmosphere

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at 7.30 PM — Feb. 1 — 191 — was marked in No. 1 space

Readings Taken Every Hour: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

See bottom on page 1 after this reading.

Inside Temperature and Relative Humidity

	7.30 PM	9.30 PM	
Dry	33	Degrees	36 degrees during all the balance of the test
Wet	32	"	34 the barn was too cold to take the
R.H.	90%		91% relative humidity.

Wind Velocity at Ground in Open Space

Time Taken / Feet Per Minute: The report on the cow barn room shows this reading

Wind Velocity at Peak of Roof — Feet Elevation

Time Taken / Feet Per Minute: The report on the cow barn room shows this reading.

Air Flow Thru the Ventilators on Roof

Time Taken / Feet Per Minute: The report on the cow barn room shows this reading

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks
1	Same as cow barn.		Taken at center of feed alley ceiling.		
2	Same as cow barn		Taken at center of feed alley ceiling.		

Nos. 3 & 4 taken in cow barn room.

These samples sent to University of Sask. for analysis.

Page 3

Air Movement Thru Fresh Air Intakes

7.30 PM	9.30 PM	9 AM	11 AM	2 PM
All the south intakes are open but no movement of air thru the North intakes all shut.	Intakes in same position very light trace of air movement in two of the open ones from the south.	All the intakes have been left open all night and this morning only two show any flow from the South. All north 3 intakes were delivering air into the room when open.		North intakes were all closed and at this time the south intakes show a back-draft thru each as follows: 1 Southeast 424 ft. 2 — 324 ft. 3 — 535 ft.

Air Movement Thru Foul Air Flues

	7.30 PM	9.30 PM	6 AM	11 AM	1.30 PM
S. E.	292 ft.	206 ft.	263 ft.	268 ft.	263 ft.
S. W.	415 ft.	211 ft.	198 ft.	80 B.D.	38 B. D.
South			165 ft.	152 ft.	149 ft.
North			77 ft.	100 B. D.	1115 B. D.

Page 4

Carbon Dioxide Determinations

Samples	Marks	Amount of CO2 in 1000 Parts of Air	

Outside Air Sample

Remarks

1. Dimensions: 100'x44' outside
2. Basement: No
3. Wall: No
4. Thickness: No
5. Height: No
6. Material: No
7. Sheeting: Shiplap and paper stripped with 2"x4" strips over
8. studs, then match lumber on the inside.
9. Outside Wall: Drop siding only.
10. Studding: 2"x6"-24" on center, 22' long.
11. Plate: Double 2"x6"
12. Purline: Self supporting roof, point of purline on elliptic.
13. Peak: Loft floor to peak 22'.
14. Hay Track: Yes.
15. Floor Joists: 2"x10" set 24" O. C.
16. Girders: 3-2"x10" spiked together on edge set front and back
17. edge of stalls.
18. Windows: 8"x10" 6 lights, 6 on north and 6 on South side 2 on E. side.
19. Doors: 1-3. middle 6'x7' 2 on E. end 5'x7' each corner.
20. 1 in north middle to pig pen under drive outside 4x7'.
21. Built 1917. (1 doors in partition between cows and horses. 1
22. of these 3x7' 2-3' 4"x7' 1-6' 10"x7'
23. Dead air space: Yes in sheeting, but the windows are single with
24. Weatherstripping: no storm sashes and the doors are not fitted tight

Exhibit J

Exhibit "K" Page 1

January 5 1918.

Barn Ventilation Test

Owner ~~St. Mary's Hospital~~ Present / Absent

Manager Sister Joseph Present / Absent

Visitors Father Tracey visited a few minutes. Sister Julia present about one hour and Mike Cass the farmer was present. Present / Absent

Barn Location In the hospital grounds in Rochester, Minn.

Statement of Ideal Ventilated Conditions

According to our best information, a room where animals are housed should never contain over 3.3 per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 59 cubic feet per minute per cow in order that the standard of air purity shall approximate 96.7 per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is 20 Cows 3 Calves No Yearlings 2 Horses No Yearlings No Colts

Total Cubic Space to Ventilate see remarks below

Therefore, the volume of air moving in and out should total 1377 per minute Cubic Feet through the ventilating system.

Description of System, See Plans Inside.

Total Foul Air Flues 4 Size at Bottom 12"x12" Size at Top 2-15" round 2-16" round

Height Above Floor 1' Where does top of flue end in King aerator

How made Galv. metal & insulated

Dimension at Smallest Place 15" round 16" round Material Galv. met.

Total Intakes 7 Where is this located above loft floor: Outside Opening 10"x16" Inside Opening over feed alley

How far below ceiling none Total length 21'

How made boxing the spaces between alley Material used lumber & King Po[illegible]ost.

How many ventilators 2 What make King

How constructed See catalog (King) Size #360

REMARKS:

The cattle room measured 32x52x8' = 13312 Cu. Ft.

" horse " " 18x18x8' = 2592 " "

" calf " " 11x20x8' = 1760 " "

All in one air space estimating 3 calves equal to one cow & estimating a large requirement at 59 Cu. Ft. of air per minute see total volume stated above.

Note the cubic air space in this barn equaled 908 cubic feet per grown animal. Six hundred cubic feet per grown animal is about the limit of space that can be warmed in cold weather, where the barn is well built and is equipped with a good ventilating system.

Page 2.

Temperature of Outside Atmosphere

Readings Taken Every Hour

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at 4 P.M. Jan. 5th 1918 as marked in No. 1 space.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Inside Temperature and Relative Humidity

Dry	48	49	4848	4648	4949	47	Barn Test
Wet	458	47	4646	4647	47465	45	Concluded.
R.H.							

Wind Velocity at Ground in Open Space

Time Taken None taken. Wind coming north east.

Feet Per Minute

1/5/18 Wind Velocity at Peak of Roof Feet Elevation

Time Taken	4 PM	7 PM	11 PM	5 AM	9 AM	11 AM
Miles per hr.	5 miles	6 miles	4 miles	4 miles	1 miles	5 miles

Air Flow Thru the Ventilators on Roof

Time Taken

Feet Per Minute No test taken.

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks
1	10.30PM	Near ceiling over cleaning alley E. Side			
2	10:35PM	" floor " " " E. Side 5-18			
3	10:40PM	" ceiling " " " W "			
4	10:45PM	" floor " " " " "			
5	10:50PM	2' above floor middle east cleaning alley "			

Outside Sample

Page 3

Air Movement Thru Fresh Air Intakes

Time	5:40 PM 1/5/18	7PM	11PM	5 AM	9AM 1/6/18	11 AM
1	242' per M	224' per M	282' per M	287' per M	240' per M	
2	148' per M	140' per M	210' per M	315' per M	258' per M	208' per M
3	168' per M	200' per M	242' per M	302' per M	202' per M	218' per M
4						218' per M
5						
6			None			

This intake in calf pen closed all the time.

#4, 5 and 6 on south side away from the wind so the wind pressure on north side accounts for the south flues not working.

Air Movement Thru Foul Air Flues

Time	4:45 PM 1/5/18	7:10 PM	11 PM	5 AM	9 AM 1/6/18	11 AM
1	216' per M	220' per M	240' per M	330' per M	246' per M	262' per M
2	231' per M	245' per M	308' per M	240' per M	230' per M	308' per M
3	231' per M	302' per M	300' per M	300' per M	283' per M	288' per M
4	218' per M	225' per M	270' per M	282' per M	270' per M	254' per M
5	896 Feet	992 Feet	1018 Feet	1068'	1086'	1099'

992 / 1018 / 1042 / 1086 / 1067 / 6)6035 / 1006

2-15" 2-16" Round flues average 1.21 Sq. Ft. Area.

1006 × 1.21 = 1006 / 2012 / 1006 / 1217.26 average cubic feet flow per minute.

Page 4

Carbon Dioxide Determinations

Samples	Marks	Amount of CO_2 in 10,000 Parts of Air	[illegible]

The samples of air taken unfortunately were not analyzed on account of a rush of work at the Chemistry Department of the University.

Outside Air Sample

Remarks

1 Dimensions See Plans.
2 Basement
3 Wall
4 Thickness
5 Height
6 Material
7 Sheeting
8 Ceiling
9 Outside Wall
10 Studding
11 Plate
12 Purling
13 Peak
14 Hay Track
15 Floor Joists
16 Girders
17 Frame
18 Windows
19 Doors
20 Driveway
21 How old
22 Photograph
23 Dead air space
24 Wind proofing

Exhibit K

under the roof, especially underneath the ventilators. This indicated that a mass of frost and ice had accumulated in the base of the ventilators, but had not piled up high enough to stop the working of the foul air ducts.

The inside surface of the west wall and doors was frosty and the north wall was wet. Where the ceiling was insulated with the hay above, it was dry but where the floor was bare the ceiling was frosty.

During the four tests taken in the cattle room the three intakes leading in from the south were open but no air passed through them, except an occasional light movement that was hardly perceptible and which only lasted but a moment.

All intakes leading from the north wall were kept closed on account of the heavy wind pressure against that side of the barn, as air passing out through those intakes cooled the barn too much.

Note the back-drafting of the north flue at 2 P. M. test on the second day, as indicated on page 3 of the record of the test. No. 6.

The north flues in the horse room had commenced to back-draft before the 11 A. M. test, and both rooms cooled off rapidly as soon as the back-drafting commenced; this made it necessary to close these flues.

During the last two readings on the second day the wind was blowing from the north and rapidly increasing in velocity. No. 7.

The test record shows the intakes were not doing much work and this is partly accounted for because the air was coming down one set of foul air ducts and up the others.

We were careful to close all doors in the hay loft and tried in every way to stop the back-drafting.

Apparently, the cause of the back-drafting was the effect of the high wind on the ventilators, probably blowing into them, because during the light wind of the previous day the foul air ducts all worked the right way.

This again emphasizes the importance of properly designed ventilators on the roof to control the air movement through the foul air ducts.

In this case it is a Type "X" system and in the cases previously noted it was a Type "Y" system, so it seems that in any case a scientifically designed ventilator is a vital element in the success of the ventilating system.

THE ST. MARY'S HOSPITAL BARN

A Type "X" system. Exhibit K is a record of the test, which we offer without further comments because there is nothing in this test worthy of special comment which would not be a repetition of previous statements in this report.

THE E. C. SCHROEDER BARN

This is a Type "X" system. Exhibit L is a record of the test.

This barn is very well constructed, the walls and ceiling being

EXHIBIT "L"

Page 1

Feb. 10th 1918

Barn Ventilation Test

Owner — E. C. SCHROEDER — Present / Absent

Manager — G. R. HELD — Present / Absent

Visitors — Albert Honeyout (assisted with test)

Barn Location — Near Moorhead.

Statement of Ideal Ventilated Conditions

According to our best information, a room where animals are housed should never contain over 3⅓ per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 50 cubic feet per minute per cow in order that the standard of air purity shall approximate 96⅔ per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is 80 large type Holstein cows. ____ Calves ____ Yearlings ____ Horses ____ Yearlings ____ Colts

Total Cubic Space to Ventilate 130x37x8'6" = 43718 Cu. Ft. Therefore, the volume of air moving in and out should total 3840 Cubic Feet through the ventilating system per minute.

Description of System, See Plans Inside.

Total Foul Air Flues 8 Size at Bottom [illegible] Size at Top same as at bottom.

Height Above Floor about 16" Where does top of flue end in King Aerator.

How made King Ventilating Co. style Material Gal. metal King-Felt

Dimension at Smallest Place same full length surround.

Total Intakes 20 Outside Opening 8"x18" Inside Opening 8"x18"

How far below ceiling 12 below Total length 8' Dimension 8x22"

How made between studding Material used lumber & King Felt.

How many ventilators 3 What make King Size #500

How constructed see King Catalog.

REMARKS:

The room was filled at this time with 30 large holstein cows and 21 holstein heifers coming two years old.

Page 2

Temperature of Outside Atmosphere

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at 3:30P.M. 2-10 1918 as marked in No. 1 space.

Readings Taken Every Hour

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
44A		37A			37A									32A		32A				36A			

Outside Temperature and Relative Humidity

D. [illegible] 57 54 58, 54, [illegible] 53 57 58

W. [illegible] 55 53 55, 53, 53 52 55 53

R.H. [illegible] 83 91 88 94 88 86

taken at 4Pm 7 PM 9 AM

Wind Velocity at Ground in Open Space

Time Taken	3 PM	6:30PM	10:30PM	7 AM	9:30AM	1PM
Feet Per Minute	325	804	580	103	nothing	268
Miles per hr	3.7 Mi.	8.73 Mi.	6.6 mi.	1.17 Mi.		3.05 Mi.

Wind Velocity at Peak of Barn

Time Taken	3PM	3:40 PM	6 PM	10:30PM	7 AM	9:30Am	1PM
Feet Per Minute	8 1/3 Mi.	8½ Mi.	6½ Mi.	6 Mi.	3 1/4 Mi.	8 Mi.	6½ Mi.

Air Flow Thru the Ventilators on Roof

Time Taken					
Feet Per Minute		Not taken			

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks

Outside and inside temperature.

	Outside	North end	South end	ceiling	floor	North	South
3:30 PM	44A		50 A	58 A	50 A	54 A	55 A
7 PM	37A		54 A	60 A	47 A	55 A	57 A
10:30 PM	37A		54 A	58 A	48 A	55 A	53 A
1 AM	32A		58 A	56 A	44 A	52 A	55A
9 AM	32A		54 A	60 A	48 A	56 A	57 A
1 PM	36A		52 A	60 A	52 A	54 A	56 A

Outside Sample

The heat doors were opened at 7:10 PM 2/10/18 after the 1 PM temperature readings.

Page 3

Air Movement Thru Fresh Air Intakes

		Time 3 PM	6:30 PM	10:30PM	8:30 PM	1 P.M.	
1							
2	N	212	280	223	112	184	
3	S	closed					
4		56	270	172	180	288	
5	E	84	200	182	154	224	
6		114	252	182	170	204	
7		90	270	228	244	312	
8	N	88	280	232	200	248	
9	W	184	240	263	254	243	
10		114	240	230	258	288	
11	wall	80		98	178	388	
12					152	210	
13		114	150	128	78		
14	N	144	150	118	40		
15	E	104	110	97	46		
16		104	85	96	94	98	
17		184	110	126		132	
18	S	114	163	148	158	180	
19	E	188	110		88	168	
20					88	182	
21	S	170	290	208	92	188	
22							
23							
24							
25							
26							
27							
28							
29							
30							

Air Movement Thru Foul Air Flues

Time 2-10-18	3 PM bottom	6:30 PM bottom	10:30PM top	8:30 AM	8:30 N.D. bottom	N.D. bottom
1	230	240	185	210	240 - 180	286 - 356
2	214	140	110	160	340 - 164	314 - 234
3	344	380	248	210	316 - 284	320 - 310
4	284	350	150	240	284 - 248	290 - 256
5	366	480	300	254	126 - 170	268 - 204
6	288	540	220	263	302 - 222	260 - 196
Total Ideal ft. per min.	1486	2110	1301	1337	1668-1268	1738 - 1556
			2586		2936	3294

The average sq. foot area is 2.12"

The cubic feet Flear 2574.32 4473.20

Page 4.

Carbon Dioxide Determinations

Samples	Marks	Amount CO_2 in 10000 Parts of Air	CO_2 Expressed in Volume Per Cent
1	north ceiling		
2	north floor		
3	middle ceiling		
4	middle floor	Samples taken 11:00	
5	south ceiling	Febr. 11, 1918.	
6	south floor		
7	outside		
Analysis by R. Adams Dutcher, Prof. Agri. Chemistry.			
	University Farm School, Hamline, Minn.		
1	north ceiling	26 parts in 10000	.026
2	north floor	24 parts in 10000	.024
3	middle ceiling	23 parts in 10000	.023
4	middle floor	19 parts in 10000	.019
5	south ceiling	32 parts in 10000	.032
6	south floor	29 parts in 10000	.029
7	outside air	5½ parts in 10000	.0055

Outside Air Sample

Reminders

1. Dimensions
2. Basement
3. Wall
4. Thickness
5. Height
6. Material
7. Sheeting
8. Ceiling
9. Outside Wall
10. Studding
11. Plate
12. Purline
13. Peak
14. Hay Track
15. Floor Joists
16. Girders
17. Frame
18. Windows
19. Doors
20. Driveway
21. How old
22. Photograph
23. Dead air space
24. Wind proofing

Exhibit L

insulated with ½-inch flax fiber. The inside surface of the stock room now remains thoroughly dry and *Mr. Schroeder says this is the first winter he has had the inside of his barn free from frost.*

During the test the wind pressure was very light and the difference between the temperature inside and outside was from 16 to 24 degrees; under the circumstances the movement of the foul air through the ducts was unusually good.

THE JEAN DU LUTH BARN NUMBER TWO

This barn was planned by Prof. A. M. Bull of the Minnesota Farm School. Exhibit M is a photograph of this barn, Exhibit N the test record and Exhibit O (not shown) the floor plan.

The window openings are covered with storm sash, but not well

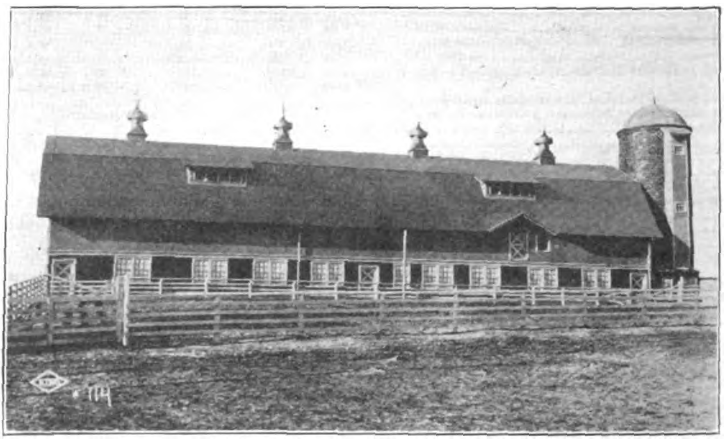


Exhibit M

enough fitted to the casing, as frost gathers on the inside surface of the glass. This is a Type "X" system and is giving the owners satisfactory results.

THE CHICAGO LUMBER COMPANY BARN

A Type "X" system with Exhibit P as a record of the test. This is a horse barn in the City of Omaha, and the test shows very satisfactory ventilation.

THE GRAHAM DAIRY BARN

This is a Type "X" system and Exhibit Q is a record of the test.

THE FLORA E. HARRIS BARN

A Type "X" system with Exhibit R a record of the test, and Exhibit S, photograph of the barn.

A test was made in this barn late in the winter, but proved of special interest in several particulars.

The full capacity of the stock room is 30 cows and 20 calves but

Exhibit "N" Page 1

Feb. 12th, 1918

JEAN DU LUTH FARM #2

Barn Ventilation Test

Owner JOHN G. WILLIAMS & GEO. P. GROUT

Managing owner Geo. P. Grout present during last part of test.
Farm Manager J. Raymond present during test.
Herdsman F. C. Crosby " " "

Barn Location Farm #2 near Nickerson, Minnesota.

Statement of Ideal Ventilated Conditions

Cows 27 Calves 1
3 Bulls

Total Cubic space to Ventilate 127'x39'x9'6" = 48100 Cu. Ft. Therefore, the ... 3248 Cubic Feet through the ... per minute.

Description of System. See Plans Inside

Total Flues 8 ... 4-11-126" Size at Top 18" round, 19" round
Height 14" ... in aerator.
... made by King Ventilating Company Material Galv. Metal
... 18"x19" round. ... in barn loft
... 20 ... 6"x18" with screen ... 8"x16"
... four inches ... 6' over sill ... 8"x22"
... spaces between studs ... doors, dampers & screen of galv. metal
... four ... King
... See Catalog Of King Ventilating Co.

27 Calves equal to 9 full grown cows. The barn walls outside; stock boards, paper and drop siding. Inside; match boards and paper. Windows eight, 12 lights wi-does 10"x12" lights on each side and 3 windows of same size on S. end and one on N. end of barn. All windows covered with storm sash, not tight. Doors. one 3'x7' on W. side: 3 doors on N. end; 4'x7' - 4'6"x7' - 3'x7' respectively. One 3'x7'. Door on S. end no storm doors. Stalls: All stall partitions made of lumber and mangers partitioned with lumber. Concrete floors all same formed b iron piping made by a well known barn equipment company.

Page 2

Temperature of Outside Atmosphere

The first reading at 3:30 PM Feb. 12 th

Thermometers placed on north end wall south end wall

		north end wall	south end wall
1st reading	3:30 PM	36 A	30 A
2nd reading	6:00 PM	30 A	17 A
3rd reading	11:30 PM	19 A	4 A
4th reading	8:00 AM	11 A	8 A

Inside Temperature and Relative Humidity

4:00 PM 6:00 PM 11:40 PM 8:00 PM

[illegible]

Time	2:30	5:30	10:50	7:20 AM
	286	511	830	1728

Wind Velocity at Peak of Roof Feet Elevation

Time	2:30 PM	5:30 PM	10:50 PM	7:20 AM
Mi. per hour	6 1/6	13 Mi.	18 4/5	33 Mi.

Air Flow Thru the Ventilators on Roof

Not taken

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks
1	10:30 PM	North	ceiling	about 8'	stock q let
2	"	"	floor	" "	" "
3	"	middle	ceiling	" "	" "
4	"	"	floor	" "	" "
5	"	south	ceiling	" "	" "
6	"	"	floor	" "	" "

Note: The letters below the relative humidity readings are explained as follows: N.C. means near the ceiling at north end of room. N.F. means near floor at north end. M.C. means middle near ceiling and M. F. middle near floor; S. C. south ceiling and S. F. south floor.

Outside Sample Not taken (strong wind blowing)

Page 3

Direction of wind at different tests.

[illegible]

	3 PM	4:15	11:...	7:...
1	124 Ft.	146 Ft.	210	400 Ft.
2	120	178	226	400
3	130	156	180	265
4	130	158	264	closed
5	170	268	260	closed
6	134	234	110	closed
7	90	316	344	closed
8	Open N.1	350	328	closed
9	230 Ft.	380	96	open N.1
10	150	96	open	110 Ft.
11	316	176	56	84
12	188	open N1	156	270
13	236	154 Ft.	330	460
14	236	100	192	434
15	136	170	298	296
16	128	260	175	384
17	140	306	158	402
18	136	220	116	460
19	118	274	220	400
20	118	244	202	465
21	3004 Ft.	4252 Ft.	4192 Ft.	4200 Ft.

Lineal ft. per min. The total cubic flow at each reading is as follows:
3:00 PM 2362.25
6:15 PM 4916.77
11:30 PM 3196.50
7:30 AM 3907.60
The area of each intake is 110 sq. in. at 3 PM 20 intakes open
6:15 20 intakes open
11:30 20 intakes "
7:30 AM 15 "

Temperature inside the stock room.

Time	wall six ft. high	ceiling	floor	wall six ft. high
3:30 PM	44 Above zero	52 Above	49 Above	50 Above zero
6:00 PM	45 " "	52 "	49 "	49 " "
11:30 PM	40 " "	48 "	49	42 " "
8:00 AM	31 " "	34 "	40 "	31 " "

North end middle South end

Time taken

	2:30 PM	5:30 PM	10:50 PM	7:20 AM
Flue A	210 Ft.	197 Ft.	278 Ft.	316 Ft.
B	202	208	212	276
C	232	220	242	450
D	215	219	303	340
E	193	244	278	334
F	210	204	224	408
G	186	179	248	510
H	196	206	246	508
	1644 Ft.	1667 Ft.	2031 Ft.	3140 Ft. Lineal ft. per min.
	2211.18	3137.82	3777.66	5844.12 Cu. Ft. flow per min.

These readings taken from four flues 18" diam. and four flues 19" diam. The total flue area is 14.91 sq. ft. divided by 8 = 1.86 Sq. Ft. Average.

The difference between cubic foot flow thru intakes and outtakes may be accounted for by air leakage thru other openings and the intakes between studding may in some cases not be full 110 Sq. In. in sectional area.

Page 4

Carbon Dioxide Determinations

Sample	Where			
No. 1	North ceiling	9 parts in 10000	or	.009
No. 2	" floor	19 parts " 10000	or	.019
No. 3	Middle ceiling	18 " " 10000	or	.018
No. 4	" floor	14 " " 10000	or	.014
No. 5	South ceiling	16 " " 10000	or	.016
No. 6	South floor	8 " " 10000	or	.008

Outside air assumed to be 3.3 parts in 10000 or .0033

1 Dimensions	Inside 127'x39'x8'6" = 42100 Cu. Ft.
2 Basement	No
3 Wall	Lumber
4 Thickness	About 8"
5 Height	14' studs
6 Material	Lumber
7 Sheathing	Matchboards
8 Ceiling	
9 Outside Wall	Stock boards, paper and drop siding.
10 Bedding	2"x8" set 24" O. C.
11 Plate	Double 2"x6"
12 Purlins	
13 Truss	
14 Hay Track	Yes
15 Floor Joists	2"x10" set 24" O. C.
16 Girders	Yes
17 Frame	
18 Windows	See first page
19 Doors	
20 Dormers	No
21 How old	Built 1917
22 Photograph	Yes
23 Dead air spaces	Good
24 Wind proofing	Good except windows and doors.

Exhibit N

Exibit "P"

Page 1

Feb. 8th 1918

Barn Ventilation Test

Owner CHICAGO LUMBER COMPANY — Present / Absent

Manager OMAHA NEBR. — Present / Absent

Visitors

Barn Location — In Omaha

Statement of Ideal Ventilated Conditions

According to our best information, a room where animals are housed should never contain over 3.3 per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 59 cubic feet per minute per cow in order that the standard of air purity shall approximate 96.7 per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is None Cows no Calves — Yearlings 12 Horses — Yearlings — Colts

Total Cubic Space to Ventilate 52'x26'x9½' = 12844 Therefore, the volume of air moving in and out should total 828 Cubic Feet through the ventilating system. per minute.

Description of System. See Plans Inside.

Total Foul Air Flues 2 Size at Bottom 1-17"x17" 1-18"x18" Size at Top 1-17" round 1-18" round

Height Above Floor one foot Where does top of flue end King Aerator

How made King Ventilating Co. Style Material Galv. metal

Dimension at Smallest Place 17" 18" round Where is this located in loft King Felt

Total Intakes four Outside Opening 12"x16" Inside Opening 2-12"x12" 2-11"x16".

How far below ceiling 4" Total length 6' Dimension 14x16"

How made King Vent. Style Material used Galv. metal and King Felt

How many ventilators one What make KING Size #400

How constructed See King Ventilating Catalog.

REMARKS:

We have taken 60' Cubic feet per minute as the ideal amount of air to enter and leave the horse barn per minute and the above figured 828 is based on this estimate. See page 3 of this record for air flow test.

Page 2

Temperature of Outside Atmosphere

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at 10:30AM Feb. 8th 1917 as marked in No. 1 space.

Readings Taken Every Hour

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
		Outside temperature 1st test. 20 Above												The temperature taken Feb. 9th at 6:45 AM. second test. Zero.									

Inside Temperature and Relative Humidity

Dry	40 Inside	Inside temperature 40
Wet	36 second	and relative humidity 36
R.H.	83 test.	Feb. 9th at 6:45 Am. 83

Wind Velocity at Ground in Open Space

Time Taken	Not taken see remarks.
Feet Per Minute	

Wind Velocity at Peak of Roof — Feet Elevation

Time Taken	Air flow thru the ventilators on roof.
Feet Per Minute	Not taken

Wind velocity at Peak of roof 22 Ft. elevation

Time Taken	11 AM. Feb. 8 1917	6:20 AM Feb. 9th 1917
Feet Per Minute	643 Feet or 7.3 Mil.	580 Ft. or 6.45 Mil.

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks
	No samples of air taken.				

Remarks: When the first test was made on Feb. 8th, there was no stock in the barn, but when the second test was made the next morning the barn was filled with eleven work horses, average weight about 1700 lbr. each. The ground level slopes up from the barn to the west and west end of barn is against a bank, the ground level even with loft floor, the wind blowing from the west made it necessary to go to top of ground level back of barn to test velocity of wind.

Outside Sample

Page 3

Air Movement Thru Fresh Air Intakes

Time	Feb. 8th 1917, 10:30 A M	Feb. 9th, 1917 6:30 AM
1		
2		
3	1- 128	248
4	2- 162	138
5	3- 115	192
6	4- 122	163
7–30		

Air Movement Thru Foul Air Flues

Time	Feb. 8th, 1917	Feb. 9th, 1917
1		
2	10:20 AM	6:25 AM
3	276	238
4	248	310
5	524	548

The average sq. foot area of flues 1.67 sq. feet. The 1st test shows a cubic foot flow of air of 875 cubic feet per minute and the second test 915.16 cubic feet per minute.

Page 4

Carbon Dioxide Determinations

Samples	Marks	Amount CO2 in 10000 parts of Air	CO2 Expressed in Volume Per Cent
	None taken		

Outside Air Sample

Remarks	
1 Dimensions	53'x28'
2 Basement	Stock room against bank
3 Wall	Brick
4 Thickness	One foot
5 Height	16' to plate under roof
6 Material	Brick
7 Sheeting	No
8 Ceiling	No
9 Outside Wall	
10 Bedding	
11 Plate	2"x12"
12 Purline	
13 Peak	22' above floor of stock room
14 Hay Track	Yes
15 Floor Joists	2"x10"
16 Girders	8 6"x6"
17 Frame	
18 Windows	4-8"x10" lights one window for each stall.
19 Doors	2-Doors 4'x7' each
20 Driveway	
21 How old	Probably 12 to 15 years.
22 Photograph	No
23 Dead air space	
24 Wind proofing	Good

Exhibit P

Page 1

Exhibit "Q" Jan. 4th, 1918

Barn Ventilation Test

Owner Dr. C. Graham Present / Absent

Manager R. J. Boynton Present / Absent

Herdsmen Chas. Calverly Present

Persons Chas. E. Allen assisted with test.

Barn Location Graham ... Rochester, Minn.

Statement of Ideal Ventilated Conditions

According to our best information a room where animals are housed should never contain over 3.3 per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 50 cubic feet per minute per cow in order that the standard of air purity shall approximate 96.7 per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is 14 Cows 15 Calves

... Yearlings ... Horses ... Yearlings ... Colts

Total Cubic Space to Ventilate 80'x28'x7'10" = 18173 Therefore, the volume of air moving in and out should total 1121 Cubic Feet through the ventilating system per minute.

Description of System, See Plans Inside

Total Foul Air Flues 4 Size at Bottom 2-14"x18" 2-17"x17" Size at Top 2-16" round 2-17" round

Height Above Floor 1' Where does top of flue end in King Aerator.

How made King V. Co. Style Material Galv. steel King Felt.

Dimension at Smallest Place 16" round Where is this located In loft

Total Intakes 10 Outside Opening 6"x18" Inside Opening 10"x12"

How far below ceiling center of Total length 20' Dimensions spaces between studs & joist

How made boxing ceiling Material used lumber and King Felt

How many ventilators 2 What make King Size #400

How constructed See King Ventilating Catalog.

REMARKS:

Fifteen calves estimated equal 5 cows. The ceiling and walls dry except about two feet wide on ceiling over sliding entrance door. Vapors caused by cold air entering door opening when door was open.

Page 2

Temperature of Outside Atmosphere

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at 3 PM of January 4th 1918 is marked in No. 1 space

Inside Temperature and Relative Humidity

Commencing Jan. 4, 1918 Wind Velocity at Ground in Open Space Door ... entering barn

Time Taken	3 PM	4:15	6 PM	11 PM	5 AM	9 AM
Feet Per Minute	200	380	380	190	234	490
Mi. per hours.	2.27	3.60	3.60	2.10	2.67	5.57

Wind Velocity at Peak of Roof Feet Elevation

Time Taken	3 PM	4:15 PM	6 PM	11 PM	5 AM	9 AM
Feet Per Minute	4.5	7	6	3	6	7.4

Wind blowing from east.

Air Flow Thru the Ventilators on Roof

Time Taken						
Feet Per Minute		Not taken				

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks

No samples analyzed.

Relative humidity in test barn. At 5 AM Jan. 5th, 1918 also 9 AM.

5 AM Jan. 5th, 1918			9:00 AM Jan 5th, 1918		
Ceiling		Floor	Ceiling		Floor
50	Dry	46	49	Dry	47½
46	Wet	44	46	Wet	45
80	R. H.	86	80	R. H.	82½

The above test is a fair sample of the average condition in the dairy barn.

Outside Sample

Page 3

The test started on Jan. 4th, 1918. ended next day

Air Movement Thru Fresh Air Intakes

Time	3 PM	11 PM	5 AM	9 AM			
1	none	110	125	none	feet	per	min.
2	none	100	very light	none	feet	per	min.
3	none light	142	293	220	feet	per	min.
4	very light	200	none	none	"	"	"
5	43	80	258	242	"	"	"
6	60	232	none	102	"	"	"
7	none	none	none	none	"	"	"
8	"	"	light	"	"	"	"
9	"	170	240	208	"	"	"
10	"	80	260	283	"	"	"
11	103	1114	1176	1055			

When test first started the barn doors were open to handle feed and added to this there was a broken window light into bull pen. The wind blowing from east accounted for some intakes not drawing air on the opposite side and end.

Air Movement Thru Foul Air Flues

	First Day			Second Day		
	3:00 PM	6 PM	11 PM	5 AM	9 AM	11 AM
	221	285	300	285	200	188
	193	265	290	310	400	368
	283	300	328	270	538	436
	134	232	348	185	230	203
Lineal Ft.	805	1082	1266	1050	1368	1195
Cubic Ft.	1344.35	1811.95	2104.20	1753.50	2274.56	1995.65

The average area of foul air flues is 1.67 sq. feet.

Page 4

Carbon Dioxide Determinations

Samples	Marks	Amount CO₂ in 10000 Parts of Air	CO₂ Expressed in Volume Per Cent
	No analysis taken		

Outside Air Sample

Reminders

1.	Dimensions	80'x30'
2.	Basement	No
3.	Wall	
4.	Thickness	
5.	Height	
6.	Material	
7.	Sheeting	Match boards.
8.	Ceiling	
9.	Outside Wall	Drop siding
10.	Studding	2x6 - 24" O.C.
11.	Plate	same
12.	Purline	
13.	Peak	
14.	Hay Track	Yes
15.	Floor Joists	2x10"
16.	Girders	8x8
17.	Frame	
18.	Windows	16 windows 8 light 10"x12"
19.	Doors	one sliding door leading to main barn.
20.	Driveway	No
21.	How old	2 years
22.	Photograph	no
23.	Dead air space	no
24.	Wind proofing	not good.

Exhibit Q

Exhibit "R"

Page 1

Winterset Iowa Mar 9 1918

Barn Ventilation Test

Owner FLORA E. HARRIS Present / Absent

Manager CADY L. HENTON Present / Absent

Visitors C. A. COBB, Associate Editor of Successful Farming Des Moines, Iowa.

Barn Location Inside the corporate limit of Winterset, Iowa.

Statement of Ideal Ventilated Conditions

According to our best information, a room where animals are housed should never contain over 3.3 per cent of air once breathed and to attain this condition, for example, in the dairy barn the air must enter and leave the stable at the rate of 59 cubic feet per minute per cow in order that the standard of air purity shall approximate 96.7 per cent, which is the ideal standard in a dairy barn.

In this barn the total capacity is 30 Cows 20 Calves Yearlings Horses Yearlings Colts

Total Cubic Space to Ventilate 80'x38'x9' = 26200 Cu. Ft. Therefore, the volume of air moving in and out should total 2124 Cubic Feet through the ventilating system per minute estimating 3 calves equal to 1 cow.

Description of System, See Plans Inside.

Total Foul Air Flues 4 Size at Bottom 2-18x18" 2-18x18" Size at Top 2-18" round 2-18" round

Height Above Floor 14" Where does top of flue end in base of cupola.

How made King Ventilating Co. design Material Galv. metal

Dimension at Smallest Place Round in loft. Where is this located loft floor to peak

Total Intakes 9 Outside Opening 9"x14" Inside Opening 8"x14"

How far below ceiling 18" Total length 6' Dimension 7x14"

How made insulated metal Material used Galv. metal with King Felt

How many ventilators two What make K.V.CO. style Sec No. 800

How constructed Details in King Ventilating Co's catalog.

REMARKS:

Mr. Cobb was present and assisted during the entire duration of the test.

Page 2

At 3:45 P. M. 3-9-18 wind from northwest by north.
At 8:45 P. M. 3-9-18 wind from west by south continued from this point to end of test.

Temperature of Outside Atmosphere

The letters "a" and "b" after figures stand for "above" and "below" zero.

The 1st reading at 3:45 PM March 9th 1918, as marked in No. 1 space.

Readings Taken Every Hour

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Inside Temperature and Relative Humidity

Dry	46	44	42½	44	----------	42		
Wet	42	40	41½	40	----------	39	(end of test.)	
R. H.	72	71	71½	71	----------	77		

Wind Velocity at Ground in Open Space

Time Taken	3:45 PM	4:45 PM	7:45 PM	8:45 PM	8:45 AM
Feet Per Minute	2466	2118	1178	1540	297

Wind Velocity at Peak of Roof Feet Elevation

Time Taken	3:45 PM	4:45 PM	7:45 PM	8:45 PM	8:45 AM
Feet Per Minute	26½	23½	15½	13½	4

During entire test the wind was very high and erratic and decreased in velocity toward night and was light next day.

Air Flow Thru the Ventilators on Roof

Time Taken					
Feet Per Minute		Not taken			

Samples of Air

No. of Sample	Time	Place	Where	Height Above Floor	Remarks
1	10 AM	north ceiling			
2	10 AM	north floor			
3	" "	south ceiling			
4	" "	south floor			
4	" "	outside air			

Outside Sample

Page 3

March 9th, 1918 — March 10th, 1918

Air Movement Thru Fresh Air Intakes

Time	3:45 PM	4:45 PM	7:45 PM	8:45 PM		8:45 AM
1	Closed	Closed	Closed	Closed		Closed
2	Closed	484'	416 Ft.	550		50'
3	"	303'	299 Ft.	101		80'
4	"	388'	90 BD	Closed		closed
5	"	343 B.D.	Closed	"		closed
6	"	Closed	"	"		closed
7	"	490 BD	"	"		closed
8	"	366 BD	"	10		385
9	"	852	"	68		234
10	"	closed	"	closed.		closed
11			"			

Time taken	Outside temperature		Temperature of stock room					
	East end	West end	North	South	East	West	Ceiling	F.
3:45 PM	23A	22A	44A	41A	44A	44B	50A	34A
4:45 PM	24A	22A	42A	38A	42A		48A	32A
7:45 PM	20A	17A	40A	37A	40A		47A	34A
8:45 PM	18A	16A	40A	36A			50A	42A
8:45 AM	22A	12A	36A	36A			43A	40A

Both of the above thermometers were broken during the test.

Air Movement Thru Foul Air Flues

Time	3:45 PM	4:45 PM	7:45 PM	8:45 PM	8:45 AM	
1	173'	388'	182'	146'	211'	
2	119'	210'	178'	173'	208'	
3	359'	267'	233'	243'	172'	
4	397'	379'	269'	342'	210'	
5	1048'	1244'	862'	904'	801'	Lineal Ft. flow
6	1949.28	2313.84	1603.32	1681.44	1489.86	Cu. ft. flow per min.

The average square feet area of the foul air ducts is calculated at 1.86 sq. ft.

Page 4

Carbon Dioxide Determinations

Samples	Marks	Amount CO_2 in 10000 Parts of Air	CO_2 Expressed in Volume Per Cent
No. 1	North ceiling		.104
No. 2	North floor		.806
No. 3	South ceiling		1.281
No. 4	South floor		.060

The analysis of these air samples was determined by the engineering experiment station at Iowa State College, Ames, Iowa. Test dated April 1st, 1918, signed by John A. Coye

Outside Air Sample .029

Reminders

1. Dimensions — 36'x80' outside measure.
2. Basement — No
3. Wall — Clay block laid in mortar
4. Thickness — 8" thick
5. Height — 8' high
6. Material —
7. Sheeting — none
8. Ceiling — Matched lumber
9. Outside Wall —
10. Studding —
11. Plate — 2"x8"
12. Purline —
13. Peak — 28' above ground
14. Hay Track — Yes
15. Floor Joists — 2"x10"
16. Girders — 8"x10" made of 2"x10" and bolted together.
17. Frame —
18. Windows — 28 single sash 8x10", 9 light windows.
19. Doors — 1 double door south end; 1-3'6" wide door into silo; 1 4' wide door on rear side; 1 door into milk house
20. Trimming —
21. New old — built in 1917
22. Photograph — Yes
23. Dead air space — Good
24. Wind proofing — Good

Exhibit R

at the time the test was made it was not filled to capacity, only 18 stanchions were filled with cows and the pens contained 10 small calves. Small calves throw off so little heat that they do not add many heat units to the temperature of the room, therefore, the 25200 cubic feet of air space in this room heated by 18 cows shows that each cow had to heat 1400 cubic feet of air, nearly two and one-half times as much as was intended.

The photograph shows this dairy barn as an addition to a large barn standing to the westward of it. When the wind blows from the west, as it did during this test, the dairy barn is blanketed by the larger building and the peak of the roof of the high building 15 or 18 feet higher than the roof of the dairy barn created. whirlpools of air around the lower barn, which induced some of the intakes to back-draft and they had to be temporarily closed.

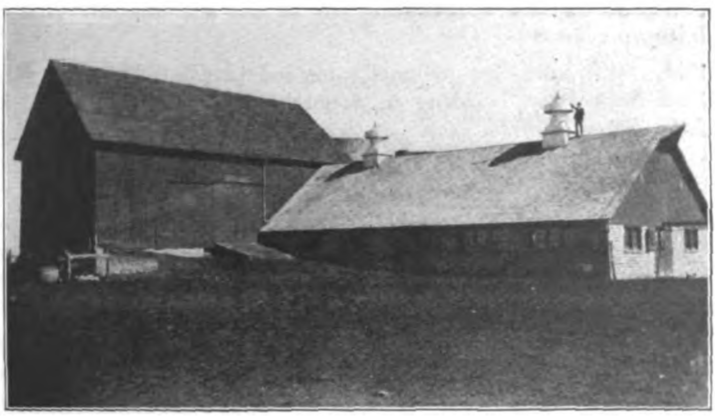


Exhibit S

Another very interesting observation was the action of the ventilators; during the progress of the test the weather vane on the south ventilator with the man standing beside it, (see photo) pointed steadily toward the direction of the wind, but the vane on the north ventilator was continually jumping around in a whirlpool of air current but pointed generally, in the opposite direction from the way the wind was blowing; the wind blowing over the high roof revolved like the rolling of a barrel over the top of the north ventilator and then turned downward and back against the south side of the ventilator cap.

The record shows that foul air ducts Nos. 3 and 4 entering the north ventilator, averaged a greater flow of air upward through them than the two ducts that entered the south ventilator; this is conclusive proof that the wind did not blow down into the north ventilator, but actually added to its suction value.

CONCLUSION

We have made a number of other tests during the year but nothing of sufficient importance developed to warrant adding it to the data presented with this report. The other tests corroborate this data and lead us to some conclusions that are presented in the following suggestions.

1st. In all climates where the temperature in winter drops to zero and below, too much emphasis cannot be placed upon the necessity for tight, well constructed and well insulated walls, ceiling, door and window openings.

The inside surface of the room must be well insulated against the cold outside air if the room surfaces are to remain dry. Ventilation cannot alone dry off the walls and ceiling, and control the temperature of the room; on the other hand, insulation alone will not do it; both are necessary to secure a thoroughly sanitary building.

2nd. Windows are primarily needed to admit light and when placed in a farm building in a northern climate, they should be tightly fitted double sash. A window of this type will be free from frost; a coating of frost cuts the light, which defeats the main purpose of the window.

We have tested the double glazed sash and find they do not keep free from frost; we believe the reason is that the two panes of glass are so close together the cold outside glass affects the temperature of the inside glass.

3rd. In a cold climate the door openings should be covered with storm doors, especially on the north and west side of the buildings; and where it is possible, the doors on these two sides should not be opened during extreme cold weather.

4th. Our investigation proves that galvanized sheet metal, when properly insulated, can be used for foul air ducts without fear of them filling with ice in the most extreme cold weather, and when efficiency and utility are considered, a galvanized metal duct is just as economical, if not more so, than any other material now used.

5th. The data accumulated thus far proves that a much more efficient roof ventilator can be made of galvanized metal than of lumber and the relative cost is not to be considered, if uniformly good results in ventilation is the paramount consideration.

6th. It is also apparent from the data accumulated thus far, that a properly designed roof ventilator is a vitally important factor to the most efficient results secured from both types of ventilating systems, in order that the tendency to back-drafting may be entirely eliminated, or at least reduced to a minimum. If the air is not under perfect control, moving through the room from the intake to foul air duct, the temperature of the room cannot be kept under control, and this defeats one of the main purposes of the investment in a ventilating system.

7th. In the case of Type "X" system, practical engineering knowledge is necessary to design the most efficient intake for each building.

In general we find a tendency to go wrong in two important particulars, namely, not to deliver the fresh air into the room at the best point, and not to arrange for a proper control of the incoming air.

In the case of Type "Y" systems, well informed engineers such as Prof. Smith, one of the members of this committee, are about ready to say that the intakes should be stationed about half way between the ceiling and floor, rather than to have the openings just above the sill, as is the usual practice in this type of ventilation.

8th. The data accumulated in Canada also proves that the Type "X" system will do good work in Canada when it is properly installed, and while the committee feel that a comparison of the relative merits of these two types of ventilation would be premature in this report, in view of certain statements that have heretofore been made, we deem it important that the society should know that both systems are at work in Canada and that the Type "X" system is producing satisfactory results.

DISCUSSION

Question: I'd like to ask Mr. Clarkson if, in his observation, he secured enough material to warrant any statement in regard to the relation of the relative sizes between the ventilators on the south side and on the north side which would indicate the difference in the temperatures?

Mr. Clarkson: At least two members of the committee (Professor Smith and myself) are of the opinion up to this time—we may change our opinion—that the intakes should be the same size all around the barn. It isn't a question of the north side of the barn being colder and the south warmer, it is a question of the wind pressure, and while most of the wind pressure in the winter time, especially from the northwest, is in the north and west, the ventilators should be closed on one side and open on the other, if necessary, and still admit a sufficient amount of air into the room. If the intake was around the barn, as far as the ouside of the barn was considered should as near as possible be equally distributed.

Mr. Kelley: It has been my experience, I have had occasion to note the very same thing—back-draft. I feel we cannot over-emphasize the position of our ventilators on the bottom roof. You clearly brought out one case that the back draft was due to faulty construction. That is clearly an impossibility. In a good many instances it is due to position and some barns have been constructed in which the ventilators, especially if constructed on the side down lower, get that same back draft which you experienced in the whirlwind over the lower barn next to the high barn.

MR. CLARKSON: You got me wrong, Mr. Kelley. They did not back-draft.

MR. KELLEY: I did not mean to state there was a back-draft in that particular barn, but the occasion of the wind coming over the roof.

MR. CLARKSON: I believe I have about come to the opinion that the scientifically designed ventilator (I don't know that there is one yet—this whole business is in its infancy) that is bound to come (because there is a demand for it) is going to draw the air upward. The whole principle is very simple. It simply means there must not be any of the outside air passing across the ventilator head that will be allowed to get into the ventilator head in any way.

MR. SJOGREN: Don't your investigations bear pretty close to the arrangement of the interior of the barn? In your investigations you state that Type "X" system of ventilation worked satisfactorily and you don't say for sure about the Type "Y." Doesn't the Type "X" system work much better where the cattle face in than where the cattle face out?

MR. CLARKSON: No, I find just as successful ventilation of barns where the cattle are facing out as where they are facing in. It is hard to get the barn owners to permit a ventilating system to be installed in the right way, with the cattle facing out, but there are hundreds of ventilating systems in both types—with the cattle facing out and facing in. The ventilating is as good as could be asker for as far as the present work has gone.

MR. SJOGREN: You use the Type "X" system, then, on both arrangements? Doesn't it work better where they face in than where they face out?

MR. CLARKSON: No sir. That is also true of the Type "Y" system. I did not say the Type "Y" system would not work. The Type "Y" system in the Manitoba barn is doing very good work. Professor Smith was the first man to admit there were two or three things that could be changed in that system to make it better. As a matter of fact, both systems are still in their infancy and there can be improvements made on both systems. I think one very important thing that will improve the Type "Y" system mightily is to have a ventilator at the head.

A Digest of Gas Engine and Tractor Short Courses

TRACTOR SHORT COURSE WORK AT IOWA STATE COLLEGE

By C. K. Shedd,[1] Member Amer. Soc. A. E.

The short course work discussed in this paper is given on the college campus and is designed to train farmers and dealers to be competent tractor operators.

For several years some lectures and demonstrations on tractors have been given during the Farmers' Short Course week. It is not possible during that week to give thorough individual training, and there has been a demand for a more complete course.

This demand was first met by offering a 6-weeks' course on tractors and automobiles in June and July, 1917. The tractor work was given in the agricultural engineering department, and the automobile work in the mechanical engineering department. The course also included some work in the forge and the machine shops. This course was repeated twice in the fall of 1917. A change was then made, separating the tractor and the automobile work, which resulted in a 3-weeks' course in tractors, which was given twice; namely, in January and in February, 1918.

In organizing the work for the present year, the length of the course was given careful consideration. Our conclusion was that it would be best to cut the course to 2 weeks and try to make the best possible use of the student's time during that 2 weeks. In order to prevent waste of time in getting started, class and laboratory work will start on the afternoon of the first day. No student will be allowed to enter after the first day.

Each half day's work will consist of 1 hour lecture and 3 hours laboratory work. Students will be encouraged to spend 2 hours in study each evening. For the laboratory work the class is divided into groups of four students. This group is small enough that each student has an opportunity to do the work himself in the laboratory. We expect to keep a careful record of attendance and to grade each student on both class and laboratory work.

The following is a brief outline of the lecture work:

FIRST WEEK

Mon., 1:00 P. M.: Organization of class.
Reference books; notebook.
Explanation of class and laboratory work.
Division into groups for laboratory work.
Locker regulations.

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	Payment of laboratory fee.
	Assigning lockers.
Tues., 8:00 A. M.:	General construction of engine.
	Two-cycle and four-cycle principles.
	Time of ignition.
	Timing of valves—stationary type engine.
	Valve grinding.
" 1:00 P. M.:	Review 4-cycle principle.
	Firing order 4-cylinder engine.
	Construction of valves, cam shaft, and timing gear.
	Timing valves 4-cylinder tractor engine.
Wed., 8.00 A. M.:	Gasoline carburetors—construction and adjustment.
" 1:00 P. M.:	Battery ignition.
	Make and break.
	Jump spark (with vibrator coil).
	Spark plugs.
Thurs., 8:00 A. M.:	Battery jump spark systems, including non-vibrating coils.
" 1:00 P. M.:	Principle of the low tension shuttle armature magneto.
	Use for make-and-break ignition. Timing magneto to engine.
Fri., 8:00 A. M.:	Oscillating magnetos. Inductor magnetos.
" 1:00 P. M.:	Low tension magnetos for jump spark ignition.
Sat., 8:00 A. M.:	High tension magnetos. Starter couplings.
" 1:00 P. M.:	Examination.

SECOND WEEK

Mon., 8:00 A. M.:	Direct current generators. Storage batteries. Governors.
	Engine troubles.
" 1:00 P. M.:	Kerosene carburetor systems. Air cleaners.
Tues., 8:00 A. M.:	Motor types.
	L-head, T-head, Valve-in head.
	Twin cyl. parallel cranks.
	Twin cyl. opposed cranks.
	Opposed cylinders. 4-cylinder.
" 1:00 P. M.:	Engine lubrication. Lubrication of tractor parts.
	Cooling systems.
Wed., 8:00 A. M.:	Piston rings and pistons. Over-size pistons.
	Taking up wear in connecting rod bearings and main bearings.
	Clutches—disk, cone, shoe, contracting band.

	Friction transmissions. Gear transmissions. Traction speeds.
" 1:00 P. M.:	Differential gear. Worm gear.
	Rear axles. Bearings. Frames.
	Comparison of two, three and four wheel types.
Thurs., 8:00 A. M.:	Tractor sizes and capacities.
	Brake horse power.
	Drawbar horse power.
	Power requirements of farm machines.
" 1:00 P. M.:	Tractor plows.
	Shape of point, suction, adjustments.
	Types of moldboard.
	Coulters and coulter setting.
	Jointers. Power lifts.
Fri., 8:00 A. M.:	Hitching tractor to plow.
	Effect of high and low hitch on tractor and on plow.
	Side draft proper position of hitch horizontally.
	Method of laying out a field for tractor plowing.
	Extension control.
" 1:00 P. M.:	Economics of tractor farming.
	Saving in man and horse labor.
	Quality of work.
	Cost of operation.
	Interest, depreciation, repairs, fuel and oil, labor.
	Housing the tractor.
Sat., 8:00 A. M.:	Examination.

The following is a list of laboratory exercises:

1. Valve timing.
2. Valve grinding.
3. Starting and operating engines (not traction parts).
4. Assembling small engine.
5. Study of tractor clutches and transmissions.
6. Study of tractor lubrication.
7. Tractor operation.
8. Study of carburetion systems.
9. Study of cooling systems.
10. Study of battery make-and-break ignition.
11. Study of battery jump-spark ignition.
12. Study of low tension magnetos and timing to engine.
13. Study of high tension magnetos and timing to engine.
14. Ignition wiring.
15. Fuel consumption tests varying carburetor adjustment.

16. Study of tractor engine types.
17. Fitting and adjusting bearings.
18 and 19. Experting.
20. Brake horse power tests.

DISCUSSION

MR. DICKERSON: I should like to ask Mr. Shedd just about what class of students he is getting in these extension courses?

PROFESSOR SHEDD: We had, for the 3-week courses given in February, thirty students. There was one dealer and I believe two or three middle-aged farmers. The rest were farmer boys. I don't think there was a city boy in the bunch.

QUESTION: Might I ask do you make any actual field test or plowing test during your short courses?

PROFESSOR SHEDD: We haven't been able to with the winter courses on account of the soil conditions. We gave some 6-weeks courses and began at the time of the year when we could do plowing. We gave each student a half-day's work in plowing.

MR. HAND: Don't you think the time of year to plan these courses is when that could be done? It would be more valuable to the farmer.

PROFESSOR SHEDD: We can't get the farmers to come in at that time of year.

PRESIDENT SCOATES: Our experience as to the class of men attending those short courses is that they are the very best—the cream of the country. I had a photograph taken of the men attending the first short course we ran at Mississippi, and sent it around to different men interested in the college; that was the one comment they all made—that the students were such an intelligent looking group of men.

TRACTOR AND GAS ENGINE SHORT COURSES AT MICHIGAN

H. H. MUSSELMAN,[1] Member Amer. Soc. A. E.

The aim of a course of training should be to produce a good operator who understands the principles of the engine and mechanism, who can make ordinary repairs with intelligence and confidence, and who can meet the emergency of more serious ones without delay. He should know the tractor in relation to the machines with which it is used, for, unlike the automobile, the tractor engine is useless in itself. Moreover, any training which he is to receive should contribute not a little to his development as a mechanic, for it is on this arm that he will have to lean more heavily in the future.

Courses of instruction may tend in two directions: first, the very short course which is more or less demonstrational in its presenta-

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tion and in which at best only a very fragmentary knowledge can be had of the principles of the machine. As a means of making a general study for purposes of selection or of adaptability this cannot be said to be without value. Second, there is the course which embodies the idea not alone of knowledge but of training. This course involves a longer time, more carefully organized work, and must in general meet more fully the needs of a larger number. It will also be found of more value to the younger student. As to which will produce the greatest good to the greater number, may be open to question. I am inclined, however, towards the type of instruction in which training is involved, for this must result in the end in more capable users, and it is trusted that the standard set by this type of student will have its leavening effect upon the success of the farmer in meeting the demands placed upon him.

The nature of work given must be practical. The student must be made to feel that he is receiving instruction which can be applied. It follows that he must work on the machines and become familiar with its parts and their functions. He must learn how to adjust, replace and repair. The work must be thorough and intensive. Non-essentials must be eliminated. Briefly it must aim at the development which might be called mechanical judgment, for this is the final test of his success.

There are three essentials to a successful tractor or gas engine course. Instructors, equipment and organization. I believe we have erred in the past in thinking that a college training is the only essential in the teacher's preparation. During the past summer the writer has had occasion to observe the grade of instruction which men with several years' practical training, supplemented by 8 weeks' instruction, were able to give. The results were indeed gratifying. Before small groups of students these men presented the subject matter admirably, and the respect of the students for their years of experience was manifest. I do not mean to discount the value of college training, but am convinced that a liberal application of practical experience is essential to the instructor's preparation. I might also add that in the cases of the practical men as instructors above mentioned, that the short class room and laboratory courses to which they were subjected added inestimably to their success as teachers.

Then again in the matter of instruction, the course must not be under normal. One instructor for each ten to fifteen students appears to be a good proportion. Where there are many details of work to be watched, it is all the more desirable that this ratio be maintained, otherwise the work will lack in thoroughness.

In the matter of equipment, difficulties will be found. As practiced by most state institutions, tractors and other equipment borrowed from the manufacturers will be used. If this equipment is to be maintained at high efficiency, it can be used for much of the work of the course. There is perhaps no better way to teach details of construction and give practice with tools than dismantling and reassembling the engine or tractor, yet on a new machine in the hands of unskilled students the effect is soon disastrous. It seems desirable to supplement new machines with used machines on which assembly work may be done with less harmful effect.

The importance of having an adequate assortment of accessories, such as carburetors, magnetos, bearings, air cleaners, differentials, governors and spare parts, cannot be overemphasized. If definite work can be assigned to these parts, the student acquires a much more thorough knowledge of the way in which they function, and becomes familiar with their adjustments and the reasons for the same.

In the organization of subject matter, there are several phases, each of which has its importance in rounding out the course. I will enumerate and give them the briefest mention:

1. Lectures.
2. Study and observation.
3. Adjustment and trouble hunting.
4. Assembly and repair work.
5. Operation.
6. Laboratory and field tests.
7. Accessories.

The lectures should not be too extended. They should touch on principles mainly, study and observation being carried out very well by means of questionnaires to which the student is to supply the answers. Judgment must be exercised, however, to make these questions serve as a guide in studying the mechanism of the machine. It has been repeatedly brought to the writer's attention that one of the best forms of study is to ask the student to trace out a part, say, for example, the fuel supply from tank to cylinder, and explain its relation to other parts of the motor. This, of course, brings in the pump, pipe connections, cut-offs, and carburetor, the function of each of which the student should endeavor to explain.

Agassiz taught his pupil to study the fish by obliging him to look at it. However, in the study of the tractor mechanism it seems desirable at least to furnish the student with a guide to sightseeing.

The student should be taught to make adjustments which will put a motor in good running order, and no course is complete which does not include some practice in "trouble shooting." The nature of this work makes it fascinating to the student. Characteristic troubles can easily be located in the farm engine, and the student should be taught the significance of knocks, pounds, and unusual sounds, as well as a systematic way of tracing out a given trouble. The matter of assembly and repair work has already been touched upon. Operation is especially valuable if carried out under operating or field conditions which do not always obtain fair results. Of course, the student must see the tractor in action and some work of this kind must be given. There is some question as to how far laboratory and field tests should be carried. For demonstrational purposes or to teach principles they are of value. It has been found in some cases, however, especially with tests like brake tests, that the average short course student is inclined to attach too much importance to the results obtained without taking into account conditions under which they are made, which results are at the best not too conclusive of the value of the machine.

The writer's observations are based principally upon work given to short-course students in agriculture for several years, a 2-weeks' farm power course presented last year, and a summer's work in the Army Auto Truck and Tractor School at the institution with which he has been connected. In the 2-weeks' course in tractors, which was presened last year, four lines of work were outlined, namely:

Forge work, which included the ordinary forging exercises up to welding.

General repair work—Soldering, brazing, babbitting, pipe fitting, fitting bearings, filing use of hack saw, rope splicing and other exercises of similar nature.

Gas engines—Operation, adjustment, correcting troubles, ignition, valve grinding, valve adjusting, brake and fuel tests.

Tractors—Study, operation and adjustments of the tractor, belt tests, hauling tests, running power machines and problems designed to develop skill in handling.

An interesting development of this course was that a few exercises in electrical work designed to illustrate the principle of ignition, and a good collection of carburetors, quickly became the center of interest, barring the tractors, eleven of which were used. Almost unconsciously the students expressed a desire for more complete work in the principles of ignition and carburetion. Therefore, in the course as outlined this year, these subjects were given a larger place as they were deemed of sufficient importance in the longer 4-weeks' course. Additional engine and repair work on the truck have also been added as an important feature of the work. The course has been lengthened to 4 weeks, and is to be repeated to accommodate all applicants. Briefly, the outline of the course is as follows:

Outline of 4-Weeks' Courses in Gas Engines, Tractors and Trucks (the work is divided into four groups, each of which is completed in 1 week.)

Farm Tractor and Gas Engine: 1 week in length.

One hour lecture on gas engines and tractor.

One hour lecture on power application and power machinery.

The remaining time is spent in practice work in correcting trouble on the gas engine, assembling, repair work, and in study and use of the tractor.

Truck Engines and Carburetors.

One lecture and 7 hours shop work each day for five days.

This work consists of a study of several types of engines, both with and without carburetors. Practical work is given.

Electrical Ignition Systems.

One hour lecture and 7 hours' laboratory work each day.

This work will consist of a study of several types of magnetos and electrical systems. Practical work will be given in wiring up several systems and finding trouble.

General Repairs.

The time will be spent in doing practical repair 8 hours per day and 4 hours Saturday morning. Election can be made as to using this time in making adjustments and repairs on trucks or in the making of repairs requiring the use of the forge.

The presentation of this course is cooperative between the Department of Farm Mechanics and the Mechanical Engineering Department. The sections are rotated to the different groups of work. Examinations, correcting papers, and reviewing questions are all done Saturday morning, so that the close of the work finds the records completed in each course. At the close of the school a statement is to be issued to the student showing his standing in the course. It is believed that this will have a stimulating effect in maintaining the standard of the work, though a lack of interest is not anticipated. A fee of $10 is to be charged.

TRACTOR SHORT COURSES AT UNIVERSITY OF NEBRASKA

O. W. Sjogren

I have not taken time to write out my discussion. Our motor short courses are of two series—or two types, you might call them —one conducted at the University farm, by the Department of Agricultural Engineering and the other being taken up through the agricultural engineering extension specialist. These courses were given out over the state, running from 2 days to 4 days for each course. I might state that these courses have become so popular that of all the short courses planned by the different departments this year, all but one have asked for agricultural engineering work.

Now in these short courses out over the state, it is planned to given the men instructions in the various lines related to the gas engine and tractor. The extension specialist carries with him a line of equipment such as carburetors, magnetos and batteries, coils, a few bearings—such things as he can conveniently take—and then he depends on the local sources for an engine or tractor of some kind. During the last year this work was given to approximately 2000 people in the state.

The other series of courses is that conducted at the university farm by the Department of Agricultural Engineering. This work was instituted some 5 years ago, and then we endeavored to give the first three weeks in June. We found, however, that it was a rather poor time to give the course, because the farmers were very busy with the farm work at that time and very few came in.

Last year we made a trial at holding the short courses at the time of our regular farmer's short course, beginning about the middle of January, and running for 4 weeks, and we were very gratified that we received ninety registrations for that work. We had only anticipated about thirty-five or forty.

The method of carrying on the work last year was according to the following outline: It was divided by the week; three half-day periods were given over to lecture work, one period to forge work, two periods for machine-shop work (such as filing, shipping, cutting keyways, etc.); tractor practice, two periods, gas engine practice, two periods, (that is, on stationary farm engine) and wood work one period.

Now, these lectures were given by the men of the department, by men from the branch houses located at Lincoln, and also specialists from the different tractor firms and accessory firms. They gave such assistance as they could, the men coming from the different tractor centers such as Chicago, Racine, Moline, Peoria and other cities.

The one difficulty we found with our arrangements was with the lecture periods, which were 4-hour periods. Now, take a man who has been out in the open air, and put him in a room for 4 hours listening to lectures, it is natural that he get drowsy and not able to follow the work.

This year we are following the scheme of giving two lectures a day, one in the morning and one in the afternoon. I think we shall find that works out very well. At the close of the course last year a survey was taken among the men, and they were asked to express their first, second, third, and fourth choices of the different subjects given, and from the answers we received I compiled the following of the first choices: Forty-two expressed first choice of tractor work, eight for forge work, seven for stationary engine work, four for trucks, two in autos, one in machine-shop and one in work-shop. I think 50 percent of the men who made a second choice made it in forge work. I really feel that in a tractor course the men should be given instructions and taught to make proper repairs, and in order to make proper repairs they should have some knowledge of iron work, so this year I have endeavored to have the man who is in charge of short-course work put in two periods of forge work a week. He objected to that on the ground that it would mean about one-fourth of the time devoted to forge work, but I think that we should endeavor to give them at least one, possibly two periods a week in metal work.

The machine-shop work was not very popular with the men. They felt that they did not want to spend 3 or 4 hours merely chipping on a piece of cast iron with a cold chisel, or trying to file some surface. They really got impatient, chiefly because of the fact they couldn't see any direct results of the work.

This year we are endeavoring to organize our course along somewhat different lines from that of last year, in that we are endeavoring to start the men out with the fundamentals, and gradually make the course more difficult. That is, we will lead them up step by step to the more difficult subjects connected with tractor work.

To give you an idea of what we are attempting to teach this year, I will mention the subjects and the time devoted to each subject. We have a general lecture one period, then a laboratory period of 3 hours. (Hereafter, when I speak of laboratory periods, I refer to a period of 3 hours, because our lecture comes at 8:00 o'clock, laboratory from 9:00 to 12:00, lecture at 1:00 o'clock and laboratory from 2:00 to 5:00.)

Transmissions	two lectures, two laboratory periods
Clutches	one lecture, one laboratory period
Lubrication	one lecture, one laboratory period
Cooling system	one lecture, one laboratory period
Motors	one lecture, one laboratory period

(That may seem as rather a limited amount of motor work or stationary engine work, but they get more of it when they come on the tractor work.)

Bearings and babbitting	two lectures and three laboratory periods.
Ignition	four lectures, three laboratory periods.
Pipe-fitting and soldering	one lecture, two laboratory periods.
Valve-tying	two lectures, two laboratory periods.
Carburetors	four lectures, four laboratory periods.
Trouble finding	two lectures, two laboratory periods.
Starting of engines	(that takes in work on stationary engines as well as on the tractor engines) two lectures, two laboratory periods.
Tractor operation	two lectures and four laboratory periods.

Repair work ....two lectures and six laboratory periods.

Forge work ....two lectures and two laboratory periods.

Then we have provided two periods for open forum.

In addition to this work, we have planned excursions for Saturday afternoons. The men visit under the direction of someone who is familiar with the different points of interest. For instance, we have there the Burlington Repair Shops, which is one of the largest plants in the middle west for repair work. We plan to take the men to that. We have the Beatrice Creamery Company, and we take the men there chiefly to visit their ice and refrigeration plans. We have the different power plants and pumping stations around the city. We have found that the men take keen interest in visiting these. We merely put this in as a sort of side issue to maintain the interest of the men, and to keep them from becoming stale, so to speak. That is briefly the work we are endeavoring to do.

In regard to fees, last year we charged a fee of $4. We felt, however, that that was rather low and this year we have increased it to $10 for 4 weeks. The first course began December 30 and we are now planning to give a second course, beginning January 27. If the demand exists for a third course, we will be in a position to give it at the conclusion of the second one.

Now, in regard to the outline that I gave you, that is not necessarily the order in which the work is given. I might say a word in regard to tractor operation, that in work with the tractors we endeavor, as far as possible, to have the students do productive work. During the open season, that, of course, is rather easily done. The men can work with implements, drag rod, etc. During the winter it is more difficult, but we have planned that in our operation work we will have what we might term a tractor train, where all the tractors will be taken out on the road and they may or may not be fixed so as to develop trouble along the road. Then as soon as any tractor develops trouble, it will be stopped and the men will be grouped about the tractor and discuss the trouble; locate it, remedy it and go on. We feel that in that way they will get more benefit than if each one takes a tractor without any regard for the other tractors. We feel the work will be much more valuable to the student.

That is all that I have unless there are some questions.

Mr. West:[1] What class of students did you have in a 4-weeks course?

Mr. Sjogren: We had rather a mixture. They were mostly young farm boys, but we had several older men from various occu-

[1] Agricultural College of Utah, Logan, Utah.

pations. We had retired farmers, carpenters and mechanics. Of the 90 men taking the course, I should say, six men who were above the forties. The others were from 16 to probably 30 years of age.

MR. HAND: Do you not have any place in your course for mechanism in adjustment of plows, proper plowing conditions, laying out of fields, etc.?

MR. SJOGREN: No, we did not last year, excepting in the lecture work. The idea has occurred to me, though, since I have listened to what is given at the other institutions, that it probably would be proper to give one or two laboratory periods on tractor implements. I think it would be a very valuable addition to the course, and no doubt it will be put into the course when I return.

MR. HAND: My experience as a plowman has been that while the farmer thinks he knows about plowing with horse-drawn vehicles, he is entirely muddled when it comes to tractor plowing, and adjustments of a tractor plow are as different from a horse-drawn plow as they can possibly be. When the farmer attempts to apply the principles, as he understands them, of horse-drawn plow management, he fails utterly, usually doing a poor job of plowing, getting into scouring difficulties, overloading his tractor and all sorts of troubles that could be very readily taken care of if the action of the tractor plow were analyzed along the lines of its actual operation.

MR. WEST: In the case of your tractor course, do you do any assembling—actually take the whole machine down and putting it together—or do you work on isolated parts?

MR. SJOGREN: We did not include that, because we depended on the manufacturers, and branch houses for the loaning of tractors, and we did not feel justified in disassembling and reassembling new machines. This year, however, we have four old tractors that we purchased for that purpose for our work, and we will use those for disassembling and assembling.

MR. WEST: How did you handle the automobile work for the soldiers? Did you buy old machines to start them on? Did they work on the old machines entirely, or work on good machines?

MR. SJOGREN: We started in that war training work, and bought up several old machines with two purposes in view. One was to obtain material for our exercise laboratory and the other purpose was to rebuild these machines. We wrecked seven or eight of the old cars in order to obtain parts for our laboratory, such as motors, transmission clutches, steering gears, etc., and the other old machines were stalled, set aside because of the fact that we got so many machines in from the city and surrounding territory that we had no time whatever to rebuild the old machines, so we put in practically all our time on actual commercial repair work.

MR. WEST: We found that in Utah the tractor has been very popular the last year or two, and we have had to cut one of our courses to 2 weeks. This brings in the older men, the middle-aged men who really want to know how to run their tractor and not ruin it. Tractor drivers are scarce, and yet it is a country very well adapted to the tractors. It is a country with very large areas. All one has to do is to rake up the sage brush and put in a crop!

We put on our 2 weeks' course last year and had so many men we could scarcely handle them.

I wonder how much repair work these 18-year-old boys can do? I know our mechanics in the shops don't think they ought to do much repair work, that is, when it comes to a real technical repair. I would say they can make good adjustments, but when it comes to being mechanics, they are not mechanics. I take it that all of the schools handling soldiers found that the first two contingents were trained men. We got three times as far with those men as we did with the 18-year-old men who came in on October 1st. We didn't make much headway working with them.

We are giving two sets of 2-week courses and a 3-months' course. The farm boys come in and get the 3-months course and the older men take the 2-weeks courses. It is working out nicely. The men who came in last year were very well satisfied.

Mr. Sjogren: In the matter of repair work, your term there was really a better one than mine, and explains better what we are attempting to do, that is, tractor adjustments rather than repair work. If we get some men in the course who have had considerable experience along that line, they, of course, will get some of the actual repair work, such as replacing bearings, probably refitting, fitting over-sized pistons and work of that nature. A man coming in for 4 weeks can't be expected to be able to do that work. The thing we are striving is to give the men a good understanding of the principles of operation and the care of a tractor, and the care will involve the making of adjustments whenever they are necessary.

Mr. West: Do your ideas now tend toward the courses you gave the soldiers more than they did last year?

Mr. Sjogren: Well, I might state that the work we gave the soldiers was built up very largely in accordance with the work we gave last year for our 4-weeks' course, and now our motor course is a combination of the two.

Mr. West: I take it, in the course that Professor Shedd outlined, there is not so much the real handling of the whole machine as it is the parts, and I thought the idea that the Government had in mind was that they wanted us to work with the whole machine more than with isolated parts. Of course, you must take it up part by part, but on automobile repairs, I figure 80 percent of them are adjustments and 20 percent mechanical work which takes a real, thorough mechanic, and we are working our courses a little more nearly in harmony with the war courses. I believe we are handling it a little more that way than to outline too much forging and machine work. There are three or four classes of men you have to meet in handling automobile courses. Some of them simply want to know how to run their cars. That is the case with some of our tractor men. Then there are some men who want to be real mechanics. They have to take the forging and machine work to ever be real mechanics, and in our course this year we are giving them 3 days a week—2 hours in the forge shop 3 days a week, and 2 hours in the machine shop, and that gives us a chance to handle two groups. We can take two classes of probably 35 men each through in that way.

Mr. Sjogren: I might say that the aim of the work which we have in mind is not merely to fit the men to work their tractor but also to help them make repairs on their machines.

Mr. West: Have any of you found a man who could do chipping and filing in an interesting way? I know one man up at Minneapolis—I am sorry I did not question him further, but he thought chipping and filing was the most important part of the whole course. I see the value of chipping and filing, but I would like to find a man who can give it interestingly so you can make the students stick with it. I know it has been one of the hardest jobs I ever found to keep men in the chipping and filing course because it is absolutely dead from all points of view the way it is handled and we can't get them to use automobile parts and really make them see the connection in what they are doing—connect it up with real automobile repair work. I think it is valuable, but it is very hard to teach.

President Scoates: They had me down for the work in Mississippi and I failed to get up a paper on it. I will do that, however, so it can be put in the proceedings. I will give you a brief review of what we are doing.

We have a somewhat different situation, I believe, from that which obtains in most parts of the country. The courses we give are of 1 week's duration, connected with the extension department. I try to work the whole department together. I want my instructors to get the extension idea, the service proposition, and so I let them do some extension work over the state whenever it is possible. Of course I don't try to handicap the instruction work. Sometimes I have the extension men do a little instruction work in the college.

This year we are putting on five 1-week courses to start with. One of those is in the college and the other four will be scattered over the state.

We have arranged with the railroad company to donate us two cars, which they will transport free of charge. On those two cars we will load all our equipment—tractors, plows, harrows, and everything. We take these trains to different points and give a week's course on gas engine tractors. The question of getting the field does not bother us. If it is dry we can plow as well in the winter as we can in summer. A lot of men come to the course who want to know how to run tractors, but do not have any at the time. They want to know how to run a farm gas engine.

We don't have time to give chipping and filing or forge work. We couldn't do it. We give a lecture the first thing in the morning, and our laboratory work lasts until noon; another lecture after dinner and laboratory work the rest of the afternoon.

We dismantle the engine, put it together again, and see that it runs; we also give quite a lot on tractor troubles. We have about the same line of lectures you people do. I am sorry I don't have one of our programs here.

We haven't tried to grade the men. We decided this year we would attempt to have roll calls and keep up with the men because they have asked for recommendations.

Those men are there for a week and usually they are farmers. We have garage men coming in, of course, but we get men from 18 to 78 years old. They want to get all they can, so in the evening we have lectures of agricultural interest lasting an hour. We are very careful to select the best men we have on those subjects and then let them have a little discussion. That takes care of the evening. Those farmers sit around and don't do anything, anyway, and we have found they are very much interested in those after-supper lectures.

Another thing we have to contend with that you people don't, is the difference in the race. We can't mix black and white. I would have to put a colored man on the train and send him back. Last year we put on a short course in a colored school. We tried to get them in shape to carry on extension work, and succeeded very well, but I don't believe they have done anything. When we presented these four short courses to our field workers' council extension, they immediately said we would have to give something for the colored people, so we put on a course for them. We intend to have the colored course run 2 weeks instead of 1 week.

We tried to keep those short courses a week apart so that it would give us an opportunity to get from one place to the other, and give the men an opportunity to rest up. Those of you who have had experience running those short courses know it works the group hard, because you get more than you plan on.

We surprised the agricultural college people down in Mississippi. I advertised one week's short course in gas engine tractors. Some of them laughed and said if I got a dozen students we would do well. I limited the class to fifty and had several over that number.

I will be glad to answer any questions.

DISCUSSION

MR. SJOGREN: Do you give any work with farm machinery in connection with your course?

MR. SCOATES: Well, we didn't in our courses last year. We stuck to the tractor. This year we intend to give some plowing in addition to the tractors.

GAS ENGINE AND TRACTOR SHORT COURSE AT OHIO STATE UNIVERSITY

G. W. McCUEN

The Department of Agricultural Engineering at Ohio State University will offer this year, for the second time, a course in gas engines and tractors. The first school was held in the coliseum at the State Fair grounds last February. Governor Cox, who is an ardent tractor booster, called a meeting of tractor representatives to see what could be done to increase Ohio's food production. The meeting was two-fold—first, to ascertain the number of tractors available for sale in Ohio; and second, to promote a state tractor service school. It was the consensus of opinion that the success of the tractor depended upon the intelligent operation of it, so it was not a difficult matter to obtain the cooperation of the tractor companies for the school.

The department had previously planned a school to be given at the University, but instead, we took charge of the State School. A great deal of publicity was given to the school, and the total registration for the week was slightly over 2000. Fully 75 percent of the total registration remained for the entire week's program.

The following subjects were discussed in lectures given by men from other institutions:

1. Theory of gas engines.
2. Types of tractors.
3. The prony brake.
4. Tractor ratings.
5. Lubrication.
6. Ignition.
7. Carburetion of fuels.
8. Simple mechanics (how to figure pulley rates, etc.)
9. Tractor troubles.
10. Tractor plows and hitches.
11. Bearings. (Demonstration of babbitting and scraping in a bearing.)

Following nearly all of the lectures was a laboratory period, where the subjects discussed in lecture were amplified in the laboratory by the service men who were with each of the twenty-two machines exhibited. This part of the work was hard to manage well, due to the size of the crowd. With 50 to 75 men assigned to each machine, not much individual instruction cauld be given. However, the men seemed quite well satisfied with our efforts.

Some of the extra time was used in testing tractors for their rated B. H. P. We did not count on this part of the program being of very much interest to the farmers, but, to our surprise, it was the popular feature of the whole week's work. During the latter part of the week re-tests were run on the machines that were unable to pull their rated load for the first time up. On Thursday night of the week the tests were continued until after dark and the crowd remained until the last machine was tested. It gave the farmer an idea who was who with their ratings. It has been our observation that most of the tractors are too closely rated and do not possess enough reserve power for the overloads to which they are often subjected.

This year tractors are to featured during Farmers' Week. Ten lectures on the tractor will be given, covering all the essentials of a tractor. An exhibit will be held in the Aviation Laboratory, where the farmer will have a chance to see the several different types of machines and be able to carefully study and compare them. During this week a series of tests will be run. Each machine will be allotted 2 hours time for the tests—½ hour for a preliminary run, to make adjustments, etc., ½ hour maximum load test; and 1 hour at rated speed and rated B. H. P., during which time the fuel consumed will be carefully measured. After the first half hour's run the operator will not be allowed to make any adjustments or go near the tractor unless accompanied by the man in charge of the test. The results of these tests will be posted on a bulletin board in the testing room. This will give the farmer a basis for comparing machines, as the fuel consumption will be reduced to a horsepower basis. But one kind of lubricating oil will be used and the grade used will be suitable for the motor under test. This, we hope, will help to make the tests more uniform.

Following the Farmers' Week program the second annual tractor service school will be held. This school will be of 2 weeks' duration, and will take up in detail a study of the gas engine and the tractor, 1 week being devoted to each subject. The following lectures on gas engines will be given.

1. Theory of gas engines.
2. Types of gas engines.
3. Carburetion of fuels. Mixing valves.
4. Ignition and timing.
5. Power of an engine.
6. Mechanics, pulley ratio, calculation, etc.
7. Bearings, babbitting, and soldering.
8. Governing, cooling and lubrication.
9. Belting and pipe work.
10. Tractor plows and their adjustments, and tillage tools.

Tractor Division

1. Types of tractors, materials used in construction, etc.
2. Types of motors.
3. Transmissions and clutches.
4. Tractor ratings.
5. Carburetors.
6. Magnetos.
7. Tractor troubles.
8. Care of tractors.
9. Lubrication.
10. Bearing adjustments properly made.

A laboratory period of 2½ hours each will follow the lectures. The registration being limited to 200 will allow the placing of 100 men on tractors and 100 men on gas engines the first week and a reversal of this for the second week. Particular stress will be laid on the laboratory work, and it is planned to have help enough that individual instruction can be given to the men.

The tractor division men will receive the greatest amount of individual instruction, as it is planned to have a company service man with each tractor. The timing of the magnetos, valves, bearing adjustments, carburetor adjustments, trouble shooting, etc., will be thoroughly covered in the work. The prony brake will be used advantageously for making proper carburetor adjustments, also for showing the effect of a badly timed magneto and other things which contribute to loss of power in a motor.

Tractor accessories such as disk harrows, cutli-packers, drags, etc., will receive due consideration, as it is not only hoped to instruct the students how to intelligently operate their tractor, but to operate it to its greatest efficiency.

THE GAS TRACTOR SHORT COURSE AT UNIVERSITY OF CALIFORNIA

L. J. Fletcher

The purpose of a tractor short course, where a rather large number of people are brought together and given a few days of intensive instruction, is not to train tractor mechanics, but operators. The big majority of tractors are operated by men whose main occupation is farming. They don't wish to learn a new trade and could not spare sufficient time, if they did. What they wish to learn is the operation and care of the tractor, to distinguish the troubles as they arise and to make the regular adjustments that are necessary from time to time. There would be much less need of the factory service man, if the operator could intelligently adjust the carburetor, take up the bearings, trace ignition troubles, adjust the clutch and actually believe that the tractor requires more careful lubrication than the manure spreader or wheelbarrow.

The general plan of a tractor short course should endeavor to strike the proper balance between lecture and practice work. The instructor should be a factor all of the time, while the keynote of the successful short course is *Complete Organization.* The student would learn little of actual value if his entire time was employed in steering tractors back and forth across a field; likewise a course may be easily made top heavy by too much lecture work. Since a student learns quickest and best by seeing, a liberal use should be made of charts, models and tractor parts during the lectures, and everything possible should be actually demonstrated, not merely described.

This general plan has been carried out in the five tractor short courses which have been offered by the Agricultural Engineering Division of the Department of Agriculture, University of California, since November, 1916. The total registered attendance at these courses was 739. The following is a plan of the tractor short course given at the University Farm, Davis, from November 11 to 20, 1918.

The students were divided, or they registered, in sixteen groups, indicated by letters of the alphabet, and members of each group were numbered. For instance, the first man to register was given a ribbon with A–1 stamped on it, the second B–1 and so on. The total number of ribbons given out was 181, so each group contained eleven or twelve numbers. A schedule was prepared and posted showing where each group would be located, and what they would do, for every period during the entire course. The students were requested to wear their ribbons, and this automatically prevented confusion of the schedule, for the groups tended to stay together and at least a few in each group could be relied upon to know where they should go. It also enabled the instructors to prevent visitors from intruding.

The daily schedule was: 8:00 to 9:30 A. M., a general lecture attended by all of the students; 9:30 to 12:00, practice period. The afternoon program was similar, the lecture period 1:00 to 2:30; practice period 2:30 to 5:00. Two evenings during the course were given over to the showing of moving pictures of tractors; the films having been loaned to the division by several of the manufacturers.

A large number of charts containing diagrams of motors, motor accessories and tractor parts were placed where they could be seen by all and handily referred to by the lecturer. Tractor parts of all kinds were also on hand for reference. A compendium of the lectures was given to each student upon registering. This has proven very helpful, as the average short course student is not accustomed to taking notes. The subjects of the lectures given were:

Gas engine principles and types.

Fuels and carburetors.

Carburetor adjustment.
Ignition—High and low tension systems.
Magnetos.
Magnetos—Care and adjustment.
Governing and cooling mechanism.
Lubrication.
Testing horse power rating.
Tractor types, adaptability and construction.
Tractor motors.
Tractor operation.
Valve timing and adjustment of parts.
Engine troubles.
Tillage methods.
Tractor overhauling.
Tractor management—contracting.
Tractor implements, plows.

The first four days, the practice periods were devoted to four shop exercises and four demonstrations. The shop exercises, which accommodated two groups at a time, consisted of: First, overhauling, where the students worked on old tractors which were brought in for that purpose. Second, valve grinding and bearing adjustment, where each student ground a valve and adjusted a connecting rod bearing and was shown how to fit a piston ring. Third, babbitting, and soldering where the students, working in pairs, poured and scraped a split bearing and did some soldering. Fourth, forge work in which practice was given in sharpening and setting plow shares and similar work. In the last three exercises the instructors gave a short but complete demonstration of the work before the students started.

Four groups were handled at a time in the demonstrations. Two instructors handled this work, giving two of the demonstrations the first two days and the other two, the last two days. Thus each half day, eight groups would be doing the four shop exercises and eight groups attending two demonstrations. Care was taken in scheduling to see that the group attending the demonstrations one-half day were given practice work the next.

Tractor inspection was one of the four demonstrations. Here, such things as loose bearings, slipping clutches, misalignment, etc., were demonstrated and remedied. The class was shown the use of the service manual, which is sent with practically every tractor, on lubrication and adjustments. In short, an attempt was made to show the inspection and lubrication required daily by the average tractor. Valve timing and adjusting, the characteristic sounds and the effect on power output, of leaky valves, and too much clearance, was shown in another demonstration. How to set an engine on dead center and the use of degrees in timing was included.

Brake and drawbar horse power, with an especial effort to impart a clear understanding of the mechanical horse power, was a part of this demonstration.

A demonstration of carburetor adjustment was one of great value. Various makes of carburetors were explained and adjusted before the class. A prony brake was used to show the effect of rich and lean mixtures on power output. The value and need of air cleaners and air heaters was shown as well as other matters pertaining to the fuel system of the motor.

Ignition was the subject of the fourth demonstration. Here the class was shown how to determine the firing order of a motor; all the steps of putting a magneto on a motor and timing it properly; ignition trouble, detecting and remedying. The adjustment of magnetos was carefully shown.

The practice periods of the next three and one-half days were devoted to the fourteen different makes of tractors which were available. The students were consolidated into fourteen groups. Each group studied four tractors a day. The tractors were in the hands of tractor service men, who explained the construction and management of their machine to the group. Then each member started the tractor and operated it for a short time. While the time spent in the operation of any one tractor was not enough for the student to become proficient, yet he obtained the "feel" of the machine. The knack of steering a tractor is one that can be learned in a few hours and does not require the presence of an instructor. No tools were pulled by the tractors in this work, for the student could learn more about the machine, in the time allowed, by starting and stopping it and shifting the gears several times, than by endeavoring to steer it along a furrow while plowing. During the time spent in studying the individual tractors, the students were free to ask any questions of the service men concerning such things as ignition systems, transmission, etc.

An outline for studying the different tractors was furnished all the students and service men.

The course was concluded by a field demonstration, in which the students could see all of the tractors at work and in quite a number of instances, get on the tractor and operate it themselves.

It was found best to give the tractor practice during the latter half of the course, after the fundamental subjects had been discussed in lectures and demonstrations. The ideal system is that of telling the students in the lectures, showing them in the demonstrations, and then allowing them to perform the operations themselves.

GAS TRACTOR SHORT COURSE

SCHEDULE 1918

DATES	PRACTICE PERIODS															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Mon. A. M.	Registration															
Nov. 11 P. M.	1	1	1	1	2	2	2	2	5	5	6	6	7	7	8	8
Tues. A. M.	5	5	6	6	7	7	8	8	1	1	1	1	2	2	2	2
Nov. 12 P. M.	2	2	2	2	1	1	1	1	6	6	7	7	8	8	5	5
Wed. A. M.	6	6	7	7	8	8	5	5	2	2	2	2	1	1	1	1
Nov. 13 P. M.	3	3	3	3	4	4	4	4	7	7	8	8	5	5	6	6
Thur. A. M.	7	7	8	8	5	5	6	6	3	3	3	3	4	4	4	4
Nov. 14 P. M.	4	4	4	4	3	3	3	3	8	8	5	5		6	7	7
Fri. A. M.	8	8	5	5	6	6	7	7	4	4	4	4	3	3	3	3
Nov. 15 P. M.	9 22	10 9	11 10	12 11	13 12	14 13	15 14	16 15	17 16	18 17	19 18	20 19	21 20	22 21	....	....
Sat. A. M.	21 20	22 21	9 22	10 9	11 10	12 11	13 12	14 13	15 14	16 15	17 16	18 17	19 18	20 19	....	....
Nov. 16 P. M.	19 18	20 19	21 20	22 21	9 22	10 9	11 10	12 11	13 12	14 13	15 14	16 15	17 16	18 17	....	....
Mon. A. M.	17 16	18 17	19 18	20 19	21 20	22 21	9 22	10 9	11 10	12 11	13 12	14 13	15 14	16 15	....	....
Nov. 18 P. M.	15 14	16 15	17 16	18 17	19 18	20 19	21 20	22 21	9 22	10 9	11 10	12 11	13 12	14 13	....	....
Tues. A. M.	13 12	14 13	15 14	16 15	17 16	18 17	19 18	20 19	21 20	22 21	9 22	10 9	11 10	12 11	....	....
Nov. 19 P. M.	11 10	12 11	13 12	14 13	15 14	1[illegible] 15	17 16	18 17	19 18	20 19	21 20	22 21	9 22	10 9	....	....
Wed. Nov. 20	Field Demonstration															

LIST OF PRACTICE EXERCISES

Demonstrations:

1. Tractor Inspection—R. B. Lundy.
2. Timing and Horse Power—L. J. Fletcher.
3. Ignition—R. B. Lundy.
4. Carburetion, Adjusting and Care—L. J. Fletcher.

Practice Exercises:

5. Valve Grinding, Bearing Adjusting—Wm. Schmitt and Wm. Moore.
6. Soldering and Babbitting—H. L. Belton and J. Jacobsen.
7. Motor Rebuilding—J. R. Michelson.
8. Plow Work—R. C. Ingrim.

Tractor Practice:

9. Avery
10. Bean
11. Best
12. Case
13. Cleveland
14. Emerson-Brantingham
15. Fageol

16. Holt
17. I. H. C.
18. Moline
19. Samson
20. Sandusky
21. Wallis
22. Yuba

MOTOR OPERATION AT KANSAS STATE AGRICULTURAL COLLEGE

W. H. SANDERS

ORDER OF WORK

1. Assembly of group for roll call. Assignment and short lectures.
2. Careful examination of machine assigned.
3. Report to leader of breakages or parts missing.
4. Lubrication, every moving part.
5. Fuel and carburetion system, inspect and test all working parts, valves and tanks.
6. Ignition and wiring system. Inspect magneto, wires, switches, impulse starter, and spark plugs. Test out every part. If plugs are dirty clean them.
7. Cooling system, fill radiator full. Look for leaks on whole water system. Correct any that develop at once.
8. Examine all levers, controls, clutches and brakes. Find out what each does.
9. Prime engine to start. Stop and start until each man in squad can start motor without assistance. Have leader or instructor inspect your work.
10. Operate tractor in building.
11. Obtain permission for outside operation.
12. Replace tractor in its stall 15 minutes before end of period. Clean up, police, return all material to tool room. Have Leader inspect your work and dismiss squad.

Extension Round Table Discussion

RAYMOND OLNEY, Chairman

DEMONSTRATIONS OF FARM DRAINAGE AT SOUTH DAKOTA

R. L. PATTY[1]

I cannot honestly say that I anticipate making a talk to so learned an audience with any great degree of pleasure. I am, however, very glad to bring greetings from South Dakota to the Extension men of other states, and regret very much that the Extension portion of this program should be so limited. I should like it if we had time to hear from various states on each extension activity along agricultural engineering lines.

I presume we are all "willing to admit from the start" that agricultural engineering projects make the very best possible subject for an agricultural extension demonstration in the true sense of the word. There are two or three good reasons for this.

In the *first* place there is no guess work about them. We know just what they will do. They are not controlled or affected by any climatic conditions, insect ravages, etc.

In the *second* place, the publicity you may want to give them either through the press or through meetings, field or otherwise, can be given at almost any convenient time.

In the *third* place, the work is a permanent one that will stand as a demonstration for years and years,—so, barring poor judgment that might be used in choosing the wrong specimen to demonstrate, none of your work done from year to year is lost.

Tile Drainage for the farm is one of these subjects, and makes one of the very best demonstrations.

TILE DRAINAGE DEMONSTRATIONS

I take it you men will be most interested in the way our drainage demonstrations are carried on in South Dakota, and the results as far as have been able to check them up.

To begin with, we work very closely with the county agricultural agents in all our demonstration work, but especially so in drainage work, because they readily appreciate the value of it to strengthen them in their work. This is especially true after a single demonstration has been put on in the county. I would estimate that 75 percent of the demonstrations put on have been in counties having an agent and in cooperation with him.

I might say further that I believe the efforts of the specialists in extension should be primarily toward the strengthening of the

[1] Department of Agricultural Engineering, South Dakota.

county agent in his county. Personally, I have found that the more I have worked to boost his work in the county and give him credit, the more credit my work received.

Many of the prospective demonstrations, then, are *located* by the county agent.

The first time we are in the county we visit the place, look it over, run a preliminary survey to ascertain the amount of fall, estimate the size of the basin, examine the soil if necessary and figure the size of the tile needed. In the meantime we can talk over something of the way the lines should lay out and good practices in laying as to depth, laying to grade, etc. Especially the importance of having the grade established by an engineer.

When the farmer is ready to go ahead with the work, having secured a reliable man to lay the tile, we stake out the system complete, giving him the grade and profile if the project deserves it. After the tile are laid, we check them up, and if the system deserves a location plan we furnish it. We make few rigid requirements of the man who puts in the tile. We try to get a line on the conditions in the neighborhood as to whether *many, few,* or *none* are interested. If many are interested, we try to have a little field meeting and talk it over before the work is done or during the construction of it. If none are interested we go right ahead and do the work just the same. We find that this way will get results with men adverse to extension work better than trying to poke it down them. We do ask the farmer to keep track of the cost and later we manage to get any data or other cooperation we want.

Both the county agent and myself use these demonstrations in meetings through the community. The meetings may be called especially for drainage or it may be a Farmers' Short Course meeting. The beauty of them is that they stand as a permanent demonstration and can be referred to for years after. In fact we are just getting started with the work in the 3 years we've been on the job. We, of course, use the press at opportune times to call attention to the work.

Results:—Now, how much are we able to accomplish?—We are working single handed and in connection with the other lines of agricultural engineering in extension,—not as much as we would like to, of course. But, it is something and we are all interested in what the other fellow is doing, so I'm telling you what I think you'd like best to hear.

In the three seasons, we have recorded in the field books 102 surveys. If the demonstration did not get this far, no record was made of it. Of this number, 40 demonstrations have been completed, checked up and are working day and night. Twenty-six systems have been staked out, an estimate made on them, and are in the process of construction, or have not been started. A large number of these are due to shortage of reliable tilers, this last season especially.

Thirty-six preliminary surveys have been made, some of which will result in a demonstration later on, possibly 50 percent. In other cases no outlet was found, the property changed hands, or the outlet contested.

Now, what have they shown in dollars and cents? None of our demonstrations have raised more than two crops. Most of them only one. Most of those having raised two crops have entirely paid for both the tile and labor. While a few have paid the entire expense with the one crop. The times have, of course, been very extraordinary and we have been careful not to overestimate the returns to be expected by the farmer who is going to do the tiling.

Here are the figures given me by a man in Deuel County just a few days ago. We drained one slough that wasted 20 acres of land, a year ago this fall. We took in a few additional wet spots and the barn yard as well. But this 20 acres was practically all under water, the slough never having been entirely dry. This twenty acres was broken up last fall and this spring seeded to flax. The 20 acres threshed 170 bushels of clean flax that is contracted now at \$5 per bushel for seed or a total of \$850. The total cost of draining the land was \$1100. Eight and a half bushels an acre was not a big yield,—the owner says he would have had 15 bushels if it had been put in right.

My subject as originally given me had something about war time in it. This, we are glad to say, is out of date now, but I am sure you will agree with me when it comes to actually increasing the production of food one year with another there is no surer way to do it than by reclaiming wet lands with tile drainage. It puts the richest lands we have under cultivation permanently, not for one year or two years but for generations to come. We have exceptionally favorable conditions to work under in South Dakota and as the saying goes "got in on the ground floor" with our work, comparatively little of it having been done before. Our farmers are progressive and quick to see the advantage of improvement. I predict a great future for drainage as well as other agricultural engineering work in agricultural extension.

Mr. Patty: I would like to say a word about the way that agricultural demonstrations help the county agent's work. I have one specific instance in mind in which I am sure you would be interested. We have one county in southern South Dakota that put in a temporary demonstration agent less than a year ago. This county was considered one of the worst counties in the State, that is, it showed the least chance of ever going over as a permanent county.

We put a good man in there and he was quick to see the advantage of agricultural engineering work. He had one county commissioner that had knocked out county agents once before and came near doing so again. The agent accidentally found that this man was interested in drainage, so it was not long until he called me down to the county and we went out to this man's place and put on a demonstration. In a short time he was interested in roads —being a commissioner—and we put on another demonstration on a road 3 or 4 miles from his home, in which the commissioner and two or three men were concerned.

I might say that county went across as a permanent county about 2 months after we started work for that man, and the county agent himself says there is nothing else that would ever have put that across.

The commissioners in that state have to appropriate the money for that work.

FARM BUILDING DEMONSTRATIONS

Mr. Norman:[1] I haven't a paper. I was informed that each man would be limited to 10 minutes. I haven't had any practical experience along this line yet, and I came here to learn.

I am going to tell you what I planned to do, but I am not going to take a great deal of your time. I want a little discussion after I give you my plan. The way to figure to get the best results is to get the ideas of all the men.

I think before a man can do any promotional work or educational work along the line of farm buildings over the state he has got to have something to work with. I have been spending the greater part of the last 3 months of my time—and also using the time of one of the instructors in the farm mechanics department at Purdue —in preparing a set of farm building plans. To date we have some 35 or 40 working plans of various farm structures, and we consider that only a beginning.

Of course we cannot design a building for every person's need, but we can make plans of the different types of construction and give details of various systems used in building the different structures, so that we can handle the needs of all parties that do not know exactly what they want.

My idea is, to standardize farm building as much as possible. I believe that there should be some standard plan for practically every farm building. Some people, and some authorities, do not agree as to that, nor as to these plans, but I believe that we should work toward that end—standard farm building plans for the various types of structures.

As I said, we can handle the various needs of men that don't know exactly what they want by supplying these standard plans.

[1] Extension Rural Engineer, Purdue University, Lafayette, Ind.

Where the farmer does know about what he wants we can furnish him these standard framing plans, and show him how to frame his structures; then in a half hour's time furnish him with a pencil sketch of a floor plan that will suit his needs. The sketch, of course, won't jibe with the plan of standard framing, but any contractor that is much of a contractor can fit the two together.

That, I think, is the first thing to do if one intends doing very much along the line of farm buildings. I am getting to a point now where I feel I am ready to go out and start boosting my proposition. The first thing I want to do is to put this before the county agents. I don't know whether your county agents work the same as those in Indiana, but there they have district meetings. The state is divided into a dozen or more districts, and the county agents hold meetings once a month. I am going to these district meetings and put my proposition before them, ask their cooperation, and also ask for any suggestions that they might have as to how it should be carried on in their county.

I am not going to confine my cooperation to county agents alone. I am going to the dealers in the various building materials. They are the men that are vitally interested. They will give you more cooperation in a minute than a county agent will in a week, because the county agent is interested in so many things that he can't concentrate on farm buildings. By making some sort of an agreement between the dealer and the county agent, perhaps some plan for those two men working together, you can expect to get the best results.

I am supposed to appear on the lumber dealers' program this month at Louisville, and I intend to put the proposition up to them at that time and ask for their plans and their cooperation.

Now, after we get this thing running smoothly we will have farm buildings designed from our plans in practically all the counties. That will be true within a few months, I think. I have furnished plans to over a hundred farmers since the 20th of September, and in many cases we have furnished more than one plan. I don't know that those men are going to build—some of them have already done so, but perhaps not all of them will. But no doubt there will be from one to a dozen men in each county who will have structures built.

My scheme is to go to these farms and hold meetings, and if there are enough of them in one county we can make a tour of those farms. We had some experience with tours this summer during the Indiana silo campaign, and that worked out very satisfactorily in a great many instances. In other instances it was almost a complete failure, but by getting the dealers and county agents to working together to advertise the tours I think we can create enough interest to get these farmers together at those meetings. The dealer is in touch with a great many men who are contemplating the construction of certain buildings, and probably he knows other farmers who should have such buildings.

The county agent knows these men, and by dropping them a line I think we can get out a goodly number. I would like to hold one tour in every county during the coming building season. Of course that is out of the question, but that is my aim.

I think we are going to be able to start something that will take considerable force to stop, if we can once get those men to work together.

I am not only going to the lumber dealers but to the other dealers in building materials. So far I have a list of the lumber dealers and of the cement dealers. I would like to have a list of all the clay products men in the state. I have a list of drainage tile dealers that is rather out of date, but I think it will catch the majority of them. That doesn't include, however, the building block men.

As I said in the beginning, I haven't had a chance to try this out as yet, and I may be wrong in some of my theories, but what I wanted to do was to put the proposition up at this time and hear from a number of other people.

Mr. Smith: Do you supply those plans free?

Mr. Norman: No, we don't. We make a small charge of not more than enough to cover the cost of production. We are charging 10 cents a print at present. That little more than covers the cost of each print, but, as you know, we would be required to give a considerable number of these plans away in special instances, and we will also probably fail to collect from a few of them, but in my dealings with over a hundred farmers to date we haven't had more than two or three who have failed to pay up, and I think perhaps you can figure them as letting it slip their mind.

I have a list of these available farm building plans. I furnish this list of plans to county agents and to farmers who write in for information. The list contains a short description of each plan and the price. We also have furnished the county agent's offices with a complete set of our farm building plans. The farmer can go to the county agent's office and see what the plans are, and if he needs a plan for his own use he can send for it.

Mr. Gross:[1] Are you doing anything in the way of planning the farm or do you send just the building plan?

Mr. Norman: I have planned perhaps a half dozen farm steads. In one or two cases laid out the complete system, and in other cases we rearranged the present system, moved one or two buildings, and furnished plans for the construction of new buildings.

[1] Dept. of Agricultural Engineering, Mississippi Agricultural College, Miss.

DEMONSTRATIONS IN LIGHTING FOR FARM HOMES

Mr. Ramsower:[1] The demonstrations that we have carried on in Ohio in farm lighting have been somewhat different from the demonstrations in drainage discussed by Mr. Patty.

Our work up to date has largely been promotional work. We had so many requests for talks and lectures on the question of farm lighting at institutes, at extension schools, and at meetings of various kinds that we felt the necessity of getting together a demonstration outfit.

So we collected the representative types of various forms of lamps and lighting systems. For example, we selected one of what we considered to be the best makes of ordinary round wick, center draft tube lamps, an approved form of mantle lamp, kerosene being used as fuel; also a gasoline pressure lamp and a lantern too, a gasoline pressure system, for which we devised a stand that could be dismantled, taken down and conveniently packed. The pressure system included a pressure tank of small size, but a regular tank, an inverted lamp, and a bracket lamp. Then we made up an acetylene system having two candelabras each with six lights, making a total of twelve lights for the outfit, which was the full capacity of the plant, all of which made a very convenient outfit for demonstrating the desirability of the acetylene gas generator both with and without a mantle.

Then we were able to secure the cooperation of some local dealer in the community where the demonstration was to be held, who furnished us an electric lighting plant, so that we were able to bring upon the platform representatives of nearly all of the approved methods of farm lighting.

Our meetings, of course, were always held at night, and never except where we could be provided with a hall and platform of a size to accommodate the equipment we had. We would accompany the lecture with a demonstration of each one of the pieces of equipment, and we were able to secure figures showing cost of operation and the general desirability of each form of lighting.

We have given the demonstration lecture at quite a large number of gatherings, usually large gatherings. In the case of an Extension School it was a joint meeting of men and women, and usually that was one of the best attended meetings of the session.

We were able to make much better impression upon people by having those lamps and various equipments demonstrate the efficiency and desirability of the different forms of lighting. Our object was to attempt to convince people that we have got beyond the kerosene lamp stage, and that we are aiming toward the day when all of our farmers will have electric lighting plants. We haven't yet reached that time—it will be a long time before we

[1] Dept. of Agricultural Engineering, the Ohio State University, Columbus, O.

can hope that even a considerable percentage of them will have electric light plants. In the meantime we are urging them to get something better than the kerosene and mantle lamps which are operated with varying degrees of success, and yet are a wonderful improvement over the ordinary round wick lamp.

Then we take them through the various steps from the gasoline pressure system, the acetylene system, up to the electric lighting system. We hope this year, if our extension workers are back on the job again, to be able to follow up those promotional meetings with demonstrations covering the installation of various lighting equipments whether it be acetylene or electricity or what not, and we contemplate the keeping of records having to do with the installation of those plants. We want them installed under our supervision and keep them under our observation. That is a matter of future development which we know is coming and in which we want to have a hand.

We feel that what we have done up to date is to pave the way for real demonstrations in farm lighting.

CHAIRMAN OLNEY: There is a little time for discussion on this subject.

MR. PATTY: I'd like to ask if you have had any experience in blau gas lighting.

MR. RAMSOWER: No, we haven't.

MR. PATTY: We noticed that it was very low in cost and I wondered if there was anything wrong with it.

MR. RAMSOWER: Its use is subject to the difficulty of being able to get the equipment—get the tubes charged with the gas. That is the objection that I have heard from a number of people that have tried it. It may be overcome, but that is a question.

EXTENSION HELP IN FARM TRACTORS

MR. KINSMAN:[1] Before taking up the subject assigned, I think there is a matter that we ought to take up before we leave here, and that is a more permanent organization of the extension agricultural engineers, through which we can exchange information not only at the annual meeting but at times in between.

When someone has a good idea and thinks it would be to the advantage of every one to try it out, have some method of giving out this idea, and then report on results when we get back here at the next meeting. I think there are a lot of things along that line we can work out that will help all of us, and I would like to see a general discussion on that before the meeting closes.

In taking up my subject I want to change it slightly to "Extension Helps in Farm Power" because in Nebraska the truck is almost as important as the tractor, so we are carrying on our work more as a farm power proposition, not confining it to tractors alone.

[1] Dept. of Agricultural Engineering, University of Nebraska, Lincoln, Neb.

Up to the present year most of the extension work in tractors or farm power consisted in carrying on short courses, which has proved very popular in every case. I might say that of all requests for this year for short courses at Nebraska, half of them are for farm power. You can see it is an important subject, and we are offering three types of short courses that can be selected.

The principal one is in connection with the other short course work, and it extends over 4 years. In that case we have a demonstrating outfit that we carry around in our trunk showing the different equipment, such as carburetors, magnetos, lubricator valves, and all necessary equipment to cover the subject of overhauling tractors and power equipment, and we take up the subject first from the general principles of motors, and then the trouble work with magnetos, carburetors, lubrication, and then the general overhauling of the tractor and the motor truck or automobile.

In fact, all of our short courses follow somewhat that outline. We have a short course in which we condense the work into 2 days. Then we have another that extends over about 8 days, in which we go into the subject much deeper and give some practical work. That is, we organize classes and give overhauling work.

In addition to the short course work, we have been working on a plan for getting into the subject deeper, and we have adopted two plans for this purpose. One is working in cooperation with the farm management department who issue a farm record book for farmers to keep their farm expenses in, and we have worked out an insert to go into this record book, keeping records on cost of power farming. The idea is to get a limited number of farmers in each county, if possible, to agree to keep these records and try to get around to such farmers as least twice during the year to talk over their farm power problems with them.

Then when we hold our short courses in that community we can take these records and go over the farm power problems from that standpoint, in addition to the regular work that we give in short courses, and in that way bring out the problems that are to be met in power farming. We are merely getting ready to do this—we haven't actually tried it out yet.

The subject of demonstrations has been discussed here. We had in mind putting out a plan for carrying on demonstrations with each county agent. We have had a number of calls during the past year for outlines for putting on demonstrations. In some cases county agents went ahead and put them on to suit themselves, but they didn't always have them organized as well as they might.

One type of demonstration for which we have had at least three requests is for the farmers themselves to put on the demonstration, similar to the old fashioned plowing contest. Each farmer brings his tractor and plows, and the prize is given for the best and most economical plowing.

I think where the farmers operate their own machines, economy tests would prove quite successful. We have had three county agents on these demonstrations and we expect to put on several more. That covers very briefly the work we are doing in farm power.

Chairman Olney: Mr. Kinsman's idea of the extension men getting together is a mighty good one. There has been some talk here during the convention of doing something along that line and possibly giving the extension men a little more time at the convention for getting together and talking over their particular problems.

It seems to me you men should have a day instead of an hour to go into extension problems, and it should also come at a time when it wouldn't conflict with other sessions of the convention, because no doubt there are things going on in the other room that you would like to hear.

Are there any questions or discussions on Mr. Kinsman's talk?

Mr. Dickerson: I would like to know if he has tried out any of these farm demonstrations yet.

Mr. Kinsman: No, we haven't. We had one arranged, but due to weather conditions we couldn't go ahead, but the farmers seem very enthusiastic about it. Of course it all depends on the weather.

Mr. Smith: If you had a dozen farmers you would have to have quite a staff to take care of the fuel.

Mr. Kinsman: The fuel proposition is usually taken care of by having all the men drain their machines and then taking the wagon around and filling them up again. Of course it is necessary to see that they drain them completely, but that is about all that is necessary, and that simplifies the problem of knowing what kind of fuel they are using.

I don't believe we shall experience very serious trouble in getting the men to keep the records. We call a meeting and go over the work with them and outline each man's duty, and then he knows what he will do when he gets on the ground.

Mr. Smith: You would have to put them on their honor, because it is a big job to keep track of them.

Mr. Patty: You would have to specify that each man would have to run his own tractor, or every tractor manufacturing firm would have a man out there.

Mr. Kinsman: I might say that the tractor representatives are welcome—we invite them, but they are to have nothing to do with the machines and they are not to talk sale. If they want to go off the ground and talk sale that is their business.

Mr. E. A. White: I think a committee should be appointed to check the machine, one to keep track of depth and the other to keep track of the tractor. It seemed to be the consensus of opinion that at least two observers were necessary to each machine.

MEMBER: Mr. Kinsman's remark as to draining the tank brings to mind an article that has recently appeared in the *Engineering News Record* on the experiments with various kinds of trucks in Ohio. In those experiments they had some small tanks made with a glass gauge attached on the side. The tanks were installed in front of the trucks, where they were visible at all times. The supply of gasoline to each truck was supplied through this small tank, anl they were able in that way to get the amount of gasoline used down to a very fine point.

I thought it might perhaps be simpler to attach a tank of this kind to the tractor demonstration.

MR. KINSMAN: We had in mind that very thing. But here is a problem of the tractors. The connections on the carburetors are not standard to the extent that they are on trucks, and it would mean to have a fitting for every tractor on the market in order to do it. Then there are so many different methods of feeding the gasoline to the carburetor there would be some difficulty in getting the tank connected in the right place.

CHAIRMAN OLNEY: The suggestion has been made that we should take time at this session to organize the extension section. What is your idea as to that, Mr. White?

MR. WHITE: I am not officially on extension payroll, but I do most of the work that is done in Illinois at this time. I would be very glad to see an extension section of the American Society of Agricultural Engineers organized and I think there would be no more favorable time than this morning. It would be my suggestion that we proceed to elect a chairman of this extension or empower the incoming president to appoint a chairman and an executive section, if we are not ready to make a permanent organization this morning.

I don't think there is any more favorable time to form a section of this society for some specific purpose than right at the present moment.

CHAIRMAN OLNEY: I am wondering if, under the present rules of the society, it wouldn't be necessary before a section is organized to go into the matter of creating sections throughout the society.

There is, at present, an extension committee which might serve the purpose temporarily of an extension section. No doubt during the coming year or at the next convention the matter will be taken up of splitting the society up into sections—at least to the extent of having different phases of the work scheduled for certain sessions, instead of having the farm buildings work mixed up with the farm power and machine work.

It may be necessary to go even farther than that, but I believe that for the present the extension committee would be a sufficient organization and would give the men an opportunity to get the contact which they need. Then whoever is appointed chairman will see that there is an organization effected and that ideas are exchanged.

Mr. Norman: I think we ought to take action as to some system of letting this committee know what we want. As extension men we want the other man's ideas and how he is carrying those ideas out. I don't know how this could be done. I haven't thought enough about it to form any definite ideas, but just offhand it seems to me that monthly mimeographed letters or something of that kind would do.

Chairman Olney: I think that is a matter for the committee to handle, and I don't believe that we have the time to discuss it to any extent here this morning. Before going any further I would like to ask Professor Ramsower if he will accept the chairmanship of that committee.

My plan is to leave it pretty much up to the chairman of the committee to select the men he wants to work with him, because he is going to be responsible for results and naturally should have some say-so as to the men who will work with him.

Mr. Ramsower: I shall be glad to do anything I can to further this movement. I should like to suggest my idea of what the program ought to be. I know how difficult it is to accommodate every one. My suggestion for next year is this: To have a full three-day session of the society, devoting two days to a general program such as we have had during the last two days, and to have the third day an educational and extension program.

That will give us three full days, which we have got to have in order to cover the work we want to cover. I am not altogether in favor of having an extension session while the other meetings are in progress. I think the other subjects are of general interest to extension men, and we ought to have an opportunity of hearing them. I would like to know what the men think about that idea.

Mr. Clarkson: It seems to me that is just the reverse of what it ought to be. I think a full three days session of the society is needed for the general work of the society, and perhaps these sections—not only the extension section but other sections may be devised—ought to do their work ahead of the main work of the society rather than after. It seems to me that it is a better plan for this kind of work to be carried on and finished before the main work of the society is started.

That is especially true with the reports of committees which I take it ought to be delivered to the sections. The reports of committees in farm building work should be delivered to the sections rather than the main society. I have in mind the way I was placed last year. My paper came in reverse order from the report of the Committee, and the paper was written with the thought in mind that it would come after the report of the committee, therefore the paper was not understood the way it would have been if the committee report was delivered first, and it seems to me the section work ought to come ahead rather than after.

CHAIRMAN OLNEY: In connection with the extension work or teaching work, that part of the convention should not interfere with the rest, because it is of particular interest to the college men, and all the college men want to attend that particular session. All the men want to hear all the papers, and whether this session should come previous to the main session of the convention or after is a matter that probably requires some thought, and will take time to work it out.

MR. CLARKSON: There is one point on which I do not agree with you. I believe that the members of this society who are not college men and not in college work take more interest in this section than you realize. Doubtless other manufacturers take an interest in this work, too, and we would like to be present at these meetings as well as the main meetings.

CHAIRMAN OLNEY: My point is that the arrangement of the program will be such that any individual can attend any session —no two sessions going on at the same time. There is merely the question of determining whether this section shall come before or after the main part of the convention.

MR. PATTY: I think that it will be up to the committee that is appointed to consider whether this should come before or after the main program.

MR. CLARKSON: I would like to emphasize the fact that we would like to have the sessions so we can attend all of them. I know personally I am very much interested in all of these sessions, and I want to suggest in this connection that your news letter might be a very acceptable method of distributing this information. I think most of the members will be interested in these ideas, and I see no reason why we can't make the news letter an 8-page sheet and issue it every two weeks.

The news letter now is right good, but it isn't live enough—not issued often enough. I should like to see all this information come out through the general news bulletin.

MR. SMITH: I think we should all have an opportunity of attending every meeting. After coming 2000 miles one would want to attend all the sessions. We have no special extension men— we are supposed to devote 3 months of our time to extension work (which we never do) but we have extension work as well as regular college work, and we ought to be able to attend all meetings. That is a very important point.

MR. HAND:[1] As representing the manufacturer, I have tried to

[1] Vulcan Plow Company.

be in two places and I find it very difficult. I missed what I wanted to get here, and it is not possible to attend two sessions at the same time. I think it is a mistake to have two sessions of general interest at the same time.

Mr. Arentson:[1] I don't know how much interest the manufacturers are taking in the extension work, but I am taking a lot of interest in the manufacturers along the extension lines. I believe it is to the interest of the manufacturers to follow up this work, and I am very anxious to see that these men—especially these extension men who are representatives of different manufacturers—are in with us in what we try to do.

Mr. Hand: I should say that when a manufacturer goes so far as to place his machinery in the laboratories of the colleges to further their extension work, his interest is very vital, and that he certainly is interested in knowing what is being done along the lines that he is supposed to be furthering.

Mr. Kinsman: There are a lot of extension men working with manufacturers who have extension departments, and I believe we could receive mutual benefit if we had some of these departments report on the service they could give us, or how we could work together. I would like to see the committee work out something along this line.

Chairman Olney: It might be preferable to have this extension and teaching work come the first day for this reason: manufacturers of tractors and farm machinery, for example, would (as has been pointed out here), find a great deal of interest in these sessions, but when it come to the main part of the convention they would be interested only in those papers and discussions which referred to farm power and machinery. If they thought the extension and teaching sections of sufficient interest they could come the first day and be here the second and a part of the third day for the farm power and machinery end of it.

Mr. Gross: It seems to me that in life it is a matter of choice. We have to choose some things. I think that this society is large enough and has enough men of talent to give us a program of two or three weeks. Instead of narrowing our program down we ought to have it in sections and let people choose. I talked to several of the men and they seem to agree with me that this was the best, but I don't know what the opinion of the entire body is.

Chairman Olney: We cannot prolong the convention too long for the reason that the college men who are vitally interested in all of the sessions cannot stay here, and it would be difficult to hold the crowd for a very long time.

I believe it is time to adjourn for the business meeting.

Adjournment

[1] Department of Rural Engineering, University of Tennessee, Knoxville, Tenn.

BUSINESS SESSION

SECRETARY'S REPORT

H. C. RAMSOWER

Membership.—During the year 1918 new members have been taken in as follows: 23 members, 18 associates, 2 juniors and 1 affiliate; total, 44. During the same period 2 members have died, 4 have resigned and 5 have been dropped. Net increase for the year, 34.

Total membership, then, stands as follows: members 134, associates 51, juniors 13, affiliates 5; total 203. Student Branch members, Iowa, 4.

Publications.—During the year the following publications have been issued:

1000	Volumes 1917 Transactions
500	Pamphlets of Information
5	News Letter Issues
300	Preliminary programs
300	Final programs

Council Actions.—With consideration for an expression of opinion by members at the 1917 convention, Council voted to hold the 1918 convention in St. Louis. Later, at the instance of several members, and in view of the causes due to war conditions, that would probably act to cut down attendance, and in view of the further fact there are some 30 members in or near Chicago, while in St. Louis there is none, the former action was reversed and the meeting place changed to Chicago.

Committees.—Committees were appointed by President Scoates, early in the year. The personnel of each is published in the Transactions. There were no changes in these committees.

Report of Election.—A canvas of the ballots by the tellers showed the result for election of officers for 1919 to be as follows:

For President	Raymond Olney
First vice-president	L. F. Seaton
Second vice-president	H. E. Murdock
Secretary-treasurer	F. W. Ives
Councilman	I. W. Dickerson
Nominating committee	P. S. Rose E. A. White E. R. Jones

TREASURER'S REPORT

H. C. Ramsower

RECEIPTS

1917 Treasury balance	$142.11	
Admission fees	92.00	
Dues	1169.71	
Sale of publications	40.61	
Pins and miscellaneous	25.25	
		$1469.68

EXPENDITURES

1917 Transactions	$652.36	
News letters	49.85	
Other printing and office supplies	161.88	
1917 Annual Meeting	151.82	
Telegrams	.95	
Postage	49.53	
Express, freight and drayage	19.14	
Stenographer	111.40	
Salary Secretary-Treasurer	100.00	
Miscellaneous	34.25	
		$1331.18
Cash balance		138.50
Total		$1469.68

DISCUSSION

President Scoates: You have heard the reports of the secretary-treasurer: one as the report of the secretary, containing no financial statements; and the other as the treasurer's report. What will you do with the secretary's report?

Mr. Dickerson: I move that the report be adopted.

Mr. Clarkson: I second the motion.

President Scoates: It has been moved and seconded that the secretary's report be adopted as read.

(Motion carried unanimously.)

President Scoates: Regarding the treasurer's report, I will now ask the secretary to read the report of the auditing committee.

(Mr. Ramsower, secretary, reads report of the auditing committee.)

President Scoates: You have heard the treasurer's report, and the report of the auditing committee, signed by Messrs. Shedd, Collins, and Detwiler. What is your pleasure as regards the treasurer's report?

Mr. Dickerson: I move that the report be adopted.

Mr. Sjogren: I second the motion.

(Motion carried unanimously.)

RESOLUTIONS

Committee on Resolutions: E. R. JONES, Chairman,
L. S. KEILHOLTZ, RAYMOND OLNEY

WHEREAS our esteemed and unusually active member, M. F. P. Costelloe, was called by death a few days after our last Convention; Therefore be it

RESOLVED: THAT the American Society of Agricultural Engineers in Twelfth Annual Convention assembled record its highest appreciation of his career, both as a man and as an agricultural engineer; and,

THAT a copy of this resolution be sent to his bereaved family.

(Resolution was adopted, and a copy sent to Mrs. Costelloe and family.)

II

WHEREAS the great war has been won for the cause of democracy and international decency, and we are permitted once more to pursue the ways of peace; and,

WHEREAS a large number of our members helped in camp and battle line to win this war; and,

WHEREAS some of our members who answered our country's call have answered their last roll call here on earth and have given their lives to the great cause; Therefore be it

RESOLVED: THAT the American Society of Agricultural Engineers in Twelfth Annual Convention assembled record its lasting appreciation of those of its members who fought so nobly.

(Resolution was adopted.)

III

WHEREAS the work of the Secretary is becoming more voluminous; and,

WHEREAS it is necessary that our growing Society branch out into new fields; Therefore be it

RESOLVED, By the American Society of Agricultural Engineers in Twelfth Annual Convention assembled, THAT the Secretary be authorized to employ an Assistant Secretary to aid particularly in carrying out a wide publicity to increase the membership and extend the usefulness of the Society.

(Resolution was adopted.)

IV

WHEREAS the re-absorption of the discharged soldiers and other war workers into the occupations of peace can be facilitated by the building of new farms on the undeveloped lands of the country; Therefore be it

RESOLVED: By the American Society of Agricultural Engineers in Twelfth Annual Convention assembled, THAT we welcome the proposition that Federal funds be provided to finance the development of wet, arid and cut-over lands into farms for settlers;

THAT we favor the development of those lands in the order of their availability for immediate settlement and use;

THAT immediate search should be made for lands that can be developed for crops of wheat and corn and potatoes next year, and not next decade;

THAT the constructive program of the National Drainage Congress be endorsed relative to the reclamation of the larger areas of wet lands and the promotion of public works;

THAT we favor, not the giving of money or lands to soldiers or other settlers, but merely the loaning of money at a low rate of interest, with proper safeguards for development purposes, or the actual purchase and improvement of undeveloped but potential lands by the Government at a rock-bottom price and the re-sale of those lands as farms to settlers on easy terms at actual cost of land, plus cost of improvements;

THAT the Government, as such, engage in such improvements as drains, irrigation systems and land clearing and such other improvements as can be done most economically under competent engineering supervision in comparatively large units, and that the settler be left to put up his own buildings and other improvements;

THAT the soldiers who have returned victorious from the great war for democracy be given the first opportunity to purchase these farms; and,

THAT after the soldiers have been given ample opportunity to make their purchases, the sale be open to any suitable settler honestly desirous to make his home on a farm.

(Resolution was adopted, and copies were ordered sent to the appropriate committees in both houses of Congress; also to Hon. Franklin K. Lane, Secretary of the Interior, and to David F. Houston, Secretary of Agriculture.)

V

WHEREAS the officers of the Association and the committee in charge of local arrangements have given the Society perhaps the best Annual Convention it has ever held; Therefore be it

RESOLVED, THAT the Society record its keen appreciation of the efforts of these tireless workers for the cause of Agricultural Engineering; and

THAT the thanks of the Society be extended particularly to the Clay Products Association and the Portland Cement Association for their contribution to the entertainment of the members of the Association.

Resolution was adopted.

DISCUSSION

Mr. Dickerson: One of those resolutions carries with it a recommendation that the incoming secretary be authorized to appoint an assistant.

President Scoates: The idea was that it be a stenographer. The Secretary wants a stenographer, and the Resolutions Committee have dignified it with the title of assistant secretary.

Mr. Ramsower: May I say in connection with that particular resolution that it was a vital need to the welfare of the Society to take a step in that direction. No one of our members can have the time in connection with his other work to give the Society the service that it demands, service that it ought to have. I believe that securing a competent stenographer is a step toward a permanent secretary. I believe it is the most that we can afford to take at this time.

I should like to say to you that even that small step means that every member of this Society must do two things—first, you must pay your dues when the secretary asks you to pay them. Within the next 3 months the secretary will be called upon to pay bills amounting to seven or eight hundred dollars, with the total in the treasury of $138. It is a source of considerable embarrassment to incur bills and then not be able to pay them. Furthermore, if, with our present membership we hired a stenographer at $65 or $70 a month, the secretary would come out in the hole to the extent of seven or eight hundred dollars at the end of the year, so the second thing that each member has got to do—if we are going to take this, what to me is a very important step—is to assist in getting new members.

I presume that the president will appoint a membership committee that must do something, and that membership committee can't do what they ought to without the assistance of every member of the Society.

My experience during the past year leads me to believe that it is easily possible for us to secure at least 200 members during the next year. That is a small thing. That is one member for each member that we already have, and certainly every man in our Society can at least sufficiently impress some prospect with the value of our organization to him to induce him to become a member. If we can come to this Convention next year with 450 members we can then see our way clear to employ a permanent secretary. Until that time comes we shall never be able to make the progress that we ought to make. We shall never be able to impress other societies with the importance of this Society. So my appeal to you as a secretary who has had to do with these affairs of the Society for a year, is not to go away from here and forget the Society, and let each man feel that it is up to the secretary and the president to run things for the year, but go away from here with the feeling that during this year you are going to do something to promote the interests of this Society, that you are at least going to exert your best efforts to secure one new member. When the secretary writes to you for a list of prospects, don't lay the letter aside and say, "Oh, they'll get them, I'm busy and I can't think about that," but think about it and send in a list of prospects. I know that from every list of prospects that is sent in, we can impress them sufficiently to get a large percentage of members from that list, and it is the individual members here and there over the country in touch with commercial men who can make up the best prospective list, so do that and you will help wonderfully toward that time when we can have a permanent secretary, which will be a wonderful step in advance.

President Scoates: Any further discussion of these resolutions? Any questions to be asked regarding them?

Motion carried adopting resolutions as presented.

Is there anything else to come before the meeting at this time before the installation of the new president?

Mr. Ramsower: Mr. President, in connection with a report that a committee made which included the handing in of suggested rules and regulations for tractor tests and demonstrations, there appeared a clause which suggested that the Hyatt dynamometer be used. I don't know whether I am taking the wrong stand on that proposition, but I think it is wrong if that is the case. I don't believe it is the province of this Society to suggest that the Hyatt dynamometer be used, or any other dynamometer. I should like to make a motion that that report be amended by striking out the name of any commercial product that might be used in connection with that demonstration.

Mr. Olney: I followed the work of that committee to a certain extent. I do not know the reason for specifying a Hyatt dynamometer, unless it was because so far as known, that seems to be most used among manufacturers in testing the drawbar of tractors. I don't know that the Hyatt dynamometer was especially mentioned so much as the type of dynamometer. As a matter of fact, the Hyatt people are not building that dynamometer for commercial purposes, that is, as a sales proposition. They are not building it themselves. It is simply for the benefit of their customers and other individuals or organizations in the field who wish to use it for a testing purpose, and we really cannot class it as a commercial proposition.

If there is something better than the Hyatt dynamometer for testing tractors, all well and good. There may be, I don't know, but they have had very good success with it, and while it would perhaps be preferable to strike out the name of the dynamometer, I believe it is a matter which should be left to the Committee to select the best thing available for testing purposes.

MR. SJOGREN: I feel that no dynamometer or instrument used in connection with the demonstration should be named in these rules. If that were done in one case, why not also include material or instruments designed and made by the members of the Society?

MR. DICKERSON: I fully agree with Professor Ramsower that it is not wise at this stage of the game, when manufacturers are very touchy on this whole business, to specify anything except a suitable, recognized dynamometer. I think that is as far as we can go.

MR. CLARKSON: Just as a matter of inquiry, I want to suggest this thought, that perhaps the committee really intended to suggest one dynamometer to be used in a test and not have two or three makes used in the same test.

MR. OLNEY: Well, whatever is used it will be standard throughout all the tests that the committee make, as I understand it, and the aim will be to use the best available.

PRESIDENT SCOATES: Question has been called for.

MR. DICKERSON: Will you state the question?

PRESIDENT SCOATES: That all reference to any commercial equipment in these specifications for tractor tests be eliminated. I think that is the sense of it. All in favor of the question signify by the usual sign.

(Motion carried.)

PRESIDENT SCOATES: Anything else to come up at this time?

MR. SJOGREN: I wonder if any action should be taken or could be taken toward recommending to the office of Public Roads and Rural Engineering, the recognition of what might be termed, the Farm Equipment Department? Some talk has been done along that line by various members, and I wonder if any definite action could be taken?

PRESIDENT SCOATES: I spoke to the Resolutions Committee and I thought they were going to bring in a resolution on that. It may be the thing is so mixed up they don't know just what is the best thing to do.

MR. KEILHOLTZ: I think Mr. Wirt was to handle that all the way through. Is Mr. Wirt here?

PRESIDENT SCOATES: No, he is gone.

MR. OLNEY: Mr. President, I believe that Mr. Cook of the Department of Agriculture made the statement that there was a bill in Congress, which had been presented to Congress previous to the country entering the war, but had been shelved, naturally, and I recall the bill now myself. I didn't at the time, but in the course of events, I believe some attention will and should be given to that matter during the coming year, and the Society should be instrumental in getting action along that line. We need a good strong department at Washington, and we need it separate from the office of Public Roads.

PRESIDENT SCOATES: I think, personally, it would be a mistake to call on any department but the Department of Agriculture. You have got that term started and I think you ought to keep it going. If you start a new term it is a question of educating the people up to that term.

PRESIDENT SCOATES: I will now ask Mr. Dickerson to escort the newly elected president to the chair.

MR. DICKERSON: Mr. President, I appreciate the honor. I beg to introduce to you your president for 1919. (Applause.)

(President Olney takes the chair.)

PRESIDENT OLNEY: Members of the American Society of Agricultural Engineers, I surely appreciate the honor that has been conferred upon me, and don't know what I can say other than that I have been very much impressed with this convention. I was surprised to come in here Monday morning and find so many people at the opening session. There are about three times as many as I anticipated seeing, and it is a very favorable sign, indeed. It seemed to me that the Society had rather lost interest in the past two or three years, but this meeting has changed my ideas along that line very materially.

We have a wonderful opportunity. Now that the war is over, there is going to be a greater demand for work along agricultural lines than ever before, and the Society has an opportunity to put itself on the map in good shape, and to do so, no time should be lost. We should occupy a place with other organizations that will be second to none in the point of influence, etc.

Professor Ramsower has spoke of one thing here this morning which has been foremost in my mind since coming to the Convention, and that was, work toward the idea of a paid secretary by 1920. He set the mark for 200 new members. I believe there is no harm to set the mark high enough, and I would much rather put it to 400. From things I have heard people say since I have been here, I do not believe we would have any difficulty in getting 400 members. One man said he had 10 men. I have heard others say they had 3 and 4 men. In my estimation, the membership committee will be the most important committee during the coming year. It will have the biggest job, and I have promised myself one thing—that is, to ride that membership committee to a fare-you-well. I am going to take considerable time to appoint the members, and then I am going to stand behind them with a big stick and see if we can't put this membership campaign over in good shape, because it will be absolutely necessary to have a much larger membership before we can have a paid secretary.

I believe that to have a paid secretary we should have plenty of money so that we can have a good one—a man that will be located probably here in Chicago, and can give the thing his entire time, and that, of course, will take money. I said 400 new members during the coming year. It seems to me that every member of the Society surely ought to be able to get two men. I know there are a great many who have never even been approached. Two men said to me yesterday they wanted to become members.

Another big job for the Society this year is in connection with tractor demonstration and testing. If this Society isn't careful, the Society of Automotive Engineers, of which I am a member, will beat us to it on this tractor proposition. They have a large membership among the tractor engineers, and until recently they have been going to it strongly. It seems to me that this Society should logically be foremost in the tractor and power farming field, but unless we wake up and get busy, the other society will beat us to it. I do believe, however, that we should work in conjunction with the other society, and that we can do each other a great deal of good.

It seems to me that the tractor demonstration and test committee will be in position to do some valuable work for the manufacturers and the industry, and will add greatly to the prestige of the Society in the farm equipment field.

There has also been some talk of dividing the Society into sections—something along the line of the National Implement and Vehicle Association. That is a matter which will have to be gone into during the year, and discussed or thought about by the members, and possibly brought up in the following convention.

I also want to express my appreciation to the secretary for the excellent program which we have had this year. It is one of the best the Society has ever had; this is evidenced by the attendance which we have had at each session.

This is all I have to say, and if there is nothing more to come before the convention, adjournment is now in order. Before we adjourn, I want to say this, that the new committees will be appointed as soon as possible. In the first place I will decide on the chairmen, and in getting their acceptance, will request that they give me a list of the men they would like to have act with them on their committees. The job, of course, will be put up to the chairman of each committee, and as he will be responsible for the work of the committee he should naturally have some say as to the men he would like to have associated with him, and that will be done as soon as possible.

If there is nothing further, the motion for adjournment will be in order.

Adjournment *sine die*.

Transactions of the

American Society of Agricultural Engineers

Report of the Thirteenth Annual Meeting
Chicago, December, 1919

Vol. XIII

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of
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With Business Records

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BUSINESS MEETING

Officers, 1920

President .... F. N. G. Kranich
First vice president .... F. W. Ives
Second vice president .... W. B. Clarkson
Secretary-treasurer .... J. B. Davidson

Councilmen	Term Expires
A. J. R. Curtis, chairman	December 31, 1920
Daniel Scoates	December 31, 1921
I. W. Dickerson	December 31, 1921
Raymond Olney	December 31, 1922
F. A. Wirt	December 31, 1922

STANDING COMMITTEES, 1920

STANDARDS

Raymond Olney, chairman

O. W. Sjogren
Geo. W. Iverson
G. B. Gunlgson
M. A. R. Kelley
F. M. White
K. J. T. Ekblaw

FARM STRUCTURES

W. G. Kaiser, chairman

W. D. Gerber
R. S. Whiting
W. A. Foster

RESEARCH AND DATA

E. A. White, chairman

Daniel S. Scoates
R. W. Trullinger

FARM BUILDING EQUIPMENT

Frank H. Williams, chairman

DRAINAGE

J. A. King, chairman

John T. Stewart
James A. Reeves
Ralph L. Patty
D. P. Weeks

FARM POWER, BELT AND FIELD MACHINERY

BELT AND FIELD MACHINERY

L. W. Chase, chairman

STATIONARY ENGINEERS

E. R. Wiggins, chairman

TRACTORS

A. H. Gilbert, chairman

FARM LIGHTING

L. S. Keilholtz, chairman
I. W. Dickerson

HORSE

A. E. White, chairman

IRRIGATION

O. W. Israelson, chairman

W. D. Gerber
P. A. Welty
A. R. Williams
E. R. Webster

SANITATION

H. W. Riley, chairman

ROADS

E. B. McCormick, chairman

NOTE—The Standards Committee represents the Society in coöperation with the National Implement and Vehicle Association and other interested societies on the Committee of Agricultural Equipment Standards.

SPECIAL COMMITTEES, 1920

BARN VENTILATION

W. B. Clarkson, chairman

R. U. Blasingame
A. R. Greig
W. A. Foster
L. J. Smith
J. L. Strahan
Wm. Aitkenhead
R. L. Patty

EDUCATION AND EXTENSION

F. A. Wirt, chairman

MEMBERSHIP

J. B. Davidson, chairman

P. S. Rose
W. B. Jones
A. P. Yerkes

PUBLICITY AND DEVELOPMENT

W. B. Jones, chairman

E. R. Wiggins
H. M. Railsback
J. B. Davidson

Thirteenth Annual Meeting

American Society of Agricultural Engineers

PRESIDENT'S ANNUAL ADDRESS

RAYMOND OLNEY,* President Amer. Soc. A. E.

Agricultural engineering — the art and science of engineering as applied to agriculture — is rapidly coming into its own; it is now beginning to receive the recognition which it merits. The pioneers in promoting the agricultural engineering idea, as represented by the membership of the American Society of Agricultural Engineers, have, in reality, been ahead of their time, as far as the acceptance of the idea by the general public is concerned. The application of engineering to agriculture dates back to the early history of farming, but progress has been slow. The present age, however, shows many signs of waking up to the real need, and it is not too much to say that the go-ahead signal has already been given for a rapid development of agricultural engineering in all of its phases.

The wise men of this country and other countries of the world have devoted a great deal of study and research to the improvement of other branches of agricultural science, while comparatively speaking, agricultural engineering has been sadly neglected. In the past decade it has been a mystery to many people, particularly those more intimately associated with agricultural engineering work, why agricultural institutions were apparently asleep to what, in a large sense at least, is the most important phase of agriculture, that of agricultural engineering.

Agricultural engineering may be spoken of as the mechanical side of farming. It includes all mechanical equipment, that is, operating and structural equipment, and all the mechanical operations of farming. A careful analysis of the farm business, giving due consideration to all aspects of the science of agriculture, will reveal the fact that if any one phase of agriculture is more important than another, it is the application of engineering principles and practices.

This statement as to the relative importance of agricultural engineering as compared with other branches of agricultural science, is considered from the profits standpoint and this is naturally what the farmer is most interested in. It is the demand for better profits and better living conditions on the farm that is principally responsible for the more rapid progress that is being made today along agricultural engineering lines. Agricultural engineering, embracing as it does everything that pertains to the design, construction, application, operation, care, repair, management, economics, etc., of farm motors, implements, machines, and all tool equipment; farm buildings and building equipment; farm lighting, heating, ventilating, power, water supply, and sanitation systems; country roads; drainage and irrigation, is the most potent and essential means for securing better farm profits and living conditions.

It is growing increasingly apparent to farmers, and to the public at large as well, that better profits from farming must be secured largely through decreased production costs. The farmer's income in proportion to the capital invested is lower than in any other business, which emphasizes the great need of cutting down the cost of producing the products of the farm. In agriculture as in the manufacturing industries, this must be recognized as the surest road to bigger profits, especially from now on. With the item of labor in the cost of food production amounting from two-thirds to three-fourths the total cost, and the expense of hired labor becoming all but prohibitive, to say nothing about being able to secure it at all, those who are seriously and intensively studying farm problems are realizing or are beginning to realize that the farmers' production problems are very largely problems in agricultural engineering.

More economical production and increased yields resulting from performing operations at the proper time call for the use of tractors, tractor-operated implements and machines, motor trucks, motor cars, motor cultivators, etc., etc., to reduce the man and horse labor requirements to the minimum, for it must be admitted that a rapidly increasing number of farmers are finding that under proper management most farm operations can be performed quicker, easier, and cheaper with mechanical power than with man and horse labor.

Better housing of farm animals and equipment, safe and adequate storage of farm products, and convenient quarters for performing indoor operations call for farm buildings and building equipment of proper design and construction and scientifically arranged. Living conditions on the farm are being made more comfortable, enjoyable and healthy by modern homes suitable to the needs of the farm family; by proper heating, lighting, and ventilating; by a clean and convenient water supply; and by adequate sanitation provisions. None of these things can longer be considered luxuries for the farmer and his family. He is providing for himself, and is in every way entitled to all the comforts and conveniences of life that are available to any class of people.

Furthermore, better farm profits depend in no small degree upon improved country roads, and upon drainage and irrigation, wherever they may be needed to increase the productivity of farm land and facilitate its operation.

Naturally the result of this greater progress in the application of engineering to agriculture is to place farming on the same basis as the more thriving manufacturing industries. It will raise the standard of living and business operation on the farm, and what is most interesting and vital to the farmer, it will increase the profit and attractiveness of farming.

As agricultural engineering assumes the larger sphere to which it is slowly but surely attaining, there must come an increasing demand for men especially trained along agricultural engineering lines, men who are familiar with the needs of agriculture and who have had agricultural and engineering training to fill the positions which will be open. An agricultural engineering profession is no longer a mere theory; it is already becoming a practical reality.

In the promotion and development of agricultural engineering the American Society of Agricultural Engineers stands in a unique and responsible position. Its membership made up, as it is, of men from both the educational and commercial fields, this society should exercise a great influence in coördinating and correlating the work of all activities involving agricultural engineering, and to this end its principal efforts should be to draw into closer relationship the farmer, the man in commercial agricultural engineering work, and the man engaged in agricultural engineering educational activities, on the basis of a common understanding and mutual coöperation.

It is just twelve years ago that a small body of instructors in agricultural engineering subjects at several of the state agricultural colleges met at the University of Wisconsin to effect an organization which would enable them to assemble at intervals to exchange ideas in their particular line of work. The American Society of Agricultural Engineers is an outgrowth of that meeting.

Early in the history of this society, men in commercial lines became interested and began taking an active part in its work. At the present time the greater part of the membership is made up of men representing commercial interests. Considering the fact that the activities of this society are, in a sense, in advance of the times, substantial progress has been made during its existence and as time goes on and the general public awakes to a realization of the important work which the society has started the rate of progress is bound to be much more rapid. The society has laid off its swaddling clothes; it has reached a position where it can be of real service. A good foundation has been laid for the future work, and the go-ahead signal has sounded.

Members of this society can well be proud of the accomplishment that has already been made. The A. S. A. E. transactions, for example, constitute the best reference library on agricultural engineering in existence, and much praise is due to individuals and to committees for the splendid work which they have contributed.

It is a pleasure to announce a recent step which we have made along the line of progress. Several months ago a plan was proposed by members of this society for a working arrangement with the manufacturers of farm-operating equipment in matters pertaining to standards and other engineering work. Early in the autumn of this year the National Implement and Vehicle Association voted favorably upon this affiliation, and I am confident that this society at its business session this week will also act favorably upon it. While the American Society of Agricultural Engineers is now in reality the technical or engineering section of the National Implement and Vehicle Association, this society in no way loses its identity nor its freedom of action in matters coming within its scope. Already considerable progress has been made as a result of this arrangement, which will be covered later in detail in the report of the chairman of the standards committee.

On October 1 of this year your president, with the assistance and coöperation of individual members, presented to the Secretary of Agriculture a memorial covering the need and scope of a bureau of agricultural engineering in the United States Department of Agriculture. Fortunately we had very good contact at Washington through members of this society who have followed up our efforts very closely. As a result there has just been presented to Congress a bill for a separate and distinct bureau of agricultural engineering in the Department of Agricultural engineering, while, in addition to providing for taking over all the agricultural engineering work now being carried on by the various bureaus, also provides for the testing and rating of farm tractors. The membership of this society will be called upon at the proper time to render all the assistance possible in the passing of this bill, and it is hoped that every member will respond promptly and to the best of his ability.

We cannot hope to do everything at once. The goal we set at the beginning of this year for a paid secretary by 1920 has not yet been reached. I want to assure you, however, that every effort is being made and if the present plans under consideration should bring the results which we anticipate, a paid secretary will be an accomplished fact before very long.

Membership also has not reached the figure which we set at the beginning of the year, yet the percentage increase over previous years is very high. It at least indicates the rapidly growing interest that is being taken in the work of the society and recognition of the fact that membership in this organization has tangible value.

In closing I want to urge that every effort be made by the society as a whole, and by the members individually, for a paid secretary. It is absolutely essential to the progress that the society should henceforth make.

Another recommendation which I would make, and which seems highly essential at this time, is in the direction of greater publicity for the society. Individual members should not miss an opportunity to bring the work of the society before the public view. This must be done not with the idea of putting the society in the limelight, but rather as an opportunity to be of real service through the dissemination of valuable agricultural engineering information which we have at our command. I bespeak for the future of this society a rapid growth and a valuable service to agriculture and related industries as well as to mankind as a whole.

The thought I want to leave with you in closing is this: The growth and success of any organization is in proportion as it serves the public. The future of the American Society of Agricultural Engineers is based on service, and the better the service which it renders, the greater will be its success. It is distinctly within the power of the membership to make it what it will.

AN EXTENSION PROJECT IN FARM MACHINERY

F. W. Duffee,[1] Member Amer. Soc. A. E.

This paper describes an extension project in farm machinery consisting of demonstrations in the field in adjusting plows. Walking, wheeled, or tractor plows are used, depending upon local requirements.

A plow is started that is out of adjustment and those attending are asked for suggestions how to remedy the trouble, making the adjustments recommended and continuing until the plow is in adjustment. In some localities new types of plows might be shown. Dynamometer tests to determine effect of of side draft and improper hitches may be made.

The project which I have outlined here is the result of conferences with several people who have had more or less experience with this type of work, as I am a great believer in coöperation to secure the best results.

The first thing in an extension project in farm machinery is to determine the scope of the work to be covered. Are we going to take up all lines of farm machinery that are used in a locality or the state and in some way try to put across something

[1] Assistant Prof. Farm Machinery and Tractors, Univ. of Wisc., Madison, Wisc.

on all of them, or shall we pick out a machine that is of vital importance and do intensive work on it. My observation and belief has always been that it is better to do one thing thoroughly and well rather than try to cover considerable ground inefficiently, as the latter plan is apt to end up with having accomplished nothing at all. If we have not left the farmer with some real, new information, something that we will remember tomorrow and a year from tomorrow and use it, we have not accomplished what we set out to do.

So I would decide, and have decided to pick out a particular machine or phase of farm machinery and work on that. Having decided to limit our activities to one machine or a group of machines closely related, we must select for our first project in any section a phase of this work for which there seems to be the greatest need. That machine, except under very extraordinary circumstances, which is used most commonly, upon which the most good can be done, and one which is of vital importance to the farming business is the one that should be selected. First we must consider the general divisions. They are:

1. Machines for seed bed preparation.
2. Seeding machinery.
3. Cultivating machinery.
4. Harvesting machinery.
5. Miscellaneous machines, including manure spreaders, silage cutters, etc.

Of these, those machines used for preparing the seed bed most nearly fill the requirements set down for our project, in that they are universally used, and upon their proper use depends the entire success of the farm. The very first thing we must do in farming is to prepare a first class seed bed before we can produce a maximum crop, and that is certainly the ambition of every industrious farmer. Of all the machines used for preparing the seed, the plow stands out preëminently as the most important, from the standpoint of actual work done in seed bed preparation. It is universally used and almost as universally abused. It is a machine of extremely heavy draft, and that draft is tremendously increased if improperly adjusted. More time has been spent upon its development than upon that of any other machine, and more time is spent plowing than upon any other farm operation.

We will work with the horse plow as well as the tractor plow, for it will probably be several years before the horse plow will be obsolete throughout any very large section of the country. Also, most of the things learned about a horse plow can be applied to a tractor plow.

We must next decide whether our project is to deal with the selection of better, larger or different types of plows; the use and adjustment of the plow, or the care, repair and housing of it. It seems as though the use and adjustment is most important, and along with this a little can be said about the use of larger plows, the selection of plows particularly adapted to that locality where the demonstration is being held, and the care and repair of the plow. This project, then, is to consist of field demonstrations showing the use and adjustment of plows, walking, wheeled, or tractor, the type depending upon the requirements of the particular locality, only one of these at one time and place. In deciding which it shall be, we must look well toward future as well as present needs, for we can in this way promote progress and pave the way for it.

The coöperators in the demonstration will be:

1. The County Agent, who will arrange for the place of the demonstration and advertise it.
2. Implement dealers and manufacturers, who will furnish plows, experts, attachments, etc.
3. Agricultural Engineering Department of the College of Agriculture, which will assist in organizing the demonstration and furnish the demonstrator.
4. The farmer who will furnish field and power.

The success of the project rests largely upon the ability of the demonstrator to be one of the crowd, to get the men to thinking for themselves about the various problems that come up before he explains them, and then to be able to explain clearly and simply in a way that will be acceptable to the men.

The demonstration will consist of starting a plow that is as nearly as possible out of adjustment all round. After going a few feet, far enough to show that the plow needs adjusting, stop and ask for suggestions as to what is wrong, and here is where the ability of the demonstrator will show itself. Then ask for suggestions as to what to remedy first, how to make the adjustment, and how much it should be adjusted. The factory plow expert will make the adjustments. In determining adjustments to be made first, considerable can be done in showing why certain things naturally come first. After correcting the faults noticed at first, drive on a little way farther and look for further troubles, repeating the procedure above. Continue this until the plow is set properly for the back furrow; then repeat for another furrow or two. Oftentimes it will be advantageous in making an adjustment to throw it out on the other side in order to bring out the opposite effect of misadjustment.

This procedure may be repeated on several of the makes of plows in common use in the locality, and as the repetition goes on the similarity of the general adjustments can be brought out.

The use of an indicating dynamometer can be used to excellent advantage to show the effect on draft of several adjustments, such as excessive side draft, improper adjustment of rear wheel to carry weight in wheeled and tractor plows, excessively high or low hitch and proper and improper setting of rolling coulter and jointer, with and without this attachment.

Special attachments and equipment may then be demonstrated, such as methods for covering trash. Also some different bases could be shown, where special conditions exist, and a study of pulverization and compactness of seed bed be brought out.

Successfully advertising the demonstration will be one of the difficult things, as most farmers feel they already know the plow fully, so the special features such as the use of the dynamometer, different bases and special equipment will have to be played up. One point of especial value in advertising for a tractor plow demonstration will be the saving of time at a busy season, by "experting" their own plow rather than waiting for a factory trouble man. It might also be brought out that cutting down service will help to cut down prices.

A demonstration showing how to measure a gang plow for sprung parts would also be of considerable value. This could be carried out in the same way as the adjusting of the plow.

It would be very interesting to carry on several of these demonstrations in a section, say one county, and then check up on the "experting" required before and after the demonstrations.

In most cases the county agent would hardly be able to repeat the demonstration on a scale of any size. His work would consist largely in offering suggestions to remedy trouble, and referring those in trouble to men who attended the demonstration.

DISCUSSION

Mr. Wiggins: What relation will this extension work have to the implement dealer?

Mr. Duffee: As outlined, the dealer will be asked and I feel sure will be glad to coöperate in arranging for the demonstration. The demonstration should help his business in that it will promote more and better machinery and if successful, reduce to a certain extent the experting which he is called upon to do. It will also be valuable to him from an educational standpoint as quite frequently the dealers knows less about the actual operation of the machine in the field than does the farmer. The manufacturers particularly have always been glad and willing to help us in any scheme of this kind which we have tried.

Mr. Ives: I would like to ask Mr. Duffee how he gets follow-up on this proposition? In the state of Ohio the county agents are extremely busy and it is difficult to get the county agents to do this work. I think we are really asking too much of them a great many times to do the follow-up, and our own research bureau is so short of help that it is exceedingly difficult to get any evidence of tangible results after the demonstration.

Mr. Duffee: The scheme which I have in mind is to inquire of the dealers and manufacturers as to whether they have noted any improvement of sales in the community where the demonstration was given, and whether there has been a decrease in experting services required. This information could be secured either directly from the sources mentioned above through correspondence or through the county agents.

Question: I would like to ask Mr. Duffee how many of these demonstrations should be put on at any one place or in any one county?

Mr. Duffee: It is extremely hard to answer that question because the counties vary in size and the conditions vary. Any one demonstration will cater largely to a local community the number of which in a county will of course vary. I believe that one demonstration in a local community is sufficient, but that demonstrations should be put on in several adjoining local communities.

Question: What method would you suggest where the demonstrations would follow one another closely? Would you consider advertising all the meetings at one time or each one separately?

Mr. Duffee: I think I would advertise from one to the next, because if the work is of the right kind it will grow in this way. If something worth while has been accomplished a good report will spread, and this publicity is worth more than any other. This is another reason why several demonstrations staged in adjoining community centers seems advisable.

Question: Do I understand that you want the demonstration agents from the college to attend each meeting and not leave it to the county agent?

Mr. Duffee: Yes, keep the demonstrator right on the job.

Question: You don't think that the county agent could handle it efficiently enough after two or three demonstrations?

Mr. Duffee: No.

Question: I did not quite understand whether you would have special plows there with you, have the dealer furnish them, or use the plows that are on the farm.

Mr. Duffee: If the farmer has good plows, use them. If not, then secure plows from the dealer or manufacturer. Practically all the plows in common use in the community should be demonstrated.

Question: What attitude should be taken in regard to the introduction of new machines such as corn pickers, etc.? Should these be demonstrated, and if so, how?

Mr. Duffee: This is a little different type of work and one that I had not thought of particularly along this line. I believe, however, that demonstrations of such machines would be valuable, remembering of course that the advertising of a commercial proposition by the State College is a delicate proposition. Considerable could be learned regarding the good and weak points of a machine in this way.

MEMBER: I believe that is the right attitude to take. We owe it to the men to let them know what it will do, and that is what they are interested in.

MR. DUFFEE: If it is good we should all be behind it, if it is not good the quicker we and the farmers know it the better.

QUESTION: Would you hold your plowing demonstrations in the fall or in the spring?

MR. DUFFEE: Mostly in the fall in Wisconsin as this is when most of the plowing is done.

QUESTION: Would you give hitch demonstrations at the same time?

MR. DUFFEE: A demonstration of horse gang plows might well include a hitch demonstration, but a tractor plow demonstration should consist of tractor plows alone, I believe.

MEMBER: We have never done any of this work on farm machinery but we have done some with hitches. Perhaps it might be well to show a multiple hitch, showing with the dynamometer the difference in draft due to side draft.

A PROJECT IN HOUSEHOLD EQUIPMENT

M. H. HOFFMAN,[1] Member Amer. Soc. A. E.

Demonstrations in home equipment may be carried out to advantage by the Agricultural Engineers working with the County Agricultural Agent and the Home Demonstration Agent. These meetings may be held in homes, not modern, where there is a desire to equip with labor-saving devices. The points taken up are remodeling and rearrangement of kitchen, lighting systems, heating, plumbing and sewage disposal, power and refrigeration. The demonstrations are supplemented by talks in farmers' institutes and short courses and by automobile tours in the summer. The Farm Tour is a most effective way of creating a desire for modern equipment.

It is an old saying, "What is sauce for the goose is sauce for the gander." Conversely, what's sauce for the gander is sauce for the goose. If agricultural engineering is worth while for the farmer it should be worth while for the farmer's wife, and something is wrong if it isn't.

In the October *News Letter* appeared a discussion headed, "Why is the A. S. A. E.?" The shining lights of agricultural engineering expressed their views. They said it is to hear each other talk, to standardize equipment, to marry the farmer to the manufacturer, to catalog information, to produce acquaintanceship among professional men, to get the latest in agricultural

[1] County Agricultural Agent, Davenport, Iowa.

engineering, to furnish a clearing house for scientific information, but not one of them would concede that the Society can do anything to ameliorate the conditions of the farmer's wife and children or make their work more effective. Possibly, after all, we are wrong in thinking that the barn and tractor do not constitute the sum and substance of helpful agricultural engineering work, that really there is a place where our profession can assist in simplifying the house work for the farm women, but we feel that while it is helpful to know how to ventilate a barn, it might not hurt anything to know how to get the pancake smoke out of a farm house, that while adequate drainage is the first step in crop production, the farmer's wife likes to have some other method of carrying out dishwater than in a bucket, that while the multiple hitch may make horse labor more efficient, the single hitch should be worked out to the limit to make woman labor as efficient as possible; that while proper threshing methods save an enormous amount of wheat, proper facilities for baking bread save a lot of time and temper; that while it is important to keep the soil from washing off our farms it is also necessary to provide equipment to wash it out of our clothes. We predict that the farm women of the future will lapse their membership in the Ladies Aid Societies and join the A. S. A. E. and that when they do the complexion of the yearly program will be painted up a little.

To quote a statement made by a farmer about to retire from active farm work, "When we are ready to quit the strenuous period life, wife and I have planned to fence off a couple of acres along the road and put up a house modern in every respect. We will have our own lighting, water, and sewage systems, furnace heat and maybe a mechanical refrigerator. We won't move to town where nobody wants us, but we'll stay right here where our friends and interests are and where we can help along with the work just as much but not any more than we care to." Now there is some good common sense expressed in the farmer's statement, but he needed this vision a long time ago. The period of retiring from farm work is usually not determined by how long father can stand it, but how long mother can.

The vision of a house conveniently arranged and having the full quota of labor saving devices should be realized in the period of rosy cheeks and elastic step, in the period of buying horses and harrows not in that of bent backs and farm sales when the work time is over. Of course it is better late than never, but better never late.

The arrangement of the house, especially that of the kitchen should not be worked out haphazard as is too often the case. The architects used to be criticised for their inability to sense the needs in their designs of farm kitchens but at their worst it is doubtful if they ever perpetrated the awful crime of a house recently erected by a man who made this statement: "I had a lot of plan books but the more I studied them the more muddled I got, until finally I drew my own plan." If it had been built for his own wife who had passed the time of hard work it would not have been quite so bad, but it was for his son about to be married, whose wife was just beginning the hard working life of the farm woman. Thank heaven it is a frame building and cannot last forever. When the time comes that we build nothing but permanent buildings let us hope that more care will be exercised in their design. A woman who had reared eight sons and had done practically all the housework herself when asked how she had ever done it replied, 'Its my little kitchen. Its so conveniently arranged that I do not have to walk miles in doing my work."

When St. Peter hands out the shining bits of head gear it would not be at all surprising if some of the crowns most gorgeous with stars should go to the smooth tongued salesmen who sold the farmers electric lighting plants whether they wanted them or not, for they have put into hundreds of homes a nucleus from which has not only come light but power for many labor saving devices and heat for the electric iron and mangle. Once the plant is installed it isn't so much of a step for the farmer's wife to acquire the vacuum cleaner, the electric washer, a fan to temper the fierce heat when cooking for threshers, power to run the separator, the churn, and the sewing machine.

The electric plant or the high tension line, also makes possible mechanical refrigeration. It would be interesting to know how many farm homes are equipped with ice refrigerators and what per cent of these go uniced in the summer because it was impossible or else too much trouble to put up ice in the winter. But let the mechanical refrigerator once be coupled to the lighting system and it keeps the box chilled as long as current is to be had. The big problem is to get it in, for here again the item comparisons comes to the lady's rescue. Let her make two parallel columns; the electric refrigerator heading one, her husband's favorite tractor heading the other. The items running down the lists will read something like this: Initial cost, interest on investment, depreciation, cost of operation, help necessary to operate, days use per year, days lost per year while being repaired, cost of repairs per year, ultimate life. It might not be a bad idea to make an extra column and include the automobile.

To have water piped into the house has been for generations the ne plus ultra, the thing to be dreamed of by farm women more than any other one thing. When the choice lies between running water, electric lights, furnace heat or power washers the majority vote is for the water. Fortunately there are water systems to suit every pocketbook and if the air pressure system is out of the question, the old fashioned pitcher pump in the kitchen is a substitute not to be scorned. Where it is impossible for the pitcher pump to draw directly from the well, it can draw from a two barrel concrete cistern placed below the cellar floor and filled each day by a pipe running from the same pump that fills the stock tank. In Iowa today, there is hardly one man in a hundred that pumps by hand the water for his stock. The windmill or gas engine does the work and it usually is not difficult nor expensive to add on a house line as suggested. Of course this method is a "hard time" substitute only. If a force pump is being used and the pipes can be kept from freezing in the house the windmill can just as well pump up into a steel pressure tank or an attic tank and the necessity of pumping by hand be obviated.

In extension work, it is the duty of the specialist to get results. In the days before the County Farm Bureaus were organized, it was more difficult to carry on demonstration work than now. Then the talks in farmers' institutes and short courses had to be relied on to spread the gospel of home equipment. When the automobile came into common use, the farm tour was instituted. This was in the nature of a picnic. The farmer and his wife and children went with the crowd on a tour of the county. Stops were made at six or eight farms where some special feature was made the subject of a talk by one of the extension force. Naturally, household equipment became the one topic of absorbing interest for the women and many an improvement dates back to the time when the housewife found out what the other women had and how much it cost. One of the first improvements was plumbing in the house and this led to demonstrations in installing farm sewage disposal systems. In these demonstrations a septic tank was actually constructed and so far as possible the sewer lines were put in. It usually took three days for each demonstration and the afternoon of each day saw from ten to thirty men inspecting the work and asking questions.

Now I don't care to discuss that any further because I see there is another paper on the program this afternoon dealing with the same sanitary features of extension work, but that is one of the things that has been coupled up with our home equipment demonstrations. Later on, we put on in coöperation with the county agents what we have called the Agricultural Engineering Service. This took the form of professional help in solving the problems that they had along all lines of agricultural engineering activities. Now that may seem to some of you to bring very meager results. But when we look back to the places that we visited a number of years ago and we come back to those communities and see how, from that one instance, an idea has spread around in the whole community, and how far out from that one nucleus the people know about these things, we find it is enormously worth while.

Now as soon as the home demonstration agents began to take up the work in our state we put on this home equipment project. In that, I will read very briefly some of the things that we take up. The time — September, October, and November, in 1918; duration of time — not to exceed three days in a county; the object — to demonstrate how homes may be partly or completely modernized at small cost; the home demonstration agent was to arrange for and advertise a series of demonstrational meetings in homes where modern equipment is desired. We didn't intend to go into homes that were equipped with the very latest of everything. What we wanted to do was to go into some of the homes where the people didn't have money enough to build a brand new house; where they didn't have money enough to put in the very best of equipment, and show how, for the small sums of money that they could invest, they could make the house more nearly modern, and how they could put in a lot of equipment that would help them in their work. We had planned a series of demonstrations for the fall of 1918. We had all the arrangements made, the advertising done, and everything was coming along fine, and then that epidemic of influenza swept over the state and we held, I think three demonstrations, and quit. Well, all of our other time was taken up with other work, and we have not since put on the kind of demonstrations that we would like to, but if you will bear with me, I will try to give you the idea of how we think the demonstrations should be carried on, and of the need for them, what they should include.

HOME EQUIPMENT PROJECT

EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
IN..COUNTY, IOWA
THE IOWA STATE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS AND THE UNITED STATES DEPARTMENT OF AGRICULTURE CO-OPERATING

NAME OF PROJECT: Home Equipment Demonstration.

LEADER: ....Home Demonstration Agent.

LOCATION: County of..

TIME: As arranged in September or October, 1918. Duration of time not to exceed three days in a county.

OBJECT: To demonstrate how homes may be partly or completely modernized at small cost.

METHOD OF PROCEDURE: A. The Home Demonstration Agent will arrange for and advertise a series of demonstrational meetings in homes where modern equipment is desired.

B. The Agricultural Engineer will give careful consideration to the problems presented in the house where the meeting is to be held and will make suggestions as to the needs for equipment, the cost and the method of installing the same. The points taken up will be plumbing and sewage disposal, heating, lighting, power, ventilation, and arrangement.

C. The number of meetings per day is left to the discretion of the Home Demonstration Agent, but it is suggested that one in the morning, and one or two in the afternoon be scheduled.

Co-operation: A. The Home Demonstration Agent and the Agricultural Engineer will attend these meetings together, conveyance being provided by the former.

B. The Agricultural Extension Department will pay the traveling expenses of the Agricultural Engineer to and from the county and the county organization will provide for the expenses within the county as they see fit.

Approved: ....
Agricultural Engineer

Approved: ....
Home Demonstration Agent

Approved: ....
Director, Extension Department

In the plan that we have worked out for holding these meetings, and in the three cases where we did get into the communities, we have received some very encouraging reports, and we have reason to believe that the work was not in vain, although we would like to have carried it out to the conclusion that we had planned.

DISCUSSION

Mr. Zeasman: Do you carry any large amount of equipment with you in any of that work? Any small models or equipment of any sort, or is it charted material?

Mr. Hoffman: Ordinarily we don't carry very many charts. We don't like to carry charts along because that is one of the relics of our old time extension work, and people sort of look down on the chart. But we do like to have small models. It is pretty hard to get models. What is even better than a model is something that is right in the house, a life size model. Where we can refer to this house or that house right in the neighborhood where they have the things that ought to go in the house where we are in, it is worth a good deal more than the models. We don't do any plumbing at all. The idea is this. There are plenty of plumbers all over the country, and they do a good job. We don't feel it is our province to do purely service work. If we can do work that will be educational, that will help to have plumbing installed, we are glad to do that, but simply to put on something that would be just saving a few dollars to the man, who is able to pay for it himself, we don't feel that is our province.

Question: Do you work any in connection with the dealer?

MR. HOFFMAN: Yes, we do, just as much as we can, and the dealers are always glad to coöperate with us. They are glad to loan us equipment, and we have used a good deal of equipment in that way.

MR. ZEASMAN: Do you do very detailed planning for any particular house, that is, the first one that is to be equipped in the locality, and make that stand out as a demonstration to educate the rest? Suppose a man wants to install a water system. Do you make all the field studies necessary?

MR. HOFFMAN: We have done that in the case of water systems and sewage disposal systems. We have put in up to date twenty-three septic tanks and at those times one of our agricultural engineers would go right out on the farm, stay with the farmer and help along with the work. Usually all he had to do was to cut the lumber for the forms and have those put in place and sometimes help shovel in the concrete. Once in a while he would dig a little bit, but more as a matter of getting a stand-in with the people than as really helping. We would spend the three days in finishing up the septic tank with demonstrations every afternoon, when the people would come to see how the work was going on.

MR. ZEASMAN: We have done something similar to that. In connection with the forms, we have actually built a knock down steel form. Just now we are planning an extension of that form so we can fix up several sizes with the same form, with only the addition of a few sheets. I was wondering if any of you used that same principle in extending other household conveniences.

MR. HOFFMAN: No, we have not. In the sewage disposal demonstrations we have nearly always used old lumber. We don't very often have to buy the complete bill of lumber that is required for building the forms, because the farmer nearly always has lumber lying around the place that will do all right, and when that material is used for the forms they take it out and use it over for something else anyway.

MR. ZEASMAN: Maybe I am asking too much here, but a report has come to me of a defect in constructing some septic tanks. Now in your construction of the septic tanks do you have the liquid in the chamber at a lower level than the dosing chamber?

MR. HOFFMAN: We use the single chamber septic tank; we use a filter in connection with it.

QUESTION: Do you work through the home bureau of the county agent?

MR. HOFFMAN: Through the home demonstration agents.

QUESTION: How many of these home demonstration agents do you have?

MR. HOFFMAN: We did have sixty. We don't have quite that many now. The last report, as I remember it, there were somewhere around twenty-five or twenty-six.

QUESTION: Have you found, from your experience, that the home demonstration agents can intelligently discuss the installation of water systems and give tentative plans to the farmers themselves?

MR. HOFFMAN: They never undertake that. What we want of the home demonstration agents is that they shall find a place for these demonstrations.

QUESTION: Don't you find that when a farmer wants to discuss a thing of that sort with a person he is not interested unless they can talk to him and show him about how much it is going to cost? I have found in my work that about ninety-five per cent of the women are absolutely at sea when anyone begins to discuss anything of that nature.

MR. HOFFMAN: If the home demonstration agents do know those things it will help, but even if they don't, we wouldn't want to turn them down. We would want to use the organization that is already existent for carrying on the demonstration.

QUESTION: A question has come up to us as to whether we ought to push it through the home demonstration agents or through the county agents, who can, as a general thing, discuss those things more intelligently with the farmer.

MR. HOFFMAN: While he may be able to discuss it more intelligently with the farmer, they won't get far with the farmer's wife.

QUESTION: We have run across this thing, too, that the farmer's wife doesn't always have the deciding vote.

MR. HOFFMAN: We always make it a point to have the farmer or the husbands of these others come in there. They usually stand around in the yard, but they don't come into the house; we like to have them there so as to carry on the financial discussion with them.

QUESTION: I don't know whether you have run on to this situation that we have in Missouri, but in some localities it seems that in a great many of our sections the women are the ones that are holding the work back. They will sit back and count the dollars and cents. In a great many instances the man would be willing, and also anxious to have things of this sort if they could show him that it was all right, but the woman was holding him back. In other cases, the woman would say, "Well, you will have to see the boss on that." I just wondered what sort of mediums you considered as being the most beneficial for talking those things up. You decided on the tour around the country and talking them up that way, did you?

MR. HOFFMAN: That is simply on the lecture part. But for an actual demonstration of just how plumbing and lighting, etc., should be installed in the house it really ought to be in the home. Now we don't find any ways nearly so much of that idea that the women are holding back, as I had an idea we might. It seems like the women are beginning to read more, they have been reading more, and they are getting these things in.

AN EXTENSION PROJECT IN LAND DRAINAGE

E. R. JONES,[1] Member Amer. Soc. A. E.

This paper describes the conduct of extension projects in farm drainage by the University of Wisconsin. The relation of this work to professional engineers and the county agents is discussed. Supervision of community drains and the State Drainage Association is mentioned.

The College of Agriculture of the University of Wisconsin does its extension work in land drainage under a Smith-Lever Project. The aim of the project is to stimulate land drainage. When the project was outlined for acceptance by the U. S. Department of Agriculture, several ways of stimulating drainage were suggested, but the work has now shaped itself along four definite lines.

DEMONSTRATIONS IN FARM DRAINAGE

The College of Agriculture conducts drainage demonstrations in communities where several land owners are considering drainage. The drainage engineers of the College will lay out a drainage system on one farm in such a community. They stake out the lines and establish grades. At a meeting, they explain to the land owners assembled the methods employed. In this way the farmers are taught to help themselves in the simple projects, and to hire an engineer in the more complex ones. This service of the College is free, but is limited to communities that need object lessons in land drainage, and the person served must agree to engage a private engineer to insure the perfect installation of the plans recommended by the College. We require all applicants to fill out the following blank:

1. Name ....
2. Address ....
3. Railroad station..
4. Other stations from which farm can be reached easily by automobile ....
5. Location of farm (section and township)...............................
6. How many acres of wet land?..
7. How much of this has been plowed?......................................
8. How much wet land like this is there in your township? ....

[1] Professor of Agricultural Engineering, University of Wisconsin.

9. Will you have to enter a neighbor's land to get an outlet? ....
10. Will he coöperate with you? ....
11. Will you install at least a portion of the drainage system recommended by the College, if our preliminary survey proves that drainage is feasible? ....
12. Will you engage a private drainage engineer to insure perfect installation without requiring a second trip by the engineer of the College? ....
13. Name of engineer you expect to hire ....
14. Convenient hall or school house for a drainage meeting ....

On the day set for such a demonstration the land owner is expected to advertise the demonstration and commonly thirty or forty farmers assemble out in the field to see the Station worker stake out the drainage system. Usually an evening meeting in a school house completes the work of the day.

While we keep in touch with a project until it is completed, we usually try to get the farmer to hire an engineer to inspect the work when we are unable to get there. This must be done for protection because we must know that the drainage system is put in according to our direction.

At first engineers were inclined to object to this service on the part of the College. It has developed, however, that these demonstrations have eventually increased the demand for engineering work. For example, near Ettrick in Trempealeau County where the College laid out one demonstrational system, fifteen car loads of tile were laid there the next season in a community that had never seen a drain tile before. A resident engineer now has all the work he can do laying out drainage systems for farmers in that county.

We are trying now to limit our farm demonstrations to those places in which the land owner agrees to install the drainage system which we lay out. This prevents work being done where a community asks to have a drainage system laid out merely as idle curiosity.

This service has been rendered for about ten years. Today there are very few communities in southern and eastern Wisconsin that do not have within ten miles a tile drainage system to which we can refer in our correspondence. For instance, when a man from Dousman writes us describing his drainage problem, we can tell him that on a farm five miles south of Dousman there is a drainage system on land similar to his. We suggest that he go and see this system and use it as a basis for a drainage system on his own farm, getting an engineer to aid him in carrying out the details.

A great many of the applications for farm demonstrations come from county agents. Our county agents are not always keen in selecting the right projects for demonstrations. They are apt to consider the individual more than the community. Whenever we visit a county to make a demonstration, we coach the county agent so that he can take care of the simpler drainage projects that arise. By that we do not mean that he shall lay out the drainage system. He merely advises the farmers in a general way what they should do on the basis of the instructions we have given him. By working through the county agent we are able to reach more farms than we could do otherwise.

FIELD STUDIES FOR COMMUNITY OUTLET DRAINS

The Drainage District Law (Chapter 557 Laws of 1919) and the Farm Drainage Law (Chapter 446 Laws of 1919) are now in operation. These two new laws place upon the willing land owners the responsibility of addressing a petition to the Circuit Judge for a drainage district, or the county judge for a farm "drainage" when they desire an outlet drain through the lands of unwilling owners. The land owners must base this petition upon a sketch which they make to the scale of one inch equals eighty rods showing (1) the forties of land to be included in the proposed project, (2) the approximate location of the edge of the wet land, and (3) the location of the proposed drains. If a forty contains only one acre of wet land that will be benefited, it is best to include the whole forty because it is easier to describe than an irregular tract and the tax is levied against only the one acre benefited. There is no tax on the other thirty-nine acres unless benefits can be proven. The boundary of the district and the location of the drains may be changed later by the court upon recommendation of the state chief engineer but it is best to have them as nearly correct as possible in the petition.

The College of Agriculture is willing to help land owners make an intelligent start in a drainage organization. So far as time permits, it will send its drainage engineers, E. R. Jones or O. R. Zeasman out into the field to help the land owners decide whether an organization is desirable and, if so, how much land to include in the project. There is no charge for this service, but communities are required to wait until the field trip can be made at least expense in time and money to the college. Some projects are not advisable at this time. To enable the college to decide upon the general merits of a project, fill out this blank:

1. Name of applicant..
2. Address ....
3. Railroad station nearest to the area..
4. Other convenient stations from which it may be reached by auto...

5. Township and sections in which the wet area lies..................
6. About how many acres of marsh..
7. How much of the wet land has been plowed............................
8. Is the marsh open or timbered..
9. Names and addresses of other men in favor of the proposed drains...
    ....
10. Total number of land owners involved....................................
11. Total number of forties involved...

Form 3

SUPERVISION OF COMMUNITY DRAINS

For eight years the College of Agriculture has been asked to write a report on the feasibility of all drainage districts and town or county drains organized. This is another feature of our extension work in land drainage. In 1919, the legislature strengthened this service by permitting the college to put its report in the hands of the state chief engineer who has police powers to prevent the organization of drainage projects on poor lands and the execution of faulty plans on any lands. The agricultural engineer of the College of Agriculture is thus made state drainage engineer with the office of the state chief engineer back of him. Both the preliminary and final plans and the assessment of benefits must be approved by the state drainage engineer. Good results are being accomplished with very little friction by this service. While the engineers are working up their plans, they keep in touch with the Agricultural College and take our suggestions so that when the final plans are made they are usually in such shape that the approval is a mere matter of formality.

STATE DRAINAGE ASSOCIATION

Another channel for extension work is the State Drainage Association which has between three and four hundred members and publishes reports from time to time. We have a convention each winter and a field meeting each summer. The extension worker of the College of Agriculture is secretary of this association. The duties consume at least one-tenth of his time each year, but we feel that it is time well expended. The association is a strong organization and was one of the strongest forces in bringing about the revision of the drainage laws at the last session of the legislature.

A PROJECT IN FARM SANITATION

HOWARD W. RILEY [1]

This paper sets forth the necessary steps to develop successfully interest in improved sanitary conditions on the farm. The person charged with the work must know farm conditions. The best time is winter, because the farmer has leisure time. Bulletins and lectures are not considered as effective as actual demonstration. A program of a meeting is furnished, a simple system is recommended and experiences are related.

With better prices for farm produce and the acute scarcity of domestic help, all farmers should give serious thought to the improvement of living conditions in and about their homes to the end that their wives and daughters may not exhaust themselves in daily tasks, that health and efficiency be maintained and that their children may not be lured to the city by a desire for personal comfort not provided on the farm.

While the need for pure drinking water and for the best possible domestic equipment seems to require no special arguments to establish its importance, there will be found in every community those who will scoff at special effort in these lines as superfluous and extravagant, in view of the many more obvious needs for the investment of capital in other branches of the farm activities that can show more direct financial returns. The farmer and his wife have, it may be, by their own unremitting toil, paid for their farm. They have grown old in the process; they have become accustomed to the inconveniences of rude quarters; their round of life is simple and unpretentious; by much drudgery their field of vision has been narrowed down to one of very limited scope; the forced economies that earned the farm are still fresh in their minds, and so a part of their lives that they cannot readily see the vision, the realization of which would bring to their declining years more pure comfort and satisfaction than they have known in all their hard worked lives.

And so it comes about that the first step in our extension project of this kind shall be an attempt to furnish inspiration to all the community to consider this thing, discuss it in all its phases, until it may be that public opinion may be brought to hold a good water and sewage system installed and a kitchen and a bathroom well equipped as more certain indications of superiority and progress than fresh wall paper on the sitting room or a new seven passenger touring car.

The person to succeed in promoting this phase of the work must be some one who has had so intimate and personal a touch with actual farm conditions that all his points ring true and inspire the good will and confidence of his audience. Ability as a speaker is of course necessary but oratory should not be set above sincerity and experience.

[1] Professor of Agricultural Engineering, Cornell University.

The time for this work is undoubtedly the winter, when there is more opportunity to think and when domestic life is normally less overshadowed by the insistent stress of the work of the fields. Lecture hours in the grange and farm bureau community meetings are admirable opportunities, and while these talks should be in the main general and non-technical so as to hold a mixed audience, a little simple demonstration material will be found to stimulate interest among the men.

The next need will be for information, which can be met in part by bulletins carefully written and freely illustrated with well considered cuts, setting forth plans for only such disposal systems as are simple, easy to build, absolutely reliable, and easy to care for. No other engineering error is quite so unfortunate as a sewage system put into operation and then found to be incorrectly designed, so that it either fails to operate properly or that necessary care is given only at the expense of much unpleasant inconvenience.

General talks and the distribution of bulletins will not, however, result in a sufficient amount of actual construction. More effective stimulation is needed in the form of demonstrations. For the man who works with his hands, there is no other teaching so effective as the actual construction before him of the type of work he is to do when matters are so planned that the demonstrations illustrate, clearly, general methods of procedure. The equipment needed will be so bulky that an automobile truck will be required, manned by the demonstrator and an assistant. All field arrangements should be made by the Farm Bureau agents so as to require the minimum of road travel. The advertising should indicate clearly the nature of the work to be given so that it will gather a selected group that will be uniformly interested.

The best possible demonstration is the explanation of a system actually under construction, but as a rule these are not obtainable and work must usually be given complete by the extension men, all the necessary equipment being carried in the truck. A program for such a meeting might be essentially as follows:

Discuss briefly sanitation in general and the principle of sewage disposal.

Erect a studding house wall braced to stakes.

Attach brackets to carry overhead open water tank.

Place tank.

Connect shallow well force pump to suck from washtub reservoir showing capacity of pump for lateral suction.

Connect small hot water tank with oil water heater.

Attach sink to stud wall and connect faucets.

Fill water tank and start heater.

Attach sink trap and grease trap.

Erect soil pipe, trap and vent.

In shallow trench lay short length of four inch sewer.

Show and explain forms for full sized septic tank.

Explain grades for septic tank.

Excavate for miniature septic tank.

Insert special fitting for connecting sewer to miniature tank.

Place miniature forms.

Go through form of pouring cement.

Replace miniature forms with ready made miniature septic tank.

Insert baffles.

Insert special fitting to connect miniature tank to purifying tile.

Lay three-inch purifying tile in two pairs of two short runs, using sewage switch and dividers.

Turn on hot water at the sink.

Distribute bulletins.

Discussion.

Supplementary demonstrations:

Demonstrate dosing siphon set in small glass sided tank.

Demonstrate iron pipe cutting, reaming and threading, and soil pipe cutting, leading, and calking.

Demonstrate electric lighting plant and electric driven pressure tank water system.

If a meeting of this kind is well advertized and properly conducted in a reasonably alert community, there will normally be a very good reaction. The men will go home and with the help of what they have seen and the numerous cuts in the bulletin be able in many cases to work out their own problems unaided. In many other cases, however, for one reason or another, special aid will be called for. The extension project would be left incomplete if this individual aid is not given. Requests should be recorded in the Farm Bureau office and when practically all are in they should be grouped and the extension specialist routed so that he may speedily visit each in turn, study the special problem, offer the best advice he can and pass on to the next. He should preferably travel in his own car as the county agent could hardly be expected to devote his own time to such routine work. Subsequent contact, where necessary, would be maintained by mail.

The entire project then would be divided into five stages, for as many purposes — Inspiration, Information, Stimulation, Meditation, and Realization.

Now just a word as to some technical points which might well be discussed here.

The farmer is a busy man and he should never be advised to install a complex disposal system if a simple one will work. Where a cesspool will work and there is no danger of contaminating the water supply a cesspool had best be used instead of a septic tank.

For domestic installations of moderate size, where subsurface irrigation is necessary, there is no need of distributing the effluent by means of the dosing siphon. The only requirement is that the liquid be evenly distributed throughout sufficient tile somewhat intermittently. If the tile be laid in runs not much over 100 feet in length, with a relatively heavy grade of say one-fourth inch per foot at the inlet end, decreasing to level at the other, the natural flow will give sufficiently even distribution if the amount of liquid supplied each run be not excessive. If soil conditions be such as to require twenty-five feet of tile per person served, a family of eight would require two runs of tile each 100 feet long. A special five sided concrete block, about fourteen inches on a side, and four or five inches thick, can be readily constructed with a channel in it so shaped that the small stream that flows from the tank will be forced to flow through a narrow round bottomed throat and be directed immediately against the sharp edge of the wall dividing the two channels, which diverge from the throat at this point. A duplicate or special block may form the cover, the ends of the channels being enlarged to receive drain tile of desired size. This block was designed in 1914 and described as the Cornell sewage divider in Cornell Reading Course for the Farm Lesson No. 59, now out of print. By the use of several dividers successively, the sewage stream may be divided accurately in halves as many times as may be necessary in order to distribute the liquid uniformly to the requisite number of tile runs.

If the soil be heavy, it will be advisable to have two such sets of tile and to alternate the flow at weekly or fortnightly intervals between these two sets. A V channel block like the divider, except that at the throat the channels are flat on the bottom, is used for a switch, the flow being diverted as desired by small concrete blocks cast in the branch channels as forms.

These two devices have been in use in New York for over five years and are thoroughly effective. They are cheaper and simpler than the dosing siphon and make possible the distribution of the effluent without the loss of head necessary where the siphon is employed. Where the ground is level, this makes it possible to keep the disposal tile reasonably near the surface for better aerobic action.

In the design of the tank a volume below the flow line of six cubic feet per person allows three cubic feet for the daily sewage flow and three cubic feet for sludge and scum accumulation. Since all the sewage enters the tank in a raw condition there usually develops more scum than sludge, necessitating in many cases scum removal about once in five years. At this time a small manhole is of but little service. In small tanks the entire cover should be removable as slabs. In large tanks with permanent covers, there should be left at either end a slot completely across the tank in each case, each slot being wider at the top than at the bottom so that it may be readily closed by a row of concrete blocks cast in place with paper separaters. Such openings greatly facilitate the removal of scum and by locating them over the slots for the end baffles they make possible the easy renewal of the baffle boards if necessary.

The use of single "Y" branch fittings for inlet and outlet connections commends itself for the following reasons: the part going through the wall of the tank is straight and therefore, very easy to locate in the forms and since it extends well through the wall there is no trouble in pouring the concrete. The opening at the end of the run at the inlet gives opportunity for cleaning the tile if stoppage occurs; at the outlet it is used as a gas vent opening. Baffle boards extending vertically to mid-depth at either end promote uniform flow in the body of the tank and a clear effluent.

But enough of details and minutia. There are many ways of building good disposal systems and the safeguarding of wells is not technically difficult. The main thing is to get a goodly number of farmers to appreciate the importance of these matters, and once their interest is aroused, to take full advantage of the situation and stimulate and aid them on to actual accomplishment. The project is a worthy one, well deserving of the best efforts of able workers because it has as its objective the highest of all aims, the promotion of human health and happiness.

DISCUSSION

QUESTION: Does it seem advisable in your practice to put printed material, bulletins, general information on the subject of sewage disposal, in the hands of the farmer and expect him to use his own judgment in design and installation of the system?

MR. RILEY: We started out on that assumption and wrote a bulletin, a reading course lesson, five years ago. Some of the designs of unusual types of construction had not been thoroughly tested out and were based on somebody else's bulletin. The omre unusual designs failed absolutely — and I am speaking now of a closet directly over a septic tank, which was taken from the bulletin on the sanitary privy. I know of one particular case where that caused an abominable nuisance about a home, but there have been hundreds of small septic tank installations put in by individual effort or by the effort of uneducated contractors on the basis of the general principles laid down in that lesson sheet, and with very few exceptions, well, with the exception of very few reports of difficulty, they are, so far as we know, in satisfactory operation today.

QUESTION: Do you have any great difficulty in getting the farmers to take hold of such technical information as you feel they should have?

MR. RILEY: There are a lot that don't understand it. That would be, to my way of thinking, the advantage of a series of demonstrations with the auto truck, put on, if you will, every ten miles, one in the morning and one in the afternoon, and another after the evening meal, using a miniature tank on the work, and it can be done without an excessive quantity of excavation, but then I would leave with the man some information, something that is written so the man could really get some information from it.

MR. RILEY: I would like to ask Mr. Hoffman what purifying system they recommend in Iowa. I understand they use a filter. And will you please tell me, at the same time, why you disregard subsurface irrigation.

MR. HOFFMAN: As to what method we recommend that depends on who is recommending it. The question is: shall we recommend a sewage disposal system that has the elaborate dosing chamber and the filter beds, and all that, that we feel pretty sure only one out of a hundred or maybe fewer than that will install, or shall we recommend something that we feel will be able to take care of the sewage satisfactorily and have them put in generally; and if the other kind, the complicated kind, will not be installed, is the substitute that they use for it, that is the open privy, in most cases, more satisfactory than what our simple septic tank would be? Well, I put the question up to Mr. Trullinger a couple of years ago himself, and I believe if he remembers, he came to the conclusion that it was a case where if the simple tank will take care of it that is the thing to advise.

Now we have records of over 300 single chamber septic tanks that have been put in in the state of Iowa and not a single one of them has gone wrong. I believe it is a whole lot better to put in a single chamber septic tank, something simple, that will be put in, than to recommend a complex outfit that will not be put in, because while we quarrel around over the design of complex systems these folks are either going to dump their sewage raw out into the ditch or they are going to keep on using privys.

MR. RILEY: I wanted to get the point as to the disposal of the effluent where you have to get rid of it all. I understood you to say you used a special filter.

MR. HOFFMAN: We use a line of four inch field drain tile placed over a line of the same kind of tile and separated from it by a foot and a half of sand. This ought to be in the neighborhood of thirty to one hundred feet long. Where that has been used it has been found to be amply long for the average system, the average sized family.

QUESTION: What do you use if you haven't an outlet for that lower drain tile?

MR. HOFFMAN: If we haven't an outlet we don't put in a sewage disposal system. Then it is a case where we ought to recommend a very complex system, one we know they won't put in.

MEMBER: I beg to differ with you in that respect, because I know of a great many that were put in under conditions of that kind in various parts of Wisconsin, where they have no outlet. They have an absorption system large enough so it will get away in the ground.

MR. HOFFMAN: Several years ago we had a frost that in several cases was reported as far down as seven feet, but we had no reports of our disposal systems being frozen up. Of course the septic tank itself goes down a long ways into the ground and then the warm water coming into it from the house makes it pretty hard to freeze up. What I mean is, the bottom of it goes down a long ways.

MR. RILEY: I would like to get a report of experience on the depth of laying purifying tile. We recommend shallow trenches if the ground is going to be plowed, just deep enough for the plow to clear, but a good many installations are going in with tile three feet deep.

MR. HOFFMAN: Where we have tile as deep as that it means it goes into some tile line after it has filtered through the sand filter. From there it goes into an outlet. Where we advocate the use of sub-surface irrigation I believe a depth of fifteen inches or even less than that is advisable, because we don't want it to go down; we want it to come up.

CHAIRMAN: We might ask a few of these men that are recommending installations what their practice has been. In my own case I have been recommending from fourteen to eighteen inches.

MEMBER: In Wisconsin we use about fifteen to twenty.

MR. RILEY: I have in mind a region near Ithaca where the valleys are gravelly and practically all the water supply comes from springs on hill sides. The valleys are very narrow and the water comes from ideal springs down to the houses in old lead pipe, most of it. A lot of the farmers have improved their farms; they have been running the sewage from the house into cesspools for a generation. If an extension man goes into that region and tells them they have to have a septic tank in order to have the work correct and sanitary, his stock drops to about two cents on the dollar. To refute the imputation that the extension man in rural engineering is superficial in his knowledge and not in sympathy with fundamental research, I feel certain that I voice the sentiments of every extension man in this room when I say that no one in the rural engineering profession is more keenly alive than he to the vital need of engineering knowledge that is fundamentally sound and absolutely reliable. And it is natural that this should be so because the extension man is the one who carries the findings of research to the farmer who is the ultimate consumer, and for whose benefit the research departments of the agricultural colleges and the Federal Government are maintained. It requires but brief experience in the field, however, to bring forth vividly the fact that technical advice offered to the farmer must, if it is to be accepted, be such as is exactly suited to his needs and not the least important need is his own mental attitude, due in part to the nature of his profession and in part to the environment in which he has been reared. The extension man therefore soon decides that if he is to do a reasonable modicum of good to the greatest number, he must thoroughly absorb into his own mind as much as possible of the findings of research, distill them in the retort of his field experience and condense for actual presentation only such facts as the farmer really needs to get results. In doing this he is a benefactor alike to the farmer and the investigator by vivifying and energizing the many vital truths which but for his energy and wit might in the technical records lie entombed forever.

Question: I would like to inquire of the members if anybody here has had any experience with the chemical tanks.

Mr. Riley: I had one on the farm and in order to be specific, it was a "Kaustine Outfit." After the tank was adequately charged with chemical and had been used long enough to be full I thoroughly agitated the contents and took a sample to the college and had it plated in the dairy department and they found it to be absolutely free of any kind of bacteria life. It therefore was sterile, I presume. But the fact of its sterility did not make one feel any more comfortable in pumping it out.

Mr. Hoffman: From the experience that we have had with some of the chemical toilets installed in country school houses we have been led to believe that as long as the chemical is present in sufficient quantity and strength that the material was perfectly sterile, but the human element comes in there again. It was said some time ago — suppose that father has "flu" just about the time it should be cleaned out and the thing may be let go a little too long, and it is anything but a pleasant job to clean them out, too.

Chairman: You might also say that it isn't fool proof.

Mr. Blasingame: We had the Kaustine Company put one of their tanks in the laboratory at the Pennsylvania State College. We called it a laboratory — it was used from time to time, not regularly, but we charged it with chemical and had very little trouble with it.

Mr. Riley: In this connection I think it should be noted that where these outfits are installed in school houses it would be highly desirable to vent them, to vent the riser pipe to the chimney, because there is a certain amount of odor which can be entirely removed by a chimney vent connection.

MEMBER: Some time ago the engineers of the Ohio State Board of Health made an extensive study of the subject of chemical closets. As a result of that they are absolutely forbidding their use in public schools of Ohio, mainly for the reasons which have been brought out. They are not fool proof, first; and secondly, the lack of ventilation and the poor ventilation even if the vent pipes are used, on account of the fact that the seat cover is very seldom closed and therefore the vent does not work properly. The report does not indicate that they wouldn't favor this closet if those objections could be overcome.

MEBMER: I might add that the U. S. Public Health Service takes just about the same attitude toward them.

MR. PATTY: I had a problem come up similar to the one that Mr. Hoffman named. I recommended the chemical closet there. It is the one place I think it is satisfactory.

A PROJECT IN FARM BUILDINGS

DANIELS SCOATES,[1] Member Amer. Soc. A. E.

The subject is divided into three divisions, the location of buildings, plans, specifications and bill of materials and assistance in construction.

Each subject is drawn up in the order mentioned and the writer's ideas as to how the extension work should be carried on, are given. The paper is based on the writer's experience during the nine years as Professor of Agricultural Engineering at Mississippi A. & M. College.

The Extension Work in Farm Buildings can be very well divided into three sub-divisions, i.e.:

1st. Location of buildings.

2nd. Plans, specifications and bill of materials for buildings.

3rd. Assistance in construction.

I will take these up in the order named.

LOCATION OF BUILDINGS

Assistance in location or relation of farm buildings is a service very often called for and one which is greatly needed. Many new farmsteads are coming into existence. Particularly is this true of the less thickly populated states. A specialist who can devote some or all of his time to this will render a great service. I have never been able to give one man's entire time to this work. However, I have given some attention to it and have perhaps helped a large number of farmers with such problems. The farmers, as a rule, are very grateful for such assistance. Nevertheless, I have not been able to do the job as it should be done.

It is, of course, necessary to have some one visit the farm, dis-

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cuss the situation with the farmer and make a plat of the farmstead as it is, then the suggested location should be sketched and a permanent record of all made. The farmer to receive a blue print. This project should not cease here but the progress of the location kept up with by visits made to see if plans are carried out. If they are not, reason for change should be noted. A final study of the operation of the plan, after it is completed should be made, at which time the advantages and disadvantages of the plan should be noted in order to be of benefit in similar cases as they come up. This service in farm building work is one of the most important and yet one of the hardest to furnish. The reasons for this, I think, are obvious, i.e., a trained specialist in this line is hard to find and the expense of sending a man to that part of the state where the location is to be made. Often, if due time is given by the farmer, the trip can be combined with some other calls and the expense thus cut down. I have always made it a plan to require plenty of time or else they could not have the service. All such trips are made without expense to the farmer.

PLANS, SPECIFICATIONS, AND BILLS OF MATERIALS OF FARM BUILDINGS

This is the biggest end of the farm building project, furnishing the plans of the building. And in saying "plans" let us for the time being leave out the specifications and bills of material.

The first thing to decide on in rendering this service is to say whether it is to be charged for or not. Some states require a small sum of money for each print, other states furnish the prints absolutely free. Where they are charged for — the charge is upheld upon the grounds that the prints get more attention and are not wasted. I am not so sure that the prints receive any better attention than where they are given. Then there is the expense of getting that little amount of money, which I have found is a nuisance. It will cost you as much as the print is worth to collect the price of it. Let the farmer think he is getting something for nothing. If he pays ten cents for the blueprint he may think he is paying architect's fees or the total cost of getting out the plans. I am absolutely in favor of rendering the service free to all residents of the state in which the Extension Service is given. Outsiders should pay some more than actual cost in order to get the service. It is not a great financial burden for any Extension Service to assume the entire burden. For example, in Mississippi this year approximately 8,000 blue prints 18x24 will be sent out. These will cost about five cents each to make and mail, total cost $400. Show me where $400 could be spent to a better advantage in extension work.

What should be the limit of the farm building plan service?

In other words, what buildings are you going to offer blue prints of? The Mississippi slogan is "Everything on the Farm." That's what I think it should be. Of course, when you start you are not going to be flooded with requests, but take them in order and work up plans as fast as possible. You can regulate the requests by the amount of advertising. It will be impossible to design a new barn for every farmer that comes along. It is better to work towards some standard plans that will meet the needs of the state, i.e., in dairy barns, ten, fifteen, twenty, thirty, and forty cow barns. When a farmer wants a twelve cow barn send him a standard plan for a fifteen and tell him to build with the future in mind, or else cut it off so many feet. In other cases, say in a combination barn where changes are needed, make changes on blue print in red pencil.

House plans are perhaps the most difficult to handle. Now I might digress here just a minute to tell you how in Mississippi we got our set of house plans. We designed some house plans there in the department that weren't absolutely according to "Hoyle." The architecture wasn't necessarily the best, but we had to do something to take care of the calls, so we sent those out. The leading architect in the state got hold of some of them and then he got hold of the president of the college and began to talk architecture to him. He said, "Now these plans aren't just what they ought to be, but if your man, Scoates, I don't know what kind of a man he is, is willing, I will be consulting architect for his department free of charge." So the president told me about it and I said, "You just tell Mr. Overstreet that he has a job." The next time I went to Jackson, I took a bundle of our house plans to his office. He said he would try to help me out and he sat down (he is a first class architect — the best man in the state) and he gave me two or three hours of his time sketching over those plans, and gave me a good lecture on architecture. It was an appalling job to go over the design of every house we had, so he just reached down and gave us all the plans he had in stock. He said, "You take these up to the college and trace them and send them out." I was kind of dumfounded to find how good he was about it, so I said, "Why do you do this? Where do you get off on this proposition?" "Well," he said, "I will tell you. You are sending these plans out all over the state. You are creating taste for good or bad architecture. If you send good plans out and get these people in the country appreciating good architecture, when they want school buildings and court houses and municipal buildings they will want a good architect, and they won't be satisfied with anybody who isn't, and that is where I come in." He said, "A house is a nuisance to me; I lose money on it. I haven't time to monkey with that." So the most of the Mississippi plans on houses are Overstreet's designs. In the corner are his initials or his name, and that is all he gets out of it in the way of advertising. There is quite a possibility of coöperation there with the architects of the states. Of course, in our department we all hope some day to have a first class architect.

Everyone should design their own floor plan, and that's about what happens. It takes a draftsman from one to two weeks to design a house. So standard plans are absolutely necessary. A large assortment of house plans is a costly and difficult thing to get, yet it can be attained in time. Before putting a building plan on tracing cloth, I would first consider if it was typical and if there was to be a considerable call for it. If it was just of mediocre interest, I would put it on tracing paper in pencil. Sometimes you are forced to design something that you, perhaps, would not advocate for the average farmer and yet, there will be a call for it; for example, some barn at the college. These barns are not always just what they ought to be, yet they are investigated by visitors and plans called for.

You will find a lot of farmers that will demand a certain plan and you will have to design it for them. Now you can lay down all the rules you want, but that is going to happen. In our farm building work, we had to do a lot of school house work; we didn't want to do it, but it was thrust upon us. We got over into a church one time. Well, we balked at the church proposition, but the fellow writing in for it was a leading senator in the state legislature, so we very courteously designed the church for him and sent him a blue print with the result that we got a friend in the senate.

When we have a building to design which we think there won't be a general demand for and which we don't want to put in the standard files, we sketch it up on tracing paper and send him a blue print of it. The farmer thinks a blue print is absolutely the thing.

The size of prints is another important item. Select a standard size or sizes for all prints. The ones I have used are 9x12, 18x24, and 24x36. Most of the prints are 18x24. This allows the use of thirty-six inch blue print paper and folds up nicely into a bulletin envelope. The tracings are kept in drawers and never handled except to make prints. A sample blue print of each tracing is placed in order in a large loose-leaf ledger file. The prints are posted to a linen tag which holds them in the ledger. This file is used for all reference. The accompanying photo shows two of these ledgers. They are just like the bookkeepers use for transfer ledgers. We keep those in there so when farmers come in we can refer to it. Of course the blue print paper won't stand a hole punched through them so we paste the blue print to a linen tag paper and that holds it very well.

Each tracing is given a serial number. Originally, this would show which tracing was made first, etc. Now, as old tracings become obsolete they are thrown away and new ones put in with their number on them. No attempt is made to segregate different kinds of buildings. It might be an improvement to use certain series of numbers for each kind of building.

The title on the blue prints should show the usual information such as name of structure, scale, capacity, designer, tracer, date, and name of Extension Service with the proper words to allow the use of the franking privilege.

The requests come in from specialists, county agents and farmers. When they come in from the former two, usually a very good idea of what is wanted can be obtained from the letter. Farmers, however, usually want a "40x60" barn or "all the plans you have." To overcome this, we have used questionnaires for each type of building. The attached request blank is used in sending out blue prints. The serial number of the print is placed on this blank. The date the request is received and the date sent is very important, because the farmer wants it "right away," and if the farm building work is going to grow and give service, you must get the blue prints out in a day or so. We number these requests. Number one request starts on January first. We make duplicates of this request blank. One is filed according to its number. This is in order to keep up with the number of requests. The other will be filed according to counties. Now, filing them according to counties has a couple of advantages. One of them is that it will allow you to study your state as to where your farm building extension work is in demand, and the other will help you to trace the farm building plans. Somebody will write back and want another set of plans, such as you sent them a year ago. As I had it happen in Mississippi, I got a phone call from one county agent saying, "One of your barns is falling down." I told him I was leaving on the next train, that I wanted to see that thing. The first thing I said to the farmer was, "Let me see your blue prints." Well, he didn't have them. The contractor had left town with them. I wanted to trace those blue prints and I never could find what number was sent, but if we had filed the requests by counties we could immediately have turned to Washington county and found the request. Well, the trouble with that barn was, they hadn't nailed the plate onto the posts, so of course the roof started to go. (Laughter). I finally satisfied him that it wasn't the college's fault. I went out to his corn crib that was just finished and I told him it would be in the same shape unless they got some nails into it, so he got busy and put it in shape.

Regarding specifications and bills of materials — most farmers call for plans and specifications, when he really wants plans and bill of materials, and an essay on how to build it. Bills of materials for each building should go out with the plans, but that is hard to do. However, I fixed up a standard bill of materials for farm buildings and left blank spaces for the amounts. When a bill is figured on this, it is put in a loose leaf book and from it additional bills for the building can be copied without much trouble. Whenever possible, such as in small buildings, the bill should be lettered right on the tracing. Wherever specifications are needed they should be written up specially.

ASSISTANCE IN CONSTRUCTION

Whenever possible this kind of service should be rendered. However, when given, it should be in the shape of a demonstration and every effort should be made to see that as many people as possible profit by it. When the agricultural specialists cannot furnish the assistance, often other specialists will. For example, in constructing silos in Mississippi, the Agricultural Engineers furnish the plans and bills of materials and the dairy specialists help the dairy farmers build the silos while the Beef Cattle Specialists help the beef cattle farmers. Many of the other specialists help out the same way. It is fine that such is the case and all work together so well.

You will find some cases where the farmers will let their barns be built by contractors and you will have to write up specifications. You will get hold of a school house, and it is a specification job as a rule. But keep away from the school house proposition if you can.

DISCUSSION

SECRETARY: Just a word about the way we coöperate with the county agents on the farm building proposition. We have found that when we offered this service we began to get in so many requests for blue prints that we couldn't possibly supply the demand; it runs up into the thousands. They write in and want all the blue prints you have got. So we worked up a scheme like this. We got up miniature plans that we have on 8½x11 sheets. We have had some 100 different sheets. Each sheet represented a typical structure. If it were a dairy plan we would put on the plan with perhaps a cross section or an end view or a little prospective sketch. We bound these blue prints up into sets, 100 of the different ones, with the key number, our regular filing number, in the corner for reference. We sent out to each county agent one of those sets of miniature blue prints. Now when we get a request in from a farmer that is not very definite, or wanting a large number of blue prints or something of the sort we have a series of post card forms that we mail to the farmer and to the county agent. We say: "Dear County Agent: Mr. ——— ——— of your county has sent in a request for plans for barns. Please get in touch with this gentleman and find out what kind of plans he wants." We write to the farmer and say: "Dear Sir: Please get in touch with your county agent. He has a set of plans which he will show you and aid you in the selection of the proper plan." In this way we are sure that the two men will get together, but if we leave it to just one of them, well, the county agents are pretty busy men and so are the farmers. That plan has worked out very well. I should say that this year it has saved us over $700.00 for blue prints.

MR. NORMAN: What do you think about charging for plans? I notice our friend, Scoates, doesn't believe in it, but I would like to hear what you think about it.

SECRETARY: Our auditor of state won't allow us to. We don't do our thinking for ourselves.

MR. NORMAN: I will guarantee that you won't get orders for all the plans you have from them if you do. I charge fifteen cents a sheet for blue print plans. We have disposed of some 5,000 of them this last year.

SECRETARY: We would be glad to charge for them if the auditor of state would let us, but he won't do it. He says "Too much bookkeeping."

MR. NORMAN: I don't think that the auditor of state knows what I am doing. (Laughter).

MR. KAISER: I would like to ask Professor Scoates if he thinks that the blue prints serve the purpose better than the bulletins. If you will get out a bulletin on dairy barns or poultry houses with a number of typical plans to send out to a farmer, when he writes in for the plans we give him something in the booklet to study and see about what sort of a plan he wants and then he could write for the blue prints offered in the bulletin. The bulletin also would give information for building, tell how to build the foundation and the floor and precautions concerning the framing. That is the way we conduct the Portland Cement Association. Nearly all of our plans are offered through a bulletin. Whenever we do receive a request for a plan it means in half the cases that the farmer is going to use them for buildings. When I was connected with the Iowa State College we sent out blue prints at five cents a sheet, but only in a very few cases did we have records of the blue prints ever having been actually used in erection. We send along a questionnaire for the farmer to fill out when the building is completed. So far as I know, over a period of two years, we never received one questionnaire filled out. I do know this, from experience, that when you write a letter to the farmer you have to enclose postage and stationery and envelopes and make it just as convenient as you can. But I would like to have Professor Scoates's opinion on the bulletin versus the blue print.

PROFESSOR SCOATES: Two or three things are involved there. One of them is that you can't always get your executive to finance the bulletin, but he would finance the blue print proposition because it looks like it isn't going out all at one time. There is something about a blue print that is magic. I think if you give a man a blue print he will study it much more than he will a bulletin. He is getting too many bulletins. We have found that that is about the situation. It is purely psychological.

MR. KAISER: The farmer wants to imitate the engineers and the architects whether he can read them or not.

MR. SCOATES: That is about it. You don't want to expect too much from the blue prints. If you find a building that is absolutely built according to your blue print and plans; take a picture of that and have it enlarged and put up in your office. They are very rare, as a general proposition. But I think the big job that they do is their influence for better farm buildings, that is, the resulting structure is so much better than what would have been built without the blue prints that you are gradually building up and in the course of years you will be surprised at the amount of good they will do.

MR. KAISER: I have often thought in connection with the catalog listing the plans that if we could have a small half tone of a newer plan presented along with each number it would be a big help.

COUNTRY WATER SYSTEMS

L. C. LANDIS,[1] Member Amer. Soc. A. E.

The paper sets out in a brief way the early methods of handling water on the farm, together with mention of the different methods which are now employed. It also goes into some detail with regard to the number of plants which are now in actual operation and the field in general for the sale of water systems, together with a brief statement showing the loss which is being sustained by the American Agriculturist through the lack of adequate facilities for watering. The paper urges that, for the reason that an enormous amount of money is being lost every year, all members of the American Society of Agricultural Engineers should encourage wherever possible, the making of these improvements.

Country water systems may be divided into three distinct classes. (1) the gravity storage system, which takes in the elevated storage tank and underground reservoir, which are located higher than the points to be served.; (2) the hydro-pneumatic storage system, and (3) the "Direct from the Well" or non-storage system.

The first country water systems of which there is any record

[1] Milwaukee Air Power Pump Co., Milwaukee, Wisc.

were, as a general rule, springs located on higher ground than the buildings.

The water was conducted through wood troughs into the basement and to a storage tank or barrel, provided with an over-flow to take care of the surplus water. This was a very satisfactory system for cooling purposes, laundry work, etc., but was dangerous from a hygienic standpoint, for the reason that the troughs through which the water passed were subject to contamination from dirt carried into them by the wind, and by barn yard fowls and domestic animals.

After iron pipe came on the market, this plan was much better as the conductors could then be buried under the ground and where the source of supply was higher than the buildings, water could be piped to the upper floor in much the same manner as at the present time.

The underground storage system is still used in hilly localities, where the conditions are favorable and if proper sanitary precautions are taken, makes a very satisfactory plant, for the reason that there is no machinery to care for and no operating cost, except the replacing of the pipe every fifteen to twenty years.

The elevated storage tank soon followed the underground storage system. This method is used extensively today and has many advantages, as well as some draw-backs as compared with the newer methods.

The fact that the elevated tank may be made any size and that it may be "elevated" any height, thus providing any desired pressure, is perhaps its most prominent or outstanding advantage. In many cases it is desirable to have a large volume of water stored, which is immediately available for fire fighting or for supplying large institutions, small towns, villages, etc.

The disadvantages are the freezing in cold climates and the warm stagnant water in warm climates. If the tank is made frost-proof, the expense of construction for ordinary farm use is, for the same capacity equipment, usually much more expensive than either the hydro-pneumatic or non-storage method.

About twenty-five years ago the first hydro-pneumatic plants were placed on the market. The designers learned that by forcing water into a closed iron or steel tank, that the air would be compressed on top of the water and form stored energy or power to deliver the water out of the tank. By pumping the tank two-thirds full of water, a pressure of thirty pounds per square inch would be attained — three-quarters full forty-five pounds, etc.

This system is in more general use today than the underground or elevated storage systems. The low cost of installation where only a small amount of water is needed, is the outstanding feature of the hydro-pneumatic plant, as the initial cost, where hand power is used, is as low as $75.00 for a tank and pump, less the piping and fixtures. The tank must be protected from freezing and is usually placed in the basement or buried in the ground. Provision should always be made for cleaning the tank to prevent contaminating the water, on account of slime, mud and other foreign matter settling in the bottom of the tank.

About twelve years ago the first non-storage or "Direct from the Well" plant was placed on the market. Hydraulic engineers, many years ago, recognized the advantages of this method and U. S. and foreign patents were issued covering the mechanical features of the pneumatic pump, as early as 1847. Today there are perhaps 250 patents issued on different devices of this character, but only some five or six have been perfected to a point where they are considered merchantable.

In order to install a "non-storage" water system it is necessary to have an air reservoir or tank, an air compressor, with power to operate it, a set of fittings, such as pressure guages, air, and water valves, air and water pipe and one or more pneumatic pumps. Air tanks, air compressors, power, valves, guages, etc., are generally well known and understood, but pneumatic pumps are not so familiar to most of us, for the reason that they have been on the market only a short time.

The principle of operation of a pneumatic pump is the forcing of water out of a closed receptacle by the use of compressed air. By filling an ordinary range boiler with water and introducing compressed air at forty-four pounds pressure, at the top and connecting a discharge water pipe at the bottom, the water would be forced out of the tank and elevated 100 feet, since the weight of a column of water 100 feet high is forty-four pounds per square inch of area exposed.

The principle of operation is simple enough, but the first inventors soon discovered that the mechanical construction of the necessary water and air inlets and the air exhaust valves, was a very difficult problem to solve.

In order to be practical, the pump must be automatic in operation. In other words, the pump must start delivering water the instant a faucet is opened at any point in connection with the system and stop when all outlets are closed, but thanks to American (I say American, for the reason that there are no foreign-made pneumatic pumps on the market) inventive genius, the problem has been successfully solved and there are today about 30,000 American agriculturists enjoying the benefit to be derived from the use of the "Direct from the Well" equipment.

The first pneumatic pump brought out was "double cylinder," consisting of two water chambers. While water was being forced out of one cylinder or chamber, the other was filling. Experience in the field soon taught the manufacturer that they were too delicate and too complicated to be practical, under the various conditions where they would be used. The water from many wells contained sand, iron, lime, and other foreign substances, which would soon interfere with the fine valve adjustments, which were necessary in shifting or changing the air automatically from one chamber to the other.

Frictional parts must be eliminated and the construction must be so simplified that ordinary mechanics could make any necessary repairs or adjustments.

About five years ago the first single cylinder pneumatic pumps were brought out. This construction eliminted the troublesome shifting mechanism used in the double cylinder pumps. Only one air inlet, one air exhaust or air outlet and one water inlet were necessary. A couple of ordinary copper floats with air and water pressure did all the work.

I would like to show cuts of several of the early models, but remembering our secretary's recent bulletin asking us to *cut* the cuts as much as possible, I will show only two of the later single cylinder pumps, together with a description of their operation.

MODEL X

STARTING WITH CYLINDER FILLED WITH WATER

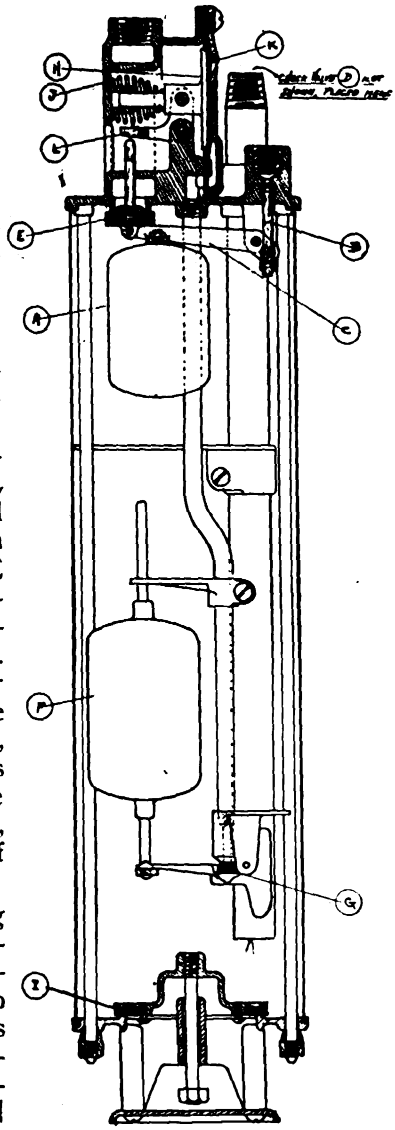
In this position, float A closes exhaust outlet and opens cylinder to air supply through arm C and air inlet needel valve B.

As water is driven out of the chamber through check valve D, the air pressure retains air exhaust valve E in place until water reaches its discharge limit and float F drops, opening valve G, which permits water pressure to operate diaphragm and member H, which in turn opens exhaust valve E through member L.

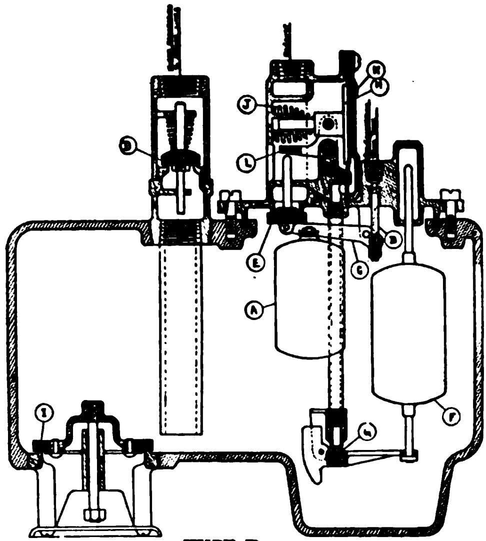
Spring J then returns diaphragm and members H and L to place, expelling the trapped water back of diaphragm through bleed hole K. Valve E then hangs open, due to weighted float A and shuts off air inlet by means of needle valve B.

When air is exhausted, water flows through inlet I and while filling cylinder raises float F, closing valve G and also raises float A, closing exhaust valve E and opens air inlet valve B, which again starts the flow of water.

Model "X" is now being built for four inch or larger inside diameter wells and in delivering capacities from 400 to 3,000 galonsl per hour. This model can be built for any capacity, providing there is sufficient space at the source ofl water supply to place it.



TYPE X PUMP


TYPE R

(Description of Pump "X" applies to Pump "R" also.)

Model "R" is designed for soft water cisterns and other places where there might at times be only eight inches to twelve inches of water in which to place it and is known as a "shallow water" pump.

It will be noted that there are no fine valve adjustments and that there are no frictional parts. The operation is governed entirely by floats A and F.

This pump should last longer, working under the same conditions, than any deep well plunger pump, for the reason that friction has been entirely eliminated.

From the fact that compressed air is the power or stored energy which operates the pump, the following simple rules will be of interest to those who have not given the subject consideration.

Pressure in the tank or reservoir will be attained at the ratio of 15 to 1 as to its capacity or by forcing 100 gallons of "free air" into a 100 gallon tank, 15 pounds pressure will be attained, 200 gallons 30 pounds, 300 gallons 45 pounds, etc., therefore, to find the number of gallons of free air necessary to attain a desired pressure in a tank, divide pressure desided by 15 and multiply by capacity gallons of tank. Example: To attain a pressure of 100 pounds in a 42″x14′ — 1,000 gallon tank, 100 divided by 15 equals 6⅔x1,000 equals 6,666⅔ gallons of "Free Air."

To compute the capacity of an air compressor in gallons, multiply the area of the cylinder by the length of the stroke and by the number of strokes per minute, divided by 231 cubic inches per gallon.

Example: A 6″x6″ single cylinder air compressor at a speed of 200 R. P. M. would deliver, 6x6 equals 36x.7854 equals 28.27 (area)x6 equals 169.62x200 equals 33,924 divided by 231 equals 142½ gallons or a trifle over 19½ cubic feet per minute.

To find the time in minutes required to charge a tank to a given pressure, divide the number of gallons of free air necessary by the capacity of the compressor.

Example: To charge a 42"x14'——1,000 gallon tank to 100 pounds pressure using a 6"x6" single cylinder compressor operating at a speed of 200 R. P. M. 6,666⅔ (100 divided by 15x1,000 equals 6,666⅔) divided by 142½ (6x6x.7854x200 divided by 231 equals 142½) equals 46½ theoretical or approximately fifty minutes actual time.

In delivering water by the use of direct air pressure, a volume of water will be delivered by the consumption of an equal volume of compressed air at the pressure being used plus 15, or in other words, if 45 pounds air pressure is being used, one gallon of water will be delivered by each four gallons of "Free Air" consumed.

From the fact that it requires forty-four pounds pressure to lift or raise water 100 feet, it will be readily observed that the delivering capacity of a given tank at a given pressure will be in direct proportion to the lift, in the ratio of one gallon of water to four gallons of free air used at a 100 foot head, provided, however, that the water discharge pipe is sufficiently large to take care of practically all friction. (If a faucet pressure of fifteen pounds should be required, the ratio would be 1 to 5).

Careful experiments by the leading compressor manufacturers show that one-fourth H. P. is required to deliver one cubic foot of free air per minute against 100 pounds pressure. It is, therefore, advisable in estimating the power necessary, to figure one H. P. for each four cubic foot capacity of the compressor where a maximum of 100 pounds pressure is desired.

The following table shows the number of gallons of water that may be drawn at lifts from twenty feet to 100 feet by compressing air to 100 pounds in each of the five standard size tanks.

30"x5' 180 Gal. Tank	36"x6' 315 Gal. Tank
20 ft. lift— 610 gallons	20 ft. lift—1060 gallons
40 ft. lift— 410 gallons	40 ft. lift— 715 gallons
60 ft. lift— 290 gallons	60 ft. lift— 505 gallons
80 ft. lift— 210 gallons	80 ft. lift— 370 gallons
100 ft. lift— 155 gallons	100 ft. lift— 270 gallons
42"x7' 500 Gal. Tank	**42"x10' 720 Gal. Tank**
20 ft. lift—1680 gallons	20 ft. lift—2420 gallons
40 ft. lift—1136 gallons	40 ft. lift—1630 gallons
60 ft. lift— 800 gallons	60 ft. lift—1150 gallons
80 ft. lift— 590 gallons	80 ft. lift— 850 gallons
100 ft. lift— 430 gallons	100 ft. lift— 620 gallons

42"x14' 1000 Gal. Tank
20 ft. lift—3360 gallons
40 ft. lift—2270 gallons
60 ft. lift—1600 gallons
80 ft. lift—1180 gallons
100 ft. lift— 860 gallons

The following material is necessary to install an average capacity plant, outside of piping and power:

1 pneumatic pump with expansion chamber (500 gal. per hr.)
1 36"x6' 315 gal. tank (extra heavy, 150 lb. test)

1 3½"x4" double cylinder air compressor, 22" wheel (8 cu. ft. capacity)
4 compression grease cups
1 ⅜" pressure reducer (double acting)
2 3½" pressure guages
1 ¾" safety valve
3 ⅜" special globe valves for air
2 ⅜" drain cocks
1 ¾" angle check valve (special)
1 1" gate valve for water
1 ¾" special globe valve for air
1 3"x16' Balata belt with lacing.
2 H. P. necessary to operate.
Cost of plant F.O.B. factory $329.00 (less power).

Plants for farm use cost from $250.00 to $750.00, depending on size and capacity of equipment.

The outstanding features of the "Direct from the Well" are:

First. Water direct from source of supply to faucets, thus insuring even temperature and freshness at all times.

Second. Flexibility. Plant and power may be located at any point desired, where engine or motor may be utilized for other work, regardless of the distance to the location of the well or other source of water.

Third. Two or more wells may be pumped from one tank and power plant, regardless of where they are located.

Fourth. An even pressure is maintained at all openings by the use of a pressure regulator, which is placed on the air line.

Fifth. Under average conditions, a much larger volume of water may be drawn with a given capacity tank than where water is stored in the tank.

CONCLUSION

The question of Country Water Systems should be of vital interest to all agriculturists at the present time.

The granaries of the world are empty today. We are told that the H. C. L. is due to underproduction and that underproduction, agriculturally speaking, is due to scarcity and high cost of farm labor, yet, the actual waste of feed and loss of time, caused by the lack of water systems on the farm, is almost unbelievable.

Careful experiments made by state agricultural colleges, county agents and individual dairy cow breeders, show, beyond any question of a doubt, that the milch cows will produce from three to ten pounds more milk each per day, on the same feed, where water at a temperature of from forty to forty-eight degrees is available at all times, than where water is supplied two or three times a day.

The U. S. Department of Agriculture report dated January 1, 1919, showed that there were at that time 23,467,000 milch cows in the country. We, of course, realize that all milch cows are not dairy cows. We will, however, take the lowest reported gains and figure three pounds of milk per cow. 23,500,000 cows at three pounds each would be 67,500,000 pounds more milk per day. Three cents per pound is certainly a conservative value, which would mean a saving or gain of over $2,000,00 per day or $730,000,000 per year.

According to the U. S. Census Bureau there are over 6,000,000 farms in the United States. Water in the barn and house will certainly save one hour's time per day per farm or 6,000,000 hours per day. Twenty cents per hour is not a high price to pay for farm labor, which makes another $1,200,000 per day or $438,000,000 per year, which is wasted in money alone, to say nothing about the loss by sickness on account of bad sanitary conditions which now predominate in the rural districts.

There is unquestionably a large loss sustained by the producers of beef and pork through lack of adequate arrangements for watering, but take the two items mentioned and there is a loss of over one billion dollars a year to the American farmer. Estimating the average cost of a farm water system as being $500.00, the loss would pay for a water system for every one of the 6,000,000 American farmers in just three years.

According to the best data obtainable, there are approximately 250,000 water systems now in use on farms in the United States, 90,000 of which were purchased during the last twelve months. This shows that the American agriculturist is beginning to realize the fact that he has been overlooking a very important subject.

The causes for this increase are very well set out in a recent report issued by the Research Department of "Domestic Engineering," which is as follows:

"A. The great demand and consequent high prices during the World War caused the American farmer to put forth exceptional efforts to increase his acreage, and per acre crop in order that he might take advantage of the unusually high market prices. In fact, he wanted to 'make hay while the sun shines.'

"B. But, even before the war, the farmer was beginning to equip his farm with improved machinery. The tendency of farm labor to flow toward the city made this necessary. Increased costs of land, implements and materials tended to weed out the inefficient farmer.

"C. Then, too, the rural carrier, the telephone and the coming of automobiles at a price within his reach, educated the farmer to a higher standard of living. He travelled more, and came in contact with people who had improvements. He found that hauling by truck to town over improved roads (for the coming of the automobile brought road improvements) was far cheaper and more satisfactory. He became more and more acquainted with gasoline engines and their possibilities. His farm journal carried advertisements for modern machines; experts from agricultural schools, and regular bulletins from his state agricultural college, together with county agents, gave him many new and practical ideas.

"D. But the Farm Loan Act, and the development of farm associations for marketing are what finally brought him greater returns, and a better financial standing, so that he could buy without cash or paying exorbitant interest rates.

Of course, one of the most important factors is the development of water supply systems to the point of comparative simplicity, and to an initial cost and operating expense low enough to be met by the average farmer and still give long and satisfactory service."

The one thought I wish to leave with you is that our friend, the American farmer, is losing money by producing less and in consequence, is increasing the H. C. L. if he overlooks this important improvement, and that we, who are all interested in agriculture and agriculturists, should not overlook an opportunity to do "our bit" in giving the subject publicity.

DISCUSSION

MR. EKBLAW: May I ask if you have figures on the cost of pumping water by this system?

MR. LANDIS: That is quite a hard question to answer without a specific case. If you talk efficiency I can tell you what the figures are, about sitxy to sixty-five per cent. The cost of pumping depends upon the height of the lift. The efficiency is around sixty per cent, or about twelve to fifteen per cent less than a direct pump.

MR. EKBLAW: Where you have to have a 100 foot lift, what would be the cost of pumping 100 gallons with a gasoline engine and a cost of twenty-five cents per gallon for gasoline?

MR. LANDIS: It would cost you close to ten cents a 1,000 gallons to pump the water.

QUESTION: What is the depth of water required for this to operate in?

MR. LANDIS: The model shown in Fig. 3 will work in eight inches of water. On the other type, from twenty-eight inches to three feet are required.

MR. EKBLAW: What is the smallest diameter of casing this can be used with?

MR. LANDIS: Four inches is the smallest type that is practical. We are now experimenting with three inch wells. I have a pump model in the case here which I can show any of the gentlemen that might be interested. This is a pump to put in a four inch well.

QUESTION: Did the price include an allowance for depreciation?

MR. LANDIS: You have to figure that on any proposition. I am figuring on ten cents a thousand gallons just the actual cost of operation. The depreciation on the gasoline engine and the air compressor will be the only other depreciation, because the tank doesn't depreciate. A steel tank, if kept painted, will last a life time.

QUESTION: What is the affect of quicksand in the water?

MR. LANDIS: That should be kept out of the pump. With any pump quicksand will cut the valves out. We make a special sand screen, lengthening out this screen here, and bringing it down so the area of the intake is the same. The first thing we do is to get rid of the sand, and that can be done, in almost every case.

QUESTION: I suppose it is a hard question to answer, but it is a question that we have to advise on sometimes, and that is as to how much trouble a farmer is going to have with the pump. The report has been abroad with the older types that they will get out of order very quickly. Have we any number of years of experience to base our statements on and guide us as to the trouble a man is going to have?

MR. LANDIS: We operated a No. 4 pump in an actual test in our factory, and the pump ran for thirteen months without stopping, and it was pumping sand, too. In that thirteen months, operating constantly, day and night, without once being allowed to stop, that pump pumped as much water as the ordinary farmer would use in fifteen years.

The first pneumantic pumps, I may say, that I have had the honor, or the dishonor, of assisting in installing and manufacturing were built twelve years ago. It was sold to Mr. J. C. Bauer, living near Naperville, Ill., in this state. Those pumps were just as crude compared to the modern pump as were the first automobiles compared to the modern touring car. The friction was the main trouble with the pneumatic pumps constructed in the early days. In the No. 4 pump the entire operation is governed by that float. You have no piston or plunger which gave trouble with the first pneumatic pumps. This float will drop down until valve B is closed. It may drop down a quarter of an inch or a half inch. We claim that this pump as constructed will last as long, if not longer, than any common well pump. It can be repaired just as easily, too. Sometimes the farmers put the pumps down into the mud and get them so full of mud that the floats will not operate. But if the farmer will take the tube off with a bicycle wrench and wash the sand and mud out it will work all right again. The demand for these pumps is something wonderful, but they must be simplified to a point where they will give continuous service and must be so simple that the average farmer can take them apart and locate the trouble and remedy it. I feel that today there are several pumps which are merchantable pumps, pumps that can be sold and the company will back them up and make good any statements they make concerning them.

MR. EKBLAW: I recently made a little survey on the fresh water pump proposition. I have a number of letters in the office from men that have had the older type of pneumatic pump in use. There was only one man that said the system didn't give perfect satisfaction. I think that is a pretty good record for the pumps which Mr. Landis says he had the dishonor to be connected with.

MR. JONES: Can you state whether it is practical to use these air systems in connection with the current from farm lighting plants? That is to say, whether a generator, as a motor, and compressor installation of such small size as not to constitute an undesirable load on a storage battery will operate satisfactorily?

MR. LANDIS: For very small consumptions, yes; for large consumptions, no. If a man wanted to use, at a moderate lift, only a hundred gallons of water a day, then it is all right to use them in connection with a storage system, but where 1,000 or 2,000 gallons a day is to be used, it is cheaper to get power direct from the engine. You have simply another stepping down of your power, which means a loss of power in every case. You can't, to illustrate, with a one horse power engine operate a generator that will let one horse power out the other end of it. That is why our method is a little lower in efficiency than the direct pumping method; when we use the genergy out of the tank we step it down again. The same thing is true of your farm lighting system. Where only a small amount of water is needed it is practical, but not for large plants.

AGRICULTURAL ENGINEERING EXTENSION WORK IN MISSISSIPPI DURING 1919

DANIELS SCOATES,[1] Member Amer. Soc. A. E.

This paper deals with three special phases of agricultural engineering extension work that was taken up in Mississippi during the past year. The three projects were: Mississippi Retail Hardware and Implement Association, Washing Machine Campaign and Junior Farm Mechanics School.

The Hardware Association was reorganized and given new life to the benefit of both the association and the extension work in the state. The Washing Machine was put on the map in the state because the women needed it. The Junior Farm Mechanic School brought 681 farm boys to the A. & M. College for 10 days to study gas engines, farm machinery, tractors and other mechanical problems of the farm.

There are three special phases of the Agricultural Engineering Extension Work in Mississippi that I shall call to your attention. These three projects are Mississippi Retail Hardware and Implement Association, Washing Machine Campaign and Junior Farm Mechanics School.

MISSISSIPPI RETAIL HARDWARE AND IMPLEMENT ASSOCIATION

To be successful in Extension Work, it is absolutely necessary that you have the coöperation of every agency which can assist in the work to be done. In Mississippi, the extension organization has the coöperation of almost every agency in the state that can be of assistance. It is of course "up to" the various specialists in extension to see that the special agencies that can help them are selected and "gotten in line." The Agricultural Engineering force realized two or three years ago that the Hardware and Implement Dealers of the state could help them immeasurably in putting across their campaigns. Accordingly, these dealers were put on their mailing lists and one of the A. E. specialists attended their conventions. In every case, the specialist was accorded the privilege of the floor and in his talks would explain the extension work and usually some particular extension campaign which was on at that time. Resolutions were, as a rule, adopted by the association supporting the work.

Up to this time the association was known as the Mississippi Hardware Association. It was not a strong organization, due to the fact that no one was giving it much attention. There was no driving force behind it, and as small associations cannot support a full time secretary they must depend on someone to give part time. The Agricultural Engineering Extension force felt that perhaps an Implement Association in the state would be of considerable help to them in getting before the farmers the better farm machinery idea. The members of this association could

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be gotten together and demonstrations given, etc. The dealers were circularized on the proposition and the responses showed quite a demand. Hence in February, 1918, a convention was called at the college and the Mississippi Implement Dealers Association was formed, with myself as secretary. A very good program was rendered and a fine start was made. In May of that same year the Hardware Association met at New Orleans and appointed a committee to approach the Implement Association with the idea of consolidation. At a meeting of the Implement Association in July of that same year, this consolidation took place with the resulting organization being known as the Mississippi Retail Hardware and Implement Association. I was elected secretary. I accepted this responsibility, feeling that it was my duty as a member of the college force to see that it was put on its feet, and further realizing that it offered a wonderful opportunity to extend the extension work.

This organization work was an entirely new game to me and it took considerable study and work to get onto the points of contact. But all this paid, and paid "big."

The consolidated association started with about fifty members and in a year had worked up to about 100. New life and spirit had been brought into the association and I feel sure that it is going to accomplish good things in Mississippi. My experience shows the following advantages to be obtained by the college by having their Agricultural Engineering Department closely identified with the State Retail Hardware and Implement Association.

First. It absolutely sells the hardware and implement dealers ideas to the force. The average extension worker and farmer has not studied the hardware dealers idea and his place in the community — hence, they do not appreciate his full worth. The cry today is to cut out the middleman and get close connection between producer and consumer. The conclusion jumped to is that the hardware dealer is not a producer and should be cut out, but economists tell me he is a producer. Anyway apply this test to your dealer controversely — what would happen to the farmers of any community if all the hardware and implement dealers were taken out of it? Study the service he renders, the quality of his goods, and his mission before condemning him. Your hardware dealer is an absolute necessity and the sooner a state or nation comes to that point of view, the more prosperous it will be. The collective buying of hardware and implements is dangerous unless it is handled through your dealer. Remember that the community must support the hardware dealer if he stays in business, regardless of his volume of business. So do not let a community "kid" itself into believing that it is not "paying the fiddler."

Second. The association offers an excellent source of contact between the extension work and the farmer. To get anything "across" to the farmer these days, it is necessary that it be given to him two or three times. (This is not only true of the farmer but everybody in fact). Your specialist may talk to the farmer, he may read it in the paper, but if in addition to this, the banker or the implement dealer tells him the same thing, he begins to think about it, at least. Did you ever realize that the hardware dealer talks to your farmer perhaps more often than any other dealer? Hence the farmer is perhaps more friendly with the dealer and will seek his advice quicker.

Third. The assistance of the association in getting proper financial support from the legislature is worth considering. These associations usually have legislative committees which assist the state legislature in framing desirable laws, and defeating undesirable ones, that affect the hardware and implement business. Such a committee can assist with the college and extension appropriations and other legislation fostered by these forces. Then too, the individual members of the association by being in close touch with college affairs can be of considerable help in creating sentiment for proper support.

Fourth. The association can assist the Agricultural Engineering Department in getting equipment. The members, by visiting the department, can make suggestions as to the types of machines that they would like to see in the department laboratory. If it is not easily obtained from the manufacturer, usually a word from one or more dealers will bring it.

These are a few of the benefits to be derived by the college. Now what does the dealer get out of it?

One of the missions of the Agricultural Engineering Department is to encourage more efficiency in farm work and better living on the farm. This all calls for implements and hardware. Therefore, the dealers by tying up close to you will have increased business. They get the best and biggest advertising at a very small cost. If their association is a small one and they persuade the Agricultural Engineer to become secretary, they obtain, as a rule, a very efficient secretary and their association prospers.

I shall not attempt at this time, to define all the benefits the dealer gets from a live association. It will suffice to say that he gets more than his money's worth and the association is a vital need.

I am, therefore, of the opinion that every Agricultural Engineering Department should, if they have not already done so, get in touch with their state hardware and implement association and work with them. Investigate carefully the dealers mission and his point of view.

WASHING MACHINE CAMPAIGN

Another mission of the Extension work is to help out in acute situations that develop in their field.

One year ago, Miss Susie V. Powell, state leader of Home

Economics Agents in Mississippi came to me with the state's need of clean clothes. She explained that due to the shortage of female help, housewives were having considerable difficulty in getting their washing done. In some instances clothes were being shipped hundreds of miles to city laundies, and very high prices being paid while in other places it was just impossible to get the work done at any cost.

After studying the situation, two lines of procedure were decided upon. One was to advocate the installation of community laundries such as Wisconsin has and the other to put on a state wide campaign to encourage the use of home washing machines. Mississippi has never used many of these machines and people did not understand that they existed. This state campaign for the use of home machines I will discuss.

The campaign was to be carried on through the Home Economics Agents. So the first thing to do was to demonstrate to these agents the benefits, practicability and different kinds of home washing machines. The annual meeting of the agents was held in February and one of the features of their program was to be this home laundry problem.

I invited all the washing machine manufacturers to send me one machine each, on consignment, freight prepaid, for the demonstration. I got about fifteen. Through the correspondence I discovered that there was an American Washing Machine Manufacturers Association with headquarters in the Otis building, Chicago, Ill. Mr. Raymond Marsh is secretary of the association and should any of you want to get in touch with the washing machine manufacturers for any reason, I suggest that you take the matter up with Mr. Marsh, as he is a fine fellow and one who appreciates the extension work.

With these fifteen machines we got Mr. Marsh to come to the annual meeting. He presented the washing machine situation to the agents in a big way and at the same time, he was able to give the Agricultural Engineering Specialists considerable information regarding washing machines. At this annual meeting, besides having Mr. Marsh talk, the various machines were demonstrated. There was considerable doubt present as to the ability of the machines to do a good job of washing. In order to settle this forever some old dirty greasy overalls were run through one washer, while another one was washing some children's white clothes and still another some fine dresses. This demonstrated beyond question the ability of the machines to take care of a family wash. Power and hand machines of various kinds were shown, explained and used. Then one afternoon the agents themselves operated the machines. This gave them opportunity to get familiar with them by actual use. The next step in the campaign was meetings of the women of the different communities called by the agents on their return home. The agents also got the local hardware dealer to order one machine to use in a demonstration and we sent an agricultural engineer to demonstrate this machine and lecture on washing machines. A set of lantern slides was used by this specialist in the work. The Western Electric Co. loaned a film which was also used with excellent results. One man was on the road giving these demonstrations from February until May. The result is that washing machines are sold in carload lots in Mississippi, something unheard of before. The hardware dealer was circularized two or three times regarding this campaign and he helped out materially in making it the success it was. We were very careful to link him up with it.

JUNIOR FARM MECHANICS SCHOOL

Last February, the state director of the Boys' Working Reserve came to us with a proposition of holding in each county in the state a ten days' farm mechanics school. At this school nothing but farm mechanics, gas engines, farm machinery, etc., to be taught. In order to have sufficient teachers for these schools, he wanted a two weeks' course given by the Agricultural Engineering Department in these subjects. He proposed that the course be given at the college in June and that there would be 100 to 150 boys in attendance. These boys were to be the teachers. We agreed to take care of it.

So he traveled all over the state to get up the crowd. The outcome of it was he got about a dozen boys at the college for the course.

Fig. 1. Tractors were a great joy to the boys.

Mr. C. A. Cobb, the assistant state agent in charge of boys club work in the state was attracted by the idea and he asked us if we would offer such a course to the club boys. We agreed to put on such a course; the time agreed on was August 18 to 27. The number Mr. Cobb asked us to be able to take care of was 200. The failure in attendance of the Boys Working Reserve School to offset Mr. Cobb and his co-workers' enthusiasm made us get ready for 200, as a maximum. These club workers organized their campaign for students in a very effective way. They got out considerable printed matter, such as posters, bulletins, circular letters, and newspaper articles. In order to finance the boys' trip to the course they asked each member of the state Hardware Association to pay one boy's way. They asked bankers, commercial clubs, etc., to do the same. The total expense of any boy was the amount of his railroad fare plus the $6 he was charged by the college for board and room for the ten days and any spending money he wanted. The business men rallied to the call and when the day came for the course to open, letters, telegrams, and telephone calls came in from county agents asking that room be reserved for their boys. The boys came in autos, wagons, trucks, and by train. When the course finally started and noses were counted it was found there were 681 on the grounds. You can imagine the trouble that resulted from a teaching standpoint. We got together with President Smith to see what could be done. It was decided to use everybody that would and could help — county agents, extension specialists in other than engineering lines, engineering professors and in some cases other professors. For example, the professor of drawing gave valuable assistance in teaching belt lacing which he learned while teaching it to the boys.

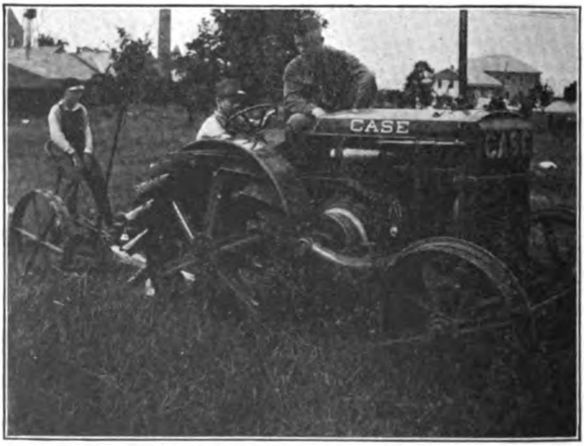

Fig. 2. Learning to drive a tractor.

Our history "Prof." tried to help in pipe fitting but it was too modern and he gave up in disgust. With all the instructors that could be gotten together it was found that the only solution was to handle them in large groups. The entire corps was divided into squads of twenty-five each and each squad was given a leader and a number. In the shifting from one class to another a squad was considered as one man. These squads were shifted in most cases each half day, in order to keep up interest. The routing of the squads from one class to another was in the hands of a special man. He kept up with what each squad had studied and saw to it that they never got the same work twice or that one instructor got more students than he could handle.

Roll call was easy because each man was given a number when he registered. The squads were numbered according to the numbers of the students, i.e., students Nos. 1 to 25 was squad No. 1; Nos. 26 to 50 inclusive was squad 2, etc. Absences were turned in each half day and an absolute check was kept on each student. The subjects taught were divided into groups and each group was under a competent head instructor.

Group 1. Farm machinery — plows, harrows, planters, mowers, and rakes. Tractor operation.
Group 2. Gas engines.
Group 3. Belt lacing and rope tying.
Group 4. Terracing and washing machines.
Group 5. Fencing.
Group 6. Pipe fitting.

The idea in Group 1 was to give lectures on the different kinds of farm machines and also to give practice in the operation in the

Fig. 3. Teaching 200 boys at a time to lace belts.

field, while with tractors, operation, and adjustment was given. We tried to limit the number of students in this group at any one time to fifty students to an instructor.

The idea in Group 2 was to teach them the different parts of a gas engine and how to operate one successfully. The limit of students at any one time, in this, was twenty-five to an instructor.

In Group 3 we used a belt lacing card which the Agricultural Engineering Department at the University of Wisconsin developed and by its use we taught 200 boys at once with two instructors. To accommodate the crowd we used the grand stand at the athletic field. In rope tying we gave each man ten feet of rope and taught him the various knots. We could in that way with three instructors take care of 100 to 150 boys at a time.

Group 4 taught how to run the level and lay out terraces and the limit was twenty-five to an instructor. Usually had 100 to 150 boys on the field at once in this work.

In the washing machine work fifty boys at once was the limit. The idea was to teach the boys how to operate a washing machine. This was included in the course in order to link the washing machine campaign up and carry it on.

Group 5 was the fence work. The American Steel & Wire Company sent Mr. E. M. Ryan, one of their special representatives, and by the way, a good one to handle the work. Mr. Ryan did not talk to the boys much but rather he had them build a fence. The work was very effective. We were anxious to have this work, because of the lack of good fences in the state, and because a state wide fence campaign was at that time in progress.

Group 6, pipe fitting, was in charge of a mechanical engineering instructor and he did a good job. We had to give him fifty at a time but got good results. We were anxious to have this work given because of the lack of waterworks in farm homes.

The boys worked six hours per day. In the morning from 8 to 12 and in the afternoon from 1:30 to 3.30. After 3:30 they had an elaborate play program as to base ball, volley ball, foot ball, basket ball, etc. But after the first three or four days those in charge of this play for the boys gave up in disgust. The boys played so hard at their work they were too tired to play. At the Agricultural Engineering Building we found it difficult to get the boys to leave at 3:30; they wanted to hang around and get more. It was a paradise to them. All their life they had wanted to have "carte blanche" to play with a gas engine or a tractor all they cared to and here it was — so they were not going to let it go without getting all they could.

Perhaps some of the problems other than teaching in handling these boys would be interesting. Of course our understanding in both these courses was that we were to take care of them only during the six hours they were working, and our responsibility ceased after that.

The mess hall prepared for 200 and didn't altogether understand a boy's appetite. The result was that the boys in one day ate up all the provisions they had on hand for the entire course.

In the housing they found that a number of the extension men had to sleep in the dormitories with them and eat with them. Not much trouble was experienced. One suggestion developed as a result of the course and that was that boys of different ages be separated, as there was a tendency on the part of the larger boys to "bully" the smaller ones.

There was a bank provided for them and they all had to deposit their money in this bank when they came. This cut out most of the stealing.

When the course was over the boys went home highly pleased with their visit. The net result of the course was that possibly a little agricultural engineering information was scattered out over the state. Anyway a large number of homes had found the source of supply. The boys had seen the A. & M. College and many of them, no doubt, will come back and take a course. These boys taking home their impressions of the college will cause it to be better understood over the state. In fact, it was a great ten days for all who entered into it. It seems to me that this boys' work is another opportunity for the agricultural engineer. The boys like this kind of work and everything possible should be done to train them in it.

MY IMPRESSION OF FARM MACHINERY IN THE SOUTH

E. R. Gross,[1] Member Amer. Soc. A. E.

With cotton a chief crop and the negro tenant system prevailing, we find a great many small one-horse machines and even hand tools used. Scarcity of labor makes it necessary to improve this situation. This is possible, for even the negro is desirous of using larger machinery. Larger machines will increase man production tho it may reduce acre production.
In cotton delinting and selecting seed, the use of better planters will reduce labor. Flat tillage should replace ridge tillage in many cases.

As my stay in the south has been short, I can truly speak of my impression of farm machinery in the south. I do not in any sense expect to find the same kinds of machinery nor the same uses made of machinery in agricultural lines in any two regions where the type of agriculture and the crops differ very materially.

I did not, of course, come to the Southland without knowing something of the agriculture of the section. I knew that cotton, the chief crop, required much hand labor, and that it was common to find small farms tenanted largely by negroes. I knew also that the negro, only recently delivered from a savage state, is not

[1] Agricultural Engineering Department of Mississippi Agricultural College.

qualified to handle successfully any very complicated farm tools. In beginning my subject, then, I wish first to state that my firm conviction that better, larger, and more readily adjustable tools are needed comes very largely from the mouths of people who have long been in the pursuit of agriculture in the south. My own observation also bears witness to this need. Anything I may say is intended in no way as criticism but is suggestive as to possible means of lightening the labors of farming.

I had the pleasure of being the central figure in a campaign for washing machines in Mississippi. In this work I found that the whip which was persuading Mississippi women to desire and to use washing machines was shortage of labor. Probably shortage of labor is also stimulating the men to investigate power machinery, larger horse drawn tools, full row and even two row cultivators and planters, power haying machinery, mowers, rakes, loaders, tractor plows, discs, and pulverizers. The inquiries received by our office is something of an indicator of the extent to which people are awakening to the need for larger farming operations. By larger farming operations I do not refer to the size of farms, for of course you are well aware that southern farms compare very favorably with the farms in other sections. What I do mean is that southern agriculture is too low in yield per man, i.e., the production per man is too low. This low production per man was not disastrous to prices when labor was very cheap. Now that negro labor has advanced to such an extent that it is impossible to get help for undesirable tasks, high yield per man is a very important factor. When we must pay a man two dollars to get the time and services that could once easily be obtained for fifty cents, we must see that labor produces more.

I have seen more plows of a small size (six to eight inches) in the two years of my stay in Mississippi than I ever saw before. Furthermore, I have seen smaller plows than ever before. Do not take it that I mean to say that small plows have no place in farming operations. But I do mean that there is no reason at all why we cannot use larger plows as soon as we make up our minds to hitch two, three or more horses instead of one. The small plow will still have its use for inter-cultivation. When we go into the realm of larger plows, sulkey, gang, either for horses or tractors, it is necessary to train one man for successful operation instead of having many poorly trained men. This is possible though in many cases it is difficult. There is a great demand for trained men, white or black, who can adjust and keep in adjustment gang plows or tractors and tractor plows. There is a difficulty which we must overcome, namely, that the average negro has been allowed to work with the gear for his mule so ill-fitted that even here in its simplest form he is not working his machine efficiently. Thus training for larger machines is very difficult. To the brave man, no obstacle is insurmountable. I realize fully what such troubles mean. I have seen men buy new plows, take them home, try them for a half day and discard them for lack of ability to adjust. This is even more deplorable for the new plow was of the same make as the old and had many of the same adjustments. When this will happen among white men what difficulty may we not expect to find with negro help? Yet the times demand that we get more from our labor.

The plow is not the only tool to which this applies; I remember on our home farm my father had an old two shovel cultivator stock with which he used to cultivate a few corners about the place, short rows of grapes, odd corners in the orchard and the like. There were four of us boys but father never thought it necessary that we should use this tool. It was used only on rare occasions and then he used it himself. He knew that it was, for Nebraska farming, an obsolete tool. The question arises in my mind, is there need for so much one horse cultivating in the south? Are we permitting it merely because it is easier to let our negroes continue in the use of simple tools than to train them in the use of larger ones? All row crops should be planted and cultivated with at least two horse tools. Cultivate with a full row or a two row cultivator and do more and better work. If the land is stumpy have it cleared. The added crop and labor saved will, in a short time, pay for the clearing. We cannot allow ourselves to believe that our labor does not want improved machinery. I have seen negroes out in their cotton and corn fields working hard, trying again and again to get the proper set to a new riding cultivator, one which the man had bought and paid for himself. A little assistance and encouragement with such men will increase their productiveness and their usefulness to a community many fold. They want to advance, not because they are too lazy to work, but because they want to farm more ground and work it better. American cannot vie with Europe in acre production, but it can in man production. While we have vast tracts of land subject to reclamation, I see no good reason for much tendency toward intensive farming.

Much hand labor should be eliminated. Hand hoeing, chopping, blocking, thinning the stand and such operations can at least be reduced to a minimum by better methods. Earlier cultivation with a machine adapted to the work should do away with hoeing the young crop. Well can I remember how my father slowly weaned himself from hoeing corn. A better cultivator and more timely use kept the field nearly as clean. A greater acreage made up for the loss of individual plants which is always incident to the use of a horse drawn machine when used instead of a hand tool. Proper selection and preservation of seed and testing when necessary will insure germination to a high percentage. Proper planting implements should then give us the proper stand without thinning or blocking. Even if blocking is deemed necessary, it can be done mechanically. Machines have been made for blocking sugar beets. Why not cotton, if indeed we need to continue thinning the stand in cotton?

With cotton, we need another new operation. That of delinting the seed. I am convinced that better germination, a more uniform stand and more hardy growth may be obtained when all lint is removed from the seed and a planter used very similar to a corn planter. Corn in the northern states is planted with a drill drop, the operator feeling certain of his spacing and, except under unusual conditions, sure of his stand. His seed is tested, was selected in the field from the stock, tip and butt grains discarded (not because they will not grow but because the planter must have regularly shaped grains to plant uniformly), carefully housed during the winter and hand shelled. He knows just what he may expect. I have myself planted seed, two years old, in preference to new seed that tested poorly. No one will recommend the use of two year old seed corn, but I got a stand with this which had been kept shelled in a cool place throughout the year. It all leads to this conclusion — if we know and regulate conditions we can reduce labor.

To return to cotton, since that is our chief money crop, if we will delint the seed, make a drop that is accurate, preserve the seed properly, test its germination if necessary, prepare the seed bed well and then if need be, plant at the same time at two depths (such planters are being made) there is scarcely any reason why thinning will be necessary. Since the invention of the cotton gin there has been deplorably little done to improve cotton farming conditions. The cotton stand is also uncertain because of the weakness of the young plant. There is need for a press wheel or wheels which thoroughly compact the soil round the seed, yet leave a loose surface. Cotton must be planted so close to the surface that it will not germinate before the soil dries out unless this process is hastened by compacting the soil to such a degree as to bring the moisture at once to the seed. This is why delinting will so much help germination. The secret of a uniform stand in cotton seems to be speedy germination. All the plants should come up at one time. Together they will be strong enough to break any but a very hard surface crust.

Necessity is the mother of invention. So be it — then I hope there is so great a shortage of labor that cotton prices advance until it is absolutely necessary to produce more, and by this means get better machinery for its production. We still have men foolish enough to work on perpetual motion machines; if so, then why do we fear to try to produce machinery for saner purposes? Though we may not be able to overthrow the universe and entirely obviate the need for labor and power, we may be able to accomplish something in labor saving in our cotton production.

It is probably unnecessary to go into detail in the matter of larger farming operations in connection with tractors and power machines. I wish to dwell a little upon some things we have found and partly corrected in Mississippi. We have found a narrow plow — ten inch — is better than a twelve or fourteen inch in some of our soils. Instead of using two fourteen inch plows on a 10-20 H. P. tractor, we recommend the use of three ten inch plows. More ground is turned, thirty inches instead of twenty-eight inches, and it seems the tractor is able to handle the load even easier. In plowing eight to ten inches deep with these ten inch plows in sod which is common on the black land, the plow for the most part simply sets the furrow slice upon edge instead of inverting it. Following this with a disc, pulverizer and packer, a good seed-bed may be prepared. Even though this style of plowing should prove to be only a step in the process of converting farmers to the use of larger and more powerful tractors for deeper plowing, I am willing to recommend it. Later, if necessary, a larger plow with still more power can be used and the furrow slice completely inverted. I have no conviction in the matter at this time, but I am convinced that better results are obtained by deep plowing with narrow furrow slices set on edge than with former shallow plowing.

Many sections of Mississippi practice ridge tillage. Some of this could be turned to flat plowing to advantage. Yet there are parts of the state where bedding is the sanest method. On this account there is need for power machinery for the purpose. Farmers put off the preparation of the soil for seeding until spring. Then in the rush to plant the crop, the soil is broken very shallow and a poor seed-bed is the result. Weed seed is up and growing with the crop. The planter is at a disadvantage in every way. We have been urging the planters to begin the middle bursting of their cotton ground early. As soon as the cotton is picked off a field, it should have the stalks cut and the middles thrown out. Some of this would come in December, a great deal more in January, and February, whenever the weather will permit. We have also worked with the manufacturers to the end that they are making every effort to perfect a tractor middle burster.

The Department of Agricultural Engineering at Mississippi A. & M. College is now advertising a short course in tractors and improved farm machinery for farmers of the state. We expect to spend much more time in a study of the machinery, hitches and adjustment than on tractor study. We believe the farmer is more interested in what he can do with the tractor than in the tractor itself. He believes the tractor will work. He is willing to hire a man to operate it. Now what can he do with the machine which represents an investment of $2,000 or more and an operating cost of $150 per month? Of course we know there are plenty of operations but how many are represented on this particular planter's farm. Furthermore, there are yet many difficulties with hitches for binder, mowers, haying tools and so on. Even in plowing the hitch gives much trouble. The farmer must not only see that he has operations enough to keep the tractor busy a good working season but he must be sure the operations can be successfully accomplished in the proper season. The whole question resolves itself to converting the man to the use of a new tool, a new method, in short to making him think progressively.

We have three directions in which we must put forth our efforts: The manufacturer, to help him get the machinery rights. The dealer, to cause him to stock and sell it. Some stock—more wish to sell without stocking. The farmer, to get him to buy, and he is the easiest to influence. The dealer is probably the harder of the other two. I have seen dealers who were selling riding cultivators, and full row machines faster than they could get them in and yet they were afraid to order more than a half dozen at a time. On the other hand the negro out with his new purchase is happy. Ask him if he likes it, "Yassah, boss! I don' 'xactly know how to set it, but I'se gwine get it." Invariably they are afraid of cultivating too close to the row. They are accustomed to barring-off and hoeing. That territory next to the plant is sacred to the hoe. This idea must be overcome. Swat the hoe with the cultivator, but not at the expense of the crop. Teach proper and timely use of the cultivator.

On account of seed of low germination, corn is planted like cotton, very thick in the row, in order to get a stand. This necessitates thinning. This can be eliminated in the south as well as in the corn belt. We can improve machinery and encourage the use of better machinery but with it we must teach better methods.

INFLUENCE OF SPEED UPON THE DRAFT OF PLOW

J. B. DAVIDSON,[1] Member; L. J. FLECTHER,[2] Associate;
E. V. COLLINS,[3] Member

This paper reports the results of tests made in California and Iowa to determine the influence of speed on the draft of a plow. The experiments were confined to the general purpose plow. It was found that increasing the speed from two to four miles per hour increased the draft for different conditions from 16 to 25 per cent. There were no difficulties in plowing at a speed of four miles per hour.

Recognizing that plowing is by far the most expensive operation in the practice of agriculture, requiring for its consummation an enormous expenditure of power, the Division of Agricultural Engineering of the College of Agriculture, University of California, outlined for study and investigation the subject, or the project as it is styled in experiment station terms, of the power required for plowing. It will be fully appreciated that this study is a very general one and has many ramifications intricate and extended in character. Several of these subdivisions are included in the outline among which is the study of the influence of speed on draft.

The question of the influence of speed upon the draft of a plow and in turn upon the power requirement for plowing is one of particular interest at this time, owing to the growth of the school of designers advocating higher speeds particularly for plowing. The designers advocating higher speeds contend that there is an economic advantage to be gained in increasing the field speed from the horse standard of one and three-quarters to two and one-half miles per hour to three or more miles per hour. It is argued that the drawbar pull of any tractor regardless of its wheel equipment is dependent upon the weight of the tractor as a limiting factor. Furthermore, with the development of the internal combustion motor and transmission design and the improvement of materials permitting a reduction of weight, it is now possible to put into a tractor a much larger motor than can be utilized at normal field speeds due to the limiting of the drawbar pull by the weight. It is maintained by these advocating higher field speeds that a higher speed is the most logical method of utilizing the full power of the motor. Furthermore, it is pointed out that the cost of manufacture varies with the weight and it is desirable from the standpoint of the user to use the higher speeds.

It is not the purpose of this paper to enter into the argument of the question of the desirability of increasing the field speed for it is to be appreciated by all, that there is much to be said on both sides. It is quite clear and has been demonstrated quite fully

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that it is impossible to operate some of our horse drawn machines at high speeds such as the binder and mower without serious destructive action upon the machines. But this does not apply to plowing and the question upon which it was undertaken to throw some light was the practicability of plowing at so-called high speeds.

Those who have undertaken to determine accurately the draft of a plow fully appreciate the many factors which influence the draft among which may be mentioned:

1. Depth of plowing
2. Width of plow
3. Character of soil
4. Moisture
5. Previous treatment of soil
6. Smoothness of surface
7. Shape of moldboard
8. Sharpness of share
9. Hitch
10. Rigidity of plow
11. Speed

In the tests reported it was attempted to maintain all of these factors constant except speed and only those who have tried will know how difficult this is to do. Few plows, when carefully watched, will run at a constant depth and only with extreme care can they be made to cut the same width. Often furrows side by side will show considerable difference in resistance due either to natural difference of the soil or to previous treatment. For instance, the furrow including the wheel track of the tractor, perhaps made during a former operation in the soil may show much difference in draft from that of a parallel furrow. The fact that the plow did not run a uniform depth at the previous plowing or that more straw or organic material was covered by one furrow than another during a previous plowing affects the draft.

Fig. 1. Showing dynanometer and carriage for controlling width of furrow.

Moisture has a decided influence upon draft and as most observers will agree may reach an optimum amount from which either an increase or decrease will result in added draft. Irregularities of surface not only affect the operation of the plow but also affect the moisture content owing to the tendency for the water to settle in the low points.

The velocity with which the furrow slice leaves the moldboard varies with the sharpness of the curvature of the moldboard. It is clear to all that high speeds are impractical with abrupt moldboards and it has generally been suggested that with extremely high speeds special shapes would be required.

A large part of the draft of a plow goes into the cutting of the furrow slice; therefore, it follows that the sharpness of the cutting edges materially affects the resistance of the plow. This is particularly true if the soil contains roots.

The angularity of the hitch away from the optimum angle adds to the draft of the plow on account of added friction, even if correction be made for the angularity of the line of draft. Few plows are sufficiently rigid to run at a constant depth and width even when the soil is comparatively uniform. The variation are not large but it is to be noticed that they are of importance when careful measurements are made, even the sticking of the soil to the rims of the plow wheels produced considerable variation of depth.

The freezing of the soil tends to make the soil uniform, an advantage not secured in warm climates was an observation, made in connection with the tests here reported.

TEST NO. 1

Date of test: January 10, 1919.

Location: Stubble field, University Farm, Davis, California.

Conditions: Sandy clay loam, firm moist soil covered with stubble and volunteer growth, in splendid condition for plowing. Field level.

Equipment: P. & O Little Genius power lift gang plow provided with twelve inch general purpose bottoms, and rolling coulters. Cleveland tractor.

Plow adjustment: Plow set to run as near seven inches in depth as possible. It was noticed however that the depth varied during tests. Plow attached directly to tractor through dynamometer.

Speed: Rate of travel during test was determined by stop watch. Summary of results:

Draft at one mile per hour — 695 pounds or 100 per cent.
Draft at two miles per hour — 785 pounds or 113 per cent.
Draft at three miles per hour — 872 pounds or 125½ per cent.
Draft four miles per hour — 962 pounds or 138½ per cent.

Work: It was noticed that the furrows were smoother laid and the soil better pulverized at the higher speeds.

TEST NO. 2

Owing to the variations encountered in the soil a field was prepared specially for the tests, plowing the same to a uniform depth and preparing in such a way as to secure uniform texture of the soil as far as possible. Furthermore, by establishing stations or starting points individual tests were compared with others made directly parallel with it.

Location: Specially prepared field at University Farm Campus, Davis, California.

Conditions: Sandy clay loam, ground previously plowed a uniform depth in October, 1918. Surface smooth and level. Soil moist fairly loose, with light mulch on top. Four test stations were established designated as 1E, 2E, 1W, 2W respectively. Some difficulty was experienced with scouring at slow speeds.

Equipment: P & O Little Genius power lift gang plow provided with twelve inch general purpose bottoms and rolling coulters.

Plow adjustment: Adjustment of plow was not changed during tests. Set to run as near as possible to seven inches in depth and twenty-four inches in width. The hitch to plow was thirty-three inches long and nineteen inches from furrow bank at tractor, thirteen inches from ground at tractor and eleven inches from ground at plow.

See Curve No. 2, Curve No. 3, Curve No. 4, Curve No. 5, respectively. The heavy drafts at low speeds due perhaps to failure of plow to scour.

Fig. 2. Showing another arrangement of dynanometer.

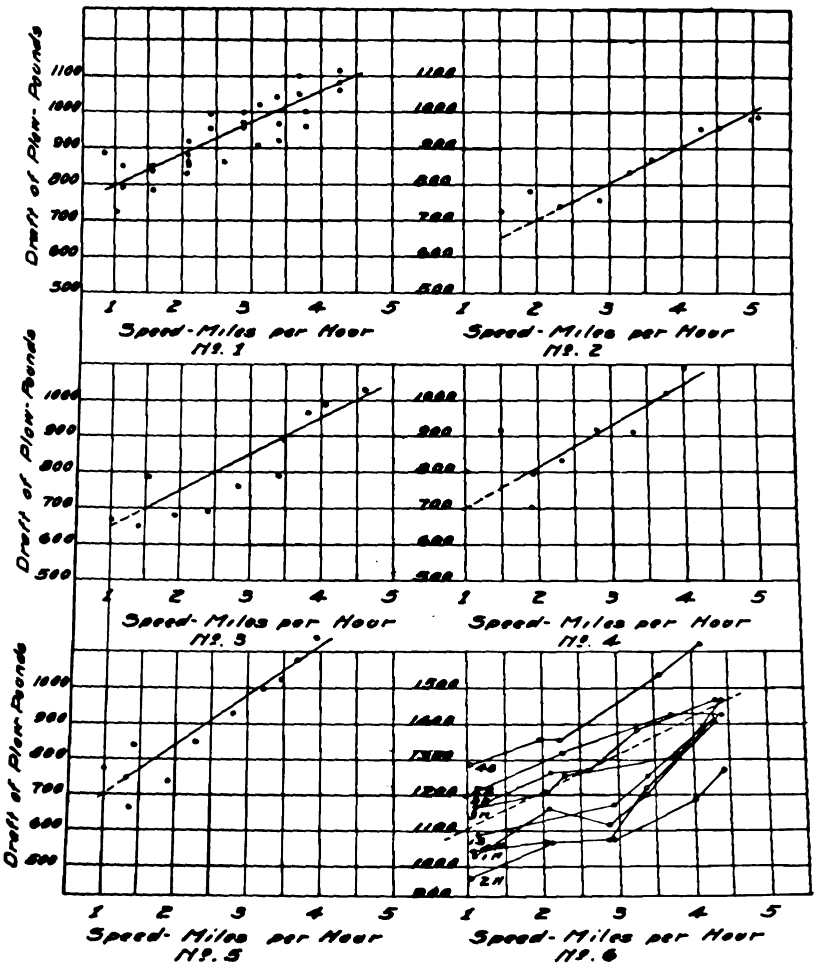
SUMMARY

DRAFT

SPEED	E1		E2		W1		W2	
MILES PER HOUR	POUNDS	%	POUNDS	%	POUNDS	%	POUNDS	%
1	650	100	Same		700	100	700	100
2	750	115	as		817	117	840	120
3	850	131	E1		933	133	980	140
4	950	146			1050	150	1120	160

TEST NO. 3

All conditions were the same as those of test No. 2 except a truck was used between tractor and plow to control the width of cut. Eight separate stations were established. Chart 6 shows



how the draft at different points varied and that there was a general increase due to increased speed.

TEST NO. 4

Made at Ames, Iowa, October 12, 1919.

Equipment: Moline tractor with rear carriage and improvised platform, Iowa integrating dynamometer, and two bottom Grand Detour tractor plow with general purpose bottoms.

Field: The field was one of the soils experimental plots on the campus. It was clover sod on black loam and was quite level, about 150 feet wide and 400 feet long. The soil was quite moist.

Methods: The plow was set to run between six and seven inches in depth and to cut twenty-eight inches in width. The width was held constant by the fact that the tractor rear carriage crowded the corner of the furrow. The plow adjustments were not changed after beginning the test.

Four readings were taken each round, starting at the same points each time. Each round the speed was changed by means of the electric governor control on the tractor. Thus it will be noted that there are four sets of tests.

SUMMARY OF RESULTS

Speed miles per hr.	Station 1	%	Station 2	%	Station 3	%	Station 4	%
1	1440	100	1420	100	1520	100	1440	100
2	1460	108	1530	108	1660	109	1570	109
3	1680	117	1640	115	1800	118	1700	118
4	1800	125	1750	123	1940	127	1830	127

See charts No. 7, No. 8, No. 9, and No. 10.

GENERAL SUMMARY

CALIFORNIA TESTS—CLAY LOAM

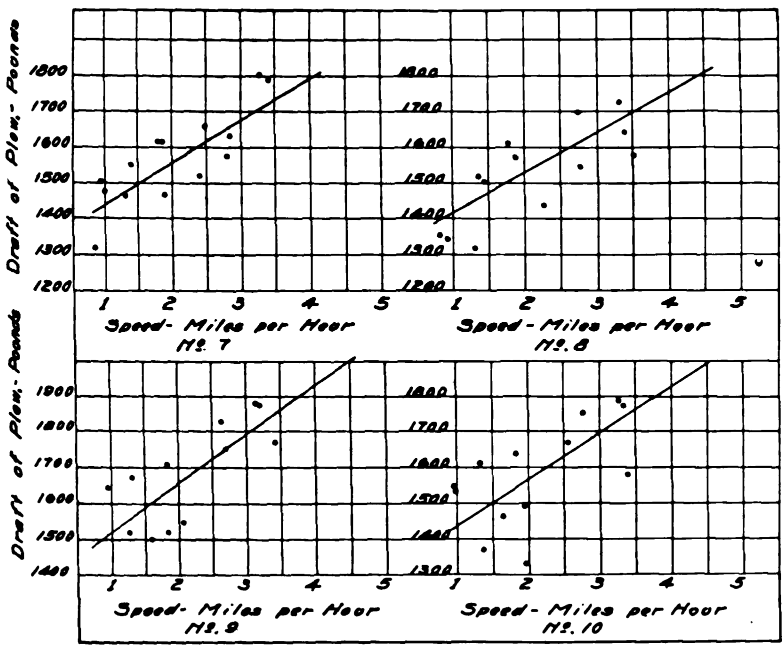
Speed 1 mile per hour	Draft in per cent	100%	
Speed 2 miles per hour	Draft in per cent	114%	100%
Speed 3 miles per hour	Draft in per cent	128%	112%
Speed 4 miles per hour	Draft in per cent	142%	

IOWA TESTS BLACK LOAM

Speed 1 mile per hour	Draft in per cent	100%	
Speed 2 miles per hour	Draft in per cent	108%	100%
Speed 3 miles per hour	Draft in per cent	117%	108%
Speed 4 miles per hour	Draft in per cent	126%	

It is pointed out that the curves shown are in each case straight lines. Perhaps it requires some imagination in connection with a few of the tests to reconcile the observations to a straight line when plotted but it is clear that the stright line comes more nearly fitting the case than any general type of curve.

It has been suggested that a very rapid increase of draft would come with an increase of speed and a more rapid increase was expected. This was based on the fact that the momentum or the kinetic energy of a moving body is represented by the quantity $M V^2$ where M represents the mass and V the velocity in feet per second. There are perhaps several reasons why this factor does not play a larger part in the draft of a plow. It would seem that a large part of the resistance of the plow is due to cutting and breaking up the furrow slice and furthermore the velocity is not great. Suppose that the moldboard shape is such as to give, when mvoing at three miles per hour, an average velocity of one and one-half miles per hour to the furrow slice, then the velocity of slice is only 2.2 feet per second.



CONCLUSIONS

1. An increase in the field speed of a plow with a general purpose moldboard from two to three miles per hour will result in an increase of the draft of from eight to twelve per cent varying with the soil. Doubling the speed will result in an increase of draft of from sixteen to twenty-five per cent. The amount of work accomplished is increased fifty and 100 per cent respectively.

2. The furrows are laid more smoothly and the furrow slices better pulverized at the higher speeds.

3. There are no inherent difficulties in plowing stubble ground in good condition for plowing at a speed of four miles per hour.
4. It is quite clear from observation made during the tests that plows could be operated at even higher speeds if the plows were especially designed for such speeds.

DISCUSSION

QUESTION: May I ask again just what each of those curves indicate, in No. 6?

MR. DAVIDSON: The furrows were started at the same point. Each of those lines or curves represents a starting point; but each of the observations represents an individual furrow. There are five observations from each starting point.

QUESTION: Under what conditions was your plow set?

MR. DAVIDSON: Everything is uniform as to width and depth. The thing to observe, is that if we had made all the observations at different parts of the field and put them together we would have covered the whole chart, but by charting the draft of parallel furrows we were able to get something out of them. We used an integraitng dynamometer which operates for fifty feet. The theory of the instrument is that we want an accurate draft for short distances, where the conditions are known.

QUESTION: What accounts for the droop of the curve?

MR. DAVIDSON: I do not know. In curve six it might indicate that it wasn't a straight line increase but increased faster with the higher speeds.

QUESTION: Was it due mostly to soil conditions or draft condition of the tractor?

MR. DAVIDSON: More likely the depth of the plow than anything else. There are a good many factors. Perhaps we wern't watching the plow just then and some mud balled up on the furrow wheel and made it run shallower or something of that kind.

MR. JONES: Would it be fair to raise the presumption that at a speed between two and three miles an hour the draft falls off slightly because it is at just that speed that the plow is designed to run?

MR. DAVIDSON: From all of our observations we were not able to conclude that the increase in draft is anything but something approximately a straight line increase.

MR. BOHMKER: I should like to ask Professor Davidson whether the speed and draft produce a straight line or curve of the first degree or whether according to these charts it seems to indicate that it does not follow a straight line, but tends to follow a curve of some other degree?

MR. DAVIDSON: Answering that question, we expected that the law governing the increase of draft would be, as you suggest, a curve of some other degree because of the influence of kinetic energy, which is lost as the furrow slice comes to rest. Perhaps in test six there is something to indicate that that is true but I don't believe the other observations would indicate that. The other observations would indicate it is a straight line, as far as we are able to observe. Since we started on this work Professor Hoffman of California stumbled on a German thesis by Mr. Koehne of the University of Berlin. This investigator using a miniature plot of soil seventy centimeters long and a miniature plow at a speed from ten to forty centimeters per second reports a reduction of draft with an increase of speed. The speeds used were much lower than practice but a reduction of draft is reported with an increase of speed. In our tests high draft was reported at low speeds but was in each case attributed to failure of the plow to scour.

MR. JONES: In view of the fact that the report states that there is a wide variation in the actual work done in the way of tillage, that is to say, of seed bed preparation, is there any way of drawing a conclusion as to the draft of the plow in relation to the tillage accomplishment?

MR. DAVIDSON: Well, the part of this contemplated investigation was a determination of the degree of pulverization on the furrow slice. Now we haven't said anything about that because we have not arrived at anything definite. Mr. Hoffman who is now carrying on the investigation in California has provided a cylinder by which he goes out and takes a sample of that furrow slice following the methods used by the German investigators and he is determining the size of the soil lumps or particles in the furrow slice. This is not an easy thing to do and the results are about as irregular as they could be.

MR. RILEY: It seems to me that that point is an extremely important one, because the advent of the tractor, I believe, is going to bring into prominence the consideration of the number of horse power hours of work required to put a field into the condition of tillage that we call a suitable seed bed. If it may be possible to show that an increase of draft of fifteen per cent produces fifty per cent more tillage effect, we have got a very profound fact that will have to be given a very serious bit of attention.

EFFICIENCY OF HORSE LABOR

WAYNE DINSMORE [1]

This paper compares the available animal and mechanical power used in agriculture. In general, discusses the efficiency of a horse as a prime mover, overload capacity of a horse, practical advantages of the horse and makes recommendation concerning research work for raising the efficiency of horse labor. Reports experiments in using four, six and eight horse teams, hitched tandem.

One of my friends who recently learned that I was to address this meeting stated that I would be about as popular as a republican in Texas, because of the common idea among horsemen — for which there is some ground — that the agricultural engineers are not interested in horses or in anything that horses do. The United States is noted as having the greatest production per capita of any nation in the world. That supremacy in economy of production has come about through the utilization of power in the shape of animal power, chiefly horses and mules, for the introduction and use of mechanical motive power has occurred largely within the last three years, and their total contribution to motive power on farms is still so limited as to be almost negligible.

Many authorities among agricultural engineers, including Professor Davidson, who preceded me on this program, have stated that the available primary power units on farms exceed all available primary power in manufacture. Most of that power on farms, so far as motive power is concerned, is in horses and mules, for oxen, although used to a slight extent, may be considered negligible in considering the problem.

At the very outset, it may be well for us to consider a few facts and figures regarding the relative contribution of animal power and mechanical motive power to agriculture. I know that the men in charge of the larger interests responsible for mechanical power regret it as much as anybody — that false statements and extremely misleading statements have appeared in journals supposed to be reputable and supposed to have a standing.

As an illustration of this, is an article which appeared in the *Scientific American* on November 22. I shall read just a brief quotation from this. They state — and this appears in the guise of an article on the draft horse situation: "In 1917 it was estimated that there were about 35,000 farm tractors employed in the United States. In 1918 about 100,000 more were turned out. Now we have the estimate of the probable output of farm tractors in the United States for 1919. This is placed at not less than 314,000. Of these, 224,000 will be put to work on American farms. Suppose that these farm tractors averaged ten horse power net, each. Then we have an aggregate horse power of 2,240,000 which means that that number of farm horses will be put on the shelf." I will not read any further. Yet that appeared in the *Scientific American* of November 22.

Now the facts are these: In 1910 there were in this country about 23,000,000 horses and approximately 4,500,000 mules. Eighty-six per cent of the horses were on farms, ninety-four per cent of the mules on farms. In 1919, according to the most reliable data that we have been able to obtain from all sources, there were on the farms of America about 200,000 tractors, and if we grant that each of them displaced three horses, which is more than the facts warrant, because all of the investigations and the information furnished by the Department of Agriculture and other authorities indicate that the displacement is only about 2.4 horses per tractor at the outside, but if we grant they have displaced the former figure, then they have only displaced about 600,000 horses, or approximately 2.2 per cent of the horses on the farms. In other words, gentlemen, animal power today furnishes ninety-seven per cent of the motive power used in agriculture, and yet, no work has been done by any college or experiment station respecting the efficiency of animal power or methods of increasing that efficiency, or respecting methods of increasing the efficiency of the animal power units, with the exception of the work done at Illinois in 1918 by Dr. E. A. White, which work I myself initiated and which work was subsequently given publicity through the Percheron Society of America.

The efficiency of horse power, as a subject naturally divides itself into four principal phases. These, in the order in which I shall discuss them, are: (1) The efficiency of the horse as a prime mover, (2) the efficiency of the horse as respects power rating and overloading capacity, (3) the efficiency of the horse as shown in actual use on the farms, and (4) recommendations or suggestions regarding means by which this efficiency of animal power may be increased.

On the efficiency of the horse as a prime mover, so far as I can ascertain, nothing has been done in this country. Dr. White who worked with me in 1918 tells me that his reading and investigations into this particular matter have revealed nothing regarding the efficiency of the horse as a prime mover, save investigations made in Germany some years past and that those investigations indicate that the horse is more efficient as a prime mover than any type of engine, merely regarded from the standpoint of power delivered. That does not take into consideration the activities of the animal power until in replacement, and it must not be forgotten that the horse, viewed as a power unit, is not only capable of delivery of power, but also carries out self-repair and is self-reproducing.

Coming to the second phase, the efficiency of animal power as respects power rating and overload capacity, we find that the common idea and the one which has been generally accepted, is that horses can deliver about one-tenth of their live weight in tractive pull, or in other words, that horses weighing 1,600 pounds can deliver a tractive pull of 160 pounds at the draw bar and continue that all day long; yet we know in actual practice they do much more than that, because even under common plowing conditions with a fourteen inch plow running six or seven inches deep, pulled by a pair of horses, you well know that the tractive pull runs from 400 to 700 pounds, yet a pair of horses of moderate size will rank right along with that plow. We need some thorough research work in connection with the load horses should be expected to carry.

Research should also be made in the power rating of 1,400 pound horses and also 1,100 and 1,200 pound horses of certain types. We have had millions of dollars spent on researches in the soil improvement and soil survey work. Yet, so far as I know, not a dollar has been spent on this question of the study of the power rating of horses of different weights and types and temperament. Had we exact scientific data we could bring about a very much more rapid improvement in the types of our horses. You gentlemen have done nothing on this, which is one of the most important problems before us today, and which relates to animal power, which today furnishes ninety-seven per cent of the motive power on the farms.

Coming now to the question of overload capacity, you all know that the overload capacity of a mechanical power unit is at best 100 per cent. The overload capacity of horses is from four to five times their normal capacity. Tests have been made showing that a horse can exert a tractive pull of two-thirds his live weight for a short time. This overload capacity is very important on the farm.

Coming now to the third phase of our subject, the efficiency of aniaml power or horse power as actually used, we find some very very interesting things in this connection, and great variations in the efficiency with which horse power is used in different parts of our country. In the fall of 1917, I made a trip clear across the United States from New England through to the West, studying this particular question, and I found in New England they considered a man had done a good day's work if he plowed one acre a day. A man would go out with a pair of horses weighing only 900 to 1,000 pounds and a little ten inch walking plow. They thought an acre's plowing was a good day's work.

I came on down through Pennsylvania and I found that there the common hitch was a three horse hitch on a single bottom walking plow, sometimes a twelve, sometimes a fourteen inch plow. There they thought a man had done a good day's work when he plowed two to two and a half acres a day. I found that the common hitch used in Illinois or Iowa was a four or five horse hitch; however, there were very few fives; four abreast hitch was the common hitch, and the common plow used was a two bottom gang plow and the amount of plowing done ranged from four to five acres a day. The average ran around four acres and a half per day.

I went to Oregon and Washington only a couple of weeks later. While at Lewiston I met the leading stockmen and farmers from all over the country, and I found that there it was customary to use three bottom plows and eight or ten horse teams strung out tandem fashion. Virtually all of the plowing there is done by tandem hitches. Nearly all of them were eight—some ten—horse hitches, and most of the work done with three bottom plows. I questioned them with regard to difficulty in having men to handle the eight and ten horse teams strung out that way. Well, you know the thought that there might be difficulty in handling those hitches had never even occurred to them. When I came back here and told the people here in Illinois and Iowa that they were driving eight and ten horse outfits, with three bottom plows, and averaging nine and ten acres per day out there, a lot of these fellows here thought I was kidding them.

Having come to the conclusion that we needed more work on the use of horses in more efficient ways, in large units particularly, I took the matter up with Dr. E. A. White because Professor Edmonds, the head of the Animal Husbandry Department, told me White had been working for three years on a dynamometer with which to carry out accurate tests. Dr. White very readily took up the suggestion that we do some work on the problem of larger horse hitches, which would be efficient and satisfactory, because even with the hitches used in the west we found they were not entirely efficient on account of faulty line of draft. I shall not go into the details of the work which Dr. White carried out for the Illinois experiment station in 1918. I may say that part of the work was carried out there, part at the Oliver Plow Works at South Bend, Ind., and part on the Dunham Farm west of Chicago. We found that the ordinary four-abreast hitch was an inefficient hitch, both from the standpoint of the delivery of power and from the standpoint of the horses. We found it was impossible to eliminate side draft with the four abreast hitch unless part of the horses were worked on the plowed land, which of course is not practical. We found that regardless of any claims that may have been made by patentees of different types of patent hitches, it is absolutely impossible to eliminate side draft with any four or five abreast hitch, and you have some of it even with a three abreast hitch. We found that

the side draft ran from fifteen to thirty-five per cent and found, roughly speaking, averaged around twenty-five per cent wasted power through the use of these four abreast hitches.

We not only found it possible to eliminate the side draft with a tandem hitch but ascertained the plows not only ran lighter but did better work than with the four abreast hitch, because they had a true line of draft and consequently the moldboards turned the ground more as it should be turned.

Our next problem was to solve the line of draft. We found, when we had three or four teams strung out tandem, that the line of draft tended to rise and the traces to come out parallel with their sides. This decreased the efficiency of the horses, because instead of coming at right angles to their shoulders, the pull was pulling up on the collar and tended to bring the pull in the wrong place on their shoulders. We finally solved this by weighting the point of draft so we had the angle of traces the same on the lead teams and the first and second swing teams as it was on the wheel team. As soon as we did that we found that our horses quieted down and worked easier.

Now the main problem in increasing the efficiency of horse hitches and the use of horses is to encourage the farmers to use more horses per man. They have the horses, and why should two men go out to plow when one man can drive the same number of horses and do the same work as two men in the field? A friend of mine remarked recently, "I would a whole lot rather go out and help hitch up an eight horse team and let my man get started with a three bottom plow than to plow all day myself." It is a matter of labor saving. If you gentlemen, through your lines of work, can encourage the use of larger horse power units generally throughout the west and the east as well, you can cut our farm labor bills one-third within the next two or three years, and that is a matter of great importance.

That is the first step in increasing the efficiency of horse labor. The second step is to increase the efficiency of the horses. As soon as you give us research work showing how much less efficient the little horses are than the 1,700 and 1,800 pound horses, you will see the most rapid improvement in horse breeding that you ever saw in this section of the country. The men that are displacing animal power with mechanical motive power I find to be almost invariably men that are using the little scrubby good-for-nothing horses. That is, where mechanical motive power is coming in and displacing the horses, it is because they have been using an inefficient type of motive power to begin with.

As the researches of Professor Hanschin of the University of Illinois indicate, on farms under 260 acres the horse furnishes the most efficient and the most economical type of farm power. His cost researches have indicated that very conclusively. He

adds further that on farms over that size seventy-five per cent of the work will still be done the most efficiently and cheaply with horse power. That is the statement of a man trained in farm management and farm economics and it is based on seven years cost studies, five years of which were carried out by trained cost accountants, visiting the farms every other day for that period.

What I have said indicates the importance of animal power on farms today, and its probable importance in the future. I think that you men owe it to the most important motive power interests in American agriculture today, to start some research along these lines and to give the breeders of animal motive power practical assistance because you can give them the most magnificent support in the world, if you will carry out researches along this line and give us the concrete facts with which to eliminate the scrubby inefficient types of horses.

DISCUSSION

CHAIRMAN: I am sure that Mr. Dinsmore's point on the need of research along the lines of horse labor is mighty well taken by this society. A thought which has occurred to me while he was speaking was that this society should take a step in that direction by at least appointing a committee, a special committee to encourage, or itself undertake some research work along that line. There are a good many of our members who are located at the agricultural colleges who are in position to conduct that research work in behalf, not only of the society but of their individual institutions, and I am sure that something should be done along this line, and no doubt the new officers will start something when they take office.

MR. EKBLAW: He stated that he found in some of the tests with four and five horse hitches that the side draft amounted to twenty-five per cent. How was that determination made? Was it made by dynamometer measurements?

MR. DINSMORE: Yes, by tests with the Gulley Dynamometer. We plowed round after round with the four horse teams and the dynamometer was read according to the speed and the draft at each point; then we changed to the four tandem. We also tested the draft of the plow when the hitch was attached ten inches from the furrow edge, 14, 18, 22, 24, 26, and so on up, and we found the point on the plow where we could hitch and cause the plow to operate with the least exertion on the part of the teams. The complete records are in the possession of Dr. White. The tests were very comprehensive and very conclusive. We found that the lightest load with four horses hitched abreast ran from fifteen to thirty-five per cent heavier than the lightest load with the four horses hitched tandem.

MR. EKBLAW: If the side draft amounts to twenty-five per cent of the total with the four horse team hitched four abreast, and since, with the three horse team, it is possible to get a true line of pull and eliminate the draft, then three horses would be able to pull the bottom plow with the same draft as the four horses would.

MR. DINSMORE: You still have some side draft with three horses abreast unless you have very small horses that you can crowd together, and then with the three small horses you haven't enough power; with three large horses you will still have some problems in side draft to solve, and your load is too heavy, anyway.

I may say that Professor White and I were responsible for causing these tandem pulley hitches to be put on the market this last year, and 175 or 200 of them have been sold. I have been interested because of the fact that I was checking up the reports of men who have used them this last year and I noticed one report in "Farm and Fireside" the other day from a farmer who said that his teams had worked much easier and he had no trouble throughout the entire season. He also cited the greater ease of operating the plow. Your particular point that three horses could pull it as easily as four would hold true providing you could use three horses of the same size and give them spread enough to work satisfactorily without incurring side draft.

MR. DAVIDSON: Does the use of six and eight horse teams have a material effect upon the quality of the work, particularly in conditions where you demand rather high grade work?

MR. DINSMORE: In answer to that I may say that you can do just as good work with the sixes or eights as you can with the ordinary fours. You can use a four tandem anywhere that you can use a four abreast. It requires laying off your lands a little differently. You use side lands and head lands the same as you do with tractors and finish up those lands afterwards with the four horse tandem hitch instead of using the eight.

MR. DAVIDSON: In the manipulation of the plow, would you raise it at the ends?

MR. DINSMORE: Yes, throw the plow out at the end. You can get a three bottom foot lift plow and two companies are now at work on the preparation of three bottom power lift plows.

MR. GUNNESS: I would like to ask if, in the use of horses on the three bottom plow, you would always string them out in pairs or would it be worth considering hitching them any other way? Three bottoms are wider than two horses.

MR. DINSMORE: No, because you use longer doubletrees. The true center of pull is thirty inches from center of furrow, and you use a sixty inch doubletree. The point you make is well taken, and I may add that a good many of the men in the Canadian Northwest are using two fours, with the same pulley hitch, hitching two fours instead of using eight strung out. I am not prepared to take a denite position on this particular point. Personally, I wouldn't recommend using the eight horse hitch strung out unless the fields are half a mile long. The fields in the Canadian Northwest run from a mile to two miles in length.

MR. JONES: I don't believe Mr. Dinsmore has called attention to a thing which farmers sometimes mention and that is that the use of the horses two by two and thus wide spread apart facilitates the keeping of the horses cool, so they operate to better advantage in hot weather.

MR. DINSMORE: That point is particularly well taken, and I regret that I did not mention it. We found that was one of the great advantages in using the six strung out or the four strung out. There is a chance for the breeze to move down between them, pregnant mares are not crowded or jostled by their mates, and the horses are not trampling on each other's feet on the turns, which is inevitable with the four abreast hitch.

MR. CLARKSON: I want to call the attention of the men present to the statement made by the late Professor King in his book where he makes the statement that has been proven out in observation by others, that the middle horse in a three horse team is always in a bad position, especially so when the others were pulling a little in the lead, and he always worked the hardest on account of insufficient air.

MR. DINSMORE: That point is especially well taken. I would say that this past year I checked up every case that I could find where horses died from overheating during harvest and in every case it was the middle horse that died. It is no harder to handle horses strung out two and two than it is to use them abreast. It is just as easy to drive six as it is to drive two. Of course, on such a thing as harrows it is oftentimes easier to drive them six abreast than it is to drive them tandem fashion, but not on such implements as plows and harvesters, particularly.

MR. CUNNINGHAM: I think the atmospheric condition would be quite a factor to be considered in any research work that you have on the efficiency of the horse in a team, and I think it would be quite a problem to set down that a 1,100 pound horse pulls so much, because in the early mornings especially in harvest time, you would find that even a 1,600 pound horse won't be able to pull steadily a load that a 1,200 pound horse might be able to pull under other atmospheric conditions.

MR. LLOYD JONES: Mr. Dinsmore left out some of the efficiency of the horse. When you take out a four horse team and break a tug you just leave them standing there and go to the barn, get a new tug and put it in, and you are going again in half an hour, but when you break a tug out of your tractor you go to the house and go to town and you wait a week or ten days maybe to get the "tug" put back into the tractor.

MR. JONES: I would like to raise the question whether the German figures on the efficiency of the horse as a prime mover were based on the continuous work or upon the amount of work done in a year?

MR. DINSMORE: I cannot answer that. I simply took the figures from Dr. White.

MR. JONES: Is the overload capacity of the horse as compared with other forms of primary power with respect to drawbar pull or with respect to horse power?

MR. DINSMORE: With respect to drawbar pull. A tractor, at the outside, won't pull over 100 per cent overload. A horse will pull as much as four or five horses ordinarily will.

MR. JONES: I think that we are willing to concede that the overload capacity is present all right, from the horse power load of the horse; on the other hand, you can provide as low a gear with the tractor as may be desirable, the only difference being that the animal power pulls its greater drawbar pull without changing gears.

MR. RILEY: I just want to interject a remark to modify a little what Mr. Jones said, that your drawbar pull is only dependent on your gear ratio. Of course he knows that that is limited by the capacity of the front end of the tractor to stay down.

MR. JONES: If the statement is to be made complete, "by the adhesion of the driving units," that is to say, traction. That is pretty thoroughly understood and I thought that might be left unsaid.

May I raise the question with respect to the testing of horses; if any systematic tests are to be undertaken should the tests be over thirty days, or over sixty days or over ninety days, should any attempt be made to maintain the horses at constant weight from start to finish? At the test, how many hours a day should they be operated on the dynamometer?

MR. DINSMORE: The testing of animal power is one of the most difficult problems that can be undertaken, which probably accounts for the fact that so little research work has been done on it. The Farm Power Conference called by the Secretary of Agriculture here in Chicago in October blocked out very comprehensive recommendations regarding the testing of animal power and the particular lines on which they should be carried out.

MR. KELLY: I would like to ask for the latest figures on the cost of horse labor.

MR. DINSMORE: I purposely omitted any mention of the cost of horse labor because that is a problem in itself which would take an hour to discuss. I went into that rather exhaustively in an address that I made in New York City on October 30. Any of you who would like to have copies of that may have them.

RELATION OF THE HARDWARE DEALER TO THE AGRICULTURAL ENGINEER

H. P. SHEETS [1]

In this paper the engineers' close coöperation with local hardware and implement merchants is urged inasmuch as they come in closer contact with the farmer than any other community factor. Tribute is paid A. & M. College of Mississippi for its constructive work in utilizing the coöperation of merchants in its service of the farmers of the state and brief mention is made of the splendid results of its Washing Machine and Farm Fence campaigns of the past year, and the Junior Farm Mechanics' Course.

It seems to me that the problems or the functions of the local merchant and particularly the hardware and implement men are very much the same as yours, that of educating the farmer to greater production and to educating the farmer and his family to the desire for greater conveniences and more of the things which will make life easier and happier on the farm. Therefore, it seems to me that you men might well coöperate with this great class of merchants. The hardware and implement man perhaps comes in closer contact with the farmer than any community factor because he furnishes the things to the farmer essential to his business. Often he is the adviser, often stands closely in relationship, closer, in fact, than any other merchant in the community or any other community factor. Having held that opinion for so long, that was what interested me particularly in the work that Mississippi has been doing in the last few years. I heard something about the linking up of the work of the college with the dealers of the state. I heard a good deal about it from one source and another, until I finally determined to go down there which I did last July, and you know I was pretty blamed anxious to do down there. I spent several days around the college and met the members of the faculty. I met President Smith and talked with him about what they were doing. I found they had made a very remarkable success there, perhaps more so than they anticipated. First of all they got it into their noodles that the merchants have an economic function. Sometimes we talk about the merchants as being non-essential, not being producers. We have heard all about the definition of production, the application of service. We forget about the utilities and the particular utilities that the merchant performs or creates. These men seem to have gotten the vision. They have gone out and interested the dealers in what they were trying to do for the farmer. The county agent work in the early days particularly was financed by the merchants of the town. They wanted to see the communities lifted up. They wanted to do something for the communities. Mississippi is just a little backward in some

[1] Secretary of the National Retail Hardware Association, Argos, Ind.

respects, backward in agriculture. I apprehend, as compared with Illinois and Indiana and Iowa, it is backward in a mercantile way. But the fellows in the college went out and interested the dealers in the washing machine campaign. I heard Professor Scoates tell last night what has been accomplished in the washing machine campaign. After the campaign had been put on, the Secretary of the Washing Machine Association said they had sold 1,000 power washers in Mississippi in the first six months. Then they put on a farm fence campaign. That didn't go quite as well as the other campaign because it was put on late in the fall when the shortage of wire was very great. Yet they did great things in that. They found that the dealers were already selling fence down there at a margin of five or ten per cent. We know that nobody can live on that, and yet the mercantile conditions where they were doing that were such that perhaps some of the buyers thought they were profiteering.

It seems to be the big thing they did was in their Junior Farm Mechanics Course. They were planning that, when I was down there and I heard a good deal about it. It was put on in the fall. They planned that at the very most they would have 200 men there, yet Professor Scoates said last night they had 681 boys, more than they could take care of. They ate the whole commissary and the dining room department out the first day they were there. How did they get all those boys there? One big reason was they had a bunch of hardware and implement dealers down there in July and they told them the difficulties, how anxious they were to get there, but how difficult it was. Those fellows, practically all of them who sat there, said, "We will send one boy or two boys" or whatever it was. The very fact that with all their anticipations and all the promotion work they did, they expected 200 and got 681, looks as though they sold the idea to the merchants and they brought those boys there for their course. Those boys, many of them, are coming back for their regular course later on. That plan has sold the college to the merchants of the state. The chances are the merchants of the state didn't know much about the college until they got into this coöperative work. And, incidentally, the college faculty of that institution knows a good deal more about the merchants of the state and what they are trying to do.

It seems to me here is a big opportunity, a big point of contact for every agricultural college engaged in the educational work. You are trying to reach the man who needs education. We need all the points of contact we can possibly get and you need all the help you can get. I am quite sure that if you will get in contact with the hardware and implement men of your state and let them know what you are trying to do, you will get the fullest coöperation. I represent now something over 17,000 retail hardware merchants, and we have associations with membership in 40 odd states. We are out at Argos, Indiana, because 75 per cent of the men that we represent are doing business in towns of five thousand or less. One reason for being there is that we can keep in contact with the class of people that they are in contact with, and can understand their problems. The only function our organization has to perform is to educate the merchants to give better service to their patrons. I know that my Board of Governors will back me up in everything that I have said. I know they will back me up in giving you the broadest kind of an invitation to utilize such assistance as we may be able to give you.

THE NATIONAL SERVICE COMMITTEE

CHAS. B. BURDICK [1]

This paper explains the organization and work of the National Service Committee. A permanent office has been established in Washington and the service available to engineers is explained. The author explains why engineers should work for the legislation creating a National Department of Public Work.

I want to take a few moments of your time today to tell you something about the National Service Committee ,and as engineers are generally not very well acquainted with the work of the Engineering Council, I want to tell you something about the Engineering Council, the parent organization of the National Service Committee. During the war the government had great need for engineers. The President and his advisors found it necessary to call upon engineers for assistance in carrying out this great war and they felt the need of some central organization to which they could turn. As a result of this demand the four founders societies, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Mining Engineers, formed an organization known as the Engineering Council, made up of representatives from each of these associations, whose function it was to represent these organizations, particularly in its dealings with the government.

A very large number of engineers were furnished to the government in this way, and recommendations were made for reserve officers that carried out this great military work which has so recently been completed in such an effective way. Upon the signing of the Armistice it was found there was much work in peace time that could be done by the Engineering Council and it is accordingly being continued.

Now the object of the Engineering Council, as stated in their

[1] Of the Alvord & Burdick Company, Chicago.

circulars is, "An organization of national technical societies of America created to provide for consideration of matters of common concern to engineers as well as those of public welfare in which the profession of engineering is interested, in order that united action may be possible."

The work of the Engineering Council is done through committees. A large number of committees have been created dealing with compensation and employment for engineers. I might mention that there is an employment bureau which has done a very valuable service. It has placed over a thousand engineers in positions during the last ten months and has conducted something like 17,000 interviews. There are committees that deal with patents, fuel conservation, public affairs, and water conservation. We have correspondents in all the states which are collecting data other than that collected by the geological survey, which will be published and put in the possession of engineers.

The National Service Committee is one of the committees of the Engineering Council. It was created because the Engineering Council felt the need of having an organization in Washington, a permanent organization, that could keep in touch with legislative affairs and speak for the Engineering Council and the profession of engineering when needed. The objects of that National Service Committee cannot be stated better than to read them as contained in the circular of the National Service Committee. They are: (1) To discover public services which may best be performed by engineering societies, to inform the Engineering Council thereof, and when desired, to offer the proper men for such service. (2) To speak authoritatively for the Engineering Council before committees of Congress, and departments of government on all public questions of common interest or concern to engineers, within such limitations as may be fixed by the Engineering Council from time to time. (3) To give wide circulation among engineers, promptly, of first hand information regarding pending legislation and executive actions which may affect the interests of engineers in any way; to gather opinions of engineers upon matters arising for action within the field of the committee."

Now in order to carry out this work a permanent office has been established in Washington. Mr. M. O. Leighton has been employed as permanent chairman. He was formerly Chief of the Geological Survey. He has as his Secretary Major Chenery, an engineer of broad experience, formerly with Sanderson & Porter, and we are attempting through our Washington office not only to keep engineers and engineering societies in touch with legislation and the official actions in Washington that are of concern to engineers, but we are also attempting to advise engineering societies and engineers individually as to matters upon which they may desire information in Washington. If any of you, as individuals,

desire to know what legislation has been enacted, if you will drop a letter to Mr. Leighton he will collect the information for you and will send you the copies of the bills.

Now there is considerable other work that is being done by the National Service Committee. It is working on the reclassification of government salaries in coöperation with a joint committee of the Senate and the House of Representatives. It has furthered the passage of special legislation which will remunerate engineers for the travel that they incurred in their war service, particularly the Reserve Officers who found it necessary to travel long distances, who were discharged a long way from home. That was an injustice which few of us realize.

The Committee also has secured an alteration in the census classification of engineers. Heretofore technical men were lumped in one group with locomotive engineers. This coming census which now is about to be undertaken will classify technical men separately from the practical men and will divide engineering into its four principal specialties or branches.

The Committee also has accomplished a good work during the past year in coördinating the mapping service of the government. There are a large number of bureaus in Washington interested in mapping, some six or eight or more. Through the instigation of the National Service Committee the President has called a conference of those bureaus engaged in mapping and they are now completing a report which will result in the elimination of much duplication of work in regard to mapping.

Now in regard to the National Department of Public Works one of the chief works of the National Service Committee has been the instigation of the movement to create a National Department of Public Works with an engineer in the cabinet.

The acquaintance gained in government work by engineers during the war disclosed an amazing amount of duplication. Government business was carried on by some seven departments. Each one is divided into a large number of bureaus, from six to a dozen. Matters pertaining to engineering are carried on in a great many of these different bureaus.

Now anyone who is familiar with construction knows the possibility of waste in maintaining organizations in all these different departments to carry on construction work, owing to the use of different specifications, maintaining different purchasing departments, and that sort of thing.

Now in order that this matter might be brought to the attention of engineers the National Service Committee called a conference in Chicago last May and invited all the technical societies of which they could obtain the addresses to meet here to discuss this problem, and we had a meeting in the rooms of the Western Society of Engineers at which 74 societies were represented, engineering

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the side draft ran from fifteen to thirty-five per cent and found, roughly speaking, averaged around twenty-five per cent wasted power through the use of these four abreast hitches.

We not only found it possible to eliminate the side draft with a tandem hitch but ascertained the plows not only ran lighter but did better work than with the four abreast hitch, because they had a true line of draft and consequently the moldboards turned the ground more as it should be turned.

Our next problem was to solve the line of draft. We found, when we had three or four teams strung out tandem, that the line of draft tended to rise and the traces to come out parallel with their sides. This decreased the efficiency of the horses, because instead of coming at right angles to their shoulders, the pull was pulling up on the collar and tended to bring the pull in the wrong place on their shoulders. We finally solved this by weighting the point of draft so we had the angle of traces the same on the lead teams and the first and second swing teams as it was on the wheel team. As soon as we did that we found that our horses quieted down and worked easier.

Now the main problem in increasing the efficiency of horse hitches and the use of horses is to encourage the farmers to use more horses per man. They have the horses, and why should two men go out to plow when one man can drive the same number of horses and do the same work as two men in the field? A friend of mine remarked recently, "I would a whole lot rather go out and help hitch up an eight horse team and let my man get started with a three bottom plow than to plow all day myself." It is a matter of labor saving. If you gentlemen, through your lines of work, can encourage the use of larger horse power units generally throughout the west and the east as well, you can cut our farm labor bills one-third within the next two or three years, and that is a matter of great importance.

That is the first step in increasing the efficiency of horse labor. The second step is to increase the efficiency of the horses. As soon as you give us research work showing how much less efficient the little horses are than the 1,700 and 1,800 pound horses, you will see the most rapid improvement in horse breeding that you ever saw in this section of the country. The men that are displacing animal power with mechanical motive power I find to be almost invariably men that are using the little scrubby good-for-nothing horses. That is, where mechanical motive power is coming in and displacing the horses, it is because they have been using an inefficient type of motive power to begin with.

As the researches of Professor Hanschin of the University of Illinois indicate, on farms under 260 acres the horse furnishes the most efficient and the most economical type of farm power. His cost researches have indicated that very conclusively. He

adds further that on farms over that size seventy-five per cent of the work will still be done the most efficiently and cheaply with horse power. That is the statement of a man trained in farm management and farm economics and it is based on seven years cost studies, five years of which were carried out by trained cost accountants, visiting the farms every other day for that period.

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DISCUSSION

CHAIRMAN: I am sure that Mr. Dinsmore's point on the need of research along the lines of horse labor is mighty well taken by this society. A thought which has occurred to me while he was speaking was that this society should take a step in that direction by at least appointing a committee, a special committee to encourage, or itself undertake some research work along that line. There are a good many of our members who are located at the agricultural colleges who are in position to conduct that research work in behalf, not only of the society but of their individual institutions, and I am sure that something should be done along this line, and no doubt the new officers will start something when they take office.

MR. EKBLAW: He stated that he found in some of the tests with four and five horse hitches that the side draft amounted to twenty-five per cent. How was that determination made? Was it made by dynamometer measurements?

MR. DINSMORE: Yes, by tests with the Gulley Dynamometer. We plowed round after round with the four horse teams and the dynamometer was read according to the speed and the draft at each point; then we changed to the four tandem. We also tested the draft of the plow when the hitch was attached ten inches from the furrow edge, 14, 18, 22, 24, 26, and so on up, and we found the point on the plow where we could hitch and cause the plow to operate with the least exertion on the part of the teams. The complete records are in the possession of Dr. White. The tests were very comprehensive and very conclusive. We found that the lightest load with four horses hitched abreast ran from fifteen to thirty-five per cent heavier than the lightest load with the four horses hitched tandem.

how the draft at different points varied and that there was a general increase due to increased speed.

TEST NO. 4

Made at Ames, Iowa, October 12, 1919.

Equipment: Moline tractor with rear carriage and improvised platform, Iowa integrating dynamometer, and two bottom Grand Detour tractor plow with general purpose bottoms.

Field: The field was one of the soils experimental plots on the campus. It was clover sod on black loam and was quite level, about 150 feet wide and 400 feet long. The soil was quite moist.

Methods: The plow was set to run between six and seven inches in depth and to cut twenty-eight inches in width. The width was held constant by the fact that the tractor rear carriage crowded the corner of the furrow. The plow adjustments were not changed after beginning the test.

Four readings were taken each round, starting at the same points each time. Each round the speed was changed by means of the electric governor control on the tractor. Thus it will be noted that there are four sets of tests.

SUMMARY OF RESULTS

Speed miles per hr.	Station 1	%	Station 2	%	Station 3	%	Station 4	%
1	1440	100	1420	100	1520	100	1440	100
2	1460	108	1530	108	1660	109	1570	109
3	1680	117	1640	115	1800	118	1700	118
4	1800	125	1750	123	1940	127	1830	127

See charts No. 7, No. 8, No. 9, and No. 10.

GENERAL SUMMARY

CALIFORNIA TESTS—CLAY LOAM

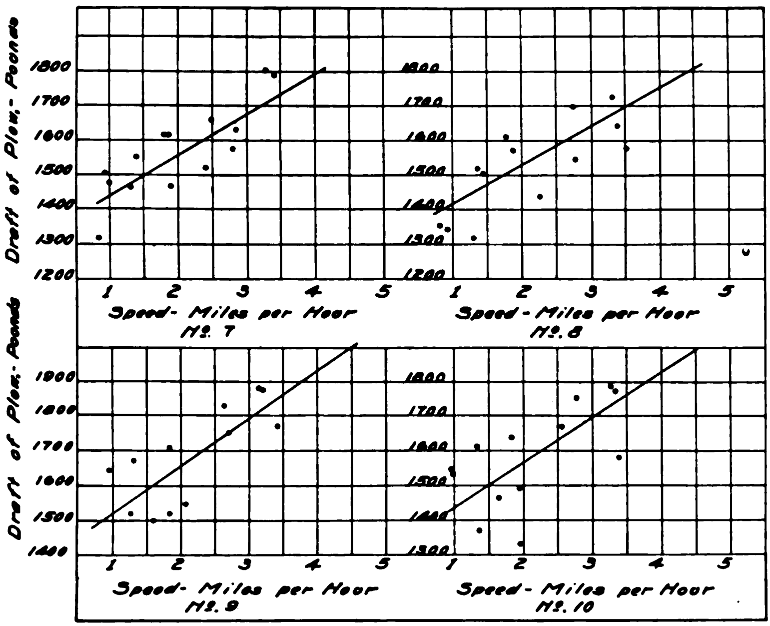
Speed 1 mile per hour	Draft in per cent	100%	
Speed 2 miles per hour	Draft in per cent	114%	100%
Speed 3 miles per hour	Draft in per cent	128%	112%
Speed 4 miles per hour	Draft in per cent	142%	

IOWA TESTS BLACK LOAM

Speed 1 mile per hour	Draft in per cent	100%	
Speed 2 miles per hour	Draft in per cent	108%	100%
Speed 3 miles per hour	Draft in per cent	117%	108%
Speed 4 miles per hour	Draft in per cent	126%	

It is pointed out that the curves shown are in each case straight lines. Perhaps it requires some imagination in connection with a few of the tests to reconcile the observations to a straight line when plotted but it is clear that the stright line comes more nearly fitting the case than any general type of curve.

It has been suggested that a very rapid increase of draft would come with an increase of speed and a more rapid increase was expected. This was based on the fact that the momentum or the kinetic energy of a moving body is represented by the quantity MV^2 where M represents the mass and V the velocity in feet per second. There are perhaps several reasons why this factor does not play a larger part in the draft of a plow. It would seem that a large part of the resistance of the plow is due to cutting and breaking up the furrow slice and furthermore the velocity is not great. Suppose that the moldboard shape is such as to give, when mvoing at three miles per hour, an average velocity of one and one-half miles per hour to the furrow slice, then the velocity of slice is only 2.2 feet per second.



CONCLUSIONS

1. An increase in the field speed of a plow with a general purpose moldboard from two to three miles per hour will result in an increase of the draft of from eight to twelve per cent varying with the soil. Doubling the speed will result in an increase of diaft of from sixteen to twenty-five per cent. The amount of work accomplished is increased fifty and 100 per cent respectively.

2. The furrows are laid more smoothly and the furrow slices better pulverized at the higher speeds.

3. There are no inherent difficulties in plowing stubble ground in good condition for plowing at a speed of four miles per hour.
4. It is quite clear from observation made during the tests that plows could be operated at even higher speeds if the plows were especially designed for such speeds.

DISCUSSION

QUESTION: May I ask again just what each of those curves indicate, in No. 6?

MR. DAVIDSON: The furrows were started at the same point. Each of those lines or curves represents a starting point; but each of the observations represents an individual furrow. There are five observations from each starting point.

QUESTION: Under what conditions was your plow set?

MR. DAVIDSON: Everything is uniform as to width and depth. The thing to observe, is that if we had made all the observations at different parts of the field and put them together we would have covered the whole chart, but by charting the draft of parallel furrows we were able to get something out of them. We used an integraitng dynamometer which operates for fifty feet. The theory of the instrument is that we want an accurate draft for short distances, where the conditions are known.

QUESTION: What accounts for the droop of the curve?

MR. DAVIDSON: I do not know. In curve six it might indicate that it wasn't a straight line increase but increased faster with the higher speeds.

QUESTION: Was it due mostly to soil conditions or draft condition of the tractor?

MR. DAVIDSON: More likely the depth of the plow than anything else. There are a good many factors. Perhaps we wern't watching the plow just then and some mud balled up on the furrow wheel and made it run shallower or something of that kind.

MR. JONES: Would it be fair to raise the presumption that at a speed between two and three miles an hour the draft falls off slightly because it is at just that speed that the plow is designed to run?

MR. DAVIDSON: From all of our observations we were not able to conclude that the increase in draft is anything but something approximately a straight line increase.

MR. BOHMKER: I should like to ask Professor Davidson whether the speed and draft produce a straight line or curve of the first degree or whether according to these charts it seems to indicate that it does not follow a straight line, but tends to follow a curve of some other degree?

MR. DAVIDSON: Answering that question, we expected that the law governing the increase of draft would be, as you suggest, a curve of some other degree because of the influence of kinetic energy, which is lost as the furrow slice comes to rest. Perhaps in test six there is something to indicate that that is true but I don't believe the other observations would indicate that. The other observations would indicate it is a straight line, as far as we are able to observe. Since we started on this work Professor Hoffman of California stumbled on a German thesis by Mr. Koehne of the University of Berlin. This investigator using a miniature plot of soil seventy centimeters long and a miniature plow at a speed from ten to forty centimeters per second reports a reduction of draft with an increase of speed. The speeds used were much lower than practice but a reduction of draft is reported with an increase of speed. In our tests high draft was reported at low speeds but was in each case attributed to failure of the plow to scour.

Mr. Jones: In view of the fact that the report states that there is a wide variation in the actual work done in the way of tillage, that is to say, of seed bed preparation, is there any way of drawing a conclusion as to the draft of the plow in relation to the tillage accomplishment?

Mr. Davidson: Well, the part of this contemplated investigation was a determination of the degree of pulverization on the furrow slice. Now we haven't said anything about that because we have not arrived at anything definite. Mr. Hoffman who is now carrying on the investigation in California has provided a cylinder by which he goes out and takes a sample of that furrow slice following the methods used by the German investigators and he is determining the size of the soil lumps or particles in the furrow slice. This is not an easy thing to do and the results are about as irregular as they could be.

Mr. Riley: It seems to me that that point is an extremely important one, because the advent of the tractor, I believe, is going to bring into prominence the consideration of the number of horse power hours of work required to put a field into the condition of tillage that we call a suitable seed bed. If it may be possible to show that an increase of draft of fifteen per cent produces fifty per cent more tillage effect, we have got a very profound fact that will have to be given a very serious bit of attention.

EFFICIENCY OF HORSE LABOR

WAYNE DINSMORE [1]

This paper compares the available animal and mechanical power used in agriculture. In general, discusses the efficiency of a horse as a prime mover, overload capacity of a horse, practical advantages of the horse and makes recommendation concerning research work for raising the efficiency of horse labŏr. Reports experiments in using four, six and eight horse teams, hitched tandem.

One of my friends who recently learned that I was to address this meeting stated that I would be about as popular as a republican in Texas, because of the common idea among horsemen — for which there is some ground — that the agricultural engineers are not interested in horses or in anything that horses do. The United States is noted as having the greatest production per capita of any nation in the world. That supremacy in economy of production has come about through the utilization of power in the shape of animal power, chiefly horses and mules, for the introduction and use of mechanical motive power has occurred largely within the last three years, and their total contribution to motive power on farms is still so limited as to be almost negligible.

Many authorities among agricultural engineers, including Professor Davidson, who preceded me on this program, have stated that the available primary power units on farms exceed all available primary power in manufacture. Most of that power on farms, so far as motive power is concerned, is in horses and mules, for oxen, although used to a slight extent, may be considered negligible in considering the problem.

At the very outset, it may be well for us to consider a few facts and figures regarding the relative contribution of animal power and mechanical motive power to agriculture. I know that the men in charge of the larger interests responsible for mechanical power regret it as much as anybody — that false statements and extremely misleading statements have appeared in journals supposed to be reputable and supposed to have a standing.

As an illustration of this, is an article which appeared in the *Scientific American* on November 22. I shall read just a brief quotation from this. They state — and this appears in the guise of an article on the draft horse situation: "In 1917 it was estimated that there were about 35,000 farm tractors employed in the United States. In 1918 about 100,000 more were turned out. Now we have the estimate of the probable output of farm tractors in the United States for 1919. This is placed at not less than 314,000. Of these, 224,000 will be put to work on American farms. Suppose that these farm tractors averaged ten horse power net, each. Then we have an aggregate horse power of 2,240,000 which means that that number of farm horses will be put on the shelf." I will not read any further. Yet that appeared in the *Scientific American* of November 22.

Now the facts are these: In 1910 there were in this country about 23,000,000 horses and approximately 4,500,000 mules. Eighty-six per cent of the horses were on farms, ninety-four per cent of the mules on farms. In 1919, according to the most reliable data that we have been able to obtain from all sources, there were on the farms of America about 200,000 tractors, and if we grant that each of them displaced three horses, which is more than the facts warrant, because all of the investigations and the information furnished by the Department of Agriculture and other authorities indicate that the displacement is only about 2.4 horses per tractor at the outside, but if we grant they have displaced the former figure, then they have only displaced about 600,000 horses, or approximately 2.2 per cent of the horses on the farms. In other words, gentlemen, animal power today furnishes ninety-seven per cent of the motive power used in agriculture, and yet, no work has been done by any college or experiment station respecting the efficiency of animal power or methods of increasing that efficiency, or respecting methods of increasing the efficiency of the animal power units, with the exception of the work done at Illinois in 1918 by Dr. E. A. White, which work I myself initiated and which work was subsequently given publicity through the Percheron Society of America.

The efficiency of horse power, as a subject naturally divides itself into four principal phases. These, in the order in which I shall discuss them, are: (1) The efficiency of the horse as a prime mover, (2) the efficiency of the horse as respects power rating and overloading capacity, (3) the efficiency of the horse as shown in actual use on the farms, and (4) recommendations or suggestions regarding means by which this efficiency of animal power may be increased.

On the efficiency of the horse as a prime mover, so far as I can ascertain, nothing has been done in this country. Dr. White who worked with me in 1918 tells me that his reading and investigations into this particular matter have revealed nothing regarding the efficiency of the horse as a prime mover, save investigations made in Germany some years past and that those investigations indicate that the horse is more efficient as a prime mover than any type of engine, merely regarded from the standpoint of power delivered. That does not take into consideration the activities of the animal power until in replacement, and it must not be forgotten that the horse, viewed as a power unit, is not only capable of delivery of power, but also carries out self-repair and is self-reproducing.

Coming to the second phase, the efficiency of animal power as respects power rating and overload capacity, we find that the common idea and the one which has been generally accepted, is that horses can deliver about one-tenth of their live weight in tractive pull, or in other words, that horses weighing 1,600 pounds can deliver a tractive pull of 160 pounds at the draw bar and continue that all day long; yet we know in actual practice they do much more than that, because even under common plowing conditions with a fourteen inch plow running six or seven inches deep, pulled by a pair of horses, you well know that the tractive pull runs from 400 to 700 pounds, yet a pair of horses of moderate size will rank right along with that plow. We need some thorough research work in connection with the load horses should be expected to carry.

Research should also be made in the power rating of 1,400 pound horses and also 1,100 and 1,200 pound horses of certain types. We have had millions of dollars spent on researches in the soil improvement and soil survey work. Yet, so far as I know, not a dollar has been spent on this question of the study of the power rating of horses of different weights and types and temperament. Had we exact scientific data we could bring about a very much more rapid improvement in the types of our horses. You gentlemen have done nothing on this, which is one of the most important problems before us today, and which relates to animal power, which today furnishes ninety-seven per cent of the motive power on the farms.

Coming now to the question of overload capacity, you all know that the overload capacity of a mechanical power unit is at best 100 per cent. The overload capacity of horses is from four to five times their normal capacity. Tests have been made showing that a horse can exert a tractive pull of two-thirds his live weight for a short time. This overload capacity is very important on the farm.

Coming now to the third phase of our subject, the efficiency of aniaml power or horse power as actually used, we find some very very interesting things in this connection, and great variations in the efficiency with which horse power is used in different parts of our country. In the fall of 1917, I made a trip clear across the United States from New England through to the West, studying this particular question, and I found in New England they considered a man had done a good day's work if he plowed one acre a day. A man would go out with a pair of horses weighing only 900 to 1,000 pounds and a little ten inch walking plow. They thought an acre's plowing was a good day's work.

I came on down through Pennsylvania and I found that there the common hitch was a three horse hitch on a single bottom walking plow, sometimes a twelve, sometimes a fourteen inch plow. There they thought a man had done a good day's work when he plowed two to two and a half acres a day. I found that the common hitch used in Illinois or Iowa was a four or five horse hitch; however, there were very few fives; four abreast hitch was the common hitch, and the common plow used was a two bottom gang plow and the amount of plowing done ranged from four to five acres a day. The average ran around four acres and a half per day.

I went to Oregon and Washington only a couple of weeks later. While at Lewiston I met the leading stockmen and farmers from all over the country, and I found that there it was customary to use three bottom plows and eight or ten horse teams strung out tandem fashion. Virtually all of the plowing there is done by tandem hitches. Nearly all of them were eight—some ten—horse hitches, and most of the work done with three bottom plows. I questioned them with regard to difficulty in having men to handle the eight and ten horse teams strung out that way. Well, you know the thought that there might be difficulty in handling those hitches had never even occurred to them. When I came back here and told the people here in Illinois and Iowa that they were driving eight and ten horse outfits, with three bottom plows, and averaging nine and ten acres per day out there, a lot of these fellows here thought I was kidding them.

Having come to the conclusion that we needed more work on the use of horses in more efficient ways, in large units particularly, I took the matter up with Dr. E. A. White because Professor Edmonds, the head of the Animal Husbandry Department, told me White had been working for three years on a dynamometer with which to carry out accurate tests. Dr. White very readily took up the suggestion that we do some work on the problem of larger horse hitches, which would be efficient and satisfactory, because even with the hitches used in the west we found they were not entirely efficient on account of faulty line of draft. I shall not go into the details of the work which Dr. White carried out for the Illinois experiment station in 1918. I may say that part of the work was carried out there, part at the Oliver Plow Works at South Bend, Ind., and part on the Dunham Farm west of Chicago. We found that the ordinary four-abreast hitch was an inefficient hitch, both from the standpoint of the delivery of power and from the standpoint of the horses. We found it was impossible to eliminate side draft with the four abreast hitch unless part of the horses were worked on the plowed land, which of course is not practical. We found that regardless of any claims that may have been made by patentees of different types of patent hitches, it is absolutely impossible to eliminate side draft with any four or five abreast hitch, and you have some of it even with a three abreast hitch. We found that

the side draft ran from fifteen to thirty-five per cent and found, roughly speaking, averaged around twenty-five per cent wasted power through the use of these four abreast hitches.

We not only found it possible to eliminate the side draft with a tandem hitch but ascertained the plows not only ran lighter but did better work than with the four abreast hitch, because they had a true line of draft and consequently the moldboards turned the ground more as it should be turned.

Our next problem was to solve the line of draft. We found, when we had three or four teams strung out tandem, that the line of draft tended to rise and the traces to come out parallel with their sides. This decreased the efficiency of the horses, because instead of coming at right angles to their shoulders, the pull was pulling up on the collar and tended to bring the pull in the wrong place on their shoulders. We finally solved this by weighting the point of draft so we had the angle of traces the same on the lead teams and the first and second swing teams as it was on the wheel team. As soon as we did that we found that our horses quieted down and worked easier.

Now the main problem in increasing the efficiency of horse hitches and the use of horses is to encourage the farmers to use more horses per man. They have the horses, and why should two men go out to plow when one man can drive the same number of horses and do the same work as two men in the field? A friend of mine remarked recently, "I would a whole lot rather go out and help hitch up an eight horse team and let my man get started with a three bottom plow than to plow all day myself." It is a matter of labor saving. If you gentlemen, through your lines of work, can encourage the use of larger horse power units generally throughout the west and the east as well, you can cut our farm labor bills one-third within the next two or three years, and that is a matter of great importance.

That is the first step in increasing the efficiency of horse labor. The second step is to increase the efficiency of the horses. As soon as you give us research work showing how much less efficient the little horses are than the 1,700 and 1,800 pound horses, you will see the most rapid improvement in horse breeding that you ever saw in this section of the country. The men that are displacing animal power with mechanical motive power I find to be almost invariably men that are using the little scrubby good-for-nothing horses. That is, where mechanical motive power is coming in and displacing the horses, it is because they have been using an inefficient type of motive power to begin with.

As the researches of Professor Hanschin of the University of Illinois indicate, on farms under 260 acres the horse furnishes the most efficient and the most economical type of farm power. His cost researches have indicated that very conclusively. He

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MR. EKBLAW: If the side draft amounts to twenty-five per cent of the total with the four horse team hitched four abreast, and since, with the three horse team, it is possible to get a true line of pull and eliminate the draft, then three horses would be able to pull the bottom plow with the same draft as the four horses would.

MR. DINSMORE: You still have some side draft with three horses abreast unless you have very small horses that you can crowd together, and then with the three small horses you haven't enough power; with three large horses you will still have some problems in side draft to solve, and your load is too heavy, anyway.

I may say that Professor White and I were responsible for causing these tandem pulley hitches to be put on the market this last year, and 175 or 200 of them have been sold. I have been interested because of the fact that I was checking up the reports of men who have used them this last year and I noticed one report in "Farm and Fireside" the other day from a farmer who said that his teams had worked much easier and he had no trouble throughout the entire season. He also cited the greater ease of operating the plow. Your particular point that three horses could pull it as easily as four would hold true providing you could use three horses of the same size and give them spread enough to work satisfactorily without incurring side draft.

MR. DAVIDSON: Does the use of six and eight horse teams have a material effect upon the quality of the work, particularly in conditions where you demand rather high grade work?

MR. DINSMORE: In answer to that I may say that you can do just as good work with the sixes or eights as you can with the ordinary fours. You can use a four tandem anywhere that you can use a four abreast. It requires laying off your lands a little differently. You use side lands and head lands the same as you do with tractors and finish up those lands afterwards with the four horse tandem hitch instead of using the eight.

MR. DAVIDSON: In the manipulation of the plow, would you raise it at the ends?

MR. DINSMORE: Yes, throw the plow out at the end. You can get a three bottom foot lift plow and two companies are now at work on the preparation of three bottom power lift plows.

MR. GUNNESS: I would like to ask if, in the use of horses on the three bottom plow, you would always string them out in pairs or would it be worth considering hitching them any other way? Three bottoms are wider than two horses.

MR. DINSMORE: No, because you use longer doubletrees. The true center of pull is thirty inches from center of furrow, and you use a sixty inch doubletree. The point you make is well taken, and I may add that a good many of the men in the Canadian Northwest are using two fours, with the same pulley hitch, hitching two fours instead of using eight strung out. I am not prepared to take a denite position on this particular point. Personally, I wouldn't recommend using the eight horse hitch strung out unless the fields are half a mile long. The fields in the Canadian Northwest run from a mile to two miles in length.

MR. JONES: I don't believe Mr. Dinsmore has called attention to a thing which farmers sometimes mention and that is that the use of the horses two by two and thus wide spread apart facilitates the keeping of the horses cool, so they operate to better advantage in hot weather.

MR. DINSMORE: That point is particularly well taken, and I regret that I did not mention it. We found that was one of the great advantages in using the six strung out or the four strung out. There is a chance for the breeze to move down between them, pregnant mares are not crowded or jostled by their mates, and the horses are not trampling on each other's feet on the turns, which is inevitable with the four abreast hitch.

MR. CLARKSON: I want to call the attention of the men present to the statement made by the late Professor King in his book where he makes the statement that has been proven out in observation by others, that the middle horse in a three horse team is always in a bad position, especially so when the others were pulling a little in the lead, and he always worked the hardest on account of insufficient air.

MR. DINSMORE: That point is especially well taken. I would say that this past year I checked up every case that I could find where horses died from overheating during harvest and in every case it was the middle horse that died. It is no harder to handle horses strung out two and two than it is to use them abreast. It is just as easy to drive six as it is to drive two. Of course, on such a thing as harrows it is oftentimes easier to drive them six abreast than it is to drive them tandem fashion, but not on such implements as plows and harvesters, particularly.

MR. CUNNINGHAM: I think the atmospheric condition would be quite a factor to be considered in any research work that you have on the efficiency of the horse in a team, and I think it would be quite a problem to set down that a 1,100 pound horse pulls so much, because in the early mornings especially in harvest time, you would find that even a 1,600 pound horse won't be able to pull steadily a load that a 1,200 pound horse might be able to pull under other atmospheric conditions.

MR. LLOYD JONES: Mr. Dinsmore left out some of the efficiency of the horse. When you take out a four horse team and break a tug you just leave them standing there and go to the barn, get a new tug and put it in, and you are going again in half an hour, but when you break a tug out of your tractor you go to the house and go to town and you wait a week or ten days maybe to get the "tug" put back into the tractor.

MR. JONES: I would like to raise the question whether the German figures on the efficiency of the horse as a prime mover were based on the continuous work or upon the amount of work done in a year?

MR. DINSMORE: I cannot answer that. I simply took the figures from Dr. White.

MR. JONES: Is the overload capacity of the horse as compared with other forms of primary power with respect to drawbar pull or with respect to horse power?

MR. DINSMORE: With respect to drawbar pull. A tractor, at the outside, won't pull over 100 per cent overload. A horse will pull as much as four or five horses ordinarily will.

MR. JONES: I think that we are willing to concede that the overload capacity is present all right, from the horse power load of the horse; on the other hand, you can provide as low a gear with the tractor as may be desirable, the only difference being that the animal power pulls its greater drawbar pull without changing gears.

MR. RILEY: I just want to interject a remark to modify a little what Mr. Jones said, that your drawbar pull is only dependent on your gear ratio. Of course he knows that that is limited by the capacity of the front end of the tractor to stay down.

MR. JONES: If the statement is to be made complete, "by the adhesion of the driving units," that is to say, traction. That is pretty thoroughly understood and I thought that might be left unsaid.

May I raise the question with respect to the testing of horses; if any systematic tests are to be undertaken should the tests be over thirty days, or over sixty days or over ninety days, should any attempt be made to maintain the horses at constant weight from start to finish? At the test, how many hours a day should they be operated on the dynamometer?

MR. DINSMORE: The testing of animal power is one of the most difficult problems that can be undertaken, which probably accounts for the fact that so little research work has been done on it. The Farm Power Conference called by the Secretary of Agriculture here in Chicago in October blocked out very comprehensive recommendations regarding the testing of animal power and the particular lines on which they should be carried out.

MR. KELLY: I would like to ask for the latest figures on the cost of horse labor.

MR. DINSMORE: I purposely omitted any mention of the cost of horse labor because that is a problem in itself which would take an hour to discuss. I went into that rather exhaustively in an address that I made in New York City on October 30. Any of you who would like to have copies of that may have them.

RELATION OF THE HARDWARE DEALER TO THE AGRICULTURAL ENGINEER

H. P. SHEETS [1]

In this paper the engineers' close coöperation with local hardware and implement merchants is urged inasmuch as they come in closer contact with the farmer than any other community factor. Tribute is paid A. & M. College of Mississippi for its constructive work in utilizing the coöperation of merchants in its service of the farmers of the state and brief mention is made of the splendid results of its Washing Machine and Farm Fence campaigns of the past year, and the Junior Farm Mechanics' Course.

It seems to me that the problems or the functions of the local merchant and particularly the hardware and implement men are very much the same as yours, that of educating the farmer to greater production and to educating the farmer and his family to the desire for greater conveniences and more of the things which will make life easier and happier on the farm. Therefore, it seems to me that you men might well coöperate with this great class of merchants. The hardware and implement man perhaps comes in closer contact with the farmer than any community factor because he furnishes the things to the farmer essential to his business. Often he is the adviser, often stands closely in relationship, closer, in fact, than any other merchant in the community or any other community factor. Having held that opinion for so long, that was what interested me particularly in the work that Mississippi has been doing in the last few years. I heard something about the linking up of the work of the college with the dealers of the state. I heard a good deal about it from one source and another, until I finally determined to go down there which I did last July, and you know I was pretty blamed anxious to do down there. I spent several days around the college and met the members of the faculty. I met President Smith and talked with him about what they were doing. I found they had made a very remarkable success there, perhaps more so than they anticipated. First of all they got it into their noodles that the merchants have an economic function. Sometimes we talk about the merchants as being non-essential, not being producers. We have heard all about the definition of production, the application of service. We forget about the utilities and the particular utilities that the merchant performs or creates. These men seem to have gotten the vision. They have gone out and interested the dealers in what they were trying to do for the farmer. The county agent work in the early days particularly was financed by the merchants of the town. They wanted to see the communities lifted up. They wanted to do something for the communities. Mississippi is just a little backward in some

[1] Secretary of the National Retail Hardware Association, Argos, Ind.

respects, backward in agriculture. I apprehend, as compared with Illinois and Indiana and Iowa, it is backward in a mercantile way. But the fellows in the college went out and interested the dealers in the washing machine campaign. I heard Professor Scoates tell last night what has been accomplished in the washing machine campaign. After the campaign had been put on, the Secretary of the Washing Machine Association said they had sold 1,000 power washers in Mississippi in the first six months. Then they put on a farm fence campaign. That didn't go quite as well as the other campaign because it was put on late in the fall when the shortage of wire was very great. Yet they did great things in that. They found that the dealers were already selling fence down there at a margin of five or ten per cent. We know that nobody can live on that, and yet the mercantile conditions where they were doing that were such that perhaps some of the buyers thought they were profiteering.

It seems to be the big thing they did was in their Junior Farm Mechanics Course. They were planning that, when I was down there and I heard a good deal about it. It was put on in the fall. They planned that at the very most they would have 200 men there, yet Professor Scoates said last night they had 681 boys, more than they could take care of. They ate the whole commissary and the dining room department out the first day they were there. How did they get all those boys there? One big reason was they had a bunch of hardware and implement dealers down there in July and they told them the difficulties, how anxious they were to get there, but how difficult it was. Those fellows, practically all of them who sat there, said, "We will send one boy or two boys" or whatever it was. The very fact that with all their anticipations and all the promotion work they did, they expected 200 and got 681, looks as though they sold the idea to the merchants and they brought those boys there for their course. Those boys, many of them, are coming back for their regular course later on. That plan has sold the college to the merchants of the state. The chances are the merchants of the state didn't know much about the college until they got into this coöperative work. And, incidentally, the college faculty of that institution knows a good deal more about the merchants of the state and what they are trying to do.

It seems to me here is a big opportunity, a big point of contact for every agricultural college engaged in the educational work. You are trying to reach the man who needs education. We need all the points of contact we can possibly get and you need all the help you can get. I am quite sure that if you will get in contact with the hardware and implement men of your state and let them know what you are trying to do, you will get the fullest coöperation. I represent now something over 17,000 retail hardware merchants, and we have associations with membership in 40 odd states. We are out at Argos, Indiana, because 75 per cent of the men that we represent are doing business in towns of five thousand or less. One reason for being there is that we can keep in contact with the class of people that they are in contact with, and can understand their problems. The only function our organization has to perform is to educate the merchants to give better service to their patrons. I know that my Board of Governors will back me up in everything that I have said. I know they will back me up in giving you the broadest kind of an invitation to utilize such assistance as we may be able to give you.

THE NATIONAL SERVICE COMMITTEE

Chas. B. Burdick [1]

This paper explains the organization and work of the National Service Committee. A permanent office has been established in Washington and the service available to engineers is explained. The author explains why engineers should work for the legislation creating a National Department of Public Work.

I want to take a few moments of your time today to tell you something about the National Service Committee ,and as engineers are generally not very well acquainted with the work of the Engineering Council, I want to tell you something about the Engineering Council, the parent organization of the National Service Committee. During the war the government had great need for engineers. The President and his advisors found it necessary to call upon engineers for assistance in carrying out this great war and they felt the need of some central organization to which they could turn. As a result of this demand the four founders societies, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Mining Engineers, formed an organization known as the Engineering Council, made up of representatives from each of these associations, whose function it was to represent these organizations, particularly in its dealings with the government.

A very large number of engineers were furnished to the government in this way, and recommendations were made for reserve officers that carried out this great military work which has so recently been completed in such an effective way. Upon the signing of the Armistice it was found there was much work in peace time that could be done by the Engineering Council and it is accordingly being continued.

Now the object of the Engineering Council, as stated in their

[1] Of the Alvord & Burdick Company, Chicago.

circulars is, "An organization of national technical societies of America created to provide for consideration of matters of common concern to engineers as well as those of public welfare in which the profession of engineering is interested, in order that united action may be possible."

The work of the Engineering Council is done through committees. A large number of committees have been created dealing with compensation and employment for engineers. I might mention that there is an employment bureau which has done a very valuable service. It has placed over a thousand engineers in positions during the last ten months and has conducted something like 17,000 interviews. There are committees that deal with patents, fuel conservation, public affairs, and water conservation. We have correspondents in all the states which are collecting data other than that collected by the geological survey, which will be published and put in the possession of engineers.

The National Service Committee is one of the committees of the Engineering Council. It was created because the Engineering Council felt the need of having an organization in Washington, a permanent organization, that could keep in touch with legislative affairs and speak for the Engineering Council and the profession of engineering when needed. The objects of that National Service Committee cannot be stated better than to read them as contained in the circular of the National Service Committee. They are: (1) To discover public services which may best be performed by engineering societies, to inform the Engineering Council thereof, and when desired, to offer the proper men for such service. (2) To speak authoritatively for the Engineering Council before committees of Congress, and departments of government on all public questions of common interest or concern to engineers, within such limitations as may be fixed by the Engineering Council from time to time. (3) To give wide circulation among engineers, promptly, of first hand information regarding pending legislation and executive actions which may affect the interests of engineers in any way; to gather opinions of engineers upon matters arising for action within the field of the committee."

Now in order to carry out this work a permanent office has been established in Washington. Mr. M. O. Leighton has been employed as permanent chairman. He was formerly Chief of the Geological Survey. He has as his Secretary Major Chenery, an engineer of broad experience, formerly with Sanderson & Porter, and we are attempting through our Washington office not only to keep engineers and engineering societies in touch with legislation and the official actions in Washington that are of concern to engineers, but we are also attempting to advise engineering societies and engineers individually as to matters upon which they may desire information in Washington. If any of you, as individuals,

desire to know what legislation has been enacted, if you will drop a letter to Mr. Leighton he will collect the information for you and will send you the copies of the bills.

Now there is considerable other work that is being done by the National Service Committee. It is working on the reclassification of government salaries in coöperation with a joint committee of the Senate and the House of Representatives. It has furthered the passage of special legislation which will remunerate engineers for the travel that they incurred in their war service, particularly the Reserve Officers who found it necessary to travel long distances, who were discharged a long way from home. That was an injustice which few of us realize.

The Committee also has secured an alteration in the census classification of engineers. Heretofore technical men were lumped in one group with locomotive engineers. This coming census which now is about to be undertaken will classify technical men separately from the practical men and will divide engineering into its four principal specialties or branches.

The Committee also has accomplished a good work during the past year in coördinating the mapping service of the government. There are a large number of bureaus in Washington interested in mapping, some six or eight or more. Through the instigation of the National Service Committee the President has called a conference of those bureaus engaged in mapping and they are now completing a report which will result in the elimination of much duplication of work in regard to mapping.

Now in regard to the National Department of Public Works one of the chief works of the National Service Committee has been the instigation of the movement to create a National Department of Public Works with an engineer in the cabinet.

The acquaintance gained in government work by engineers during the war disclosed an amazing amount of duplication. Government business was carried on by some seven departments. Each one is divided into a large number of bureaus, from six to a dozen. Matters pertaining to engineering are carried on in a great many of these different bureaus.

Now anyone who is familiar with construction knows the possibility of waste in maintaining organizations in all these different departments to carry on construction work, owing to the use of different specifications, maintaining different purchasing departments, and that sort of thing.

Now in order that this matter might be brought to the attention of engineers the National Service Committee called a conference in Chicago last May and invited all the technical societies of which they could obtain the addresses to meet here to discuss this problem, and we had a meeting in the rooms of the Western Society of Engineers at which 74 societies were represented, engineering

societies, architectural societies and chemists, and at which a total membership of 104,000 was represented. This conference endorsed the idea of a National Department of Public Works and appointed an Executive Committee for carrying it out. This Executive Committee has now been at work for about six months. An organization has been perfected in nearly all the states of the Union and a Bill known as the Jones-Reevis Bill has been prepared and has been introduced in the House and in the Senate, and it is expected that within a few months hearings will be held on this Bill.

Now, then, it seems to me that engineers should be particularly interested in this Department of Public Works. It is a good thing. It is of benefit to the public. It ought to be passed on its merits. It is a chance for engineers to do something for the public in a line where their experience will count. If I am not mistaken, there is another advantage that can come to engineers through participation in these movements. No one dreamed that a Democracy could accomplish what we accomplished during the war. No one thought for a moment that we would have two million men in France eighteen months after war was declared. All this was accomplished through coöperation, a united people working for a common purpose. Not that any such a large scale demonstration is necessary to demonstrate the value of coöperation, because it has been proven again and again, but through it we have learned that through coöperation for a worth while thing, those who participate learn to operate the machinery of coöperation and are inspired to apply it to other things of lesser moment.

It is fitting that engineers should learn the use of this tool through coöperation in the work of the engineering societies such as the National Department of Public Works.

DISCUSSION

CHAIRMAN: Are there any questions that any of you would like to ask Mr. Burdick?

MR. TRULLINGER; I would like to ask if the National Service Committee has access to military developments or anything of that nature? For instance, the research work conducted by the manufacturing division of the Ordnance Department, and the work done by the Engineering Corps in the development of coast defense apparatus and things of that nature? When the Reserve Officers were discharged there was a kind of a gentlemen's agreement, in a gentlemen's way, to forget what they knew.

MR. BURDICK: I presume that our committee has access to it. There has been no request so far as I know for any information on military matters at the present time.

SECRETARY: I might say, in furtherance of Mr. Burdick's remarks, that the office of Secretary of this society has been furnished with much valuable material by the National Service Committee, and I am very sorry that the limited scope of our newsletter has prevented the presentation of much of this material to the members of this society.

SOIL EROSION IN IOWA

M. H. HOFFMAN,[1] Member Amer. Soc. A. E.

Nine-tenths of the ditches of Iowa are caused by overfalls working back up through the land. A shield of brush and straw staked down to ease the water over the fall and prevent the churning action below prevents the further progress of the ditch. In filling old ditches a line of tile to carry off the water is of value. Low obstructions of brush and straw staked down or of old woven wire stretched across the ditch and securely fastened to low set posts are set at frequent intervals in the ditch bottom. Concrete dams have been generally unsatisfactory because they are subject to end-cutting and under-cutting. Where specially designed and built they have given good results.

In presenting this paper we wish to state that no attempt has been made to gather minute data on slope, rainfall and drainage area. Our work in the prevention of soil erosion has been from the standpoint of an Extension specialist who is anxious to fill existing ditches and keep others from forming, rather than of the geologist who is merely gathering scientific information. We realize that Iowa has some serious problems of erosion but we know that they can be solved because in every type of soil someone has successfully filled his ditch and prevented its further progress.

Nine out of every ten ditches in Iowa are caused by overfalls working back up through the land. The remaining one comprises two small classes: (1) The overstocked pastures and feedlots where the constant tramping in the mud cuts up the bottom of the ditch, causing it to deepen gradually. (2) Small side hill ditches in cultivated fields where, because it is all loose, the soil washes out to the bottom of the furrow. Water falling over a steep bank softens and loosens the soil at the bottom and permits the sides and end to fall in. If the bottom is already softened by seepage either from a less pervious layer of soil beneath or from an overloaded tile the rate at which the overfall cuts back is greatly increased. In studying the problem it is well to consider the geological history of the state.

According to geologists, Iowa was three times visited by glaciers. The first of these covered practically the entire state. The second came about half way down and the last covered only the northwest quarter. A small area in the extreme northeast corner

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was not touched by any of the three and still has the topography that probably was common all over the state in pre-glacial times. The oldest or Kansas drift, where it has not been smoothed over by subsequent glacial action or covered by later deposits of windblown soil, has gone far in the process of valley cutting. Its river systems are well defined, the tributaries being extended in a network almost covering the south half of the state. There are a few areas of this section that still retain their flat topography. These are long narrow strips between the rivers varying in width from a few rods to several miles, and in length from ten to eighty miles. They lie in a northwest to southeast direction in south central and southeast Iowa and northeast to southwest direction in the southwest part. Erosion is gradually narrowing these strips by lengthening and branching of the streams and ditches.

In the Wisconsin and Iowan drift areas the rivers have not deepened sufficiently to give enough fall to cause rapid extension of side branches. In addition the soil seems to hold together better, so that even among the moraines where the slope is steep there are few serious cases of erosion.

Along the Mississippi and Missouri rivers bluffs of loess or windblown soil have formed, covering the old drift. The Missouri loess when not undermined will stand in vertical walls for years, but under the action of a stream of water dropping over a fall, churning and cutting at the bottom, it assumes the form of columns which rapidly drop in and melt away. A few of these ditches are of large size, some being forty or fifty feet wide and fully that deep. Most of them carry water only during rains and the worst ones are often not those that receive the run-off from the greatest area. Just what combination of circumstances causes the formation of the largest chasms is hard to tell, but the following conditions nearly always exist:

1. Formed in high valley land that is well toward the upper part of the ditch system.
2. Receiving the run-off of less than a section of land.
3. The valley rather wide and flat at the bottom and evidently old.
4. Not an excessively steep slope, but lying between steep hills.
5. The product of an overfall that progressed back up into the land, becoming deeper the farther it went.
6. Neglect on the part of the landowner to check the overfall at its beginning.

The annual progress of these overfalls is from two to twenty rods, depending on the slope and rainfall. Often they are formed in several steps, one overfall following closely upon the other, each deepening the ditch. In general the first overfall is the deepest and the rest range downward in size. The overfall progresses upstream until it reaches the point where the quantity of water is so small that the current is not able to dislodge the grass that has caught root and further progress of the ditch as a whole is impossible. Meantime side ditches have grown out. These are in one way worse than the main one because, while the land could be farmed on both sides of the main ditch, it is now cut into small pieces, irregularly shaped and unfit for farming.

The Missouri loess soil, which ranges from 15 to 30 feet deep along the Missouri river thins down as it extends eastward until it disappears in about the third county from the west. In the strip of land where only a few feet of this soil covers the old Kansas drift, erosion is at its worst. Here the ditches are not so wide and deep but there are so many of them and they have so many branches that they interfere greatly with the farming operations. The trouble seems to be that in addition to a type of soil that washes easily there is the underlying Kansan that, being less pervious, turns the water soaking down from above and lessens the power of the loess soil to hold together. A flat bottom in a ditch with vertical sides is a common sight in this region. The water cuts straight down to the Kansan drift, then widens out.

In almost the entire south half of the state overfalls are to be encountered, but usually in less aggravated form. The South Iowa loess soil has somewhat greater tenacity and where it thinly covers the Kansas drift there are found many seeps or spouts half or two-thirds of the way up the side of the hill, but the gulleys are not nearly so bad. There is, however, in this part of the state another cause of trouble in the erosion of alluvial soil in the valley land. The soil is the rich top layer washed from the hillsides and covers the valley bottom often ten or twelve feet deep. This soil is usually not very tenacious and when once started cuts back rapidly. As usual the overfall is responsible, but the cause of its starting is often a dry weather crack that in time of the fall rains opens up a deep chasm. An instance of this kind has been reported where in a single rain such a crevice developed into a crack a foot wide and six feet deep, that extended back for fifteen rods and by later rains the same season was enlarged to eight feet in width and depth and more than thirty rods in length. Approximately eleven hundred cubic yards of soil were lost from this one ditch in a month's time. The drainage area was less than a half section and the slope averaged less than one foot in a hundred. The land was in pasture but was not overstocked. The fact that a creek at a twelve foot lower level ran across the foot of this valley accounts for the sudden disappearance of the soil. The strictest watch should be kept on side branches of such deep streams.

The remark of a landowner that he believes the places to begin to fill a ditch are at the upper end, so as to check the overfall and at the lower end so as to catch all the soil that comes down, is worthy of consideration. The checking of the progress of overfalls is not usually a difficult nor expensive matter if one is willing to inspect the work after rains and immediately repair any damage. The problem is to ease the water from the higher to the lower level in such a way that it loses its velocity at the ground line and that it does not come in contact with the raw surface of the soil. A method that has proved highly satisfactory is to set firmly one or more posts in the bottom of the ditch at the foot of the fall and about two feet from the place where the water falls over. If more than one post is necessary they should be spaced two and a half to three feet apart around the foot of the fall, their tops sloping downstream. After setting the posts a layer of straw is tramped down on the bottom into the corners and up against the bank. This is held in place by a layer of green brush intertwined between the posts and held down tightly against the straw by crosspieces spiked to the posts. The water comes over this in its accustomed place, but it is eased down, it cannot churn at the foot of the fall, its ground velocity is low and instead of eroding, it loses some of its load in passing through the brush. It is a mistake to build these obstructions higher than the banks, as this turns the stream around to the sides, forming two more overfalls. This is the difficulty commonly encountered in filling the overfall ditch with straw when threshing. If the strawpile is high enough to insure that it will not rise and float away on the first flood, it is so large that the stream is diverted into new channels. Furthermore, the presence of a large quantity of straw is an invitation to wild animals to make holes that lead the water through under the pile in inaccessible places and the value as an obstruction is soon lost.

Some very good results have been reported from overfalls stopped by stretching a woven wire fence across the ditch six or eight feet below the fall and filling the place with bundles of cornstalks set on end and packed tight.

There are a few cases among the bluffs along the Mississippi and Missouri rivers where by reason of the steep fall of the valley and of the hillsides that drain into it, it is better to ease the water from the higher to the lower level through chutes built of heavy plank, concrete or masonry, but the principle remains the same. It is the overfall that causes nine-tenths of the damage from ditch erosion in Iowa and it is there that any control measures should start.

After checking the overfall the problem of next importance is to raise the bottom of the ditch to such a level that it can be crossed by a team and implements. It is not always possible nor is it even desirable to leave no depression at all, for since there is a natural watercourse at this place it is much better to leave a shallow, rounded channel so that the tendency of the water to cut new gulleys will be minimized.

In all types of soil represented in our state it is desirable, and in all but the Missouri loess it is essential to tile drain the bottom of the ditch. This is rightly considered the first and most important step in filling a ditch, for where water flows constantly or even for a considerable time after rains, it is impossible to get root growth established firmly enough to hold the soil already in place and to catch that being carried by the water. A rough, straight-sided ditch in Clarke County was tile drained. Grass caught root where it had been unable to do so before and in eight years' time the ditch had filled from five to seven feet, could be crossed anywhere with any farm implement and presented the aspect of a flat valley.

Tile, to be most effective, should be placed below the bottom of the ditch, not alongside it, and following the general course but smoothing out the sharp turns. To lay tile 1½ to 2 feet below the ditch bottom is subject to a considerable risk of its being washed out by a heavy rain coming before the fill has had a chance to be compacted. To prevent this it is advisable to drive crossed stakes beside and over the tile before filling the ditch, and throw in a small quantity of straw just above. The stakes form an X against which the straw is packed. A series of these, spaced from one to several rods apart, will be found very effective in preventing a washout.

After the tile line is well established, low obstructions should be built in the ditch bottom. For Iowa conditions the most successful have been those from one to two feet high and spaced at intervals of from two to six rods. These obstructions are easily and quickly made and refuse materials may be used in their construction. The brush obstruction is the most common. It is made by setting several old posts in the bed of the ditch. These are arranged in the form of a V with the vertex downstream. A layer of straw is packed on the bottom and against the sides and is covered and held down by brush laid with butts upstream. The brush is kept from rising and floating away by crosspieces nailed to the posts. The obstruction takes the shape of the ditch, that is, higher on the sides than in the middle, thus keeping the current in midstream in times of high water. Its duty is to hold a fill of a foot or eighteen inches and when this is accomplished new obstructions should be placed half way between the old, and so on up. To build the obstructions too high to start with is to invite failure, as too much water is impounded and the danger of undercutting and side cutting is greatly increased.

Many failures have resulted from the old time method of throwing in a continuous line of brush, covering it with straw, and plowing in soil on top. This causes an inaccessible underground channel to develop, and as soon as the brush is somewhat rotten the whole fill goes out, leaving the ditch much worse than before. The use of alternate piles staked down causes solid fill to form between each pile.

When brush is not available for this purpose, old woven wire will be found of great value. Old posts are set as described above and several layers of hog fence fastened to them. A small quantity of straw against the wire completes the obstructions. When one realizes what a nuisance it is to dig out an old wire fence half covered by a fill of trash and earth, one can readily see what a help an obstruction of this kind is when put in the right place.

One of the oldest known methods of preventing erosion is the use of willows. It has, however, not given very good satisfaction. The clogging of tile lines by the roots is an objection sufficient to condemn it: (1) For a tile line is nearly always necessary in such a place. (2) The willow is easily sidestepped by a stream. (3) It is unsightly and advertises a worse ditch than really exists. Very few willows are now being planted for this purpose, and those mostly in clumps across the ditch instead of in a line along it. For preventing the widening of creeks and rivers the willow has made a name for itself but this does not cover its use in preventing the deepening of ditches or in filling them. In the soil areas hardest to hold we have seen ditches filled by brush obstructions staked down that twelve years ago would hide a man on horseback. Today they can be crossed anywhere with the farm implements, and it has not been necessary to use willows.

The use of solid dams of plank, concrete or masonry has been uniformly unsuccessful. The reason for the failure of most of them is that the current sweeping to one side washes out an end and so gets underneath. Seven out of every eight concrete or masonry dams that we have observed have failed, most of them for the reason given. A few have been undercut from the holes of crawfish or of animals and some have broken because not strongly made. If a dam is built with a footing several feet below the bottom of the ditch, with its ends well out into the banks, with the middle considerably lower than the ends and with a downstream curvature of about 120 degrees of arc, we believe it would stand in nine cases out of ten that now are failures.

A concrete dam placed against the wings of a concrete culvert, or when it is built as a unit, a culvert with a boxed inlet has proved very satisfactory. The Iowa Highway Commission has a design suited to places where the culvert must be low to take the tile water and where if it is placed low destructive erosion will result unless flood water is held back. In placing dams against culverts not built with the drop inlet, several precautions should be observed.

1. Since it is placed in the public highway, it should meet with the approval of the County Engineer and the Supervisors.

2. The space between the dam and culvert should be enough larger than the cross section of the culvert to insure that the flow will not be diminished during high water.

3. The space between the dam and culvert should be floored with concrete to prevent undermining.

4. Drain lines should be collected into a tile of large size that runs through the dam on a level with the floor of the culvert. This tile should be covered with gravel or crushed rock for the last rod or two so that water not passing over the dam will be drained away and not allowed to soften the road foundation.

The work just described is similar in operation to the earth dam with raised inlet, commonly known as the Adams dam. This was described in detail by Professor Lehmann two years ago and needs no further explanation. They have been used with success in Iowa but are open to the criticism that unless the large tile is carried to the mouth of the ditch or to the end of one's farm, the part of the ditch below the dam must be kept open. They are better adapted to ditches leading from long, low slopes than from short, steep ones. Our experience has led us to believe that it is not advisable to install them unless the dam is built two feet higher than the sides of the banks so that flood water will go around and not over. A dike should also be extended two rods downstream from each end to prevent the ends from being cut out.

Sheet washing on hillsides has carried away large quantities of soil but except for the bluff land along the rivers it is a question whether the use of terraces is advisable. Contour farming is practiced to a slight extent but most of the farmers find it more convenient to hold as much of the soil as they can by keeping it well supplied with humus than to farm on the contour. We believe the time is about here when they will do both.

The little hillside ditches that receive the runoff of only three or four acres sometimes cause considerable annoyance. The use of sod strips in places of this kind cannot be too strongly recommended. A strip of sod acts in two ways to prevent erosion. It provides a protective covering to that part of the field where the flow of water during rains is swiftest and greatest, and because of the grass and weed stems, it retards the motion of the water next to the ground, reducing its power to cut, and even in some cases causes a deposit of soil, rounding out valleys that otherwise would become increasingly angular and abrupt. When plowing fields in which sod strips are to be left, the furrows should, as far as possible, be at right angles to the strip, not parallel to it, and the plow should be taken out at varying distances from the ditch so that there is no well defined line where the plowing ends and the sod begins. To plow parallel to the ditch invites the water to follow the furrow and start a new ditch.

Where by reason of neglect or of excessive rainfall, the hillside valleys have been eroded, forming ditches from several inches to a foot or more in depth, it is often desirable to plow in and partially fill the ditch before attempting to get a sod started in the bottom. This is quite commonly done but it involves the chance for the loss of a considerable quantity of soil. A heavy rain coming before the ground has been compacted and root growth started is likely to wash out all the loose soil. The chances for success are greatly increased by putting low obstructions a rod or two apart in the bottom of the ditch, before it is plowed in. These obstructions should not be of a permanent nature and should be so low as to be entirely covered by the soil plowed in. For ditches a foot deep and two feet wide an armful of stove wood slightly sharpened and driven in the bottom of the ditch in the form of a crescent curved downstream and low in the middle and having a small forkful of straw packed against it above makes a most effective obstruction. As soon as the ditch has been plowed in it should be seeded down to rye or some other quick-growing grass and a permanent sod established as soon as possible.

The unglaciated land in the extreme northeast part of the state contains areas that are more or less troubled with sink holes. A crevice in the underlying limestone allows some of the earth to drop through and be carried away by the underground stream. Gradually this cavern is enlarged until the surface soil falls in, forming a bowl from five to fifteen feet deep, twenty feet or more across. There is usually a hole at the bottom through which soil disappears in time of rain and in which livestock is occasionally lost. In sections where sink holes are found there is no river system, since all the runoff is taken directly to underground streams. The distribution of sink holes varies considerably, there being sometimes as many as five or six on a ten acre field. Naturally, they present a serious obstacle to farming operations. Many attempts have been made to stop them by throwing in logs and brush, but the earth keeps sliding in. Some of the crevices in the rock have been plugged with stone and cement, but this results in a mudhole, since there is no other way for the water to be drained away. The problem is to get rid of the water, retain the soil and not form a surface ditch. This has been successfully done by cementing a sewer tile into the crevice of the rock and building up from it a flue of sewer tile uncemented. In time of rain the water flows over the top of the tile, leaving the dirt behind. That which cannot go over the top soakes through the joints below. Some of the larger ones need to be provided with a manhole grate, but a good many can be capped when within two feet of the level, after which they may be covered with soil, farmed over and forgotten.

On the whole Iowa is not badly eroded. The land is rolling but not rough. Some soils are much harder to hold than others, but in every section there are men who have been watching and studying the problem and are successful in checking erosion. Half the success of any method lies in the man who puts it into use and watches his work, repairing any damage in time.

WHAT WE KNOW AND WHAT WE GUESS IN DRAINAGE DESIGN

DAVID WEEKS,[1] Jr. Member Amer. Soc. A. E.

The things most guessed at in drainage planning are the amount and source of damaging water, the character of the soil and the personal element. Matters of design, that is, the determination of required capacities, proper dimensions, the adjustment of grades and the determination of size and dimensions of special features and structures are not matters of guess work but a process of systematic reasoning, making the best of all available data.

The relation between the Kutter formula and Elliot's modifications of the Poncelet formula should be known before applying either to a runoff factor found by using the other.

The only reason why I should appear before you, gentlemen, to give this paper is possibly because of a study I made of the drainage problem throughout Iowa and adjoining states last summer. It is the height of my desire to see men give papers on this subject before this society, of the caliber that I shall mention later in my paper, from whom I have received letters, at my request, regarding matters of design in drainage work. I have a right to make the statement, since I am devoting my whole attention to land development, both by irrigation and drainage, soil erosion, and allied subjects, that land development is one of the greatest opportunities for the operation of the interests of this society, and I regret that we have not more of the big engineers. We have some of the biggest men in drainage work and land reclamation work as members now, in this society, but we want a bigger representation from those men out over the country who are devoting their entire attention to land development work.

The subject matter of this paper is a very brief summary of the conclusions that I made after the study of drainage projects, some of them under construction, in Northern Iowa and South Dakota, principally open ditch and large tile projects, open ditch work in Southwestern Iowa and Southeastern Nebraska, floodway and silt basin problems in Eastern Nebraska, and hydraulic and dragline levy construction along the Mississippi river. My study of the Mississippi river projects extended from Muscatine, Iowa, to a point below Quincy, Ill., including projects in three different states, Illinois, Iowa, and Missouri.

For the purpose of my work in presenting this paper I am going to make two divisions in the work of design. I am going to use the word "plan" in designating those features of the establishment or the location of the different parts of the drainage system, and I am going to use the word "design" as referring to those matters pertaining to the choice of size and dimension and the design of structures also.

[1] Department of Agricultural Engineering, Iowa State College, Ames, Iowa.

PLAN

I am going to run rapidly through some of the things that we know and some of the things that we have guessed at in the matter of plan. This is a review, to a large extent. The things concerned with plan that we guess at most are topography, and that is not necessary at all. We guess too much at topography because of the slipshod methods of topographic surveys, source of damaging water and amount of damaging water. The amount of damaging water is guessed at more in the matter of plan than it is in the matter of design. That sounds strange, but that is a fact, that source of damaging water is not taken into consideration in plan anywhere near as much as it should be, and amount and character of the natural drainage is guessed at, and it should be supplemented by our artificial drainage systems.

Backwater, in drainage outlets, to my personal knowledge has been neglected to the extent of bringing very extensive lawsuits in Southern Nebraska, where I know of a drainage district that was compelled to pay damages for failing in this connection, and that is a court decision that will be looked to in a great many instances where a drainage district is held for failure, responsible for failure, and made to pay damages.

The character of the soil, both in plan and design, is often very much neglected. The personal, or human, element I think is the most unsatisfactory thing that we have to deal with. Unforseen difficulties in construction often cause a change in plans that would not be made if proper preliminary investigations were made.

Now other things affecting plan, and which have not been neglected as much as these things that I have mentioned are property lines and values, the cropping system, the trees, utilization of drainage water, drainage loss, machinery used in construction, whether the system is open or closed, available money, size of area, shape of area, climate and ownership of land, are all things that affect plan, but which are not neglected and guessed at as much as those previously mentioned. Now I will hurry on and present the formal part of my paper in a hurry so I can devote some time to some lantern slides which I have.

DESIGN

The determination of required capacities, proper dimensions, for tile drains and open ditches, the adjustment of grades and the determination of types, dimensions, and materials for special features including structures, pumping plants, reservoirs, silt basins, levees or structures after the plan has been made to require them, may be accomplished by well established methods.

There need be very little guesswork in the design of a bulkhead or an inverted syphon for carrying drainage waters under a floodway but practical experience will come in very convenient. The design of a pumping plant is a very definite proposition after the runoff and storage has been determined.

Runoff. A reply to an inquiry concerning the drainage problem states that runoff is the most unsatisfactory part of drainage design. In my opinion the personal or human element is the most unsatisfactory thing in drainage design.

Runoff is a special problem and is handled with a great deal more skill than is generally realized. However, there is much to be hoped for in the matter of working data for drainage engineers.

Runoff investigations have recently been made by the U. S. Department of Public Roads. On the Boyer River, Allen, Willow and Pigeon Creeks in western Iowa; on the North and South Forked Deer River and other streams of western Tennessee; in Bolivar County, Mississippi, and on a number of streams in Lee County, Mississippi. Data collected in these investigations consist of information relating to the following subjects: The size and shape of the water-sheds, the condition and arrangement of the water-courses; surface slopes of the water-sheds; the nature and amount of timber and crops; soil conditions; the rate, duration and frequency of rainfall; the flood conditions with resulting injury to crops.

Mimeographed reports of these investigations with blue prints showing maps of the respective drainage areas, hydrographs of runoff and rainfall records were sent to me for use in connection with this paper. The best I can do is to tell where the information can be found, for these reports each in itself is as concise and brief as possible. Summaries and conclusions without the accompanying descriptive matter would be misleading and not commensurate with good drainage design. Good judgment by experienced drainage engineers in connection with these reports and a careful study of local conditions would enable the engineers to make a design that could hardly be called guesswork.

Engineers are continually designing systems based upon definite amounts of runoff. Practical experience will prove that these values of runoff are too great or too small for their particular locality. While a seasoned engineer will feel safe in his selection of a drainage coefficient, the student and many instructors of drainage will feel bewildered in the selection of a proper runoff factor, often because they are trying to grasp the drainage situation over the United States as a whole while the engineer is confining his attention to a smaller area.

Runoff from an area that has been drained is so much different than the runoff before the system has been built that it requires a great deal of judgment in determining just what change will result, not only immediately by the construction of the outlet system, but by the future extension of the system and the development of farm drainage.

Runoff from Under Drainage Systems. The most extensive investigations that I know of in connection with runoff from under drained areas have been made by our own experiment station at Ames and at the Oregon Agricultural College at Corvallis.

Data of this kind are valuable only as a guide in determining values of runoff for other areas and again, as in the larger works of drainage, the experience of the engineer is necessary to make dependable adjustments for different conditions. Increasing values of land and modern methods of agriculture are demanding more thorough drainage and more thorough drainage means provision for greater rates of runoff.

Measurements of runoff from under drained areas in Iowa show conclusively that the spacing and depth of laterals have a direct bearing upon runoff. Where a flat rate coefficient is used, five-sixteenths to three-eighths of an inch in depth in twenty-four hours is recommended by the Ames Experiment Station for average Iowa conditions, where laterals are four feet deep and spaced 100 feet apart, increasing to one-half inch for laterals spaced fifty feet. Where surface inlets are used these coefficients should be increased. Great care should be exercised in estimating surface runoff as a very flat area will place a greater duty upon the sub-drainage system than an area which slopes enough to allow considerable surface runoff.

The determination of runoff for the design of county drainage systems becomes more complex than the design of farm outlet systems as the drainage area increases in size. The large tile outlets become conducting drains for both the sub-drainage water and for surface waters brought to them through various openings. It is a common practice in Minnesota to design large systems with no surface inlets, thus reducing the rate at which surface water reaches the drain.

The type of farm drainage that will be developed and the manner in which these systems are brought to the main system will greatly affect the design. It is evident that all of the factors ordinarily affecting runoff must be considered for large tile systems and in addition the effect of the probable plan of farm drainage, the spacing and depth of laterals and the general effect of such drainage upon the storage in the soil.

Runoff determination is not a matter of guesswork. It is a process of systematic reasoning, making the best of all data at hand. Exact determinations are not expected and results obtained are commensurate with the amount of investigation that can be done or that has been done.

Millions of dollars are being expended in drainage works which would not be spent if satisfactory results were not being obtained.. Dollars spent for large factors of safety are better than money thrown away on inefficient drainage. A factor of safety in drainage design is a factor of efficiency. In general factors of safety should increase as the amount of available data on rainfall and runoff decreases. In other words, economy of design increases as available data and runoff increase.

Capacity formulas: There are many undesirable features in the use of the Kutter-Chezy formula, but very elaborate investigations by the Morgan Engineering Company have shown that it was the best formula for use in connection with the flood protection and reduction work in the Ohio Valley.

The Manning formula is coming into popularity in making preliminary estimates. Investigations have been made by the U. S. Department of Public Roads which makes the selection of the value of the coefficient of roughness a comparatively definite operation. A bulletin by the Bureau of Public Roads on the values of the coefficient "n" is at this time ready for printing.

The Kutter-Chezy formula with a value for "n" .015 is considered as being the best formula for computing velocity of flow in the tile drains. Mr. C. G. Elliott, former chief of drainage investigations, has offered the Poncelet formula, with modifications of his own, for computing size of tile. Although good results can be obtained with this formula if its limitations, which are many, are understood, the best authorities, including the Office of Drainage Investigations, recommend the use of the Kutter-Chezy formula.

Although Mr. Elliott has obtained good results with his formula and it occurs in the best available text on drainage as the only means of computing tile size, its use in general is considered dangerous for the following reasons:

(1). The velocities given by the coefficient 48, if a length of 1000 feet be used, are much in excess of those given by the Kutter formula, which has been shown by experiment to give results that are in close approximation to experimental results.

(2). For drains less than 1000 feet in length the velocities increase at a rate which seems impossible.

(3). For large systems a "representative" length is selected to which the formula is applied. Nothing is definite about this representative length and widely varying results can be obtained according to what may be selected as a "representative" length.

(4). Excess head in open soil is arbitrarily taken as one-half the depth of the soil at the upper end of the drain without considering the fact that half way down the drain there may be, and probably will be, the same excess head which will offset the effect of the excess at the upper end. In other words, the hyresult, not only immediately by the construction of the outlet system, but by the future extension of the system and the development of farm drainage.

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(4). Excess head in open soil is arbitrarily taken as one-half the depth of the soil at the upper end of the drain without considering the fact that half way down the drain there may be, and probably will be, the same excess head which will offset the effect of the excess at the upper end. In other words, the hydraulic gradient is simply raised and the Kutter-Chezy formula can be applied to a hydraulic gradient based upon excess head as well as can the Poncelet formula, although it is better to keep the hydraulic gradient fairly well down to the tile for ordinary conditions of runoff, leaving the added capacity given by the hydrostalic head in the soil for freshets.

(5). In offering excess head in the soil as an excuse for reducing the size of the main tile drain no account is taken of the fact that such a tile is flowing with a hydraulic gradient considerably above the grade line with the result that the hydraulic grade line of the sub-mains is flattened and a larger sub-main is necessary to carry the maximum flow.

Mr. Elliott now offers a different value for the coefficient for

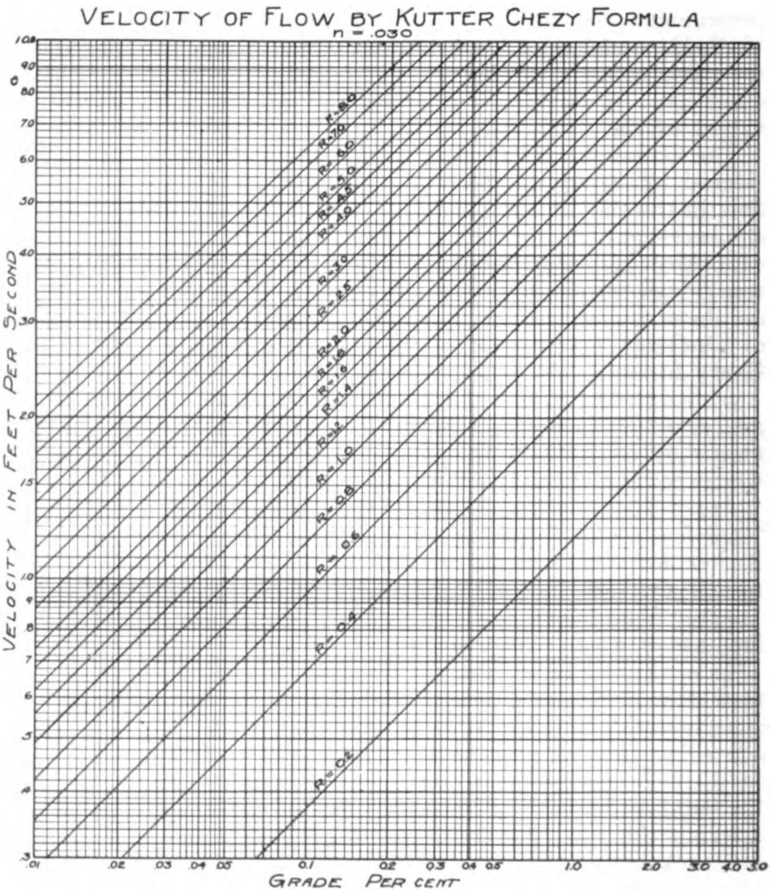


Fig. 1

each size of tile. Velocities obtained by these coefficients with a length of drain of 1000 feet are still in excess of those using Kutter's formula with n=.015. A set of coefficients can be computed which will give velocities very closely approximating the results of the Kutter formula. The greatest variations are noticed for the smaller sizes of tile but these variations are small.

If a different value of the constant is to be used for each size of tile a very much simpler formula can be suggested in the form of $V=K\sqrt{S}$ where K is a constant depending upon the diameter of the tile and S is the slope in decimals of a foot per foot of length.

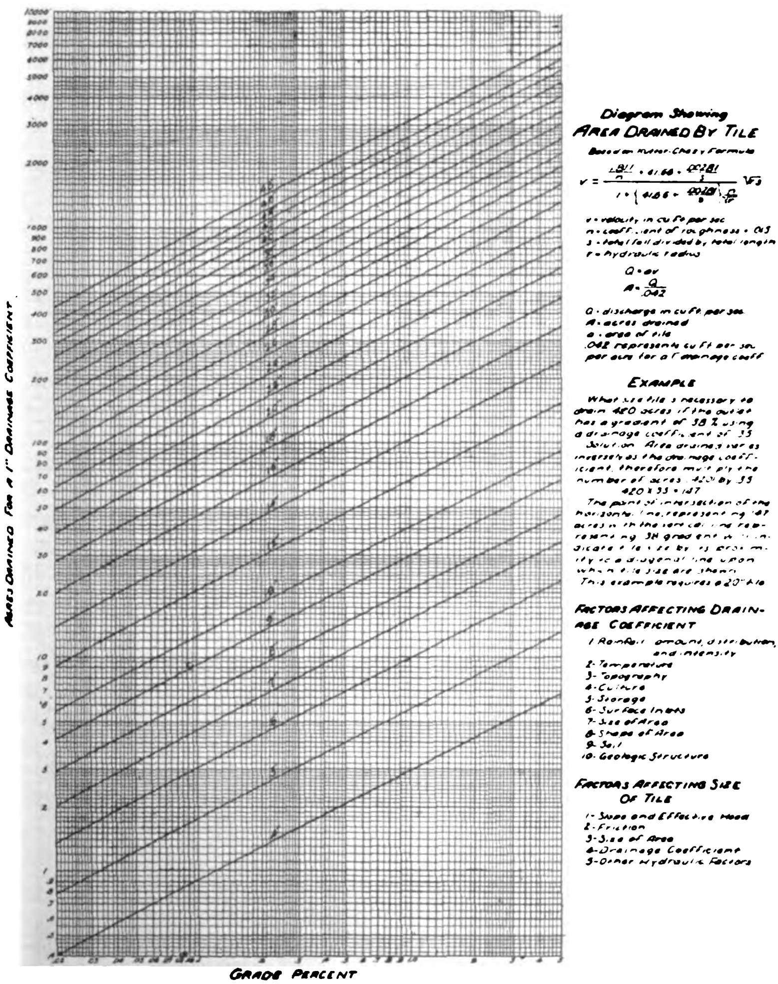


Fig. 2

Within practical limits this formula will give results almost identical with the Kutter-Chezy formula. Since velocity is only a step toward finding capacity and since capacity is an intermediate step toward determining the number of acres a tile will drain it seems the most convenient formula to introduce, especially in our simpler tests on drainage, would be

$$A=\frac{K\sqrt{s}}{C} \text{ in which}$$

A=Number of acres drained.

K=Constant for each commercial size of tile.

C=The number of cubic feet per second per acre, for the determined drainage coefficient.

Charts for the convenient use of the Kutter formula in designing under drains are shown in figures 1 and 2.

The chart shown in figure 1 is similar to a series of charts pub-

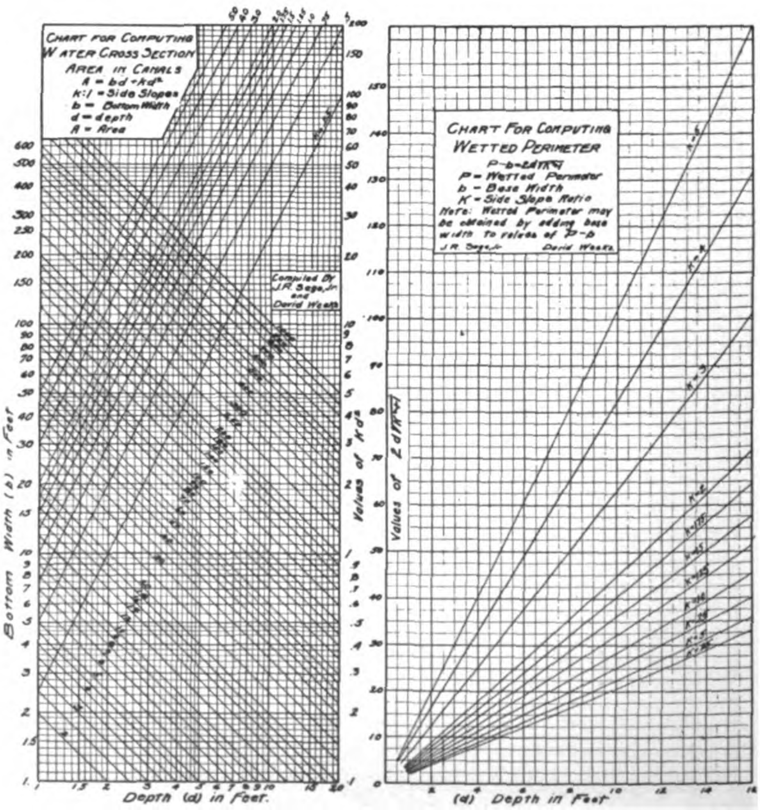


Fig. 3

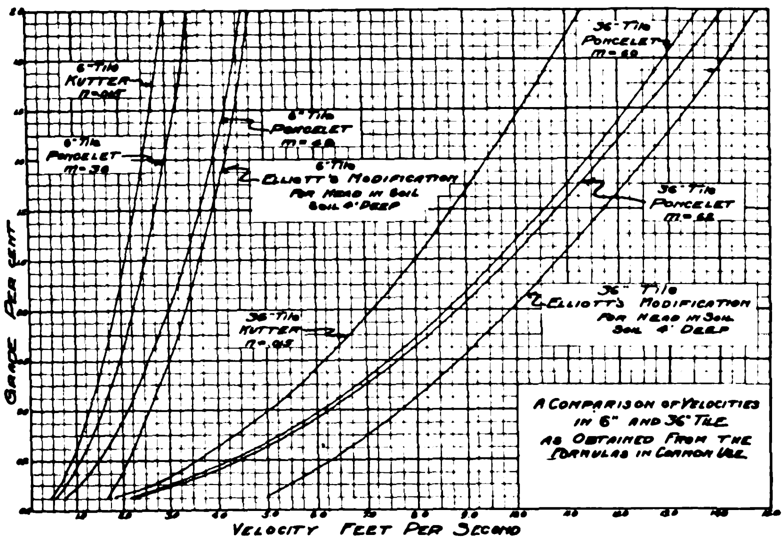


Fig. 4

lished by the *Engineering News* a few years ago. The chart for tile size shown in figure 2 is similar to one prepared by Mr. Schlick of the Ames experiment station, but has the added advantage of being more flexible in regard to the selection of a drainage coefficient. The chart shown in figure 3 for computing water cross section areas and wetted perimeter in open ditches was worked up by Professor Sage of Ames, and myself.

To find the cross section area of any trapezoidal ditch section within the limits of the chart the depth is spotted at the bottom of the chart. This line is followed vertically upward. The product of depth times bottom width is found by interpolating between the diagonal lines across the bottom of the chart at the point where the depth line intersects the width line. This depth line is followed on up to the point where it intersects the side slope line (values of K.). The horizontal line on which this point falls represents KD^2 according to values at the right hand side of the chart. $bd+kd^2$ is the cross section area. The chart for determining wetted perimeter explains itself.

Any charts used in computations should be such that the advantage of flexibility given by the Kutter formula will not be destroyed. The chart given in figure I is only one of a series that should be at hand for different values of n; however, .030 is the most common value for use in drainage design.

Figure 4 shows a comparison of velocities found by the different formulas for flow in tile drains.

There is a great deal of difference of opinion concerning the amount of allowance that can be made for erosion enlarging the capacity of open ditches. There is no question but what in some cases economic design can only be based upon a careful study of this feature. Mr. Seth Dean of Glenwood, Iowa, has had remarkable success in letting nature take her course in adapting a channel to her needs by carving off the banks. Mr. Mayne of Council Bluffs has a ditch several years old that still shows the tooth marks of the dredge. Mr. C. E. Ramser, Senior Drainage Engineer, U. S. Department of Public Roads, has made extensive investigations along this line and his data on this subject will soon be available.

One of the most important things in channel straightening is to get the new channel below the bottom of the old one.

It will be of interest at this point to know what some of our foremost engineers are using for values of n in Kutter's formula, factors of runoff and general considerations given in drainage design. I regret very much that I cannot give their letters just as they were sent to me, but time will not permit.

Mr. D. L. Yarnell, Senior Drainage Engineer, Bureau of Public Roads, states that the design of drainage projects is not so much a matter of guess as it is a matter of good judgment based upon practical experience. He states that engineers as a rule use the Kutter-Chezy formula with a value of .015 for "n" for computing the flow in tile drains. He recommends the use of .030 for an average value to be used in design of open ditches with .035 for channels cleared and .040 for floodways between levees. The importance of judgment in foretelling the change in runoff conditions brought about by drainage works was emphasized.

Mr. L. L. Hidinger, Vice-President of the Morgan Engineering Company of Memphis, Tenn., states that a value of .030 is used by them in design for a value of "n" and further adds that they are seriously considering the use of .035. For flow in natural channels where there are trees and brush they use a value varying from .045 to 075 and for shallow flow through woods they use values from .060 to .100. Mr. Hidinger made a brief discussion of runoff showing how difficult it was to give an intelligent treatment of that subject in a letter.

Quoting from a portion of his letter: "In some flat, sandy areas in this country where the territory drained is large and the shape of the drainage area is such that the water will not rush in to the low places, reasonable results will be secured with a runoff coefficient of ½ inch in 24 hours. The tendency is, however, to increase this. We are now planning to dredge some work in this locality where a runoff of about ⅜ of an inch was provided. We will plan to provide about ⅔ of an inch at this time, and even then the ground will be overflowed for a time after heavy rains."

Mr. Jacob A. Harmon of the Elliott and Harmon Engineering Company, Peoria, Ill., emphasized the human element that I have mentioned before, stating that the farmers do not appreciate the value of the engineer's services and try to do too much for themselves along the engineering line. Mr. Harmon mentions the fact that a great deal of data is still on file in the Department of Agriculture which, if published, would be of great value to the engineering profession and to the general development of drainage.

"It is going to devolve upon the Federal Government and the Agricultural Colleges and Universities to conduct such experiments and make such analyses of the data obtained as are essential to this work."

"The success of Drainage work," contiues Mr. Harmon, "has been due to the fact that very large factors of safety may usually be provided which may be effective for a few hours during the peak of the flood runoff without doing serious injury to the growing crops so that successful drainage work does not by any means require absolute perfection in drainage."

Mr. Andrew Weiss, Project Manager of the North Platte Project in Nebraska and Wyoming, writes concerning quicksand difficulties. I personally spent a year on work from which this report comes. As a general thing, Mr. Weiss has found it impracticable to build tile lines through quicksand after the water table has risen above the grade line to an extent of one or two or more feet. If it is necessary to build such a line the dragline is used and open drains with sloping sides constructed. Then such sheet piling is used as may be necessary to go down to proper depth of grade. This process is so costly that some unusual conditions must exist in order to pay for the work which is necessary in order to secure a substantial and lasting job.

Mr. R. H. Fifield, Project Manager for the U. S. R. S. at Ballantine, Montana, wrote to me concerning the failure of tile Drain No. 26 on the Huntley Project. "This drain gave good results and operated satisfactorily until March and April of this year when two or three breaks occurred in the line due to settlement of tile. These were repaired and the drain was again in successful operation until August, at which time about 1200 feet of the drain began to settle and the drain became entirely clogged. This settlement seems to occur gradually and apparently is caused by infiltration of the sand from under the tile into the drain and thence washed away. Instances have been noted where this vertical settlement has been as much as seven feet below original grade and even trap boxes with bottoms have settled two or three feet.

"For the present, we have suspended construction of tile drains in this class of material awaiting the development of some method that will insure the success of such drains." Mr. Fifield stated that will insure the success of such drains."

Mr. Fifield said that in the construction of the Huntley drain substantial cradles 16 feet long and made of 4"x 4" timbers with 1"x 6" cross ties 6 inches apart were used. Quantities of large rock and gravel were placed in the subgrade and the tile covered to a depth of 4 or 5 inches with good gravel.

ENGINEERING FEATURES OF LAND CLEARING

JOHN SWENEHART[1]

Engineering study along land clearing has been meager and relatively unproductive. Varied conditions in land clearing work seriously modify methods. In Wisconsin we have tried to study the factors controlling the situation first. Hardwood stumps do not lend themselves to use of machines. They are largely work for explosives after five to seven years have elapsed. White pine contains resinous preservatives which prevent decay. This is a problem for machines. We need study of explosives and machines. War explosives may be used but trials must be made to show how. Present machines and explosives not designed for land clearing but merely adopted from some other industry.

When our forefathers first landed in America, their first labor was to remove the forests and convert the ground into tillable land. Even the Indians before them started the cultivation of the soil but they did very little to remove the obstacles which nature had placed.

The development of the country from that day forward has followed in a considerable measure, the reclamation of wooded land. Yet, even today after three hundred years, we still have 200,000,000 acres of useable cut-over land in the United States alone and this area is in addition to stumps on land already partially developed.

In Wisconsin the problem involved in our cut-over land is greater in magnitude than the cost of the Panama Canal, and yet the annual returns from this investment in the development of our good lands, under good husbandry of the soil, will equal the entire cost. Expressed in another way, the Wisconsin problem amounts to this: We have approximately 10,000,000 acres of usable cut-over land which will average about sixty stumps per acre or a total of 600,000,000 stumps. What I have to say is, of course, largely from the viewpoint of the cut-over lands of the Lake States.

The peculiar thing about this problem is that engineering skill has not been applied to it and the methods now in use are not so very much different from the methods in use several hundred years ago. It is true a capstan puller has been developed for use of horsepower. We have also begun the development of explosives for this work, but the extent to which we have made use of this source of power is very limited. There are no contractors who are able to figure on land clearing contracts and do the work.

[1] University of Wisconsin.

In fact, there is so little information that the number of useless, ridiculous patents is astounding. Very few of these patents have even the germ of an idea which is fundamentally practical.

From the standpoint of the engineer the problem has several phases, including a study of the various factors involved and how to apply power to remove them. The factors in determining method and costs include such items as the type of soil, the moisture conditions, both from a seasonal standpoint as well as from natural drainage conditions. In other words, the water table has considerable influence not only on the root system but on the difficulty with which the stump can be broken from its anchor. In addition to these the stump itself varies with kind of tree, years since cutting, size, root system, and the quantity of decay resisting substances contained in the wood part of the stump. A maple is a very difficult stump to remove when green, yet in about eight years, sometimes less, the small roots have rotted and the top is practically gone so that a small charge of dynamite easily removes a large stump of this variety. There are no substances in the maple stump to preserve it and decay is rapid. On the other hand, white pine ten years old has not appreciably decayed because it is filled with resinous substances which preserve the wood. We have white pine stumps standing that are sixty years old and which still present much of a problem. This only indicates a few of the different phases of the problem to be solved.

The problem of the engineer is how to use one or more of the various kinds of power in removal of the stump. We must know the gross strength needed under conditions where the stump is being pulled bodily, where the stump is blasted completely out or where a combination of blasting and pulling is used. He has explosive force, engines, horse power, and even man power. Then he must know the strength required to pile these stumps. How to utilize speed to the best advantage is important. Strength of materials under these conditions is another very important item. It is quite obvious that a study of these various things presents a problem that must have for its solution considerable engineering skill. We have been going in a hap-hazard way for a long time and little can be done in the way of development unless the problem is taken up by men trained in the fundamentals of this kind of work.

At present we have fairly satisfactory explosives although there seems to be room for further extension of their use. There are several important defects in the present explosives used for agricultural purposes. Notable among these are first, that any nitroglycerin explosive is affected by change in temperature and that freezing renders the material unusuable. Further than this, nitroglycerin gives toxic effects to the user, which are very disagreeable and which reduce the extent of their use.

The present day tendency towards wider use of farm engines has not been directed towards land clearing in any extensive way.

In Wisconsin we have a section in the University devoted to the study of land clearing problems. The work of this section has been along several different lines. Use has been made of definitely planned investigations as well as observation of operations going on in a commercial way. The Land Clearing Office is now generally familiar with soil and natural conditions of the stumps in its territory.

Various chemicals have been tried to determine their effect on decay and disintegration. No conclusions along this line are as yet available. The indication from work thus far is that this is not a practical method of hastening removal.

In our study of explosives we have brought out the desirability of the use of low grade explosives, or explosives having slow heaving action rather than a quick shattering one. We have the dynamites which are made with the explosive ingredient entirely nitro-glycerin absorbed in an inactive base and we have the dynamites which have a small per cent of nitro-glycerin and the remainder mostly of ammonia or sodium nitrate or other active basic materials which latter are themselves explosives. The latter class of explosives with active bases are coming more and more into use as they are usually safer, slower in action and less affected by freezing and have less poisonous effects. Old practice in connection with explosives for this work called for the use of so-called high-grade dynamites with either a large percentage of nitro-glycerin or other substances giving equivalent strengths and quickness. Investigation has shown that for blasting the lower grades are equally and sometimes even more efficient at 20 to 25 per cent less in cost. This applies to the active base dynamites.

At the signing of the Armistice, large quantities of surplus war explosives and materials were left on hand. This office immediately took up investigations to determine the usability of any of these materials for land clearing. TNT, tri-nitrotoluene, was one of these materials which we investigated. As a result, all of such material available can be used very satisfactorily for stump removal. We determined not only that it could be used but how to cartridge it. We found that the war experience and the stories of the terrific action of TNT were misleading as well as frequently entirely false. We found that the TNT is a very desirable explosive when used in small loads as we use it in land clearing. In fact, so entirely satisfactory is it that as a result of our investigation covering the use of more than 100,000 pounds, we can say that at a price equal to dynamite it would eventually replace the latter. Study of prices, however, reveals that under present market and industrial conditions TNT cannot be manufactured to compete with the dynamites now used. There is, however, use for all the salvage war TNT that can be obtained.

Our study of machines has been largely a matter of trying out under actual conditions, the various machines now manufactured. This has included not only horse power and man power, but has included various engine outfits. The engine outfits so far, have not been sufficiently developed from an engineering standpoint to make a report along this line. Our work has developed certain weaknesses of ordinary horse power pullers as well as engine power pullers, such that we are better able to judge the needs. The machine of the future toward which we are working must be a simple, low-priced, light weight outfit. It must be so constructed, in my opinion, that both strength and reasonable speed may be developed on a pull line. Of course, when great strength is used, speed will be minimum. Piling line and haul-back also will be important.

Our study of methods has been conducted with particular reference to the conditions which have to be met. In the use of explosives we have studied their use both alone and in combination with power machinery. Such items as the use of electric blasting as against the cap and fuse method indicates the need for considerable effort to disseminate information as to the desirability of electrical method. Proper tamping or stemming has been found to be very desirable and effects a material saving in the quantity of dynamite necessary. Mud capping or bulldozing has been found to be a usable practice in connection with stumps, particularly for splitting out of the ground. A study of depth of charge indicates that there is a proper depth and that charges too shallow or too deep give less efficient results.

Our conclusions to date indicate that on the white pine areas where the stumps are saturated with preservative materials, a stump puller used with a mechanical piler and some dynamite is the most usable. We are, however, convinced that the realm of power machinery should include stump piling. It seems sure that the application of engineering skill by men familiar with the needs of the case will result in the same advances in efficiency that have resulted in the various other lines of Agricultural Engineering.

DISCUSSION

Question: I live in a country where we don't have many stumps, but I would like to know how you arrange the powder or dynamite for blasting?

Mr. Swenehart: Every stump, as I said before, is an individual proposition of its own. Yet, I don't think we can illustrate for every case, but we use a four foot bar made of one and one-half inch octagon steel and a sledge weighing eight to ten pounds and we drive that bar into the soil. Supposing these are the roots of the stump (illustrating with hands). We drive that so as to place it in the soil below the stump and then we bat that bar, after it is driven down to the proper depth, on the side, so we can pull it out. That leaves us a hole for the placing of our charge. Then we have estimated the stump to determine how much dynamite is required and we place as many pounds as are necessary in the bottom of that hole and with a proper cap detonator, which we can either set off by means of fuse or with an electric current. We will then tamp that hole just as tightly as we can, using a wooden tamping stick, and then either light the fuse and get out of the way or go back to our machine and throw the electric current through the circuit, and that of course will cause that charge placed in the soil below the stump to explode. When that charge goes off it has an equal action in all directions, and if the charge is properly placed and in sufficient quantity and the work well done, the stump will be removed with a minimum of hole and most of the roots will be pulled out to a distance below the plow line.

QUESTION: I supposed you bored a hole into the stump.

MR. SWENEHART: Not in the wood of the stump. We don't use an auger if we can help it. We always use the bar, because it is so much quicker. It is never desirable in our section of the country at all to bore into the wood part of the stump.

QUESTION: What do you use to ignite the TNT?

MR. SWENEHART: A No. 8 cap, which is about twice as large as the No. 6, which is the smallest one that you can buy for this work, and we can set that off with either the electricity or the fuse, or we use a primer of dynamite, that is, we use one cartridge of dynamite placed right in with the TNT.

MR. PATTY: I would like to ask whether this is carried on as extension work or at the experiment station?

MR. SWENEHART: We have both. It is an extension project and also a project of the experiment station from the standpoint of investigation. We have both features of it. We, of course, investigate the problem and study the thing out first, and determine the actual conditions and then demonstrate it later.

THRESHER METHODS

L. R. VAN VOLKENBURG,[1] Member Amer. Soc. A. E.

Threshing consists in separating the grain from the chaff, and taking the chaff from the grain.

To avoid "cracking" and loss of grain, there must be no end play in the cylinder, good adjustment of teeth and proper speed.

A proper and unvarying speed must be maintained on all separating parts.

The regulation of the wind blast is the important feature in the separating of the straw from the grain.

Belts must be kept in good condition to insure a constant speed and a maximum delivery of power.

Organization of the threshing crew means a curtailment of expense and greater efficiency.

Mr. Chairman and Members of the Society of Agricultural Engineers:

In discussing thresher methods, I will first take up the machine in a brief way. It is a subject at the present time that needs considerable consideration by the agricultural colleges, and the report of your committee, Mr. Chairman, this morning was very interesting to me, inasmuch as they recommended farm implement courses to be adopted in the colleges where they are not already adopted.

Up to the present time there is no adequate literature on threshing or operating threshing machines, due to the fact, presumably, that the threshing has largely been done in the past by men who are expert threshermen and who know as much about threshers as the people who manufacture the goods. Those conditions have been changed entirely, from the fact that the thresherman as an expert, or a man who made his business that of threshing, is largely a thing of the past. The advent of the small tractor has changed the threshing conditions almost entirely, so that at the present time, the condition is more that of combined threshing, or a number of farmers going together and purchasing a machine, or where the farmer buys his individual threshing machine and does his own work.

I will touch on those things again a little later on. I first want to speak of the machine. It may be plain to you, gentlemen, but perhaps some of you have not had the experience to know, that threshing is a very simple process. When it is brought down to the final analysis, it consists of only two operations: (1) of taking the grain out of the chaff, or loosening it therefrom; (2) in taking the chaff out of the grain.

The whole process of threshing depends on the teeth of the cylinder taking the grain out of the head, and it is done in two ways: (1) The speed of the tooth, which is a little over a mile a

[1] Avery Company, Peoria, Ill.

minute, striking the grain, removes it from the chaff. (2) Where we strike tougher grain, damp grain, grain of a smaller variety, or shrunken grain, it has to be done largely by rubbing, and it is the rubbing process that the average fellow forgets. That is usually what makes a good or a poor thresher. The latter doesn't know that the rubbing process is necessary to get the little kernel out along with the larger grains, and consequently he runs his machine with teeth that are badly worn.

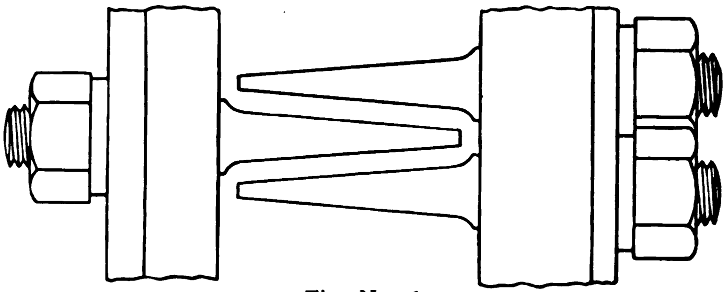


Fig. No. 1

Now a tooth that is new is nearly straight on the front, or the edge that strikes the straw. As it wears it becomes curved. The curvature doesn't matter. It is simply the rubbing of the surfaces of the side of the tooth that is being lost, so that the teeth passing, one by the other, doesn't get the rubbing process in action, and consequently there will be grain go through that is not removed from the chaff.

Another thing that is very apparent in the operation of the machine, is that very few men appreciate the necessity of a proper adjustment of the cylinder teeth in their relation to the concave teeth. A cylinder in a thresher has an adjustment for end movement. It must have a little end play in order not to have the bearings bind, but this must be very slight, not to exceed one thirty-second of an inch. The teeth of the cylinder pass between the concave teeth, and the space on either side must be equal.

Now, if the cylinder oscillates back and forth, that space is changed entirely, and we get what is known as "cracking." Just recently I got a letter from Missouri, from a man down there, saying he had just bought a machine and it was cracking all the grain. He was cracking grain and losing at the same time, and he couldn't understand it at all. He had his teeth up close and cracked the grain and still he could find grain going through. The fact of the matter was that he had end play in his cylinder, which allowed the distance between the teeth to vary, and when it came close to the concave teeth, it would crack the grain on that side and the grain would go through on the other side. That means that the cylinder must be set so there is no end play.

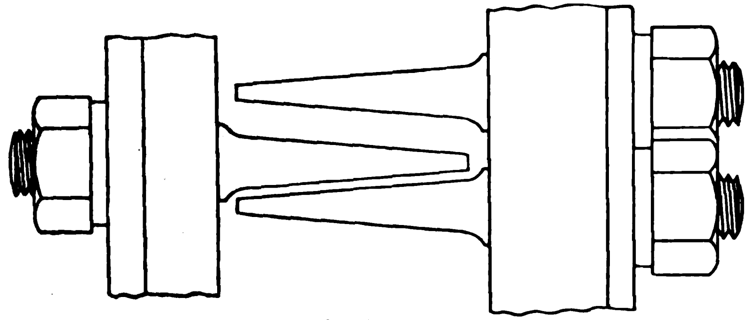


Fig. No. 2

Another bad mistake is made by the thresher who has not had sufficient experience, and that is in the morning—I am speaking more of headed and shocked threshing, but it may be true also of stacked grain—a man starts in the morning with a sufficient number of teeth in his concaves, and a sufficient speed of the cylinder to do the threshing right to get all the grain. Along about ten o'clock the dew is gone and the grain threshes much easier and he comes along and drops the concave. He doesn't realize that when he drops the concave, he has formed a hole. He has formed a hole at the end of the cylinder tooth and at the end of the concave tooth where a whole head can go through without hardly being touched.

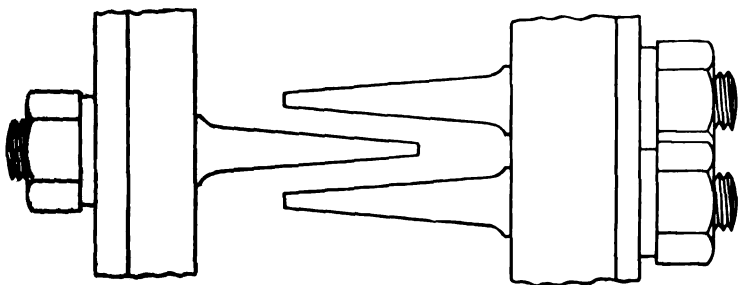


Fig. No. 3

Then, instead of remedying the trouble as it should be, he puts in another concave, usually two sets. He should have removed the teeth instead of putting in teeth. He should remove teeth when it gets dry and is easily threshed, and keep the concaves setup.

There is also a difference in the size of the grains. Some grains, even in wheat, are larger than others. Some varieties of wheat have a larger kernel. Consequently, the teeth being tapered, the dropping of the concave allows the space between the teeth to become greater. That prevents crushing the grain and still it takes it out of the head. I might say that the best threshing that I have ever been able to do, or observe being done, was where the concaves had a spacer between them, a grate or blank concave set in between the concaves, and using four rows of teeth. This grate or concave should not have an opening large enough to let a head of grain go through. It should be a fine grate, but the grate surface under the cylinder is very important when you come to threshing. In many cases where I have been called out to go to a machine because it won't separate, where the grain is not being shaken out of the straw, we found it was simply because they were threshing bundles which had foreign substance in the butts, a growth, like clover or grass, that was green, or rotted to a certain extent, in the stacks or shock, which had plugged the holes in the grates and concaves until the grain couldn't get through.

Nearly ninety per cent of all separating of the grain is done under the cylinder through the concave and grates. The balance is done by the agitating tables or straw racks. The straw rack is very easily operated and only needs one attention. If there is a broken slat it wants repairing, of course, or straw is apt to go down on the grain pan and impair the cleaning. It must be run at a constant speed. That is all the requirement there is as far as the straw rack is concerned. That means that a constant speed must be maintained at the cylinder in order to drive the straw racks at the proper speed, and it also means at the belt (and that is a thing that is overlooked more than any other one thing), that the belt driving the crank shaft should be kept in good shape.

Now, in threshing different kinds of grains, the cylinder speed can be varied greatly. In fact, in threshing rice, for instance, we run the cylinders at about 500 R. P. M. In threshing beans, we run it as low as 300 R. P. M. In threshing peanuts—and an ordinary grain thresher will thresh peanuts, which probably sounds strange to some of you. We thresh thousands and thousands of bushels of them in Texas every year by a little interchange of parts—it is all done by simply changing the cylinder speed, the number or kind of teeth in the concaves, and always maintaining the same speed on all the parts of the machine, only dropping it on the cylinder itself. If that is kept in mind, anyone, without previous experience, can go out and thresh all kinds of grain readily, by simply maintaining the proper speed of the straw racks, the fan, the grain pan, etc. You must change the pulleys. If you want to run the cylinder slower, put larger pulleys on the shaft, which will run the rest of the machine at the proper speed.

To do threshing properly, the machine must be fed practically constant. That is done by a device called a feeder. There has been very little development in the thresher itself in the last decade. In fact, the principles involved are exactly as they were when I first began to thresh, but the accessories, such as feeders, weighers, elevators, blowers, etc., have come along as developments along with the other development of the machinery. The feeder of today is a very practical machine. It is very perfect in its way.

The straw governor is needed, and also a speed governor on every feeder, a governor that will slow up the rakes the minute the cylinder speed becomes too low; and another governor that will stop the rate of the bundles going into the machine, by virtue of the volume of straw, or straw governor, so the bundle will be raked off by the knives, whether rotary or bars, and thus bring the straw into the machine evenly. This is largely taken care of by proper training of the crew, which I will speak of a little later on.

The separating of the straw from the grain is done in the back end of the machine, through a system of sieves and by a blast of wind. Different machines have a trifle different mechanism, but the principle is exactly the same in all makes and types. It is simply done by virtue of gravity. That is the only principle that has ever been used to separate the grain from the straw with any amount of success. We simply shake the straw apart, letting the grain fall out of it, and have a rack to catch the kernels on, and if a man wants to thresh successfully he must first make up his mind that this is the only way he can get the grain out, and just as soon as he sees that point he will have no trouble overcoming any difficulty that may arise in his machine. The setting of the sieves and wind is very simple. There are only one or two things to be observed. Just to lay down one or two rules: (1) When the chaff and grain come off the grain pan and strike the chaffer, the blast should strike it at that point and raise the chaff right there. Some seem to think it is very difficult to set the sieves and wind, but it all rests on that point, raising the chaff out of the mass and letting the grain fall through.

There are really two blasts. Some machines are a little different in this respect, but in our particular machine we have two wind boards. One blast should be set to catch the grain just as it comes off from the grain pan, and the other blast to go between the sieves. Back of the sieves we have the tailings auger, and if a man has any judgment at all, all he has to do is to watch his tailings spout on his machine and know exactly what his machine is doing, regarding cleaning. Personally, I prefer an adjustable sieve for all kinds of grain. There are some kinds of grain, however, where a round hole zinc sieve can be used under the adjustable sieve with some advantage. Flax is one of these grains. It is commonly thought by people who do not know, or have not had much experience, that the majority of the grains lost in threshing is over the end of the sieve, but it is a mistake. I do not believe there is a standard machine on the American market today that will waste grain off the sieve, if it is at all properly adjusted. I have operated personally every make of machine on the American market today, that is, every company's machines, and I never have found the machine yet where it wasn't the easiest thing in the world to save the grain on the sieve. It is in the head where most of the grain is lost, and some is lost in the separating device. However, if all our machinery, our farm implements, were as near perfection as the threshing machine is today, there would be little need of improvement. I think that I could say safely that any standard machine, there may be some few that I don't know about, but I am speaking of the standard companies who are building threshers, I don't think there is one on the American market today that will not save ninety-nine per cent of the grain threshed if it is properly operated.

If you go back to the self-binder, you will find that the binders of the United States and the world waste more grain in one year than all the threshing machines will waste in ten or more. The government put on some schools last year to educate the threshers to a more economic method of threshing. I was quite interested in it and helped out a little in some of the work, but there is room for work along that line with more machines than just the threshing machine alone.

The blower needs practically no attention at all, excepting the belt. I want to say a few words here in regard to belts. I find in my experience that their care is one of the most essential things in making a threshing outfit practical. Very few men appreciate the advantage of keeping the surface of any belt in proper condition. Any of you that have had experience with belts, know that a leather belt should run with the hair side to the pulley. But after a belt gets dry, it becomes very inefficient in delivering power to the driving pulley. It can be brought back in one moment's time to its full efficiency with a few drops of ordinary lubricating oil such as you use on the machine. It should be a rather heavy oil to get the best results. I have made a practice for a good many years of using 600W oil, with the result that we never lost any bearings, we never twisted off any shafts, our machine ran much better, absorbing less power, and the belts and everything lasted much longer. The drive belt also must have care. There has never been a main drive belt made, that I have ever seen, that will go out and run through a fall's threshing and deliver its maximum power without treatment, so that if a man wants to thresh to the best advantage, he must give his belts, from the main belt down, some special care. It is stated by very good authority that Neatsfoot oil is the best oil known for leather belts. However, we have belts that have never had anything on them but ordinary machine oil that are thirty years old and in absolutely perfect condition today, showing that the ordinary oil does not in any way affect the lasting quality of the belt. Motion will be very unsteady at the separator, if the belt slips on the cylinder pulley. You will also wear out the belt and lagging. I have helped many a man out of trouble, simply by showing him how to treat his belts to keep them from slipping on the pulleys.

Now I am coming down to the real science of threshing, and it is just like most everything else: it has very little to do with the machine itself. The thresher who has gone out and made good through the United States, is the man who organizes his crew, and this is a place where the agricultural colleges can get in some mighty good work. The fellow that goes out and just goes at it hap-hazard, no one knowing what they are expected to do and each man having a different task every day, never gets anywhere, but the man who goes out and organizes his crew thoroughly, the same as we do in a factory or anywhere else where a crew is used, gets the most efficiency out of each man, because he becomes an expert at the job which he is doing. Statistics show that it costs us thirty dollars to put a new man to work in our factory.

Just to draw one little picture of what I mean: I have seen a forty-inch machine and a twenty-five horse power steam engine move and set, move out of a setting of wheat into a setting of barley, stacked threshing, moved over 200 feet, all changes made by one man on the separator from wheat to barley, meaning the weigher, sieves, wind and concaves, and that same man operated the engine in making the move, and had it all done in four minutes and a half. I have seen an hour and a half consumed in doing the same job. There was no one hurried. No one was rushing around, nothing broken, but it went along like clockwork. It was just one machine, every man doing his little part. That is one of the biggest lessons that we can take to the threshing fraternity today, is to organize the crew. The farmer, in general, is not a good organizer.

Now, I want to talk just a moment on the advantage of the small thresher. In the early days, in the Northwest especially, a thresherman depended on transient labor. If he had a good fall's run, no bad weather, the threshing was done fairly efficiently, but if there were a few wet days, as there always are, this entire crew was lying idle, wasting the farmer's hay and grain and doing a good deal of other depredation, whereas, if the crew had been made up of local men like the ring proposition, which you are more or less familiar with, if there came a rainy spell or a breakdown, each man would go on about his business doing other work until the rainy spell was over, or the break-down fixed up, and this great loss would be taken care of.

Another reason for the small machine being more efficient than the large, is the fact that it keeps the money in the country. I had considerable experience in North Dakota, Montana, and the Northwest, and the amount of cash that was taken out of those states each fall was enormous. It really meant practically one hundred per cent of the farmer's profits was simply taken out of the country when the threshing was done. The transient help had all the advantage. They were there and they knew the farmer had to have them, and they worked the price up to a point where when they quit, they took the profit with them and just left the farmer enough to live on. That has not been so marked in this part of the country.

Another reason for the change of the threshing methods that is bringing in the smaller machine, is the fact that break-downs will occur and time will be lost, and with the advent of the small tractor, you know when you use a tractor, if you break a piece on the separator, that is going to lay up the machine a few days, the tractor will instinctively turn around and hitch itself to the plow and do the plowing and the crew will go on with other work and when the machine is repaired again, the tractor will come right back and step into the belt and go to work. This has been largely responsible for the development of the small machine which is selling in such enormous quantities this year, and will continue to sell in the future. The tractor has some other advantages in the way of threshing that the steam engine never had. It has made the small machine practical, in eliminating the number of the crew and expense. It has cut the crew down to a minimum.

I have just gone over and touched briefly a few things that I have observed in the last few years, without making any attempt at a formal discussion, but I hope I have made myself clear in the important points regarding threshing methods.

TRACTOR TESTING

L. W. Chase,[1] Member Amer. Soc. A. E.

This paper is a discussion of methods being worked out for testing tractors at the University of Nebraska in compliance with the Tractor Law of that state. It outlines the tests which will be made and describes the apparatus being used.

There has been a great deal of agitation relative to tractor tests, and instead of discussing this paper I am going to read to you a few paragraphs from a rather lengthy address that I gave before the Tractor Department of the National Implement & Vehicle Association here in Chicago about three weeks ago.

You have asked me to discuss the subject of Tractor Tests—Federal vs. State, so I am led to assume that you believe that tests of an official nature will materially aid in solving the problem. I, myself, believe that it will aid but it will not, especially with our limited knowledge of testing machinery and testing methods,

[1] Of Chase Tinsman Plow Company, Lincoln, Nebr.

settle the problem. It may surprise you to have such a statement come from one who has been so ardent a supporter of tests as the speaker, however, I might say that I have long since changed my mind as regards what is the perfect tractor or what approaches such a machine. At one time I was justly quoted in saying that a tractor should be a powerful, economical machine, but now I say that the ideals toward which we should work in designing and building a tractor are: (1) *Reliability.* I should both capitalize and underscore that word. (2) *Durability,* and again I would both capitalize and underscore the word. (3) It should develop efficient power. By this I do not mean that it should be an exclusively powerful machine and neither do I mean by my use of the word efficient at this time that it should be efficient in the use of fuel, but what I do mean is that it should be a machine which adapts itself to the farmer's need. (4) It should be an economical machine in the use of fuel.

Tractor tests will very accurately determine the fuel economy of the tractor and they will determine the power of the tractor and to a certain extent tell whether the tractor will adapt itself to the farmer's needs, and they will also, if made sufficiently extensive, determine the durability of the machine, but of all the tests which I can recall or imagine that may be made I cannot conceive of one which will prove the reliability of the tractor and this surely is the most important element in the design of the tractor.

THE DISCREPANCIES OF TESTS

Since it is seen that tests will solve part of our troubles, then let us analyze tests and see how they should be conducted. At one time a bushel of wheat was a bushel of wheat and a gallon of water was a gallon of water, but now we are so scientific that a bushel of wheat is a bushel of wheat only after allowances have been made for grade, compactness and moisture, and a gallon of water is a gallon of water only after corrections have been made for its temperature and its purity. And even then the human element enters to the extent that discrepancies appear in reading the thermometers, in striking off the unit and in determining the purity or the grade.

If discrepancies enter in so simple tests as measuring wheat or water it is to be expected that they will appear in testing tractors, and they surely do. No matter how careful the test is made one day the same test made the next day will not be the same, even if made by the same help, the same apparatus and in the same place. These variations should not be great; however, they will appear. If, however, the tests are made at a different place and with a different set of apparatus and by a different force of men they will be greater. Bearing this point in mind, and it is an important one, not only from a testing standpoint but from an advertising standpoint, as will be shown later, let us look to where these tests should be made.

State Tests:—The tax payers in every state of the Union are proud of their Agricultural Colleges and their Universities. They have faith in the personnel of the faculties and should these tests be made by these institutions they would develop civic pride, they would develop a local sympathy for the work and for the use of tractors and furthermore they would feel that the tractors were tested for their community. Furthermore, the testing would be sufficiently close to the community where the tractors were to be used so that the farmers would drift in and watch the work. By so doing they would soon absorb a knowledge of the tests and learn what they meant and thereby be far more conversant with what the results indicated. It is possible also that the tests could be worked out so they would be more closely related to the climatic, soil and barometric conditions. And another point is the policing which the state, because of its size, can do much better than the government.

The previous statements have been made in favor of state tests but there is another side to such tests. In the first place there are only a very few states which could bear the burden of furnishing and equipping complete testing plants. At Nebraska we have already spent some thirty thousand dollars and have as yet only started to test engines, and we anticipate that it will take some ten thousand dollars more to complete the first year's work. This sum may not appear great to some of you large manufacturers, however, and I believe it to be sufficient to retard any great amount of state testing. These states which desire to make their own tests no doubt will get around the expense by first building cheaper equipment and second by charging fees for testing.

Besides the cost to the state the expense to the manufacturers of having their tractors tested in several states would be great and possibly unwarranted; furthermore, because of a variety of apparatus, different engineers and different climatic conditions there would be a confusion of results which when thrown before the public would make such chaos of the data that it would be of only a general benefit.

Federal Tests:—As I see the points in favor of Federal Tests they would be about as follows: probably one set of apparatus would be used, or at the most not more than three sets, with no engines being tested on two sets, a uniform set of results, and a minimum expense to the manufactureres and the tax payers at large.

The adverse side of Federal Testing in comparison with state would be that the testing would be a mechanical proposition with no spirit of interest or sympathy worked up by the public, there would be practically no education in testing extended to the public, there might be considerable doubt about appropriations being furnished the department which was making the tests should some company, either large or small, which was not satisfied with the results of the test be inclined to use its influence with Congress, and above all there would be practically no policing and this in my mind would be very important if the tests were to carry a permanent effect.

There are two points in opposition to both methods of testing. One of these is the fact that all records become public. If the Federal Government would require the manufacturers to have their tractors tested all the records that the manufacturers would furnish to the Federal Government would become public property, and it is the same way with the State.

A third point which is adverse to either state or federal tests is the use of the data after the tests are made. No matter how carefully these tests are conducted, the engines which are being tested, and are of the same model, will give a slightly different fuel consumption. This variation may amount to fully ten per cent, and the engine would have to be a good one. In my mind, such slight differences in fuel consumption or power developed makes no difference in the value of the engine to the farmer, but because of the fact that these results are measured and given in the form of figures, selling organizations can assemble their data and with it compile a nice table which shows their engine up to the public as the best engine on the market. An example is given here which is made up from tests which have been made. I have taken a list of fictitious names and numbered them one, two, three and so on. I have taken tractor No. 1 and assumed thatt it developed a horse power on .86 of of a pound of fuel. Then I have taken No. 2, as the "Center" tractor, with .87 pounds of fuel, and so on down until I have the Wilson tractor with .93 pounds of fuel, the Jones with .96, and the seventh tractor, the Smith, with .97 pounds of fuel. To see the table you would think that one tractor was far superior to the other. Yet, there is only .11 of a pound of fuel consumption difference for a horse power hour, and the chances are about 99 out of 100 that the test results would just be reversed if you turned around and made the same tests again with the same equipment, so you can see how the test results can be abused.

Nebraska Tractor Law. A great many of you people have read and heard something about it, because it has been given more or less publicity. I will state that it was not conceived of and was not put across by the University of Nebraska, as a great many people think that it was. Notwithstanding the fact that I am more or less in sympathy with it, I feel that it should be a national law instead of a state law, but with a great many modifications.

Without going farther into the detail of the history of this law, suffice it to say that we have the law in Nebraska and that the University of Nebraska is attempting to use the law in such a way that it will benefit everybody that comes in contact with the use of tractors. The tractor law was introduced by a farmer and passed through both houses of the Legislature with only two dissenting votes, and they were in the Lower House. The way we have been using this tractor law to protect the farmers is to take advantage of the opportunity to aid the manufacturers in improving their tractors. We feel that it will be much more effective that way than it will to go ahead and say that you can't sell tractors in our state.

In working out a scheme for putting this law into effect, the Chairman of the Board of Engineers called together every two or three days all the engineers he could obtain. All the notes compiled by these engineers were taken down; also all discussions and the records of these conferences are now on file in the Agricultural Engineering Department and are open to everybody. The final and definite action taken by this Board resulted in outlining nine tests for these engines. It will take a total of 36 to 40 hours time for an engine to do all these tests. The tests are known by numbers and the following is the name of each test, a description of the test and its object.

Test (A). *"Limbering up"* run. The principal object of this run is to take out the stiffness likely to be found in a new machine. Record of any repairs or adjustments made and of oil consumption will be kept by an observer.

Tractors in this run will be used to pull drags and rollers in maintaining the cinder track and for other drawbar work that may be convenient. The loads pulled will be: Approximately 1/3 load for approximately four hours; approximately 2/3 load for approximately four hours, and approximately full load for approximately four hours, a total of approximately twelve hours actual running time. The tractor will be operated by an employe of the tractor manufacturer.

Test (B). *Brake Horse Power Test at Rated Load.* The object of this test is to show whether or not the tractor will carry continuously its rated load on the belt and to show fuel consumption at rated load. The tractor will be given as nearly as possible its rated load. The governor will be set to run at its rated speed. If the tractor will not carry its rated load at rated speed, this test will be made at the greatest load it will carry at rated speed. The test will begin after the temperature of the cooling fluid has become constant. The duration of the test will be two hours continuous run with no change in load or in tractor adjustments. The tractor will be operated by an employe of the University.

Test (C). *Brake Horse Test at Varying Load.* The object of this is to show fuel consumption and governor control when the load varies. All adjustments are to be as in Test (B). The loads will be as follows:

10 Minutes at rated load (or load carried in test (B).
10 minutes at maximum load.
10 minutes at no load
10 minutes at ¼ load.
10 minutes at ½ load.
10 minutes at ¾ load.

The total running time is one hour, and the test will be made without any engine stop or any change of tractor adjustments. The tractor will be operated by an employe of the University.

Test (D). *Brake Horse Power Test at Maximum Load.* The object of this test is to determine the greatest load the tractor will carry on the belt with the governor set for rated load. The brake load will be increased until the horse power developed is greatest. The governor will be set as in test (B). The carburetor will be readjusted if necessary to give maximum power. The test will begin after the temperature of the cooling fluid becomes constant. The duration of the test will be one hour continuous run with no change in load or tractor adjustment. If the speed should change during the test enough to indicate that conditions had not become constant when the test was started the test will be repeated with the necessary change in load. The tractor will be operated by an employe of the University.

Test (E). *Brake Horse Power Test at Half Load.* The object of this test is to determine fuel consumption at half load. The brake will be set to give one-half of the torque developed in test (B). The governor will be set as in test (B). The carburetor will be readjusted if necessary to give most economical operation at this load. The test will begin after the temperature of the cooling fluid has become constant. The duration of the test will be one hour continuous run with no change in load or tractor adjustment. The tractor will be operated by an employe of the University.

Test (F). *Drawbar Horse Power Test at Rated Load.* The object of this test is to show whether or not the tractor will pull its rated drawbar load continuously and to show fuel consumption on drawbar work. The test will be made on a cinder track. The governor will be set as in Test (B). The load applied will be the rated load and the speed will be that obtained with the gears set as recommended for plowing. If this load should should prove to be an overload, it will be reduced until the engine speed is up to rating and the slippage of the drivers on the ground is not more than the board of engineers considers reasonable for the cinder track. The test will begin after the load is set and the temperature of the cooling fluid has become constant.

The duration of the test will be ten hours actual running time as nearly continuous as possible, with constant load. Record will be made of the time and reason for each stop, also of any adjustments or repairs made on the tractor. The tractor will be operated by an employe of the University.

Test (G). *Drawbar Horse Power Test at Maximum Load.* The object of this test is to determine the maximum drawbar horse power which the tractor will develop on the cinder track. Records will not be kept of fuel, oil and water used. This test will be made on a level part of the cinder track. The engine will be thoroughly warmed up before this test starts. Record will be made of drawbar pull, rate of travel, wheel slippage, and engine speed for each run of approximately fifty feet. For the first run the load pulled will be about the rated load. This will be increased for each successive run until the maximum drawbar horse power has been determined. The tractor will be operated by an employe of the University.

Test (H). *Miscellaneous.* This test will be conducted to make observation on any special features of the tractor and may include work on inclines, turning radius, effectiveness of brakes and any other feature which may seem to require special observation. The tractor will be operated by an employe of the University.

Test (I). *Endurance.* It will not be possible in any reasonable length of test to determine the efficient life of the tractor; however, it will be possible to detect any features that will give continual trouble. Observation will be made of all replacements, repairs, adjustments and cleaning; also, of any difficulty in the operation of the lubrication, cooling, or any other part of the tractor. If an undue amount of wear is suspected in any part of the tractor it may be taken apart for examination at the end of the test.

In order to carry out these tests the apparatus which will be used for making these tests will consist of a Sprague dynamometer for all belt horse power tests and a dynamometer car which will be used in making the drawbar test. Probably the reason for using the latter instrument might need some explanation.

It has been the desire of the engineers in charge of this work to fix up some measuring scheme whereby all the engineers hope to do is to measure the capacity of the tractor. To do this the personal elements and climatic conditions must be eliminated as much as possible and in order to execute such a scheme some unit of measure must be decided upon and since the horse power unit is the standard all over the country, of course the engineers adopted that unit and then endeavored to design the apparatus which would exactly measure the power of the tractor by that unit.

Before constructing the dynamometer car just spoken of one must consider the conditions under which tractors work in the field. When a traction engine is working on a good, hard, firm footing like dry stubble ground or prairie sod it has an opportunity to develop its maximum horse power, because there the energy is used to move the tractor through the field and there is a good footing for the drive wheel. In contrast with this condition take a wet stubblefield which is very soft and the weight of the tractor will settle down so low that it takes a large amount of the power of the engine to move the tractor through the field and a very little energy is left for pulling the plows. These are only two of the variable conditions which confront the engineer testing a tractor in the field. There are hundreds of other such variables. When the Board of Engineers decided to eliminate as many of these variables as possible they decided upon the scheme of using a dynamometer car for the load behind the tractor and running on a track surfaced with cinders mixed with some clay to give it a binder. By the use of rollers and sprinklers the track can be kept in about the same condition all times of the year excepting the winter when it would be frozen.

A cinder-clay track about a half mile in length has been constructed. The dynamometer car for furnishing and measuring the load for the tractors under test has also been completed and in preliminary tests it has worked out admirably. By the use of this track and the dynamometer car all tractors can be tested under nearly identical conditions.

UNIVERSITY OF NEBRASKA

AGRICULTURAL ENGINEERING DEPARTMENT
TRACTOR TESTING

April 29, 1920

Amendments to Rules for Official Tractor Tests as published in Experiment Station Circular No. 10.

Par. 10. *Test (a). "Limbering up" Run.* If the tractor manufacturer believes that 12 hours is not sufficient length of run to get the tractor limbered up, reasonable additional time will be allowed. The amount of additional time above the usual 12 hour period will be stated in the final report on the test.

Par. 12. *Test (c). Brake Horse Power Test at Varying Load.* If the load changes in this test make it necessary to change any adjustments on the tractor, adjustments will be made as necessary but the final report on the test will state what adjustments were made and that these adjustments were necessary.

Par. 13. *Test (d). Brake Horse Power Test at Maximum*

Load. The object of this test is to show the greatest load the tractor will carry on belt work and operating at rated speed.

The governor will be adjusted so as to give full opening of the governor valve with the engine carrying maximum load and running at rated speed.

Par. 15. *Test (f). Drawbar Horse Power Test at Rated Load.* Adjustments of the governor and carburetor will be set as for test (b), brake horse power test at rated load, unless these adjustments are found to be unsatisfactory for the drawbar horse power test at rated load. Readjustments of both carburetor and governor may be made, if necessary, in order to make the engine operate satisfactorily and at rated speed or only a little above rated speed.

Par. 16. *Test (g). Drawbar Horse Power Test at Maximum Load.* This test will be started with the governor and carburetor adjusted as in Test (f) but both may be readjusted if necessary in order to keep the engine speed as near rated speed as possible when the load is increased.

DISCUSSION

PROF. GREGG: I would like to ask if he has drawn up a score card on which he places acceptance or rejection of the tractors in his state?

MR. CHASE: Professor Gregg I think is just a little bit humorous. You men that have not worked on the score card for the Winnipeg Motor Contest don't know what he is driving at. The only score card that we have is that if the tractor doesn't meet its advertised specifications then the Railway Commission refuses to give them a permit to sell in the state. All that we have to do is to test the tractor and then we report to the Railway Commission and they do the rest. We hope there will not be a single tractor tested but what will be up to the advertised specifications. It will be very embarrassing for us if there is, because we have so many friends among the tractor people.

MR GUNNESS: I would like to ask Professor Chase if all the information he gathered in the test is public?

PROF. CHASE: We are under no obligations whatever to the state law in the use of this apparatus. All the information that we get, because of the tractor manufacturers offering to let us use these tractors for testing, we can publish either in the form of bulletins or any other way that we mind to. For tractors that are officicially tested the results must be posted in the Agricultural Engineering Department of the University. They are submitted to the Railway Commission and they must appear in the report of the Railway Commission. Furthermore, the tractor manufacturers cannot publish any of the report without publishing all of it, the idea being that if they were allowed to publish a part of the report without publishing all of it they might select parts which are advantageous to their particular tractor.

What we are trying to do is to establish these tests so that any college can establish the same kind of a course and can make the same sort of tests that we are making.

QUESTION: Did you go into the special features? Take the angle line lug and the conical lug, there might be a type of lug in that group that would work best on a particular type and you would get more tractive effort with it.

MR. CHASE: The Board of Engineers decided to leave that to the tractor manufacturers and not go into it. I might state that there has been really a lot of trouble in working out these rules. Possibly there are some things you folks didn't gather there in the matter of brakes. There are some tractors on the market that don't have brakes. What are you going to do when you test out the efficiency of brakes and there are no brakes on the tractors? There are tractors on the market with no governors. There are a lot of things of this sort we ran into. I understand there are tractors on the market with no belt wheels, and here we have to make a brake test of a tractor that has no belt wheel on the tractor. Seriously, men, it has given us a lot of worry the past four or five months, and we don't anticipate we will get out of the woods for about a year and a half yet, so we have a lot of questions to decide when special engines do come up for test.

MR. THORPE: Are there any conclusions of the Engineering Board that are permissible in the reports of these tests, or are the results furnished without conclusions or analysis?

MR. CHASE: There is one sheet in the reports which is left open for conclusions. We hope to never have to use that sheet. We hope to have everything so it can be measured by the actual apparatus. However, if there is some freak machine that should come up to be tested, of which I hope there will be none, we might have to put in the judgment of the Board of Engineers on that sheet, but it is our sincere hope that everything will be covered under the test so that none of the human element will enter into the report.

MR. JONES: Do you mind explaining a little more completely the reason why it was out of the question to consider taking the brake horse power directly off the rim of the driver?

MR. CHASE: The reason for that was that your front wheels would be standing on the hard surface and you are not moving the plant at all. For that reason you would be only testing your power of your engine and the efficiency of the gears. It wasn't giving the farmer, at least, a fair chance. And then another thing is that you might take an engine say that weighed three tons, with a fifteen horse engine in it, and it would show up just as good a traction engine as would one that only weighed a ton and was a fifteen horse engine.

PROF. AITKENHEAD: At Purdue we have an engineering experiment station and they are just breaking in their tractor testing plant at the present time. It has almost the same equipment as the Nebraska plant as seen in the slides. They have the 150 horse power Sprague dynamometer, but we use the same dynamometer for both belt and traction drawbar tests. There are just practically two caterpillar tractors geared up and connected to the dynamometer by a silent chain. The tractor is backed into the testing plant and the teeth in the rear wheels mesh with the joints between the blocks. We have a recording dynamometer at the back end and we clamp down the front wheels and of course can run continuously there. Of course it has the objections Professor Chase just mentioned that the front wheels are stationary, but in actual testing of tractors the front wheels will either be removed or some provision made to put the front part of the tractor on a platform scales and part of the calculations will be based on the decreasing weight due to the lifting of the front part of the tractor, but at present the plan seems to be working very well. Some things we didn't anticipate in the design of it, and some places where they anticipated trouble things have gone along smoothly, but we will have to await developments until we see the thing in actual operation. At present we have a 15-30 Avery Tractor on it and have been running almost every day for seven weeks.

COMMITTEE REPORTS AND BUSINESS RECORDS.

REPORT OF COMMITTEE ON FARM STRUCTURES

W. G. Kaiser, Chairman
W. A. Foster, Elmer A. Ely, J. L. Strahan

Early in the year the Farm Structures Committee decided to make a study of the various units employed in farm building construction. Since the Committee had representatives from the cement, clay products and lumber industries it was planned to have each member furnish data relative to the building material with which he was most familiar. This seemed like the most efficient arrangement but unfortunately several members of the original committee resigned about the middle of the year, making it impossible to fully carry out the program proposed. However, our committee can report some progress. Data was collected on concrete block and hollow clay tile building units. The value of having accurate data available regarding sizes, shapes and other properties of these structural units is apparent to the agricultural engineer or architect engaged in designing farm buildings.

CONCRETE BLOCK

Concrete blocks are being used extensively in the erection of farm buildings. When concrete block first came into use, many farmers bought molds and turned out their own blocks during spare time. This scheme did not prove satisfactory and today most blocks are made in a factory, usually referred to as a cement products plant. There are 5,000 or more concrete block factories in operation at present. A large percentage of these are located in the principal agricultural states and a large portion of their output, ranging from a few thousand to three-fourths of a million block per plant, is absorbed by the farm trade.

The following pages present information on 24 types of concrete block including the name and address of the manufacturer of the machine or mold, the general shape and dimensions of the block, the kind of face, plates furnished and similar data. Special shapes such as corner, cornice, water table or jamb block are not included. However, these special units have the same general characteristics as the standard sizes. Most manufacturers of molds supply division plates for making quarter, half and three-quarter length block so as to provide the proper bond between successive tiers of block and to fill in between doors and windows without making it necessary to cut full length block. It is to be noted that the majority of the block are 8x8x16 inches in size. Actual measurements disclose such block to be 7¾ inches high, 8 inches wide and 15¾ inches long. The height and length of most concrete block are made ¼ inch shorter purposely to allow for the thickness of the mortar joint, thus eliminating fractions of an inch in computing the number of block required for a given wall section.

According to the process of manufacture concrete block may be divided into three classes:

1. *Tamped Block.*

Tamped blocks include those made from concrete of such a consistency that when tamped or compacted in the mold, it will retain its shape, permitting the sides and cores to be removed immediately.

2. *Cast Block.*

Cast Block, sometimes referred to as "poured block," are usually made in a gang or multiple mold. Concrete is mixed to about the same consistency as for monolithic construction. Forms are not removed until the concrete has attained sufficient hardness to be self-sustaining.

3. *Compressed Block.*

Compressed block are those made under high pressure. The concrete is mixed to about the same consistency as for the tamped block. When pressure is applied, some water usually

ANCHOR

Anchor Concrete Mach'y Co. Rock Rapids Iowa

Plan

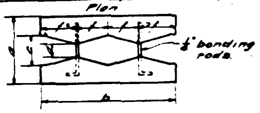


Illustration
- a. 8"
- b. 15 3/4"
- c. 3 1/4"
- d. 1 1/2"
- e.
- f. 3 7/8"
- Height. 7 7/8"
- Air Space. 30%
- Weight. 53 lbs

This type block made in the following additional sizes

a.	8	9	9	10	10	11	11	12	12
b.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
c.	3 1/4	[illegible]	[illegible]	3 1/4	[illegible]	3 1/4	[illegible]	3 1/4	[illegible]
d.	[illegible]	[illegible]	1 1/2	1 1/2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
e.									
f.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wgt.	7 7/8	7 7/8	7 7/8	7 7/8	7 7/8	7 7/8	[illegible]	[illegible]	[illegible]

Method of manufacture Machine tamped
Surfaces: Plain, Rock, Bush hammered double panel, Broken Ashlar.

BRAGSTAD

Bragstad Concrete Machinery Co. Canton S.D.

Plan

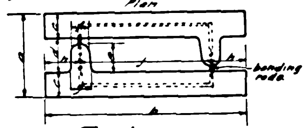


Illustration
- a. 10"
- b. 23 3/4"
- c.
- d.
- e.
- f.
- g.
- h.
- i.
- Height. 7 7/8"
- A.F. Space.
- Weight.

IDEAL

Ideal Concrete Machinery Co Cincinnati, Ohio

Plan

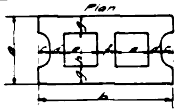


Illustration
- a. 8"
- b. 15 3/4"
- c. 1/2"
- d. 1 1/2"
- e. 4"
- f. 1 3/4"
- g. 2
- h. 4"
- Height. 7 3/4"
- Air Space. 34%
- Weight. 55 lbs

This type block made in the following additional sizes

a.	4	6	10	12	4	6	8	[illegible]	12
b.	[illegible]	15 3/4	15 3/4	15 3/4	23 3/4	23 3/4	23 3/4	23 3/4	23 3/4
c.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
d.	[illegible]	1 1/2	2	2	2 1/4	3	3	3	3
e.	3	[illegible]	4	4	4	6	6	6	6
f.	[illegible]	[illegible]	2 1/4	2 1/4	2 1/4	3	3	3	3
g.	1	1 1/4	2 1/2	3	[illegible]	1 1/2	2	1 1/2	[illegible]
h.	2	2 1/2	3	4	2 1/2	3	4	5	[illegible]
Wgt.	7 3/4	7 3/4	7 3/4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Method of manufacture Machine tamped
Surfaces Plain Rock Hand tamped

HAMILTON TILE

The Hamilton Concrete Machinery Co Cleveland Ohio

Plan End View

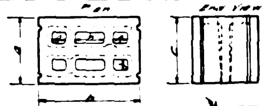
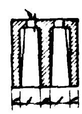


Illustration
- a. 8"
- b. 8"
- c. 3"
- d.
- e. [illegible]
- f. 2 1/4 or 2 7/8
- g. 3/4
- h. 3"
- i. 1 1/16
- Air Space. 56%
- Weight. 17 lbs.



Section

This tile made in the following additional sizes

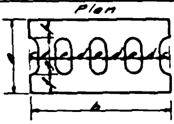
a.	4"	6"	8"	12"
b.	12"	8"	10"	12"
c.	3"	3"	3"	5"
d.				
e.	[illegible]	[illegible]	[illegible]	[illegible]
f.	2 1/4 or [illegible]	4 1/4 or [illegible]	2 1/4 or [illegible]	[illegible]
g.	1 1/2	—	—	
h.	3	4	2 3/4	
i.	1 1/16	2	1 1/16	

Method of manufacture Machine tamped
Surfaces. Sides and ends, smooth or corrugated.

BRANDELL

The Brandell Co. Cincinnati, Ohio.

Plan



Illustration

a:	8"
b:	15 3/4"
c:	7/8"
d:	2"
e:	2"
f:	2"
g:	4"
Height:	7 3/4"
Air Space:	22%
Weight:	66 lbs

This type block made in the following additional sizes.

a:	4	6	10	12
b:	10 3/4	15 3/4	15 3/4	15 3/4
c:	[illegible]	7/8	7/8	3/4
d:	[illegible]	2	2	2
e:	[illegible]	2	2	2
f:	[illegible]	2	2	2
g:	[illegible]	2	6	8
Hgt.	7 3/4	7 3/4	7 3/4	7 3/4

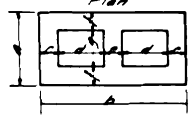
Method of manufacture. Machine tamped

Surfaces: Plain.

GREER

Greer Machinery Co. Delaware, Ohio.

Plan



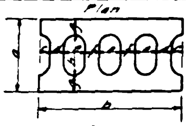
Illustration

a:	
b:	
c:	
d:	
e:	
f:	
g:	
Height:	
Air Space:	
Weight:	

HOBBS

The Anchor Concrete Machinery Co. Columbus Ohio.

Plan



Illustration

a:	8"
b:	15 3/4"
c:	1"
d:	1 1/4"
e:	2 3/16"
f:	1 1/2"
g:	1 3/8"
h:	4 3/4"
Height:	7 3/4"
Air Space:	33 1/3 %
Weight:	68 lbs

This type block made in the following additional sizes

a: Varying from 3" to 12" advancing by inches

b: " " " 3" to 24" " " " "

Height: " " 3" to 12" " " " " "

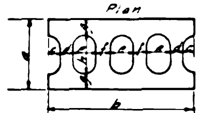
Method of manufacture Hand tamped

Surfaces. Rock, Plain, Panel, Broken Ashlar, Random Ashlar

BESSER

The Besser Manufacturing Co. Alpena, Mich

Plan



Illustrations

a:	7 3/4	9 3/4	11 3/4
b:	15 3/4	15 3/4	15 3/4
c:	1 5/16	1 1/8	1 1/8
d:	1 3/8	1 1/2	1 1/2
e:	2 3/8	2 1/2	2 1/2
f:	1 3/8	1 1/2	1 1/2
g:	1 3/4	2 1/4	2 3/4
h:	4 1/4	5 1/4	6 1/4
Height:	7 3/4	7 3/4	7 3/4
Air Space:	31%	31%	31%
Weight:	52 lbs.	75 lbs.	80 lbs.

EBERLING TILE

The Federal Cement Products Co. Cleveland, Ohio.

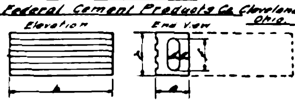


Illustration
- a. 3⅝"
- b. 12"
- c. 5"
- d. 1 3/8"
- e. 1½
- f. 4 ⅛"
- Air Space. 92½%
- Weight. 12½ lbs.

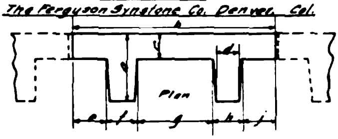
This type tile made in the following additional sizes which are multiples of the size illustrated.

a.	8⅜	12½	16⅝
b.	12	12	12
c.	5	5	5
d.			
e.			
f.	4⅛"	4⅛"	4⅛"

Method of manufacture Pressed tile
Surfaces Plain

SYNSTONE

The Ferguson Synstone Co. Denver, Col.



Illustration

a. 8"	a. 12"
b. 23 5/8"	b. 23 5/8"
c.	c.
d.	d.
e.	e.
f.	f.
g.	g.
h.	h.
j.	j.
Height. 11 5/8"	Height. 11 5/8"
Air Space.	Air Space.
Weight.	Weight.

Method of manufacture Pressed block
Surfaces Unfaced. Faced with special stone, White marble, White granite, Gray granite, Red granite, Brown granite, Bedford sandstone, White sandstone, Red sandstone.

MULTIPLEX

The Multiplex Concrete Machinery Co. Elmore, Ohio.

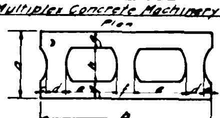


Illustration
- a. 8"
- b. 15 5/8"
- c.
- d.
- e.
- f.
- g.
- h.
- Height. 7 5/8"
- Air Space.
- Weight.

Note. Hollow and Header bond blocks also made in the Multiplex machine

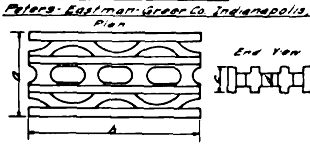
Also made in the following additional sizes.

a.	10	12	8	10	12	8	10	12	8	10	12	8	10	12	8	10	12
b.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
c.																	
d.																	
e.																	
f.																	
g.																	
h.																	
Ht.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Method of manufacture Pressed block
Surfaces Bush-hammer, Ashler, Corrugated Panel, Rock, Rock face with plain border, Rock face-sectional Brick face, Granite face, Plain-with bevel edge

P·I·C·A·B·B·S TILE

Peters-Eastman-Greer Co. Indianapolis, Ind.



Illustration

a. 9"	a. 10"
b. 20"	b. 20"
c. 3" to 6"	c. 3" to 6"
d.	d.
Air Space.	Air Space.
Weight.	Weight.

Method of manufacture Pressed tile.
Surfaces: Plain.

FLEXO

The Flexo Concrete Mould Co. Cedar Rapids Iowa.

Plan — End View

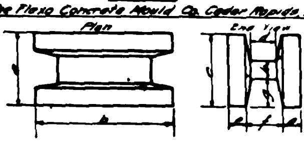


Illustration
- a: 8"
- b: 15[illegible]"
- c: 7[illegible]"
- d:
- e:
- f:
- g:
- h:
- Air Space: 33[illegible]%
- Weight: 48 lbs.

This type block made in the following additional sizes:

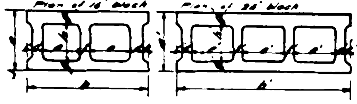
a:	8	10	10	12	12	8	8	10	10	12	12
b:	23[illegible]	15[illegible]	23[illegible]	15[illegible]	23[illegible]	15[illegible]	23[illegible]	15[illegible]	23[illegible]	15[illegible]	50[illegible]
c:	7[illegible]	7[illegible]	7[illegible]	7[illegible]	7[illegible]	5[illegible]	5[illegible]	5[illegible]	5[illegible]	5[illegible]	6[illegible]
d:											
e:											
f:											
g:											
h:											

Method of manufacture: Poured block
Surfaces: Smooth face. Facings of Marble or Granite chips, Crushed Feldspar, Mica and Micaspar and Garnet sand

ZAGELMEYER

Zagelmeyer Cast Stone Bl. Mchy. Co. Bay City, Mich.

Plan of 16" block — Plan of 24" block



Illustrations

a: 8"	a: 8"
b: 15 [illegible]/16	b: 23 [illegible]/16"
c:	c:
d:	d:
e:	e:
f:	f:
g:	g:
h:	h:
Height: 7 [illegible]	Height: 7 [illegible]/16
Air Space: 42%	Air Space: 42%
Weight: 50	Weight:

These blocks made in the following additional sizes

a:	10	10	12	12
b:	15 [illegible]	23 [illegible]	15 [illegible]/16	23 [illegible]/16
c:				
d:				
e:				
f:				
g:				
h:				
Hgt:	7 [illegible]	7 [illegible]	7 [illegible]	7 [illegible]/16

Method of manufacture Poured block.
Surfaces Unfinished Facings of Granite crystals or any kind of crushed rock

HELM

The Helm Brick Machine Co. Cadillac, Mich.

Plan

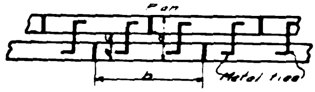


Illustration
- a: 8"
- b: 23½"
- c: 8"
- d: 10"
- Height: 7½"
- Air Space: 30%
- Weight: 38 lbs.

Method of manufacture: Pressed block
Surfaces: Plain, Rock, Bush Hammered, Panel, Ashlar.

HYDRO-STONE

Hydro-stone Co. Chicago, Ill.

Plan

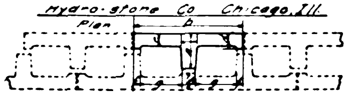
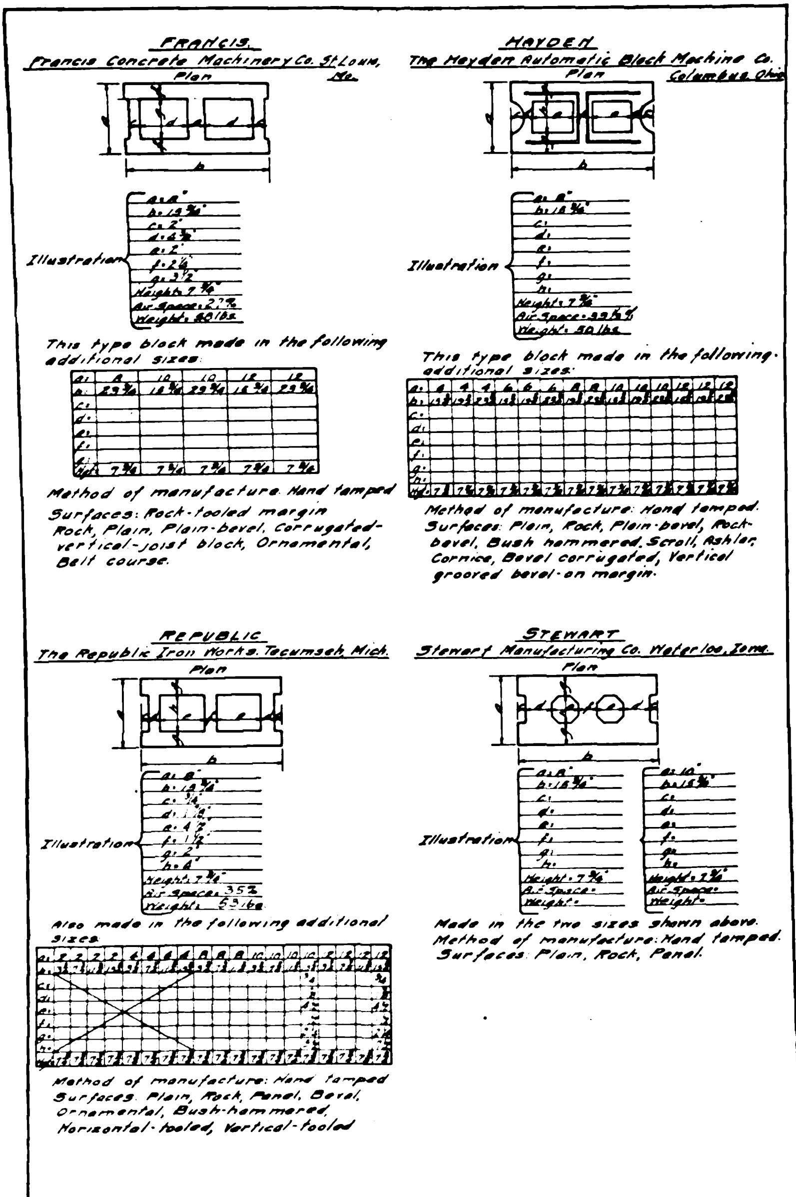


Illustration
- a: 8" Varies from 6½" to 12"
- b: 23 [illegible]
- c: 2 [illegible]
- d: 3½
- e: 3½
- f: 1½
- g: 8 [illegible]
- h: 3.4
- Height: 8 [illegible]" and 11 [illegible] ..
- Air Space: 30% 37⅞% in 12"
- Weight: 64 lbs.

Method of manufacture Pressed block
Surfaces Facings of Granite, Marble, Quartz, Micaspar, Bedford stone, Sandstone, Plain face.


FRANCIS.
Francis Concrete Machinery Co. St Louis, Mo.
Plan
a: 8"
b: 15 3/4"
c: 2"
d: 4 3/4"
e: 2"
f: 2 1/4"
g: 3 1/2"
Height: 7 3/4"
Air Space: 27%
Weight: 60 lbs.
Illustration
This type block made in the following additional sizes:
a: 8 10 10 12 12
b: 23 3/4 15 3/4 23 3/4 15 3/4 23 3/4
c:
d:
e:
f:
g:
Hgt. 7 3/4 7 3/4 7 3/4 7 3/4 7 3/4
Method of manufacture. Hand tamped
Surfaces: Rock-tooled margin
Rock, Plain, Plain-bevel, Corrugated-vertical-joist block, Ornamental, Belt course.
HAYDEN
The Hayden Automatic Block Machine Co. Columbus Ohio
Plan
a: 8"
b: 15 3/4"
c:
d:
e:
f:
g:
h:
Height: 7 3/4"
Air Space: 33 1/3%
Weight: 50 lbs.
Illustration
This type block made in the following additional sizes:
a: 4 4 4 6 6 6 8 8 10 10 10 12 12 12
Method of manufacture: Hand tamped.
Surfaces: Plain, Rock, Plain-bevel, Rock-bevel, Bush hammered. Scroll, Ashler, Cornice, Bevel corrugated, Vertical grooved bevel-on margin.
REPUBLIC
The Republic Iron Works. Tecumseh Mich.
Plan
a: 8"
b: 15 3/4"
c: 3/4"
d: 1 1/2"
e: 4 1/2"
f: 1 1/2"
g: 2"
h: 8"
Height: 7 3/4"
Air Space: 35%
Weight: 53 lbs.
Illustration
Also made in the following additional sizes
a: 2 2 2 2 4 4 4 4 8 8 8 10 10 10 12 12 12 12 12
Method of manufacture: Hand tamped
Surfaces. Plain, Rock, Panel. Bevel. Ornamental, Bush-hammered, Horizontal-tooled, Vertical-tooled
STEWART
Stewart Manufacturing Co. Waterloo, Iowa.
Plan
a: 8"
b: 15 3/4"
c:
d:
e:
f:
g:
h:
Height: 7 3/4"
Air Space:
Weight:
a: 10"
b: 15 3/4"
c:
d:
e:
f:
g:
h:
Height: 7 3/4"
Air Space:
Weight:
Illustration
Made in the two sizes shown above.
Method of manufacture: Hand tamped.
Surfaces: Plain, Rock, Panel.

HERCULES

Century Cement Machine Co. Rochester, N.Y.

Plan

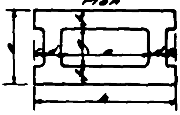


Illustration:
- a: 8"
- b: 16 3/8"
- c: 1"
- d: 2 3/8"
- e: 8"
- f: 2 1/8"
- g: 2 1/4"
- Height: 7 3/8"
- Air Space: 22%
- Weight: 67 lbs.

Also made in the following additional sizes:
a: Varying from 4" to 20"
b: " " " 4" to 6'-0"
Height: " " " 6" to 16"

Method of manufacture: Hand tamped

Surfaces. Plain panel, Rock, Rock-tooled margin, Plain-bevel edge, Bush hammer-tooled margin, Corrugated vertical, Ashlar, Plain.

DUNN

W. E. Dunn Manufacturing Co. Holland, Mich.

Plan A — Plan B

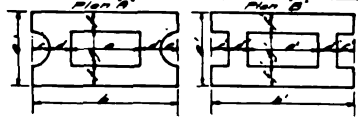


Illustration "A":
- a: 8"
- b: 16 3/4"
- c: 2"
- d: 2 1/4"
- e: 7 1/2"
- f: 2 1/4"
- g: 3 3/4"
- Height: 7 3/4"
- Air Space: 32%
- Weight: 55 lbs.

"B":
- a: 8"
- b: 16 3/4"
- c: 2"
- d: 2"
- e: 7 3/4"
- f: 2 1/4"
- g: 3 3/4"
- Height: 7 3/4"
- Air Space: 35%
- Weight: 50 lbs.

Type "B" block made in the following additional sizes.

a:	10"	12"
b:	12 3/4	12 3/4
c:	2	2
d:	2	2
e:	7 3/4	7 3/4
f:		
g:		
Hgt:	7 3/4	7 3/4

Method of manufacture: Hand tamped

Surfaces: Rock-plain margin, Plain, Corrugated.

MIRACLE

Northwestern Steel & Iron Works, Eau Claire, Wis.

Plan

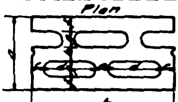


Illustration:
- a: 9"
- b: 29 3/4"
- c:
- d:
- e:
- f:
- g:
- h:
- Height: 7 3/4"
- Air Space:
- Weight:

- a: 12"
- b: 29 3/4"
- c:
- d:
- e:
- f:
- g:
- h:
- Height: 7 3/4"
- Air Space:
- Weight:

This type block made in the two sizes shown above.

Note: Single or double core blocks and continuous air space blocks also made in Northwestern machines.

Surfaces: Scroll, Rock-tooled margin, Ashlar, Rope, Corrugated-horizontal, Bush-hammer-tooled margin, Plain panel, Four inch course

PETTYJOHN

The Pettyjohn Co. Terre Haute, Ind.

Plan

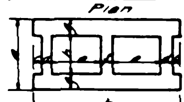


Illustration:
- a: 7 3/4"
- b: 15 3/4"
- c: 1/2"
- d: 2"
- e: 4"
- f: 2 1/4"
- g: 1 1/8"
- h: 4"
- Height: 7 3/4"
- Air Space: 29%
- Weight: 55 lbs.

- a: 7 3/4"
- b: 19 3/4"
- c: 1/2"
- d: 2"
- e: 6"
- f: 2 1/4"
- g: 1 1/8"
- h: 4"
- Height: 7 3/4"
- Air Space: 34%
- Weight: 65 lbs.

- a: 7 3/4"
- b: 23 3/4"
- c: 2"
- d: 2 3/4"
- e: 7"
- f: 3 1/4"
- g: 1 1/8"
- h: 4"
- Height: 7 3/4"
- Air Space: 32 5%
- Weight: 78 lbs.

Method of manuacture Hand tamped

Surfaces. Rock, Pebbles exposed, 2 inch pyramid, Vertical-tooled, Pick point-tooled margin, Plain panel, Bevel edge-pick point surface, Plain bevel, Ornamental-Rope Rosette, Fleur-de-lis.

Note. Size of cores, thickness of webs and weight of block may be varied to meet all requirements.

is forced out. Like the tamped block it is removed from the mold on a pallet as fast as made.

Concrete block may be divided into the following classifications according to shape or form:

1. One-piece Block:

This division includes solid block sometimes used in silo construction or for supporting very heavy loads like joist courses. It also refers to air-space block with concrete webs.

2. Two-piece Block with Metal Ties.
3. Two-piece Block.

Bond between inner and outer sections is secured in the wall by having some part of one block overlap a corresponding section on the block above or below.

4. Structural Tile.

These units are used principally as a foundation for stucco or as a backing for a veneered wall.

SURFACE FINISHES:

Due to the plastic nature of concrete, a great variety of surface finishes have been developed. Variation in the surface treatment is secured by:

1. The shape or contour of the face plate. Rock-face, grooved, beveled-edge, and a number of ornamental blocks are made by this process.
2. The employment of special aggregates such as crushed granite, marble chips, or colored sands in a thin layer on the surface.
3. Treating the surface of the block after being molded, such as bush-hammering, pick-pointing, sanding or scrubbing with acids to expose aggregates.
4. Using mineral colors in the mortar.
5. Applying stucco on plain block.

This committee recommends that the following standard specifications and building regulations for concrete building block, adopted by the American Concrete Institute, Standard No. 10, should be accepted by the American Society of Agricultural Engineers.

American Concrete Institute Standard No. 10

Standard Specifications and Building Regulations for Concrete Architectural Stone, Building Block, and Brick

1. Concrete architectural stone and building block for solid or hollow walls and concrete brick made in accordance with the following specifications and meeting the requirements thereof, may be used in building construction.

2. Tests.—Concrete architectural stone, building block for hollow and solid walls, and concrete brick must be subjected to (a) Compression and (b) absorption tests. All tests must be made in a testing laboratory of recognized standing.

3. Ultimate Compressive Strength.—(a) Solid concrete stone building block and brick. In the case of solid stone, block and brick, the ultimate compressive strength at 28 days must average not less than fifteen hundred (1500) lb. per sq. in. of gross cross-sectional area of the stone as used in the wall and must not fall below one thousand (1000) lb. per sq. in. in any test.

(b) Hollow and two piece building blocks. The ultimate compressive strength of hollow and two piece building blocks at 28 days must average one thousand (1000) lb. per sq. in. of gross cross-sectional area of the block as used in the wall, and must not fell below seven hundred (700) lb. per sq. in. in any test.

4. Gross Cross-Sectional Areas.—(a) Solid concrete stone, block and brick. The cross-sectional area shall be considered as the minimum area in compression.

(b) Hollow building block. In the case of hollow building block, the gross cross-sectional area shall be considered as the product of the length by the width of the block. No allowance shall be made for the air space of the block.

(c) Two piece building block. In the case of two piece building block, if only one block is tested at a time the gross cross-sectional area shall be regarded as the product of the length of the block by one-half of the width of the wall for which the block is intended. If two block are tested together, then the gross cross-sectional area shall be regarded as the product of the length of the block by the full width of the wall for which the block is intended.

5. Absorption. The absorption at 28 days (being the weight of the water absorbed divided by the weight of the dry sample) must not exceed ten (10) per cent when tested as hereinafter specified.

6. Samples. At least six samples must be provided for the purpose of testing. Such samples must represent the ordinary commercial product. In cases where the material is made and used in special shapes and forms too large for testing in the ordinary machine, smaller specimens shall be used as may be directed. Whenever possible the tests shall be made on full-sized samples.

7. Compression Tests. Compression tests shall be made as follows; The samples to be tested must be carefully measured and then bedded in plaster of paris or other cementitious material in order to secure uniform bearing in the testing machine. It shall then be loaded to failure. The compressive strength in pounds per square inch of gross cross-sectional area shall be regarded as the quotient obtained by dividing the total applied

load in pounds by the gross cross-sectional area, which area shall be expressed in square inches computed according to article four.

When such tests must be made on cut sections of block the pieces of the block must first be carefully measured. The samples shall then be bedded to secure uniform bearing, and loaded to failure. In this case, however, the compressive strength in pounds per square inch shall be regarded as the minimum bearing area in compression. The average of the compressive strength of the two portions of block shall be regarded as the compressive strength of the samples submitted. This net compressive strength shall then be reduced to compressive strength in pouds per square inch of gross cross-sectional area as follows: The net area of a full-sized block shall be carefully calculated and the total compressive strength of the block will be obtained by multiplying this area by the net compressive strength obtained above. This total gross compressive strength shall be divided by the gross cross-sectional area as figured by article 4 to obtain the compressive strength in pounds per square inch of gross cross-sectional area.

When testing other than rectangular block, great care must be taken to apply the load at the center of gravity of the specimen.

8. Absorption Tests. The sample shall be first thoroughly dried to a constant weight at a temperature not to exceed two hundred and twelve (212) degrees Fahrenheit, and the weight recorded. After drying the sample will be immersed in clean water for a period of forty-eight hours. The sample shall then be removed, the surface water wiped off, and the sample reweighed. The percentage of absorption shall be regarded as the weight of the water absorbed divided by the weight of the dry sample multiplied by one hundred, (100).

9. Limit of Loading. (a) Hollow walls of concrete building block. The load on any hollow walls of concrete block, including the superimposed weight of the wall, shall not exceed one hundred and sixty-seven (167) pounds per square inch of gross area. If the floor loads are carried on girders or joists resting on cement pilasters filled in place with slush concrete mixed in proportion of one (1) part cement, not to exceed two (2) parts of sand and four (4) parts of gravel or crushed stone, said pilasters may be loaded not to exceed three hundred (300) lb. per sq. in. of gross cross-sectional area.

10. Girders and Joists. Wherever girders or joists rest upon walls in such a manner as to cause concentrated loads of over four thousand (4000) lb. to block supporting the girders or joists must be made solid for at least eight (8) in. from the inside face of the wall, except where a suitable bearing plate is provided to distribute the load over a sufficient area to reduce the stress so it will conform to the requirements o farticle 9.

When the combined live and dead floor loads exceed sixty (60) lb. per sq. ft. the floor joists shall rest on a steel plate not less than three-eighths (3/8) of an ich thick and of a width one-half of one inch less than the wall thickness. In lieu of said steel plate the joists may rest on a solid block which may be three (3) or four (4) in. less in wall thickness than the building wall, except in instances where the wall is eight (8) in. thick, in which cases the solid block shall be the same thickness as the building wall.

11. Thickness of Walls. (a) Thickness of bearing wall shall be such as will conform to the limit of loading given in article 9. In no instance shall bearing walls be less than eight (8) in. thick. Hollow walls eight (8) in. thick shall not be over sixteen (16) ft. high for one story or more than a total of twenty-four (24) ft. for two stories.

(b) Walls of residences and buildings commonly known as apartment buildings not exceeding four stories in height, in which the dead floor load does not exceed sixty (60) lb. per sq. ft., shall have a minimum thickness in inches as shown in Table 1.

TABLE 1

No. of stories	*Basement in.*	*First Story in.*	*Second Story in.*	*Third Story in.*	*Fourth Story in.*
1.............	8	8	..	..	..
2.............	10	8	8	..	..
3.............	12	12	10	8	..
4.............	16	12	12	10	8

12. Variation in Thickness of Walls. Wherever walls are decreased in thickness the top course of the thicker wall shall afford a solid bearing for the webs or walls of the course of the concrete block above.

13. Bond and Bearing Walls. Where the face wall is constructed of both hollow concrete block and brick, the facing shall be bonded into the backing, either with headers projecting four (4) in. into the brick work, every fourth course being a header course, or with approved ties, no brick backing to be less than eight (8) in. thick. Where the wall are made entirely of concrete block, but where said block have not the same width as the wall, every fifth course shall overlap the course below by not less than four (4) in. unless the wall system alternates the cross bond through the wall in each course.

14. Curtain Walls. For curtain walls the limit of loading shall be the same as given in article 9. In no instance shall curtain walls be less than eight (8) in. in thickness.

15. Party Walls. Walls of hollow concrete block used in the construction of party walls shall be filled in place with concrete in the proportion and manner described in article 9.

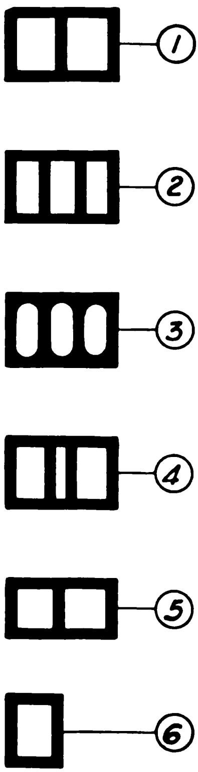
16. Partition Walls. Hollow partition walls of concrete

block may be of the same thickness as required in hollow tile, terra cotta or plaster block for like purposes.

So far as I know there has never been any attempt to have any standard regulations or specifications for materials used in farm buildings. Practically every large city in the country has a code regulating the thickness of walls and specifying the tests which the material will stand.

HOLLOW BUILDING BLOCK (CLAY BLOCK)

Probably the most common sizes of hollow building tile are the 8x5x12 tile; a style produced by practically all manufacturers. In cold climates where additional insulation is required or where even more strength is necessary than can be obtained readily with style No. 1, styles 2, 3, and 4 are used. These are variations of a three cell 8x5x12 building tile. Style 2 has the bearing webs spaced equally. The illustration given shows the vertical and horizontal webs meeting at right angles. Certain manufacturers use a fillet at the junction of these webs. Style 3 shows the fillet increased to half the width of the air space; thus forming an arch.



COMMON STYLES OF HOLLOW BUILDING BLOCKS

Figure 4 shows the type of block in which the center webs are located close together; the arrows at the top and bottom indicate a cutting line, which will be referred to later.

Figure No. 5 shows the 8x4x12 tile. While a two-cell type is shown, this block is also manufactured in the three cell type. The use of this block is decreasing as its size does not work out witht building standards set for b rick; also it is a more expensive tile to handle on the job than the 8x5x12 size.

Figure No. 6 shows the 4x5x12 size. Its principal use is in conjunction with the 8x5x12 tile to make a so-called 12" or 13" wall. Its use alone is very limited. In the codes, which are being formulated by cities and states, the section covering tile construction does not recognize anything less than an 8" wall for bearing wall construction, so that this tile would hardly find any use by itself for farm buildings.

There are certain places where 13" walls are required. As styles shown in Figure No. 1 and Figure No. 6 are very generally manufactured, it naturally follows that 13" walls are very frequently constructed of the combination of those two sizes, as shown in figure 7 and with a combination 2 and 6, a 13" wall, as shown by figure 8 is obtained

Figure No. 9 shows a 13" wall constructed of the three cell tile, illustrated in figure No. 4, and this same tile split in half, as indicated by the arrows. This construction brings the vertical or bearing webs in alignment.

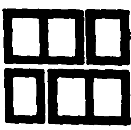

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Figure No. 10 illustrates a 13" wall, as built by use of the 8x4x12 unit only. This is a construction that is not generally used. It is an unhandy combination to lay. The variation in mortar joints together witht an unavoidable variation in the sizes of the tile themselves bother the mechanics considerably.

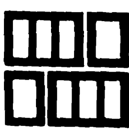
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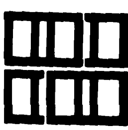
Figure No. 11 is an illustration of a one-piece block for a 12" wall. Illustration is of a 5x5x12. Many manufacturers produce the 12x12 block in thicknesses from 3 to 12" omitting the 11th inch thickness. This type of tile is not particularly popular, except in certain limited communities.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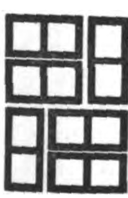
In connection with 13" walls, it might be well to mention that the thickness of a wall is not necessarily an indication of its strength. Take the case of the tile illustrated in figure No. 11 and compare it with the tile illustrated in figures 2, 3 and 4. In each instance you will note four vertical webs to carry the load and it is the strength of these webs that determines the strength of the tile. Consequently, an individual time, as illustrated by figures 2, 3 and 4 would carry the same ultimate load as the tile illustrated by figure 11 and when reduced to pounds per square inch, the latter is at a disadvantage. There are special cases where the tile as illustrated by figure 11 will work in to advantage.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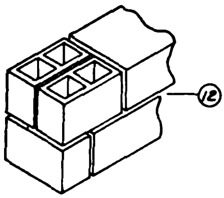
11

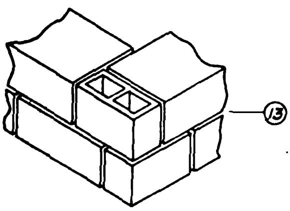
In practically all the municipal and state codes that have been formulated recently and are in process of formulation now, the matter of bearing web alignment is given consideration. Unless the vertical bearing webs will follow in alignment, they are not given credit for the full crushing strength of the block.

Nearly every manufacturer produces an especially designed tile for corner and jamb construction. The variation in these is almost as great as the number of manufacturers.

COMMON METHOD OF FORMING CORNERS

Figure No. 12 shows a common method of sealing the air cells at the end of a wall or at a door or window opening. This method employs the 4x5x8 tile when used with the 8x5x12 size and the 4x4x8 when used in conjunction with the 8x4x12. Certain manufacturers round one corner of the closure tile. Ordinary brick may be used in place of the 4x5x8, as two brick will lay up 5 inches in height.





The foregoing deals with the common tile construction. There are several special cases, which can only be treated in a very general way by showing illustrations of the products of a typical manufacturer of these types. The National Fireproofing Company advocate the standing of tile on end. Eight illustrations taken from their advertising, show the standard and special forms of their product. Another class includes a regularly shaped tile. We have taken for illustration of this tile the Interlocking tile, as manufactured by the Dennison Tile Engineering Co. of Cleveland, Ohio. An 8-inch wall section of this tile is shown.

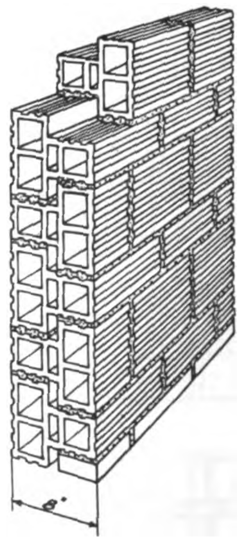
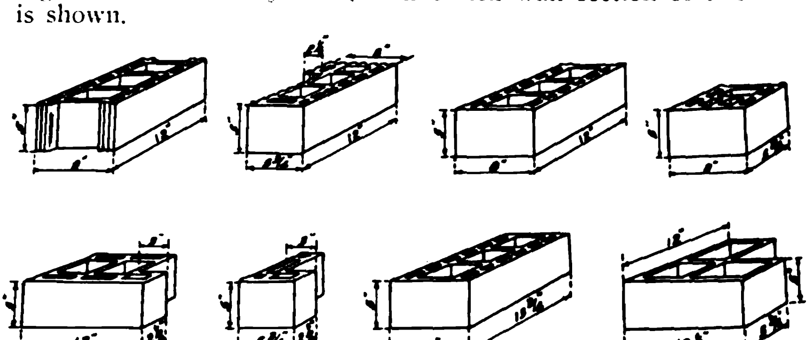


Fig. 13.
Dennison Interlocking Tile



The third class is the Dennison Load Bearing Tile. Four principal units of this system are illustrated to go with wall sections of 8 and 13-inch walls constructed of two of the principal units. With this system, as with the interlocking, special tile for corners, jambs, pilasters, etc., are provided. A combination tile and a brick unit made by the National Fireproofing Co., Erie, Pa., is also shown.

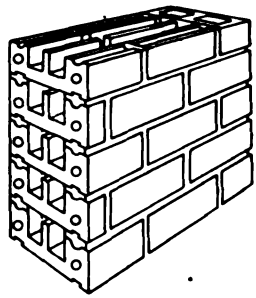


Fig. 14
Combination Brick and Tile Wall

In the four special designs, or types, which we have presented, one feature is noted in each: i. e., the avoiding of a mortar joint through the wall.

The point mentioned above regarding alignment of webs is well covered in both the Interlocking tile and the Dennison load bearing tile and can easily be followed in their illustrations.

DISCUSSION

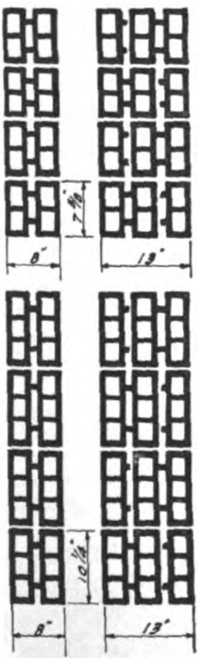


Fig. 15
Dennison Load Bearing Tile

MR. CLARKSON: I would like to, if I may, ask Mr. Kaiser what if anything his committee has done along the lines of insulation. You know, of course, that I have in mind the question of ventilation. Have they given any thought to that phase of the subject?

MR. KAISER: Along in November Mr. Ely, who is substituting for Mr. Conley on this committee, proposed that we make a study of barn wall insulation, but at that late date it was almost impossible to do anything along that line.

Years ago I began an investigation on barn wall insulation and I sent out questionnaires. It was in relation to my work with the Portland Cement Association. I sent out questionnaires to everyone I knew owning concrete barns, asking about the thickness of the walls, the amount of windows and doors and the kind of ventilation and other data which would be necessary to know to make a study of barn wall insulation. I have this data compiled. I think I have reports back from fifty or sixty barn owners, but I don't think that is a very satisfactory way of doing it because every man seems to be satisfied with his own barn. I believe it would be better for a university to undertake an investigation along this line. I have in mind proposing this to some experiment stations in the immediate future that they undertake an investigation to determine the heat conductivity of various materials. This could be done by building small buildings, using different thicknesses of materials, and using different materials. You will find no two barns alike, and for that reason any attempt to get data from owners will show that no two tests will be alike. You can't arrive anywhere unless you have all the variables eliminated except the one you are trying to determine.

MR. CLARKSON: The Ventilation Committee in suggesting in their recommendations that the Committee on Farm Structures, Sanitation and Ventilation collaborate with each other had this thought in mind. The question of the proper insulation of barn walls and ceilings is a question that is very important, and there are thousands of men all over the country that have built barns in the last two or three years that need something radically different from what they have now. They have spent a lot of money and they haven't gotten what they ought to have along those lines. It seems to me that the thing for these three committees to do is to get together and to propose to the experiment stations over the country something constructive along the line of finding out what the different materials or how they can be used to the best advantage, and how the barns and the other farm buildings can be properly insulated and taken proper care of.

A MEMBER: Along with that thought the matter of construction enters in also, as well as insulation. The application of vestibules and door openings and storm windows and any opening, for instance, put in barns, the hay chutes on the outside, they all have their influence in developing and providing the proper kind of an inside for the barn, especially north of the Mason and Dixon Line, in the cold season of the year.

REPORT OF COMMITTEE ON FARM BUILDING EQUIPMENT

M. A. R. Kelley, Chairman

William Louden, F. C. Lewis, E. B. Marsh, F. H. Williams

The work of your committee is divided into two parts.

1 — Completion of study of stall and pen specifications.

2—Completion of study of uniform capacity rating for litter carriers.

SPECIFICATIONS FOR STALLS AND PENS

Table No. 1. This was compiled by Mr. E. B. Marsh and contains some valuable data in regard to specifications for stalls, calf, maternity, bull and hog pens. It will be found useful to architects, students, and Agricultural Engineers in designing barns and serve as reference for other purposes.

You will note that the data is divided into three parts showing the minimum and maximum dimensions used, and those used by the majority of the manufacturers. The data was assembled after reviewing the catalogs of 21 companies, and represents all of the known data available. A brief study of this table shows a possibility of improvement in the selection of several sizes and the elimination of others which would result in greater economy, without the sacrifice of any essential factors.

TABLE 1

Steel Stall	*Minimum*	*Maximum*	*Majority*
Width	3′-0″	3′-6″	3′-6″
Horizontal Rails	1-1/16″	1½″	1-1/16″ or 1-5/16″
Uuright Posts	1-5/8″	1-7/8″	1-5/8″
Height	5′ 2″	5′ 3½″	5′ 3″
CALF PENS			
Height	39″	48″	46″
Size of Posts	1-1/16″	1-7/8″	1-5/8″
Size of Rails	1-3/32″	1-5/8″	1-5/16″
Size of Fillers	1-1/16″	1-1/8″	1-1/16″
Spacing of Fillers	4″	5¼″	5″
COW PENS			
Height	53″	60-	60″
Size of Posts	1-1/8″	1-7/8″	1-5/8″
Size of Rails	1-1/2 sq.	1-5/8″	1-5/8″
Size of Fillers	1-1/16″	1-5/16″	1-1/16″
Spacing of Fillers	5″	6″	5″
BULL PENS			
Height	60″	64″	64″
Size of Posts	1-9/16″	1-7/8″	1-5/8″
Size of Rails	1-5/8″	1-5/8″	1-5/8″
Size of Fillers	1-5/16″	1-11/16″	1-5/16″
Spacing of Fillers	6″	6-3/4″	6″
HOG PENS			
Height	46″	48″	46″
Size of Posts	1-5/8″	1-7/8″	1-5/8″
Size of Rails	1½″	1-5/8″	1-5/8″
Size of Fillers	1-1/16″	1-1/8″	1-1/16″
Spacing of Fillers	4″	5″	4″

STALLS

Referring to the dimensions given for stalls, the maximum width given is the maximum width shown in the catalogs. Other widths are sometimes necessary and these can be easily obtained. A stall 3′ 6″ wide is often too narrow for large cows, such as large type Holsteins, Shorthorns, Herefords and a few others, and a stall width of 4′ 0″ or even 4′ 2″ is required. If crowded into a stall which is too narrow for the cow, there is great liability of injury by the neighboring cow stepping on the udder. Many a valuable cow has been ruined in this way. On the other hand the width of stall should be kept within reasonable limits in order to cut down the size of the barn and lessen the cost of construction.

CALF PENS

In comparing the heights of calf pens we find that a height of 46″ is the choice of most manufacturers. If a height of 39″ is sufficient and 48″ is used, then the latter represents tht use of 9″ more material than necessary. The best height to use could be determined by a study of the growth of calves and the age or size at which they should no longer be kept in pens.

In comparing the size of post we find a variation from 1-1/16″ in diameter to 1-7/8″ with the best choice at 1-5/8″. The selection here is largely one of cost since it is very difficult to determine the size needed according to strength required. The selection of fillers and their spacing is also determined by the same factors.

COW AND BULL PENS

The same question arose in regard to cow pens and bull pens. What is the best height of panels for these pens and is there a greater use of material than necessary.

HOG PENS

Some good hog men say that 3′ 6″ or 42″ is high enough for a hog pen. This is the height generally used on pens where horizontal boards are used and there is more opportunity for the hog to secure a foothold for climbing up. When vertical pipes are used for partition there is no chance for foothold and hence a shorter partition could be used. I am convinced that 48″ partitions are higher than necessary for heavy type hogs such as raised in the corn belt. The height of pens for boars is usually about 6″ higher than for sows.

A comparative study of the so-called panel and curb construction for pens would bring out some interesting points, both in regard to strength, sanitation and cost of construction. Panel construction is that form of partition which uses a top and bottom rail, to which intermediate fillers are connected, the cross rails in turn being fastened to corner posts. In curb construction the filler bars are fastened to a top rail connected to corner posts and the lower ends of fillers held by concrete curb 6″ to 10″ high and 4″ to 6″ wide.

The possible savings as pointed out are small individually but when taken collectively on a large installation will amount to considerable. Your committee do not want to be understood as recommending the "skimping" of material wherever possible, for this is always bad practice. But we do believe that a careful study of this question will result in greater economy of material. The price of materials is so high that the practice of legitimate economy would be welcome. This in turn would help in the advancement of greater sanitation by placing the price within the reach of a large number of buyers. A careful study of the points mentioned cannot help but produce more economical construction.

STANDARDIZED LITTER CARRIERS

Last year your committee made a preliminary report and suggested a method of securing a uniform capacity rating for litter carriers, but owing to the lack of time to make a complete study of this subject the committee did not feel warranted in making any definite recommendations. Since then we have completed the study and are now able to make definite recommendations In order to test the merits of the recommendations, the method of study will be briefly reviewed to show the factors which have been considered.

NEED OF STANDARDIZING

That there is a need for adopting a uniform rating for litter carrieds was pointed out in our last report; when we consider that there is a variation of 20% between the maximum and minimum size of carriers rated at 6 bushels, a variation of 25% for the 8 bushels size, 32% for 10 bushels size and 48% in the 12 bushels size. The largest size shown is clearly a greater variation than should be made.

At the present time manufacturers use six different ways of rating their carriers. Of the 17 manufacturers of litter carriers, one gives the rating in pound capacity, two companies merely give dimensions, four state size, number and dimensions and one states size, number and bushel capacity. As previously pointed out in our last report, the existence of so many forms of ratings and the great variations of some of these methods lead to confusion. Likewise there is no established rule in regard to whether the capacity of the carrier should be considered as heaped or level.

The manufacturers have seen the need of a standard rating as has been shown in our last report (page 229) and several companies are in favor of its adoption. (Read paragraphs 1-2-3-4-5.)

There is also need for a standard size for a given capacity. In our last report we cited several cases where the material in the manufacture of some of the present forms was not used to the best advantage. That this is true can readily be seen by examining the cross sections shown in Fig. 1, 2, 3, 4, 5 & 6. There are three variables which must be taken into consideration in the economical use of materials, best width, depth and length, and these will be brought out in the discussion of these figures in later paragraphs.

METHOD OF STUDY

Forty-seven different sizes of litter-carriers were studied. After a careful examination of the catalogs the cross sections of these carriers were drawn to scale as accurately as possible, as shown in Figures 1, 2, 3, 4, 5, and 6. In our preliminary study the areas were secured by the use of a planimeter; in our study this year the combination of circular areas and rectangles was used and data compiled by use of tables. While these forms may not represent those actually used in any carrier of a given width and depth now manufactured they represent an accurate means of comparison.

Then all the carriers of the same rated capacity were placed together and a detailed study made of their dimensions in order to secure the best combinations. In this study it was soon made clear that some companies were not using the best forms, while others were not using the most economical combinations.

COMPARISON OF CARRIERS

In the following comparison all carriers were studied with reference to the best forms to use in order to secure the maximum cross sectional area for a minimum perimeter and in regard to the best relation of width and depth.

In the selection of the best form to use it was readily seen that the round bottom formed by a semi-circle with the addition of a rectangular increment above, was clearly the best form. The round bottom carriers are easier cleaned; in fact, they are sometimes termed self-cleaning. This is not true with the flat bottom types with sharp corners. Furthermore there is less economy of material when the flat bottoms are used as will be seen by referring to Figures 1, 3, 4, 5, and 6.

In every case it will be noted that the shapes using flat bottoms gave the least cross sectional area for the perimeter used, which requires the use of additional material to secure a desired capacity. That most manufacturers have found this to be true is shown by the fact that out of 18 makes of carriers only five use a flat bottom.

CROSS SECTIONS OF FEED AND LITTER CARRIERS

The cross sections of the various carriers were examined for comparison of maximum area for least perimeter. It will be noted that carrier B, Figure 1, gave the maximum area for a perimeter of 56″ and that carrier A, Figure 2, gave a greater area than B having the same perimeter and a similar relation is shown in Figure 3; Figures 4, 5 and 6 show that it is possible to

FIG. 1

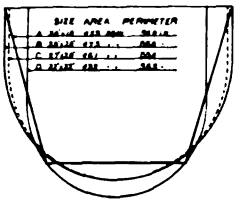


FIG. 2

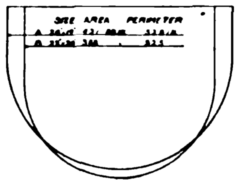


FIG 3

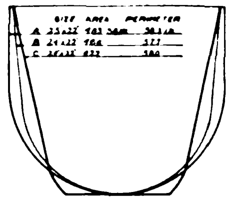


FIG. 4

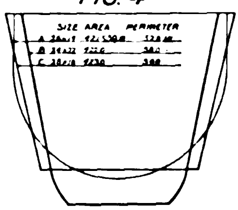


FIG. 5

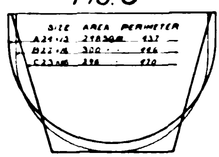
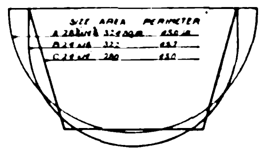


FIG. 6



secure the maximum area with least perimeter by using the circular form. Although geometrically speaking the circle contains the greatest area within a given perimeter, the semi-circle would not give us the most convenient form to use for a litter carrier, as will be seen by referring to Figure 6, Carrier A. It will be noted here that the width is too great for the depth and is not the most convenient form. Carrier B gives almost the same area for the same perimeter and is a more convenient form to use. Note the saving in material by using cross section A in place of B in figure 4, which is almost 6″. This multiplied by the length of the carrier (42″) means a saving of 252 sq. in. of metal on each carrier.

Your committee attempted to secure a mathematical formula giving the best relation of width and depth and length, but were unable to do so. We did however succeed by a "cut and try" method in securing the best relations for the capacities desired as will be shown later.

A carrier should not be so wide that it requires extra wide alleys and doors for clearance. The accompanying curves show the clearances necessary for some of the largest size carriers. Wide carriers also require special reinforcing on the ends in order to stand up well under service. The maximum width of carriers now manufactured is 34″, while the narrowest is 20″. There is one carrier made 20″ wide and 20″ deep; this carrier is not only uneconomical but is also too narrow for such a deep carrier. Since the top opening is so narrow it requires forcing the manure into the box when long straw is used and does not clean itself readily when dumped.

Cross section A, Figure 5, has a wider top opening than B, and a greater bottom clearance and for these reasons A is preferable to B. Cross sections D, Figure 1, and B, Figure 2, are too deep for their width, and are not so economical of material, and are less convenient to use.

Forty-eight inches is the maximum length now used and any length over this would require extra heavy trussing to support the load and wider alleys. Shorter carriers are more convenient and stronger. One company makes all of their carriers the same width and length and varies the depth in order to secure the desired capacity. Although this may be a convenience in manufacturing it is not the most economical use of material. In one case a saving of six pounds of metal per carrier can be obtained by using the dimensions having the best relation of width and depth. It is not desirable to have a greater depth than 24" as it is too hard to obtain sufficient bottom clearance to dump into a manure carrier. The distanct from the track to bottom of box for some of the larger sizes is now 52" upright and 54" when dumped. The smaller this distance can be made the greater the clearance obtained.

After a careful study of above factors, we have reached the conclusion that the desirable limits of dimensions are as follows: minimum width 22", maximum 28"; minimum length 36", maximum 48"; minimum depth 13", and maximum 24". On this basis we have worked out the following sizes as the most economical use of material.

INSIDE DIMENSIONS OF TUB

Size No.	*Dimensions*	*Perimeter*	*Area*	*Vol. Limits Min. Max.*	*Actual Vol.*
2	22 x 13 x 36	38.6	234	8000– 8600	8424
3	24 x 16 x 38	45.7	322	12000–12900	12236
4	26 x 19 x 40	52.8	422	16000–17200	16880
5	(28 x 22 x 38	60.0	531	20000–21500	20178)
	(26 x 21½ x 42	57.8	486	20000–21500	20412)
6	28 x 24 x 42	64.0	588	24000–25800	24696
7	28 x 24 x 48	64.0	588	28000–30100	28224

The committee would hesitate to recommend these sizes for adoption as standard, if our study had not shown these sizes to be the most economical of material. Space does not permit the giving in detail all of the calculations that were made in basing our final selection of these sizes.

These sizes were determined by the use of the rating proposed in our last report and as many as 24 different possible combinations for one size carrier were tried before making a final selection. These sizes do not represent any dimensions which are not used at present and can be obtained from regular size sheets of metal. A 46" sheet may be used to form the perimeter of carrier No. 3, while 52" may be used for number 4. Two sizes are given for size 5, although the first one given will use slightly less metal, the last one selected since it is better proportioned and gives a larger volume which offsets the slight increase use of metal.

It will be noticed that the ends of size 6 and 7 are the same and the same pattern may be used for both. The use of slightly less metal for size 7 could be obtained by using a greater width, but this would exceed our maximum, which has been set for convenient use and the saving of metal in sides does no over-balance the advantages of one pattern for the two sizes and the better width as selected.

ADVANTAGES

The sizes selected are the most economical in use of material for a given capacity. As has been pointed out, a saving of 6 pounds of metal on one carrier means 600 pounds on a hundred carriers. It is important that we keep the cost as low as possible in order to influence a wider use of this labor saving device. Collectively speaking there have been no great changes made from the present carriers and only those dimensions were used which have stood the test of years of use.

The sizes selected provide for all average conditions. It is not necessary that all these sizes be made, in fact, we believe that sizes 3, 5, and 6 would satisfy most farm conditions. No 2 may be needed in hog houses, poultry houses or small dairies, while No. 7 would only be needed in barns where a large amount of bedding was used. Standardizing the sizes of carriers does not prevent the use of individual designs in construction or material used, in fact, the present carriers are all quite similar in construction and vary little in the material used from the standard proposed. The principal difference lies in hoisting apparatus and trollies.

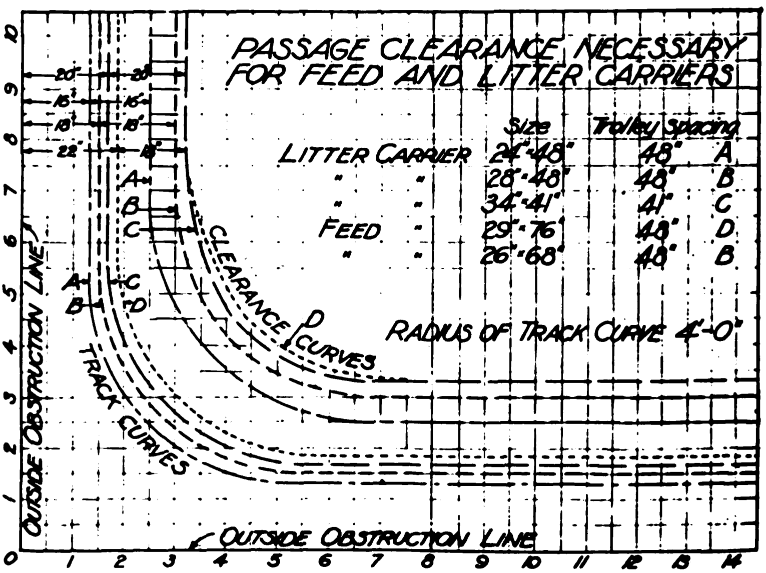
We have limited the width of the carriers in order to secure a strong end without the use of an excessive amount of heavy metal or extra reinforcing. It will be noted the sizes selected have a certain relation to each other which will prove of an advantage when large shipments of assorted sizes are made. The tub or box of number 2 can be nested in Number 3, and 4 and 5 can be nested in 6 or 7, which means that a large number of carriers can be shipped in a car load.

RECOMMENDATIONS

In view of the facts presented and the need for such a standardization, we wish to recommend that the proposed uniform rating for litter carriers as stated in last year's report be adopted as recommended practice and that the suggested sizes be used as being the most economical use of material. In securing the capacity for any carrier, level full measure is to be considered as standard. The size number, dimensions and clearance necessary to be given in all catalogs, and size number stamped on carrier. The carriers to be rated in regard to capacity, as follows:

No. 2—Carrier within limits 8000 to 8600 cu. in.
No. 3—Carrier within limits 12000 to 12900 cu. in.
No. 4—Carrier within limits 16000 to 17200 cu. in.
No. 5—Carrier within limits 20000 to 21500 cu. in.
No. 6—Carrier within limits 24000 to 25800 cu. in.
No. 7—Carrier within limits 28000 to 30100 cu. in.

and that the sizes suggested be used as best practice.



CLEARANCE FOR FEED AND LITTER CARRIERS

In regard to the standardized litter carriers I suppose that all of you run across the same trouble, that when it comes to designing a barn for stock and not specifying any particular equipment, the trouble is to get the dimensions of the barn so the farmer can use any equipment he wants to use. That cannot be done now, and the only hope for it is to have the manufacturers produce equipment that is nearly enough uniform to enable a barn that is designed to fit any equipment. In that connection I can say that Mr. Kelley's correspondence with manufacturers has shown that the majority of them are quite enthusiastic over some such step and that all of them are agreeable to it. This has been shown to be their attitude.

DISCUSSION

Mr. Ekblaw: May I ask Mr. McCormick how fully do the manufacturers of these litter carriers cooperate, or have they cooperated, and do they show any tendency that might result in the adoption of these as standards?

Mr. McCormick: I come in contact occasionally with the information that Mr. Kelley secures and this has kept me fairly closely in touch with what he is doing. Now I have seen the correspondence from several of the firms, particularly the last year. My recollection of it is that the large majority of the firms are anxious to have some such standard as suggested; others are perfectly willing. It seems to me that there is one firm, and only one firm, that took exception to it.

Mr. Clarkson: I am not prepared to say that these sizes on carriers are right or not right, because I am not in position to go into it that far at this moment, but I want to call attention to these committees, and the Chairmen of these committees in particular, that the recommendation of the Committee on Ventilation that we collaborate with each other and keep in closer touch with one another, you will notice that in this report that has been read by Mr. McCormick there is no hint or intimation made, in summing up, that any thought has been given with reference to any special obstruction like ventilation pipes on the walls and things like that. I assume that this obstruction line is the barn wall itself.

Mr. McCormick: I can't say with regard to that, Mr. Clarkson. I do know that an attempt was made to consider every obstruction in the way of posts or piping and things of that nature.

REPORT OF COMMITTEE ON AGRICULTURAL ENGINEERING DATA

R. W. Trullinger, Chairman
Daniel Scoates, H. E. Horton, W. F. MacGregor

It is noted that the 1918 Data Committee for the American Society of Agricultural Engineers recommended a classification of data to serve as an index to the data book which was adopted by the Society. It is believed that the classification which appears on pages 252 to 258, inclusive, of the 1918 Transactions of the Society is too comprehensive and that the matter in an agricultural engineering handbook should be limited to general and agricultural data only. It is also believed that matters relating to other agricultural subjects should be omitted, except where it is absolutely necessary to include them.

It is believed that the data book should consist of the two general divisions, (1) General Engineering and (2) Agricultural Engineering. Since agricultural engineering may be considered to cover the application of civil, mechanical, and electrical engineering principles to agricultural problems, it is easy to see that a great deal of the data which might be considered valuable in an agricultural engineering handbook is already included in standard engineering handbooks. For instance, there are well-known handbooks on civil, electrical, mechanical, highway, hydraulic, gas engine, irrigation, and water supply engineering. The existence of these materially simplifies the preparation of the general engineering division of the agricultural engineering handbook since it will be possible to transfer bodily certain important sections. It is believed that the general engineering section should include brief digests of mathematical, electrical, and mechanical principles, tabular data to aid in computation, and copious references to other handbooks. In short it is pretty well known what will be included under the subject of general engineering and it is perfectly proper to adopt a detailed classification of subjects on which corresponding data must be included. The detailed classification of general engineering as proposed by the 1918 Data Committee is considered to be both adequate and proper.

With reference to the strictly agricultural engineering data, however, the situation is entirely different. So far as is known, no agricultural engineering handbooks have been compiled. While it is known that considerable agricultural engineering data exists its exact nature is not known so that it is deemed impossible to prepare a detailed classification before the data itself has been compiled and classified for what it is worth. The 1918 committee has presented a detailed classification of agricultural engineering apparently without data to base it on and has put succeeding committees in the position of having to supply data to meet the classification rather than of compiling data and classifying it, as it comes in, on its face value. Such an arrangement is obviously absurd.

In order to test the classification as given, a large number (510 to be exact) of references to sources of agricultural engineering data were selected from Volumes 35 to 41, inclusive, (1916 to 1919), of the Experiment Station Record, prepared by the Office of Experiment Stations, U. S. Department of Agriculture. These references were selected with care and it is believed that in all cases they represent working data that can well be incorporated in a hand book. This data consists not only of new research data but also of computations and practical applications of old established principles and taken altogether comprises the regular run of data such as would be encountered in any technical subject.

These references were classified first in a broad general way and it was found that they fitted the following general subdivisions:

1. Materials.
2. Drainage.
3. Irrigation.
4. Farm Machinery.
5. Roads and bridges.
6. Farm building and fences.
7. Sanitation and water supply.
8. Educational and experimental.
9. Miscellaneous.

It is to be noted that this broad general classification agreed substantially and to all practical purposes with the broad general classification proposed by the 1918 Data Committee. However, when a more detailed classification was attempted it was found that the proposed classification will not do since there are subclassifications for which no data is available and there is data for which there are no subclassifications.

Therefore, it seems logical to conclude that the great mass of at present existant agricultural engineering data will be covered by the broad general classification given, but that any more detailed classification must be made only on the basis of the data available and any further developments must depend on additional data as it comes in.

It is desired to draw attention to the list of references on the basis of which this brief analysis was made. These references, as stated, were selected from those appearing in the Experiment Station Record and consist for the most part of references to data published by State or Federal institutions with some exceptions.

The Experiment Station Record is published monthly and its purpose is chiefly to digest the progress in agricultural subjects throughout the civilized world, for the benefit of State Colleges, experiment stations and other institutions. A member of the Data Committee has had charge of the Rural Engineering Section of the Record since 1912 and it has been found that with such a subject it is obviously impossible to give detailed data in a review except in certain special cases. The purpose has been, therefore, to give as concisely as possible the main facts and developments in each individual case, including formulas or data if possible, so that research specialists, practicing engineers and others may be kept generally in touch with all developments in the subject and may also know about what to expect in case the original article or report is secured for detailed perusal. The rural engineering abstracts in the Experiment Station Record, it may be said, represent a vast amount of agricultural engineering data.

There is no other existing organ than the Experiment Station Record which has made a special business of summarizing all available agricultural engineering data. While each member of this Society may know of certain little individual supplies of information which have never been published, it may be said that during the past eight years at least, excepting perhaps the war years, there has been mighty little strictly agricultural engineering data which has been published as a technical contribution to the subject and not for advertising purposes, which has not been at least noted in the Experiment Station Record. In view of all this it would seem advisable to use the Experiment Station Record for a guide in gathering references to sources of data and in adding new data. Of course, those members of the Society who have vast amounts of data hidden in their minds and note books which has never been published cannot expect to see it noted in the Record or any other publication, but it is their duty to turn such data over to the Data Committee. Not all data referred to in the Record is suitable for incorporation in a handbook, for obvious reasons. This will necessitate careful selection of references on the basis of the information in the abstract.

In addition, it is desired to mention another source of data, that is practical working data such as can be understood by the layman. Such data appears in several popular journals but being large in amount, popular in nature and usually not based on carefully stated experience, it has been considered expedient to include only the more important parts of it in the Record. A great deal of care should be used in selecting such data, but its actual value may usually be indicated by the professional reputation of the author. It would not be ethical to attempt to give a list of these journals, and anyhow most of the members of this Society are acquainted with them and know of about what they consist. It might be further stated that members of this Society who are connected with such journals should make it their duty to call to the attention of the Data Committee any bit of data or practical information which they have published, which in their judgment should be included in the data book. Perhaps the most important feature of the data in popular journals is that it is presented in actual working form.

Taking the data as a whole, it is perfectly evident that a great mass is now available. While it is of the greatest importance to deepen the research into the subject of agricultural engineering and obtain more data with a sound technical basis, it also seems extremely important to digest and summarize what we now have.

It is not believed that this Society fully realizes that the preparation of an agricultural engineering data book means a vast amount of work. Someone with a constructive mind must take charge of such a job and have able assistants to handle each division and subdivision of the work. A data committee has been appointed each year and with the exception of the 1918 committee there is little evidence that anything has ever been done. The answer is that nobody has had time. In short, it is perfectly evident that such a job cannot be an incidental job for someone to haphazardly throw together, but a long-time job which will never be finished as long as the profession exists. The suggestion made that the data book be prepared and revised each year by the secretary seems little short of ridiculous.

Experience has indicated that the careful reviewing, digestion and summarizing of technical data is a job requiring clear-headed painstaking judgment and in short is a hard job. The compiler must use great care and discretion in his selection of data and must check data here and there to insure at least a reasonable amount of accuracy.

It is, therefore, recommended that a Data Committee be appointed as usual as a standing committee and that they be given some facilities to work with and a reasonable amount of cooperative assistance. It is the duty of every member of the Society to communicate to the chairman of the Data Committee every bit of valuable data which he discovers, originates or otherwise gains possession of.

As stated above, a list of references to valuable data is submitted herewith, tentatively classified under the headings mentioned. These are selections carefully made from Volumes 35 to 41 inclusive of the Experiment Station Record. It is recommended that this be regarded as a nucleus and that work be immediately started to analyze, sift down and compile this data. It is also recommended that references be selected from Volumes 27 to 35, inclusive, of the Record, which will about cover the data from 1912 up to date. Those members of the Society who are connected with farm journals can give almost invaluable assistance by going through the back files of their journals and either preparing lists of references to data or else compiling the available data in working form to present to the Committee.

The Office of Experiment Stations of the Department of Agriculture stands ready to give such advice and assistance as it can consistent with working policies.

Now, on the basis of what I have just read, it would seem advisable, since the government publishes a reference book of this kind, to use the Experiment Station Record as a basis for reference to data. I don't believe that the statement needs to be modified. Then, in addition to that, and equally as important, are the magazines and papers which cover motor power, farm engineering and general farm subjects. I may say regarding these organs that the data in them is usually in better working shape, that is, it can be taken broadly in a large number of cases and accumulated, so I feel it is the duty of every member of the Society who is connected with any of these papers to, if a data committee is in existence, communicate to that Data Committee all of this data which they get.

Another thing. There is a tendency on the part of engineers, and I guess this society is no exception, to get a lot of valuable data and hide it around in drawers and read it occasionally, but not let anybody else know anything about it. There it is no wonder the Data Committee has to get up and say "we haven't done much," because we have been unable to get hold of the most valuable data. If the society is going to have a Data Committee, that committee can only make a success of data work when every member of the society contributes everything that he considers of value. It is obviously impossible for three or four men to drag together all of this stuff in a short time, and it is something that has got to be done from year to year. We can't wait until along in October or November, as we did this year, and start to gather together a lot of data. You all know that if you are going to put engineering data into working shape so that engineers can use it when they need it for technical purposes and so that men who are not engineers, but who want it for some work or for their information, as is often the case, can get hold of certain specific types of data, you know somebody with a keen mind and good judgment must select the data and digest it. He has got to present it in an intelligent way. I don't recall what provision has been made in the past for the Data Committee, but as far as I know there has only been acommittee appointed. There never has been an appropriation made.

DISCUSSION

Mr. Scoates: There was an appropriation this year of one hundred dollars.

Mr. Trullinger: First you ought to decide whether you are going to have a Data Book or not. If you decide you are going to have a Data Book, you had better make an appropriation for it and appoint a permanent committee, not a change every year. Get hold of somebody who is going to put some time to it. There was a suggestion made that the Hand Book be put into shape and then be revised from year to year by the Secretary-Treasurer. I can see a smile come over Professor Davidson's face right now about that. That is rather absurd because the Secretary-Treasurer is a busy man anyway and he won't have the time or the facilities to go ahead and do that. You must have a committee that is more or less permanent and they must have facilities. They must be given time and they must be given credit for doing something, whether they make a report or not, and it must be recognized that the job is a life one and that when the job is finished for once it is only just begun, because it has to be done all over again along certain lines as soon as new data comes in. This report that I have I rather doubt will all need to appear in the proceedings and transactions, but

I think it can be turned over to the next year's Data Committee as Exhibit A or B, whatever you choose to call it, and in addition to that Professor Scoates called my attention to some data sent in by Professor Sjogren of Nebraska covering rules for tractor tests and certain specific working data on measuring silage capacity and capacity of silos and data on brick equivalents and hollow tile or clay blocks and data on loads on tank floors. I will also hand that in as an additional exhibit to be turned over to the succeeding committee.

MR. DAVIDSON: I would like to ask Mr. Trullinger why the classification is not extended? I would like to ask why he does away with point six of the classification which is recognized in the Dewey system as the subdivision for education.

MR. TRULLINGER: I am not prepared to go into the details of that point. I included a section under Education and Experiment Stations which I hoped would include that particular point. As far as the arrangement is concerned I feel that is a matter open to the committee and they will undoubtedly follow the view of Professor Davidson.

REPORT OF COMMITTEE ON DRAINAGE

E. R. Jones, Chairman
J. A. King, R. L. Patty, J. A. Reeves, H. W. Riley

Report read by Mr. Reeves.

The price of poor drainage is higher than it has ever been in tht past. The farmer who lost an acre of corn on a wet spot in his field last season lost more with corn worth one dollar and fifty cents a bushel than when it was worth seventy-five cents a bushel.

The labor wasted on poorly drained land costs more than it used to also. In 1910 if a farmer lost the labor he expended plowing and trying to cultivate the wet acre within a good cornfield he was losing only ten dollars. In 1919 he was losing twenty dollars.

The committee on drainage believes that but little has been accomplished by the federal government during the past year in working out a plan for the reclamation of undeveloped lands as homes for soldiers, which was a live topic at this Convention a year ago. It reaffirms its conviction of a year ago however that no reclamation work lends itself to the land settlement program so well as the drainage of lands near good markets but too wet to raise anything for the market. Your committee has particular faith in drainage of the smaller marshes of the North Central states where the fall is liberal and homes and productive farms can be established in a year, in contrast to the larger and more level swamps where it will take ten years to get the land subdued and ready for the final settler. Your committee regrets that the plans of Secretary Lane have not taken definite shape.

There is nothing more timely than a report on (1) The actual cost of drainage work done in 1919; and (2) The ratio between the increased cost and the benefits of drainage in 1919 as compared with 1910. To this end the committee has done some investigational work.

Complete cost data has been collected on 16 open ditch projects and 41 tile projects. The following extracts from reports received are typical:

(1) *Hartford Addison Drainage District, Washington County, Wisconsin.* Work commenced May 1919 and was finished Auguts 1919. Ditch 4 feet wide at bottom, 8 feet deep and 20 feet wide at top and 2½ miles long. Total excavation 42,000 cubic yards of peat and clay. Contractor made a good profit at 15 cents a cubic yard with a ½ yard Ajax Floating Dredge. Other similar work was let at 16½, with 20 cents as the maximum.

(2) *Farm Project, Pana, Ill.* Team and scraper work on surface run 3 miles long, two feet deep and about 8 feet wide, total yardage 10,400. Done in 1919 at 28 cents a cubic yard, or about $1,000 a mile.

(3) *Kyte River Drainage District No. 2* laid 320 rods of 15" tile 6.5 deep in clay in 1917 with a machine for $4.12 a rod, and the contractor made a fair profit. Similar jobs were let at about that price in 1919, but contractors generally lost money

(4) *Mud Creek Drain, St. Martins, Wis.* Contract price for 5780 feet of 20" tile laid 7 feet deep in clay, sand and gravel was $1.23 a linear foot for tile and labor in 1918. The total contract price was $7,200 but it cost the contractor $15,000, he losing $7,800.

One surprising feature of our findings was that the labor cost on ten jobs containing tile from 12 to 18 inches in diameter laid all more than 5 feet deep and averaging 5.3 feet was done for $3.44 a rod in 1917, while seven jobs similar in size and each averaging 5 feet deep cost $2.60 a rod for the 12 inch and $3.60 a rod for the 18 inch and averaged only $2.91 in 1919. In each case it was the contractor who suffered. This means that there will be a substantial raise in contract prices for 1920.

Public contracts are usually let for 25 percent more than private contracts for the same work.

There has been a steady rise in the cost of drain tile since 1917. Before that date the prices had not fluctuated in 30 years. Then 8 inch shale tile could be delivered f.o.b. 100 miles from the factory for $64.00 a thousand feet. On December 1, 1919 it was $106.00. It will not be any less in the spring of 1920. Engineers should make liberal allowances for probable increases in cost of both tile and labor.

Table I which is used by Iowa contractors during 1919 is a good guide in making estimates. Each foot of depth a rod long for 16 inch tile costs 60 cents where the total depth is between 6 and 7 feet. If the depth is 6.5 feet the cost of labor for each rod is 6.5 times 60 or $3.90. It increases or decreases 5 cents a rod for each two inches in diameter and also 5 cents a rod for each foot of depth where the depth increases or decreases a foot. On this basis the labor cost on 20 inch tile laid 8.5 deep is 8.5 x 80 or $6.80 a rod. Likewise the labor cost on 12 inch tile laid 4.5 deep will be 4.5 times 45 or $2.02.

TABLE 1. COST OF TRENCHING, LAYING, AND BACKFILLING

Used in Iowa in 1919. Price for each foot of depth one rod long

	Average Cut					
Size	3 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10
5″-6″	$0.25	$0.30	$0.35	$0.40	$0.45	$0.50
7″-8″	.30	.35	.40	.45	.50	.55
9″-10″	.35	.40	.45	.50	.55	.60
12″	.45	.50	.55	.60	.65	.70
14″	.40	.45	.50	.55	.60	.65
15″-16″	.50	.55	.60	.65	.70	.75
18″	.55	.60	.65	.70	.75	.80
20″	.60	.65	.70	.75	.80	.85
22″	.65	.70	.75	.80	.85	.90
24″	.70	.75	.80	.85	.90	.95
26″	.75	.80	.85	.90	.95	1.00
28″	.80	.85	.90	.95	1.00	1.05
30″	.85	.90	.95	1.00	1.05	1.10
32″	.90	.95	1.00	1.05	1.10	1.15
34″	.95	1.00	1.05	1.10	1.15	1.20
36″	1.00	1.05	1.10	1.15	1.20	1.25

COST OF NO 1 SHALE DRAIN TILE

December 1, 1919; f. o. b. 100 to 150 miles from factory

Size	*Cost of 1000 feet*	*Size*	*Cost of 1000 feet*
4-inch	$ 36.50	16-inch	$ 405.00
5-inch	47.50	18-inch	530.00
6-inch	60.25	20-inch	675.00
8-inch	105.50	22-inch	885.00
10-inch	161.00	24-inch	995.00
12-inch	211.00	26-inch	1610.00
14-inch	314.00	27-inch	1750.00
15-inch	355.00	28-inch	1900.00
		30-inch	2100.00

COST OF HAULING TILE

Size	Weight	Cost of hauling 1000 feet 2½ Miles
5	8	$6.00
6	11	8.25
8	18	13.50
10	25	19.00
12	33	25.00
14	43	32.00
16	53	40.00
18	70	52.50
20	83	62.00
22	100	75.00
24	112	85.00
26	136	102.00
28	164	124.00
30	192	146.00

DISCUSSION

PROF. RILEY: I brought on some data as to the results of costs of running state ditching machines in New York. I might report briefly on that matter. At the beginning of the War there were only a few ditchers in use in the State of New York. The first year, that was in 1918, these ditchers dug forty thousand rods of ditch in the state and during the past year they probably have dug about seven thousand rods of ditch. The cost per rod on the average for all ditch and all machines during the first year of their operation was 55.1 cents per rod. I will give the average cost per rod for the twelve counties for the different items. Fuel cost per rod was 12.8 cents; operators cost per rod, 16.2 cents; helper, cost per rod, 7 cents; repairs, cost per rod, 7.1 cents; miscellaneous, cost per rod, 2 cents; total operating cost per rod, 45.1 cents. And the rental charge to the state was ten cents. There are several limiting factors to be noted in connection with that report. The element of personality of the man in charge, the administration of the machine, entered largely into the efficiency with which it was handled, and, incidentally, as to the cost of handling it. I could cite a number of instances where a little apparently unimportant matter materially affected the roddage per day. I may say that these machines were in charge of farm bureau agents, the technical administration being in the hands of Professor B. B. Robb of our department in the college. The college did all the technical surveying of those machines but we soon trained a number of operators so they were able to handle the surveying work in a very satisfactory way. If the farm bureau manager, either because of injudicious management or because he was subject to too much political stress, required of the machine too much road travel, he decreased the amount of work and ran up the repairs in a way to materially effect the total results for his machine. There was some criticism in different counties of the amount of work entailed on the farm bureau managers' office to manage these machines, but we found that where a good operator was employed and the farm bureau manager did a little good planning in the beginning, those counties dug the most ditch, and the farm bureau manager put the least time on the administration. The best daily record was 170 rods in nine hours, two and one-half feet deep. The prices for 1918 were, a minimum of 50 cents a rod for a three foot ditch up to $1.00 a rod for a five foot ditch.

In 1919 the minimum price was set for a two and one-half foot ditch at 60 cents, up to $1.50 for a 5 foot ditch. We thought in 1918 that 50 cents could have been safely charged on the basis that a lot of ditches would be two and one-half feet deep, but when the farmer found that he could get a three foot ditch just as cheap as a two and one-half, he took the three foot, even though his drainage would have been better if he had taken the two and one-half. In our state the stone are quite on item, and the increase of six inches in depth runs up the cost quite a bit, so you see that while the minimum charge was fifty cents a rod, the average cost was 55 cents a rod.

REPORT OF COMMITTEE ON IRRIGATION

H. E. Murdock, Chairman
P. A. Welty, E. R. Webster, Ray B. West

The report of this committee last year dealt with the facilities offered by universities and colleges for students in irrigation. It was proposed, at that time, to make an outline of the work which had been done in the Experiment Stations. That work was to be continued this year and has been followed up partly. The report was to cover experimental and investigational work done by the Experiment Stations and the U. S. Department of Agriculture. Each member of the committe was given a certain territory to cover in his part of the report. In addition to this, special work in soldier's settlements was to be reported from Utah.

The drought of recent years in the Northwest has brought problems forward that have required my personal attention most of the time and a report on this question was considered advisable for this section.

There have been several irrigation districts formed and many others proposed during the past year. Throughout the state the need of water for irrigation was the most prominent problem along irrigation lines for Montana. Ordinarily, this state has an abundance of water which can be used for irrigation if irrigation systems were built to conserve this water, and the agitation has been started to increase the development along irrigation lines in this state. Both the gravity and pumping systems are being used.

Another problem met by the irrigation farmers is that of the actual application of the water to the land. A large percentage of the settlers on new irrigation projects do not know anything about the use of irrigation water and these people need instruction and demonstrations as to how the water should be applied to the land.

Where there is an abundance of water, waste water occurs. As a result of this waste, which may be due to overirrigation or to letting irrigation water escape from the land, some of Montana's most valuable land has become water logged and unfit for cultivation. It is believed that the larger part of this waste could be prevented by the proper use of the water and this is one of the problems that the state is up against at the present time.

REPORT OF COMMITTEE ON FARM POWER

A. H. Gilbert, Chairman
I. W. Dickerson, L. S. Keilholtz, Ray A. Graham, G. W. McCuen, H. R. Brate

Report by Mr. E. B. McCormick

The Secretary of Agriculture, upon a request that really originated with the horse breeders, called a conference last October here in Chicago of representatives of farm management people, horse breeders, implement manufacturers and representatives or delegates from this society. These were present, in addition to those outside the department, representatives from the Farm Management, Animal Husbandry and Public Roads. The conference was held and recommendations decided upon and turned in to the Secretary. These the the recommendations:

THAT the Department of Agriculture, in cooperation with the State agricultural colleges and experiment stations, inaugurate and carry out the following studies and investigations:

ECONOMIC FACTORS

The economic factors of farm power problems should be considered under the following heads:

I. Farm Power Requirements.
 a. Field Operations.
  1. Plowing.
  2. Discing.
  3. Harrowing.
  4. Seeding.

5. Hay harvesting.
6. Grain harvesting.
7. Corn harvesting.

b. Hauling.
  1. Road.
  2. Farm.

c. Heavy belt work.
d. Small power operations.

II. Animal Power.
  a. Size of animal units.
  b. Cost of maintenance.
  c. Total untilization.
  d. Reducing unit costs.
  e. Quality of work.

III. Mechanical Power.
  a. Type of power unit.
  b. Size of unit.
  c. Cost of maintenance.
  d. Total utilization.
  e. Displacement of animal power.
  f. Effect of type and size of horses and muls maintained.
  g. Adaptation of available machinery.
  h. Quality of work.

IV. Relation of Forms of Farm Power to Man Labor.
  a. Effectiveness of labor utilization.
  b. Seasonal demands for labor.
  c. Effect of time and weather limitations.
  d. Cost of man labor.
    1. Rate per hour
    2. Enterprise labor cost.
  e. Quality of labor required

V. Influence on the Farm Organization and Operation.
  a. Size of farm.
  b. Size of fields.
  c. Topography of farm.
  d. Character of soil.
  e. Type of farming.
  f. Combination of crop and live stock enterprise.
  g. Intensity of culture.
  h. Total farm profits.

Methods of Study.
  a. Detailed cost accounting studies of the entire farm business.

b. Farm management surveys.
c. Enterprise studies of the tractor and its operation.

These three methods are all useful and supplement each other in providing satisfactory data on the farm power problem.

ANIMAL POWER

1. To determine the working rating of horses as affected by various factors existing under farm conditions.
2. To determine the cost of the horse as a source of power, said cost to be expressed in terms of food, labor, materials, etc., considering all proper charges and credits.
3. To determine the economy and efficiency of the horse as a source of power.
4. To determine how farm power needed for peak load periods can be most advantageously supplied.
5. To determine practical methods of securing the greatest possible utilization of power available from farm horses.

MECHANICAL POWER AND EQUIPMENT

Under the heading of mechanical power and equipment the following subjects are suggested for study and investigation.

1. Belt, draw-bar and fuel economy tests of farm tractors.
2. The power requirements, efficiency and possibilities of operation in combination of all types of farm machines and implements.
3. Causes of successes and failures in farm machines.
4. Education in the use and care of farm equipment.
5. Service to owners of machines.
6. Adaptability of machines.
7. Development of new implements.
8. The determination of such problems as the uniform and proper speeds of belt travel, of uniform and proper speeds of operation of farm implements, of uniform and proper grouter equipment for farm tractors and such other matters touching the construction, use and operation of far mimplements not affecting the type or fundamental design of any products as manufactured.
9. Use of power in the farm home.

RESOLUTIONS AND RECOMMENDATIONS

WHEREAS, the problems of farm power are materially influenced by State and local conditions, and

WHEREAS, The State agricultural colleges are interested in those questions and are in close touch with the agricultural interests of the States, and are prepared or can easily be prepared to assist in solving these problems.

BE IT RESOLVED, That it is desirable, as far as possible that the U. S. Department of Agriculture should cooperate with the State colleges in carrying on work connected with farm power and other agricultural engineering problems, and

BE IT RESOLVED, That we urgently recommend that Congress be asked to make adequate appropriations for fundamental studies of the farm power problem and that, when appropriations become available for this purpose, the investigations be planned by a committee of the ablest men available.

REPORT OF COMMITTEE ON FARM POWER MACHINERY

G. B. Gunlogson, Chairman
F. N. G. Kranich, E. R. Wiggins, A. P. Yerkes,
K. D. Hequembourg

This Committee desires to point out the need of some constructive work in regard to the adaption and use of some power farming machinery with special reference to the common belt driven machines such as grain threshers and ensilage cutters and to suggest a plan which in its opinion will be a step in that direction.

In the first place there has been an evident lack of interest in the mechanical phase of agriculture on the part of our agricultural men. For instance very little attention has ever been given the subject of management and labor efficiency as applied to threshing, although this operation costs the farmers of this country about $200,000,000.00 annually.

Millions of dollars are being used annually by our agricultural institutions in combating the various grain diseases and insects and to alleviate the losses from those sources, but little effort has been devoted to the problem of grain wastage in handling, notwithstanding the importance of this loss. The results of the campaign of the Threshing Division of the U. S. Food Administration indicate the possibilities along this line. According to their estimate a saving was made by reason of their efforts of nearly 22,000,000 bushels of wheat in the 21 states where the campaign was carried on, besides the saving effected in other kinds of grains.

This Committee desires to point out one phase of this work which appears to be an agricultural engineering problem. As you know, there is little uniformity in the rating or recommendations with respect to the power consumed or the capacity of most belt driven machines. The rating or recommendation given grain threshers, for instance, is sometimes grossly misleading and often results in direct or indirect loss to the purchaser as well as to the farmer he does work for. With insufficient power it is very difficult to do a good job of threshing and save the grain because of the uneven motion which results, besides it is hard on the entire outfit which means a rapid deterioration of both separator and tractor.

Take for instance the power recommended for driving grain threshers as given by the manufacturers for 20 and 22 inch cylinder machines with all attachments. This is from 15 horsepower for some machines to 30 horsepower for others. The power recommended per inch width of cylinder varies as much as 175 per cent. The bushel capacity per horsepower hour, which should be fairly uniform, varies all the way from 2½ to 6 bushels, with an average of approximately 3 or a little over.

However inconsistent these figures may be, they are not exactly wrong because it is probable that they may be applicable or have even been based upon actual results under certain conditions. There is no one to blame for the situation. It is merely a condition that has been brought about in the commercial pursuance of the industry and has gone so far without a proper solution.

Before the advent of the farm tractor, the situation was different for several reasons. First, practically all the threshing was then done with steam outfits and most of the separator manufacturers also made the steam engines to operate these machines, with the results that the two were pretty well matched regardless of the rating. The complete outfit was generally of one make.

The great part of threshing was then done by custom threshers, most of whom had considerable threshing experience before they purchased their machines.

The number of machines in use at that time was considerably less than now and the season was longer resulting in greater specialization. The poor work then was more generally because of carelessness in operation or over-crowding. The custom thresher, if he gained a bad reputation was automatically eliminated or was forced to hire competent operators, but the farmer who makes a bad selection usually tries to get along the best he can with his own threshing and that of some of his neighbors.

There are now about 30,000 small machines being sold annually to farmers and a large percentage of this number is going to farmers who have never before owned or operated a threshing machine. They are going to farmers who own tractors. Farmers are buying these machines irrespective of the type or size of tractors they possess. They are buying them because they think they can do their own threshing better and make money by operating a threshing machine since they own the tractor, which is right when they possess a suitable tractor for threshing and select the proper machine for this power.

The situation is not easy of solution. If a uniform rating or recommendation could be adopted, it would not altogether solve the problem, although it would be a great help. Threshing conditions vary so that the application of the rating would have to be determined for different conditions. It also seems hopeless at this time to attempt to standardize those conditions or to formulate a method of testing these machines upon which a standard rating or recommendations can be based which would be practical and easily performed and they would have to be both to be acceptable to manufacturers. This will have to be brought about gradually and largely through an educational effort and with the cooperation of the manufacturers.

Some tests are essential. Without tests we cannot gain experience. There is nothing to learn and we can have no issue. So far there have been very few tests of any kind conducted on grain threshers outside of those made by manufacturers. This is also true of ensilage cutters and feed mills, although a little more work along this line has been done on these machines.

The object of such tests would be first of all to determine the power required to operate the machines under different conditions and in different kinds of grains and then to determine a fair capacity under the same conditions, wastage of grain, etc.

These tests would be bound to result in a great deal of good for all concerned. They would automatically solve the question of rating and eventually bring about more uniform rating of these machines. If made in various parts of the country, some valuable data would be obtained with respect to different kinds of grain and conditions. The advantage to the agricultural industry to be derived from such work is sufficiently great apparently to warrant more effort along this line being made by the proper Departments of the Agricultural Colleges.

It is highly important that any tests of this sort be conducted along a definite plan and for a definite object in order that the results will be uniform and of the greatest value. We are submitting an outline of basis for a test on grain threshers.

Object: To determine power required to run grain thresher with attachments under different conditions.

Method: Steam engine and indicator.
Electric motors.
Transmission dynamometer.
(Any one of above methods)

Grain and Conditions:

Grain:
- Wheat
  - Turkey red and similar varieties.
  - Bluestem and similar varieties.
- Oats, average condition,
- Barley, Rye or other grain grown in territory.

Condition of grain:	Tough.	Straw:	Long
	Dry		Medium
			Short

Condition and adjustments of machine.

Data:

Rate of Threshing: Bu. per hr.
Cwt. of straw per hr.

Power: Machine empty (Normal speed)
Threshing: Max. H. P.
Normal H. P.
H. P. hr. per bu.
H. P. hr. per cwt. straw

Speed: Normal maintained.
Variation.

Waste: Percent of grain threshed.

REPORT OF COMMITTEE ON BARN VENTILATION

W. B. Clarkson, Chairman.
L. J. Smith, J. L. Strahan

In view of the pressing importance of other problems and the desirability of giving as much time as possible this year, to a discussion of other subjects, your committee on farm building ventilation has decided to outline very briefly its endeavors during the year of 1919.

In our last annual report some data was submitted for the consideration of the society to serve as examples of the character of the ventilation tests that the committee has been conducting. To those interested, a study of the data published in connection with the committee's report last year, would be of value.

While considerable data could be presented in connection with this report, it is not necessary. The committee has selected the example that follows to demonstrate the inefficiency of a ventilating system installed in a haphazard manner and without the proper supervision of an engineer with scientific knowledge of the subject.

Mssrs. Strahan and Clarkson conducted the test of the barn here referred to, and the report of the test as written by Prof. Strahan is herewith submitted.

The following is the body of a report to the management of the Clifton Springs Sanitarium Farm of a test of the ventilation system in their dairy barn. From the following description of the barn it will be observed that the system is a poorly designed and loosely constructed one which could not be expected to show a very high efficiency. A few standardized tests of such systems as this would prove valuable in emphasizing the need of adequately insulating both the barn and the ventilating flues before ventilation efficiency can be expected.

CLIFTON SPRINGS, NEW YORK, SANITARIUM BARN

DESCRIPTION OF BARN AND VENTILATING SYSTEM

The barn is 228 feet long, 34 feet wide and of an average height of 8 feet 4 inches. The total capacity to be ventilated after deducting for girders and other materials in the room is 62,429 cubic feet. It is a one-story barn extending north and south and is protected on the north by a basement barn underneath a hay barn. Young stock are housed in the basement. The ridge of the hay loft is from 8 to 10 feet higher than the ridge of the barn under test. The walls of the barn are of comparatively loose construction, consisting of an outside layer of drop siding on 4″ studs which are covered on the inside with 7/8 inch matched ceiling. The barn is separated from a low attic-loft by a floor which is sealed underneath with 7/8 inch matched boards. There are six doors entering the barn, one in the center of the north and south walls and two in each of the other walls. Those to the east and west are very poorly fitted and considerable air leaks through the cracks both between the doors and the upper casement and sill.

The windows are double sash, 12 light, 12x15″, one in the center of each bent, the bents being approximately 12 feet on centers. The windows are arranged so that the lower sash can be raised, but are not very tightly constructed so that there is considerable leakage around the window casings.

VENTILATOR ON CLIFTON SPRINGS SANITARIUM BARN

The ventilation system consists of 12 outtake flues each about 7″x24″ in cross section at the bottom starting at a point approximately 18 inches from the floor, running directly to the plate, thence to the ridge where they are joined to a galvanized iron ventilator head. Two opposite flues enter each ventilator. The flues are oblong square, constructed of one thickness of ⅞" matched lumber, the outside drop siding below the plate and the roof above the plate forming one side of each flue. In some cases there is a layer of building paper inside the flue; in other cases this is absent. Apparently this is an attempt to insulate the flue to some extent. The intakes are 17 in number, each 12"x18" total sectional area and faced both on the outside entrances with an iron grating of such construction that the total effective sectional area of the flues is cut down to one square foot, or the equivalent of 12"x12". The intakes are non-insulated, starting from a point approximately three feet from the ground on the outside and entering the stable at the point where the wall and ceiling meet.

The system as installed at present would be adequate for 81 cows if the flues were properly constructed as regards insulation. One hundred cows, however, is the capacity of the stable. Under the best conditions, therefore, the present system could not possibly be more than 80% efficient.

THE TEST

In order to test the operation of the system the stable was put in as tight condition as possible in order to prevent, as far as conditions would permit, the transfer of air in and out of the stable by any means other than the ventilation system. All the windows were closed, doors were kept closed except when necessary for feeding and other chore operation, and all doors which were not absolutely needed were sealed up tightly with burlap bags The data obtained in the test was:

1. Average temperature inside the stable.
2. Average temperature outside the stable.
3. Wind velocity at the ridge.
4. Velocity of air through intakes.
5. Velocity of air through outtakes.

The temperature inside the stable was observed by means of 8 thermometers placed around the walls and near the center both at the floor and ceiling. All these readings were taken on two occasions, once for each of the two tests.

The temperature outside the stable was observed by means of four thermometers, one on the outside of each wall. These readings were also observed twice, once for each test. The wind velocity at the ridge was determined by means of a J. P. Frieze indicating anemometer which indicated velocity of wind in miles per hour.

The velocity of air through intakes and outtakes was observed by means of a Short and Mason anemometer which read in linear feet.

TABULATION OF RESULTS

EFFICIENCY OF OUTTAKES

No.	1	2	3	4	5
	Average temp. dif.	*Average flow in cu. ft. per min. thru outtake*	*Theoretical flow in cu. ft. per min. for ideal conditions should be*	*Flow to be expected under working conditions 40% of column 3*	*Efficiency* $\frac{\text{Col. 2}}{\text{Col. 4}} \times 100$
1	28½°	52.6	694	275	19.2%
2	19½°	58.5	576	230.5	25.2%

These figures indicate the effect of lack of insulation on control of the system. The flues work only at about 20% efficiency when the outside air is cold and at 25% when it warms up somewhat. This is probably because the air in the flues above the stable is chilled before it reaches the ventilator head and the draft thereby checked to a considerable degree, the effect being more and more noticeable as the outside temperature drops.

COMPARISON OF INTAKES AND OUTTAKES

Test No.	*Total air removed through foul air flue in cu. ft. per hour*	*Air admitted through intakes cubic ft. per hour*	*Difference*
1	57156	95160	28004
2	59404	68160	8756

It is to be observed that air is coming in at the air intakes faster than it is being removed through the outtakes. This means that air is leaking out at doors, windows, cracks in the wall, etc., thus making an adequate control of temperature practically impossible by loss of heat through uncontrolled points of exit.

It is to be observed that the amount of uncontrolled air change indicated by the figures in this test is equal to 13% of the total in the second. It may be inferred in passing that a large number of tests in buildings of different construction will present data from which a factor may be deduced that will indicate what should be expected in this regard in standard types of buildings and stables. Such a factor would undoubtedly be of value as an aid in systematic design.

ADEQUACY OF PRESENT SYSTEM

At the time of the test the air was moving through the stable at the rate of 95160 cubic feet per hour, or, in other words, the air received one complete change every 46 minutes. In order to conform to the proper standard for ideal ventilation conditions the air in this stable, when full of stock, should have one complete change every 10½ minutes. The figures indicate an efficiency of 23% attained by the system using the maximum rate of flow through intakes as a basis of calculation.

Extreme lack of control is indicated by all the data observed. Undoubtedly back drafting through the intakes on the leeward side of the stable will occur when a wind velocity greater than 15 miles per hour occurs, which condition will further increase loss of heat control.

RECOMMENDATIONS

In the opinion of the writer good results will be obtained in this stable when the following conditions are met:

(1) The intakes must be insulated with felt or an extra layer of boards around a layer of building paper. In this case the insulation should be especially well constructed between the flue and the stable wall on the inside, which precaution is merely for the purpose of preventing condensation.

(2) The outtake should be insulated in the same manner, made larger in size and fewer in number and placed behind the cows continuing straight to the ridge. Their construction may be either double boarded with building paper between rectangular, or good round galvanized, thoroughly insulated on the outside.

There should be six outtake flues, each 22 x 30" square inside or 26" diameter round inside, spaced at equal intervals through the center of the stable, alternating from one side of the driveway to the other, each one running to a ventilator head of adequate size. The size of the ventilator head can best be determined from the company which manufactures it. Intakes should be of equal size to those already installed, should be 25 in number and spaced at regular intervals around the stable wall in order to insure a good distribution of fresh air. By changing the present outtakes to intakes very little alteration in the wall construction will be needed. A sufficient number of the present outtakes can be used to increase the present number of intakes to 25. The inside end of the intakes should be provided with a damper which will insure proper heat control by preventing back drafting.

TEMPERATURE CONTROL

In the continuation of testing farm building ventilation, and the accumulation of data, your committee is more than ever impressed with the necessity for well insulated walls and ceiling, and well protected door and window openings in every farm building where it is expected that the heat from the stock should be sufficient to raise the temperature of the room and maintain it at a comfortable degree.

While we are finding many instances of the inefficiency and inadequacy of ventilating systems, yet, we wish to emphasize that there are many barns with well equipped ventilating systems which are not producing satisfactory results to the owners, and this is not because of inadequate ventilation, but because of the fact that those buildings are too cold.

In a barn room containing a sufficient number of stock, throwing off enough heat, to maintain the temperature well above freezing in extreme cold weather, we find that the King system of Ventilation properly applied to such a stock room, will move the air in and out of the room fast enough to maintain its purity, and at the same time maintain control of the temperature of the air in that room.

In order that a clear idea may be had of the capacity of a stock room, for the purpose of maintaining temperature control, Mr. Clarkson, of this committee, submits an interesting table, which, while not proposed as a scientific formula, has been used for several years, and invariably when this rule has been followed in the planning of farm buildings, and the King system of ventilation has been scientifically applied, it has produced uniformly good results.

THE STANDARD CAPACITY OF STOCK ROOM

To maintain uniform control of the temperature in stock room during cold weather, where no other plan of heating is provided except the heat from the stock, the following table gives an estimated heating capacity of the domestic animals usually kept in a farm building.

These figures are based on full grown animals, and young stock should be rated in proportion to weight.

It is estimated that the average full grown horse weighs about 1400 pounds, the average cow about 1000 pounds, and the average hog about 300 pounds.

TABLE

The average horse	730	cubic feet of space in stock room
The average cow	600	cubic feet of space in stock room
The average hog	240	cubic feet of space in stock room

HEAT THROWN OFF BY DIFFERENT ANIMALS

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HEAT THROWN OFF BY DIFFERENT ANIMALS

In view of all that has been said in this and previous reports on the subject of temperature control in farm buildings your committee determined, this year, to start an investigation to find out the approximate amount of heat thrown off by each animal according to size and weight, quantity of food and water consumed and the amount of work done.

With this in mind, we have visited several agricultural colleges in the middle west, interviewing the head of the Animal Husbandry Departments, and we have written to others that have not been visited.

During a trip in the East last summer we visited Dr. H. P. Armsby, at State College, Pennsylvania, thus having a splendid opportunity to investigate the animal calorimeter which Dr. Armsby has made use of in his investigations, and to discuss with him the questions that we are interested in.

Dr. Armsby has assured your committee that if it will propose definite examples, bringing out clearly the questions that we wish answered, he will undertake to tell the number of calories of heat thrown off by each farm animal. This, then, was the question that we put up to the Animal Husbandry Departments of the colleges we visited, and others with whom we corresponded. Without a single exception, those seen personally, were very much interested in this proposition, and agreed to coöperate with the committee in any way they could. This work has progressed slowly, and up to the present time we are not able to make any report but hope to have something definite to report soon.

The scientific data in animal nutrition, accumulated by the Animal Husbandry sections of various agricultural colleges, conjoined with the life-long studies and wealth of data accumulated by Dr. Armsby in thermo-chemistry, in coöperation with this society, should place us in position to determine the heat elimination values of all domestic animals.

RECOMMENDATIONS

It is quite important that the committees on Farm Structures, Farm Building Equipment and Ventilation, work together to produce farm buildings that we may designate as CLIMATIC STRUCTURES. Therefore, we suggest that some plan be devised by which the information secured by each committee can be available at once for the consideration of the members of all these committees.

Note:—We wish to acknowledge the helpful suggestions and coöperation of the following named men in connection with our committee work this year:

Armsby, Dr. H. P.—State College, Pennsylvania.

Allen, John R.—Director of Research A. S. of H. & V. Eng's, U. S. School of Mines, Pittsburgh, Pennsylvania.

Dutcher, Dr. R. Adams—Bio-Chemistry Division University Farm School, St. Paul, Minnesota.

Eckles, C. H.—Chief Div. of Dairy Husbandry University Fairm School, St. Paul, Minnesota.

Evvard, John M.—In charge Animal Husbandry Section Iowa State College, Ames, Iowa.

Hammer, B. W.—Dairy Bacteriologist Iowa State College, Ames, Iowa.

Kildee, H. H.—Head of Dept. Animal Husbandry, Iowa State College, Ames, Iowa.

McCandlish, A. C.—Chief of Dairy Husbandry, Iowa State College, Ames, Iowa.

Stratton, W. F.—Director Bureau of Standards, Washington, D. C.

Anderson, Hon. Sydney, M. C., 1st Dist. Minnesota.

We might say in this connection that we spent two weeks in Wisconsin just prior to the holidays and among othtrs, we went into one barn that, as we approached it, it looked to be, from the outside one of the finest and latest, most up-to-date structures that could be imagined. It was a new barn in every way; the walls were built of interlocking tile up to the loft floor and in making the test of that barn we placed thermometers around the walls as indicated in this test here, we think about a dozen thermometers, on the insude and outside of that barn, altogether. The man had complained that his barn was too cold. We closed the ventilating system, tntirely stuffing it up with bags and anything that we could get hold of so there was absolutely no possibility of any air passing through the ventilating system either in through the intakes or out through the outtake flues. The next morning, with the temperature outside at 4 degrees above zero, the temperature on the inside, directly in the center of the barn below the loft floor was 28 degrees, or a difference of 24 degrees. The reason for this, in this apparently new up-to-date barn was that the walls and doors and window openings were not properly built and completed. The masons had laid up that wall and there were several places where you could actually look through and see daylight through the walls. The recommendation to him was that his wall and his windows and doors must be properly insulated if he expects to control the heat of that barn. The cubic air space per cow was figured at 790 cubic feet. It was a combination dairy and horse barn. That is an illustration of what I find here and there all over the country. Men are building fine barns, putting a lot of money into them, and yet they are not completing them properly.

DISCUSSION

Mr. Patty: I would like to ask Mr. Clarkson the position of the outtake flues in the barn tested and their operation?

Mr. Clarkson: In this barn the outtake flues were on the wall and the intakes also on the wall.

COMMITTEE ON TEST AND RATING

F. M. White, Chairman
F. N. G. Kranich, E. A. White, G. B. Gunlogson, P. S. Rose, J. B. Davidson, Geo. McCuen, O. W. Sjogren

Your committee on Test and Rating prepared, during the past year, rules for the conduct of tractor demonstrations. These rules known as Class A for demonstrations staged by County Agricultural Agents, Agricultural Institutions, Dealers, and Manufacturers and Class B for demonstrations staged by Agricultural Institutions and Manufacturers have been published and circulated among the membership and are, no doubt, familiar to all. These rules have been quite thoroughly tried out and are recommended to the Society as recommended practice.

Class C rules for tractor demonstrations of a larger scale where accurate records of performance have been considered.

Your committee would also report a conference with a committee of the National Implement and Vehicle Association concerning the development of relationship between the Association and the Society.

On November 7th a meeting was held in the offices of the National Implement and Vehicle Association at which Messrs. F. R. Todd, E. W. McCollough and E. A. Johnson represented the N. I. V. A., and Messrs. F. N. G. Kranich and J. B. Davidson represented the A. S. A. E. Mr. J. B. Bartholomew, representing the N. I. V. A., and Mr. Raymond Olney, representing the A. S. A. E. were unable to be present. Messrs. T. Brown and K. J. T. Ekblaw were present in an advisory capacity. The conference was called by the tractor and thresher division of the National Implement and Vehicle Association, the American Society of Agricultural Engineers, and other organizations in connection with standardization and other matters of mutual interest.

It is to be noted that Messrs. Johnson, Kranich, Olney and Davidson represented, unofficially, the Society of Automotive Engineers.

After some discussion concerning the work of the conference the following resolutions were passed:

Whereas, The members of this committee present, representing the National Implement and Vehicle Association, the American Society of Agricultural Engineers, officially, and the Society of Automotive Engineers, unofficially, and

WHEREAS, The membership of these bodies represented have many matters in common, particularly such matters as Standard Tractor Ratings, Standard Belt Speeds, Standard Tractor Speeds, Standard Drawbars and Hitches and other standards which will be of mutual advantage to the manufacturer, dealer and farmer. Therefore, be it

RESOLVED, That the Society of Automotive Engineers be requested to appoint a committee authorized to act with this joint committee. Also that these respective societies and associations be requested to authorize this joint committee to formulate plans for standardization in fields of mutual interest with authority to recommend and submit such standards to their respective societies or associations for consideration before adoption, and when any standards which are of mutual interest to organizations represented by the committee are adopted by the National Implement and Vehicle Association and one more society represented, such standards shall then be known as American Agricultural Equipment Standards; be it further

RESOLVED, That this committee shall be made a General Standards Committee representing said societies, and that the standards adopted through the efforts of this committee be known as American Agricultural Equipment Standards.

STANDARN BELT SPEEDS

Mr. E. A. Johnson, who had made an extended study of belt speeds as a member of the Standard Committee of the Society of Automotive Engineers, presented a report concerning practice in belt speeds.

The following is from the report of Mr. Johnson's report to the Society of Automotive Engineers:

REPORT OF SUBDIVISION ON BELT SPEEDS

In the endeavor to arrive at a series of standard belt speeds for power-driven farm machinery a very thorough analysis of available information was made. A brief summary of the precedure will be of value in considering the recommendations proposed for adoption.

MACHINERY CONSIDERED: The farm power-driven machine groups considered were:

1. Tractors.
2. Threshers.
3. Feed Grinders.
4. Ensilage Cutters.

5. Corn Shellers.
6. Corn Huskers.
7. Hay Presses.
8. Stationary Engines (small).

PREVAILING BELT SPEEDS. Each of the above groups were analyzed in a number of ways. The controlling factors for the standard and special pulley sizes and speeds for these machines are:

> Consideration of space, power and revolutions per minute required for clutch and plain pulleys for both power-driven and power-driving equipment with respect to design. Meeting speed requirements when receiving power from a variety of power-driving equipment (both for stationary engines and tractors) by means of clutch and plain pulleys. Meeting speed requirements of the product operated upon by the power-driven equipment.

CONSIDERATION OF COMPLEXITY. Consideration was given to the difficulties involved in the adoption of standard belt speeds. It is evident that it is more expensive to meet changes in clutch and plain pulley sizes controlling belt speeds in the tractor group than in any group. In the thresher group changes involve slippage and interference more than in any other group.

In practice it was revealed that prevailing belt speeds were as follows:

Tractors	2,100 to 3,150	
Threshers	1,250 to 1,650,	2,000 to 3,450
Feed Grinders	1,400 to 2,800	
Ensilage Cutters	1,300 to 1,850,	2,000 to 2,625
Corn Huskers	2,040 to 2,100,	2,350 to 2,500
Corn Shellers	2,075 to 2,100,	2,300 to 2,500
Hay Presses	1,630 to 1,840,	2,000 to 2,600

There were 40 replies to the 110 questionnaires sent out, or 36.3 per cent.

The replies were quite unanimous in approving the speeds selected as shown by the following percentages, counting only those who gave positive answers or indicated that they would adopt the speeds recommended.

Speed r. p. m.	*Total Number of Replies*	*Replies Approving of Speeds*	*Per Cent*
1,500	39	37	97.5
2,600	40	39	97.5
3,000	40	39	97.5
3,500	40	38	95.0

Other problems in Standardization proposed were:

Tractor speeds, drawbar heights and hitches, tractor rating and silo fillers.

Your committee recommends that these proposed Standard Belt Speeds be submitted to the membership for approval by letter ballot.

Your committee desires further to report that the new standards committee, the organization of which is yet incomplete, expects to take up at once a study of standards for tractor, rating, drawbar heights and hitches, tractor speeds, silo fillers and feed and litter carriers.

REPORT OF COMMITTEE ON EDUCATION

F. A. Wirt, Chairman
M. L. Nichols, E. W. Lehmann, J. B. Davidson

During the past year the Educational Committee has taken up many lines of work. It was considered very advisable to emphasize at every opportunity the importance of agricultural engineering. Much time and effort was spent which need not be dwelled upon in this report. It should be stated, however, that the Educational Committee was particularly interested in the proposed bureau of Agricultural Engineering.

Each member of the committee in addition had a particular work to do. Mr. M. L. Nichols of the Alabama Polytechnic Institute has prepared material on the teaching of Courses in Farm Buildings. Prof. E. W. Lehmann of the University of Missouri has done the same for Farm Conveniences. Prof. J. B. Davidson of the Iowa State College very kindly consented to prepare a few ideas in the Teaching of Farm Machinery. The Chairman of the committee has been working on the status of Agricultural Engineering at the colleges. The situation in the educational phase of agricultural engineering is far from satisfactory. Only eight agricultural engineering students were graduated last year and 36 schools do not offer courses in agricultural engineering. From the questionnaires returned, it seems as if only five schools granted degrees in agricultural engineering. They are the University of Nebraska, University of Missouri, Utah Agricultural College, Kansas State Agricultural College and Iowa State College.

Georgia State College, Ohio State University and Washington State College permits students to specialize in agricultural engineering in the same manner as students specialize in Animal Husbandry, Dairy Husbandry, etc.

At the present time there are only 21 senior agricultural engineering students. It is likely that all of these will graduate in the spring and they come from three institutions, University of Nebraska, Iowa State College and Utah Agricultural College. At Georgia State College there are 6 students specializing in agricultural engineering, as explained above. To our regret we do not have the number at Ohio State University and Washington State College.

The Chairman endeavored to obtain the number of freshmen taking agricultural engineering at some of the institutions. Because of the fact, however, that so many educational institutions do not classify their freshmen it is impossible to give the number. The Utah Agricultural College has 48 Freshmen, Kansas State Agricultural College 15, and the Iowa State College 39. At all other institutions the freshmen are not classified.

A startling number of vacancies exists in our colleges and universities today. The Chairman has a list of 20 vacancies. Some of these perhaps have been filled but the number is far too great when we consider the importance of agricultural engineering. It is also true that many schools who are not now trying to obtain some one would employ agricultural engineers if funds were available or if they thought it was possible to get some one for the money at their disposal.

Twenty-seven Land Grant Colleges require a farm machinery subject in their course for agricultural students. Fourteen do not require a farm machinery subject. They are as follows: Oregon Agricultural College, South Dakota Agricultural College, Utah Agricultural College, Rutgers College, University of California, Kansas State Agricultural College, Michigan Agricultural College, Cornell University, University of Illinois, University of Missouri, University of Arkansas, University of Tennessee, University of West Virginia and University of Minnesota. Of these 14, 4 require some other course in agricultural engineering for their agricultural students. They are Colorado Agricultural College, Michigan Agricultural College, University of Illinois and University of Arkansas. It might be added that too frequently only the agronomy students must take a course in farm machinery.

This situation is deplorable from any point of view. Any man with the slightest familiarity with the agricultural conditions in this country must realize, if he does not appreciate, the part played by farm machinery in the production and distribution of our farm products. The Educational Committee can only conclude that the men in agriculture do not appreciate the importance of farm machinery for its use is certainly as fundamental as knowledge of soils or crops, and if any subject is required in agricultural courses farm machinery should not be elective.

The Educational Committee wishes to make several recommendations for the consideration of the Society. We recommend: (1) That the six essentials for good farm machinery courses be approved by the Society. These essentials are as follows:

(a) A class room in which farm implements can be placed before the class.

(b) Laboratory large enough to contain not less than two samples of the most important machines and one of the less important machines used in the state in which the agricultural college is located.

(c) Use of a field of from ten to 200 acres under the sole supervision of the Agricultural Engineering Department for practical laboratory instruction and experimental work. In this connection the committee sees no reason why an Agricultural Engineering Department should not have as much land as the agroriomy, animal husbandry or some other strictly agricultural department.

(d) Two recitation periods of one hour each and a three hour laboratory period per week is the minimum amount of time that can be given a good farm machinery course.

(e) Ample time for the instructors to study improvements in modern labor saving machinery and to prepare class and laboratory material. At most institutions a mechanic to keep the laboratory equipped, and in order, and a stenographer or clerk will be found necessary.

(f) Trade literature furniture by the manufacturers must be distributed to the students to increase the effectiveness of the instruction.

(2) That a one to three week's post-graduate course be given at some university or state college for instructors in agricultural engineering. The object of this course is to present to the agricultural engineers, who are teaching and to others if they wish to attend, the most recent developments in agricultural engineering. Men best qualified from the industry and from the colleges should give the course. These men could take those attending the school to the top of the mountain and show them the glorious future for agricultural engineering in all its branches. We have been too close to the problem which has occupied our entire attention and it would be well for the Society and for the welfare of each member if a course of this kind could be held next summer.

(3) That the Society request the research committee to write the directors of the Experiment Stations about the importance of research in agricultural engineering and use any other methods that are feasible to bring about a better understanding of the need for research. Chairman E. A. White of the Research Committee in answer to a letter from the chairman about this subject gave the best explanation the writer has ever read. If such an explanation could be given the directors of the Experiment Stations, the farm papers and trade papers, much good would result.

(4) That the Educational Committee for 1920 be instructed to prepare a syllabus of a farm machinery course that can have the unqualified approval of the Society for the use of individual

members in discussing agricultural engineering problems with their Deans, Directors, and Presidents.

That is Mr. Wirt's paper. Now I have here papers from Professor Lehmann, Mr. Nichols, and Mr. Fairbanks. I might say just briefly that these papers cover specialized phases of this branch of agricultural engineering education and Mr. Fairbanks has presented here a large amount of data which he has compiled from questionnaires which he has sent out and got replies on, which seemed to have a pretty good line of reasoning in them. They are not entirely conclusive, however. We will leave this report here so that any individual interested can see it before the time of the annual proceedings, and it has been published. These other reports are very good, but we will not have the time this morning to cover them. I think Professor Davidson has a part that he wants to read. (Prof. Davidson asks Mr. Ives to read report).

Mr. Ives: (Methods of Teaching the Subject Farm Machinery.) 1. A survey of the curricula of the agricultural colleges will reveal the fact that farm machinery is by far the most generally offered agricultural engineering subject. Practically every institution near has one or more courses in farm machinery outlined. A recent report by Professor Fairbanks of Washington State College states that farm machinery is a required subject in twenty out of thirty-nine land grant institutions.

2. The fundamental purposes of teaching farm machinery is to make the student more effective in agricultural production through the use of labor saving equipment. Just how this is to be accomplished is a problem for the educator. It might seem that the objects and purposes of the instruction offered might be outlined in the following manner:

A. Furnish information concerning:
1. Mechanics of machines.
2. Elements of machines.
3. Materials of construction.
4. Practical features of machine operator.
5. Information concerning various farm machines.

B. Practice:
1. Handling machines.
2. Repairing and adjusting machines.
3. Testing machines.
4. Comparing machines.
5. Operating machines.

3. Class room instruction given primarily for the purpose of furnishing information does not differ widely with different instructor or institutions. However, it should be pointed out that it is generally conceded that the demonstration method of teaching is especially adapted to the subject. Much of what any

student receives comes through the eye and the demonstration method where the actual machines and apparatus are used in connection with the instruction raises the efficiency of instruction materially.

4. It is, however, with the methods of giving practice work that this report deals primarily. The following methods have been or are used:

A. Practice in dissembling and assembling machines.

B. Study of machines, comparing machines of different manufacture and types and making a report of observations.

C. Testing machines for the purpose for which they were made, to determine accuracy, capacity, etc.

D. Operation of the machines in the fields, perhaps, if not in competition, at least in comparison.

E. Field demonstrations for the purpose of obtaining draft or adjustment.

5. Practice, in dissembling and assembling machines has almost become obsolete as a method of instruction. The time required is great for the experience gained.

6. The study of machines by comparison is very successful for students who have had actual field experience, but is apt to become so mechanical in its execution and does not fulfill the requirement of the student who knows little about the operation of machines in a practical way.

7. The testing or calibration of machines can very well be carried out successfully with certain classes of machines. The object of a well arranged test furnishes sufficient incentive to make testing of machines a very efficient type of instruction. This method is well adapted to such exercises as the testing of grain grades and cleaners and the testing of corn planters and grain drills for accuracy.

8. Operation of machines in the field where actual working conditions are feasible with full opportunity for the demonstration of the important adjustments is perhaps the ideal type of instruction. Limitations of fields, seasons and climate prevent the fullest use of this kind of instruction, yet much more could be accomplished than is now being done. In many places this would mean the offering of machinery courses during favorable seasons.

9. The mere operation of machines in the field is not sufficient but exercises should be arranged to be highly instructive at all times. Not only should the effect of adjustment be clearly demonstrated but provision should be made for checking and determining with accuracy the character of the work performed. Instruments for doing this should be developed. Cost of operation should occupy a prominent place in the instruction.

10. No doubt the problem method of teaching should be used

more than it is in the teaching of farm machinery. The cramming of students with organized and classified information is dry instruction but problems such as the selection of the necessary equipment to produce certain crops or for certain farms is very interesting and to the student an intensely practical problem. Training for military service during the war furnished many illustrations of the effectiveness of the problem method of instruction and its study and utilization is suggested by your committee.

INSTALLATION OF PRESIDENT

CHAIRMAN: If there is no further business we will take up the installation of the new President and let him adjourn the meeting. I want to thank the membership for the support which they have given me during my term of office as President, and I have greatly enjoyed the honor and have taken great pleasure in passing it on to a man whom I know will fulfill the office the coming year very creditably. I am going to ask Mr. Kranich to take the chair now, and I will surrender the gavel to him and let him conclude the meeting. (Great applause).

MR. KRANICH: Gentlemen, Mr. Olney, the retiring President, expressed the fact that he had very much enjoyed the honor. I wonder if he enjoyed the work. It is that part of it, after all, that is the hardest.

I don't know whether I am going to or not; I have another job to hold down besides this one. I don't know whether I am going to be able to do as much as I had hoped I might; I am afraid I may not be able to. There are a lot of problems that I am going to try to work out, and I am going to assure you at this time that I will give all the attention that I can to this work, so far as my other work will permit, but I feel that with the support of you men as a body that more can be accomplished than what I can do myself, because anyone is limited in the amount of work that he is physically able to do. After all, the work that the fellows in the organization do that makes for the success of any organization, and not the man at the head of it, and it is that particular thing that I want to impress on anybody and everybody, and I am going to ask for more help than ever in trying to put this thing through so it will resound to the benefit of everybody; not that I express any credit, but that the association and each one of you will get the benefit that is derived by the success of any institution. I think that covers all I want to say at this time.

Upon motion, duly seconded, Thirteenth Annual Convention is adjourned at 4:25 P.M., December 31, 1919.

BUSINESS RECORDS

SECRETARY'S REPORT

Membership: During the year 1919 new members have been elected as follows: Sixty-two members, fifty-five associates, nine juniors, and four affiliates. Total 130 new members. During the same period four members have died, one has resigned, and three have been dropped. Net increase for the year, 122 members.

Total membership now stands: 189 members, ninety-seven associates, twenty-one juniors, eight affiliates; total, 315 members.

Student branch members: Iowa five, Nebraska five, Mississippi fifteen, Ohio State twenty-one.

Publications: During the year the following publications have been issued:

1000 Volumes 1918 Transactions.
500 Pamphlets of Information.
10 News Letter Issues.
400 Programs.
5000 Tractor Rules "A."
300 Tractor Rules "B."

Council actions: Gy vote of Council, the Society took out membership in the National Drainage Council.

Report of election: A canvass of the ballots showed the result of elections for officers for 1919 to be as follows:

For president: F. N. G. Kranich.
For first vice president: F. W. Ives.
For second vice president: W. B. Clarkson.
For secretary-treasurer: J. B. Davidson.
Councilman: F. A. Wirt.
Nominating committee: H. C. Ramsower, F. M. White, Raymond Olney.

Respectfully submitted,

F. W. Ives

TREASURER'S REPORT

RECEIPTS

Treasury Balance 1918	$ 138.50
Admission Fees	241.10
Dues	1887.45
Sale of Publications	66.00
Miscellaneous	158.70
	$2392.75

EXPENDITURES

1918 Transactions	$ 788.60
News Letters	115.60
Other Printing and Office Supplies	260.85
1918 Annual Meeting	132.32

Telegrams	6.74
Postage	153.85
Express, Freight, and Drayage	38.78
Stenographer	386.37
Salary, Secretary-Treasurer	100.00
Committee	90.58
Miscellaneous	96.63
	$2170.32
Cash Balance	$222.43
Total	$2392.75

I wish to make the following recommendations: "That as soon as possible the present News Letter and Annual Volume of Transactions be discontinued.

That a monthly publication be issued, to contain a certain number of papers and monthly news now covered by the News Letter.

Advantages:

1. That papers be published in advance of annual meeting.
2. To awaken greater interest among members.
3. Issuance of data sheets made possible at regular intervals.
4. Expense of publication but little if any more than present publications.
5. Greater sale of certain popular papers.
6. Subscription list outside of regular membership would be greatly increased.
7. Regular exchange list and establishment of Society Library possible.

Disadvantage:

1. A little more work for the secretary.

Respectfully submitted,

F. W. IVES

CHAIRMAN: I will now call for the report of the Auditing Committee, by Mr. Scoates.

MR. SCOATES: My friend Mr. Riley and myself checked up the treasurer's book, the receipts and disbursements, and signed the secretary's book with the following statement: "We, the Auditing Committee, find the total receipts for the past year to have been $2,392.75; the total disbursements to have been $2,170.-32; the treasury balance to be $222.43."

Upon motion, duly seconded the committee on autditing is discharged and their report accepted.

Upon motion, duly seconded, the report of the secretary is accepted.

Upon motion, duly seconded, report of treasurer is accepted.

CHAIRMAN: I will call for the report of the committee on resolutions.

REPORT OF COMMITTEE ON RESOLUTIONS

W. B. Clarkson, Chairman; R. L. Patty, J. B. Davidson

Your committee on resolutions begs to submit the following report:

(1) Whereas, the management of the Great Northern Hotel has made it possible for this society to hold its meeting in pleasant and adequate quarters without extra cost, at a time when the hotels of the city are greatly congested, be it resolved; that we extend to the Great Northern Hotel Company, and its manager, Mr. O'Neil, our appreciation of the courtesies extended; and

(2) Whereas, the local committee on arrangements, Messrs. Kaiser, Kranich, and Ekblaw have, at considerable expenditure of their time, so thoughtfully made all arrangements for the meeting of this society, thereby contributing so largely to its success, be it resolved; that we extend to them our thanks.

(3) Whereas, the papers presented by the guests of the society have added materially to the interest and value of the meeting; be it resolved, that we voice our appreciation to Messrs. Dinsmore and Burdick.

(4) In view of the fact that difficulty is encountered in the arrangement of the program to give recognition to all the varied interests of the society in the limited time for holding the meetings, we recommend that the executive committee provide for the formation of sections, at which reports may be considered, thereby rendering greater service to the membership.

(5) Since agricultural engineering progress is dependent in a large measure upon research and investigation, we recommend that the society in every way possible encourage its development and support.

(6) Whereas, there is great need for additional support of agricultural engineering activities in the U. S. Department of Agriculture, and whereas a recent conference on farm power has set forth the need of additional investigation and education in this phase of agricultural engineering, be it resolved; that the society lend its influence to the development and support of such activities.

(7) Whereas, a bill known as House File No. 11,306 has been introduced in the House of Representatives for the purpose of creating a Department of Agricultural Engineering in the U. S. Department of Agriculture, and whereas this bill, if passed, would create a bureau giving proper recognition and support to agricultural engineering as a profession, and whereas the creation of this bureau has been advocated by the society during the past year, be it resolved that every member be urged to work for the passage of this bill and urge his congressmen to support it,

(8) Whereas, it is a matter of common knowledge (as well as a feature of the report of the Educational Committee) that the agricultural engineering teaching staffs are being rapidly depleted of the more experienced men in being called to more remunerative fields, and whereas, the future of the profession is dependent upon the proper training of young men for the profession, be it resolved that we solicit the support of the manufacturers of agricultural equipment and materials and other allied interests in securing public support of agricultural engrineering education, and furthermore the society, through publicity, set forth the need of such support.

(9) Whereas, the society has grown in members and activity to the point where it is impossible for a member fully occupied in professional work to undertake, in addition, the duties of the office of secretary-treasurer of this society, and whereas the service of the society to its membership is greatly reduced thereby, be it resolved; that the Council be urged to employ a paid secretary for this society.

(10) Whereas it was pleased the Creator, in His all wise province during the past year to call from our midst Mr. C. E. Lord, general patent attorney, International Harvester Company; Lieut. Clyde G. Griffith; Lieut. O. D. Davidson, and Major Matt L. King, a charter member of this society, all of the U. S. Air Service, be it resolved; that the secretary be authorized to secure and place in the transactions of this society, a record of their professional services and that a copy of these resolutions be sent to the families of the deceased. (While resolution No. 10 was read, members rose and remained standing during reading.)

Upon motion the report of the committee was accepted.

REPORT OF COMMITTEE TO DETERMINE FROM COLLEGE MEMBERS, PREFERENCE FOR TIME OF ANNUAL MEETING

CHAIRMAN: I am going to ask Mr. Blasingame to report briefly on what discussion was had and what decision, if any, was come to by the members from colleges with regard to the time of the meeting.

MR. BLASINGAME: The instructors for the various colleges and universities decided that so far as they were concerned they thought that the present time for meeting, that is, at this particular time, was about as well adapted to the time that they could get away from their duties as any other time of meeting. Professor Chase made the suggestion that probably it might be a good idea for a few of the committees to meet at the various tractor meetings and implement meetings, etc., and we thought that probably the present time was about the time to meet in general meeting, so far as the instructors are concerned.

REPORT OF SPECIAL COMMITTEE ON DUES

CHAIRMAN: I will ask Mr. Clarkson to report on the question of dues, which was brought up Monday morning.

MR. CLARKSON: The committee found that in discussing the subject of a permanent paid secretary and the question of financing such a proposition, that it was a much bigger question than any special committee sitting for an hour or two during the session could attempt to assimilate in such a way as to be able to give a good report, with recommendations. The committee, however, has decided this far, that it is vital that something be done to put this Society on the map, through a paid secretary and the necessary office working connection with that office, as quickly as possible, so that the many things, the many good things, that are being brought out in these meetings can be put into form so that the membership at large can get the best use of them.

The committee believes that it would be inadvisable to make the dues of the membership anything else than a level rate all the way through, regardless of whether a member is affiliated with a commercial concern or with an agricultural college or what not. We do believe, however, that if the incoming executive council and the officers in connection with that council will take up the matter and study it carefully with a view of finding out, first, the necessary budget that would be required to put over a proposition of that kind, and then to formulate some plan by which the thing can be properly financed, that it would be a mighty fine thing to have a paid secretary just as soon as possible.

MR. WHITING: Very briefly, in connection with the report of the permanent secretary committee, and the establishment of sustaining membership in the commercial end of this association I wish to offer a suggestion to the committee that the sustaining members representing commercial organizations, the membership fee be set at $100. I merely offer that, or more, or any amount that would be reasonable. I think that is none too much. I have sat in here representing our association for several years, and we greatly appreciate the work that is being done here, and we have profited by it in many ways.

MR. DAVIDSON: Do you mean by that the manufacturers take out sustaining memberships?

MR. WHITING: Yes.

MR. CLARKSON: Then I want to offer the further suggestion that the Council consider the question of three grades of sustaining memberships.

MR. CURTIS: What would the distinction be?

MR. CLARKSON: I have in mind that Grade A of a sustaining membership would include that class of corporation whose capital stock runs $500,000 and over, and that Grade B would be perhaps from $100,000 to $500,000 and that Grade C would be small corporations of $100,000 or less and private firms.

CHAIRMAN: That has been gone into by the committee appointed for that purpose and by some of the other members, and there are quite a number of things that would have to be taken into consideration in arranging for those different grades.

MR. CURTIS: If we start out with the idea that we need a budget that will allow us to have a paid secretary say $5000.00, I make the suggestion that provision be made for sums of less than one hundred dollars, although the Portland Cement Association would certainly pay that much for this thing, but for the benefit of some smaller concerns I wouldn't want to see this level set, but if the commercial concerns were assessed enough more to make it possible for us to meet the budget, if it was only raised to $25 you see we would get pretty nearly five thousand dollars. If we had 150 commercial members at $10 per member that produces $1500.00, and at $25 per member it would be well on toward four thousand dollars. With the college membership it would run over five thousand dollars.

MR. WHITING: I have been feeling all the time that it was a sort of a stand-offishness between the college and the commercial men. I feel that the association ought to be put on a financial basis, and I feel that the commercial men are perfectly able to do that. When we are on a good financial basis the other things will take care of themselves.

PROF. CHASE: I would like to have the honor of taking out the first membership in Class C.

PLACE OF MEETING

CHAIRMAN: I am going to ask Mr. Ives to start a little discussion on the place of the next meeting. I believe he has some invitations, and that would be a good subject for discussion right now.

SECRETARY: There have been several invitations extended to the society by various cities through their Chambers of Commerce and through members of the society residing in those cities, and by other agencies, to get the annual meeting of this society. The cities which have asked for us are Cincinnati, St. Louis, Cedar Point, Ohio, in case we hold it in the summer or fall, Springfield, Mass., and I think Chicago has not asked us. (Laughter). Seriously, I think that the St. Louis proposition is the best one which has been offered.

The city of St. Louis has for three years now extended us invitations to come there for our convention. We had actually agreed at one time to hold the meeting in St. Louis and rightly so, I believe, in favor of our members who come from the south.

MR. CLARKSON: In order to get the matter before the assembly I move that the next annual meeting of the society be held at St. Louis, if suitable arrangements can be made, that we recommend that to the Council. (Seconded).

MR. GERBER: I have been at St. Louis a good many times in the winter time and my experience with their winter weather has not been such as to cause me to be overjoyed at spending three or four days down there at Christmas holiday time. The weather at Chicago at that time is very much more delightful.

PROF. GUNNESS: It seems to me it might be worth considering holding a meeting at one of the Agricultural Colleges again. I realize that none of the colleges are as accessible as Chicago or St. Louis, but we might not have quite as great trouble in getting a quorum or in getting our committee reports. We have heard considerable during this meeting regarding the necessity for further attention on the part of the colleges to many of these questions that have been discussed here.

PROF. CHASE: I have had in mind, of course, for a great many years since we had the round robin scheme of meeting at the colleges extending the invitation for the association to come to Nebraska. Some of you younger men don't know that we first met in Illinois, and then at Ames, then Madison, then at St. Paul and then at LaFayette, and then we got to Chicago and have been here ever since.

MR. WHITING: The suggestion made of having the meetings held at some agricultural college interests me, as representing a commercial interest. As Professor Chase has just said, it no doubt interests the men in the colleges. I feel certain, for myself, and the interests of our association, that it would be of great benefit to me, personally, to go to Nebraska.

CHAIRMAN: It is my personal opinion that we should at least arrange for a special meeting out there during the dedication of that building. We will work up something that will be very much worth while.

MR. ISRAELSON: I want to support the suggestion made by Professor Chase that the meeting be held in Nebraska.

PROF. GUNNESS: Has the matter of time been finally disposed of yet?

CHAIRMAN: No, it has not; that will be left to the Council, as will the place of the meeting.

MR. JONES: It would seem that the spirit which the southern members have shown in coming the distances they do have to come in the comparatively large force in which they come deserves some recognition at the hands of this society.

CHAIRMAN: Personally, I wish the other sections of the country would show the same spirit that the southern men have in attending this meeting. I believe we will have to call this discussion to a close now.

MR. CHASE: I will move that we table the whole affair and Mr. Clarkson make a motion that we will meet at one of the agricultural colleges. I move that the motion be tabled.

MR. CLARKSON: The whole matter can be handled in this way. With the consent of my second, I will withdraw my motion. (Consent given, and motion withdrawn).

MR. CHASE: I will move, then, that it be the desire of those of us assembled that the Council select some agricultural college where they will hold the next annual meeting. Motion is duly seconded and carried.

BUREAU OF AGRICULTURAL ENGINEERING

MR. CLARKSON: I move you, sir, that this society go on record as endorsing the work and the activities of the Educational Committee and the President of the Society and that we agree, collectively and individually, to back up this proposition of a separate bureau of Agricultural Engineering as provided for by the Anderson Bill, H. R. 11306 and boost it for all we are worth along the lines of the resolution presented this morning by the Resolutions Committee. (Motion seconded.)

MR. CHASE: The one thing that they should endorse at this meeting is the request of the Secretary of Agriculture for an increase of $75,000.00 of the appropriation of the past year for Rural Engineering, making a total of $100,000. That is something that should be endorsed here and gotten into the hands of Mr. McDonald at Washington between now and the sixth or seventh of next month.

Upon vote, Mr. Clarkson's motion is carried.

PROF. CHASE: This wants to be a special resolution. I move, that this organization, in view of the fact that it sees the great need of more money to support agricultural engineering in the U. S. Department of Agriculture, desires that this appropriation of $100,000 which is now being considered by the Agricultural Committee, be made at this session of Congress.

(Motion seconded and carried.)

No further business being presented the Society adjourned *sine die.*

NECROLOGY

CHARLES EDWARD LORD

Charles Edward Lord, general patent attorney and manager of the patent department of the International Harvester Company, Chicago, died suddenly on September 25, as the result of injuries received in an accident at the Deering Works the evening before.

Mr. Lord was born in Somerville, Mass., on October 31, 1875, attended the public and high schools at Somerville, and was graduated from the Massachusetts Institute of Technology with the degree of B.S. in 1898. For a year he was employed in the inspection department of the American Telephone and Telegraph Company, with headquarters at Philadelphia. He then returned to Massachusetts Institute of Technology as instructor for a short time, and later became assistant examiner in the United States Patent Office, Washington, D.C.

In 1902 he entered the employ of the General Electric Company as assistant attorney in the patent department, which position he resigned in 1904 to take charge of the patent departments of the Bullock Electric Manufacturing Company and the Allis-Chalmers Company, spending four years at Cincinnati and four years at Milwaukee in this work. During part of this period he was president of the Bullock Electric Company.

He studied law at the Georgetown University Law School, Washington, D.C., was admitted to the bar in Ohio, Wisconsin, and Illinois, and to practice in the federal courts and in the supreme court of the United States.

Mr. Lord was associate editor of the Encyclopedia of Engineering and wrote several textbooks for this publication when it was getting under way. He was a lecturer on patent law at Marquette University, and during the days of the war was a member of the war committee of the Technical Societies of Chicago. For two years and until recently he was chairman of the committee on patents of the National Implement and Vehicle Association.

His ability as an inventor is evidenced by a record of nearly forty United States Patents.

Mr. Lord was an active member of the American Society of Mechanical Engineers and the Western Society of Engineers. He became a member of the American Society of Agricultural Engineers in May, 1914.

O. DEAN DAVIDSON

Lieut. O. Dean Davidson was born in Long Pine, Nebraska, and was killed in an aeroplane accident near Richmond, Texas, April 16, 1919.

As a boy Lieut. Davidson spent most of his boyhood days in

Missouri Valley, Iowa, and Omaha, Nebraska. He graduated from the Omaha high school and entered Iowa State College from which he received the B.S. degree in Mechanical and Agricultural Engineering in 1915.

While in college Lieut. Davidson was a member of Tau Kappa Epsilon and was elected to membership in the honorary societies Tau Beta Pi and Scabbard and Blade.

Before graduation he was connected for a time, with the Louden Machinery Company of Fairfield, Iowa. His first professional work was as agricultural engineering editor of the Twentieth Century Farmer. Later, he became a partner in the Universal Motor Company of Omaha, an unusually prosperous organization and with which he was connected when he enlisted in the aviation service. He was commissioned a lieutenant and at the time of his death was in charge of the supply department at Ellington Field, Texas.

Lieut. Davidson leaves a wife and one daughter, Nancy Lee.

The accident which resulted in death happened while returning from an inspection trip to Kelley Field. Night came on before reaching home and the plane which was under the control of an experienced flier ran into a dense fog. It is supposed that the aviators lost their way and in attempting to land, misjudged their altitude for the plane crashed into the ground with the power on.

Lieut. Davidson became a member in February, 1916.

Clyde I. Griffith

Clyde I. Griffith was born in Hardin county, Iowa, September 15, 1892, and died in Ames, Iowa, January 18, 1919, at the age of twenty-six years, four months, and three days.

He removed with his parents to Ames in March, 1899. Here he was graduated from the Ames high school in 1910, being the president of his class. In 1914 he was graduated from Iowa State College as an agricultural engineer. He then became a fellowship student in the State University of Wisconsin, and after a short time was made assistant, receiving his master's degree in Agricultural Engineering in June, 1917.

In August, 1917, Mr. Griffith enlisted in the army of the United States as an aviator. He was sent to Champaign, Ill., to attend the aviation ground school, and was one of eight out of a class of forty who finished the work in the allotted time. For a time he was at Garden City, N. Y., then was sent to Kelly Field No. 2, San Antonio, Texas, with the commission of second lieutenant, where he learned to fly. His next station was Talliferro Field No. 1, Camp Hicks, Ft. Worth, Texas, where he was instructor in Aerial Gunnery. Later he was stationed at Dallas, Texas. Here he was instructor in aerial acrobatics.

Before enlisting in the service, Mr. Griffith had been engaged by R. Martons Co., an engineering company, with headquarters at London, New York, and Petrograd, and had prepared to go to Russia as an agricultural engineer to study the conditions of the country and the machinery needed to develop the country agriculturally.

Lieut. Clyde Griffith became a member of the society in May, 1917.

Matthew Leander King

Matthew Leander King, major, U. S. A., died on October 23, 1919. Major King was born in Panora, Ill., on May 20, 1878.

He was graduated from the mechanical engineering department of Iowa State College in 1906.

He spent five years as an experimentalist in agricultural engineering with the Experiment Station of Iowa State College, Ames, Iowa, during which time he invented the hollow clay tile silo. For two years he was superintendent and general manager of the David M. Bradley Implement Works at Bradley, Illinois. He organized the Iowa Clay Products manufacturers into the Permanent Buildings Society for the development of new designs of and uses for hollow-clay building tile.

Mr. King entered the army in September, 1917, with the rank of captain and was assigned to the Aviation School of Aerial Observation at Post Field, Fort Sill, Okla., in charge of maintenance and repair of aeroplanes. He was advanced to the rank of major in August, 1918, and in November of that year was assigned to Indianapolis as chief engineering officer for aviation in the Northern District. In February, 1919, he was transferred to Washington, D.C., and from there he was assigned on special missions until July when he became fight commander and chief engineering officer of All-American Pathfinding and Recruiting Expedition. He was transferred from the Officers' Reserve Corps to the regular army with the rank of major in October about a week before his death. While at Post Field he learned to fly and was given the classification of Reserve Military Aviator.

Major King was a charter member of the American Society of Agricultural Engineers, a member of the American Society of Mechanical Engineers, a member of the American Society for Testing Materials, and belonged to various aeronautical and officers' clubs.

AMERICAN SOCIETY
of
AGRICULTURAL ENGINEERS

1920
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American Society *of* Agricultural Engineers

(Founded 1907)

OFFICERS OF THE SOCIETY FOR 1921

PRESIDENT	E. A. White
FIRST VICE-PRESIDENT	W. G. Kaiser
SECOND VICE-PRESIDENT	E. R. Jones
SECRETARY-TREASURER	Frank P. Hanson

Executive Council	Term Expires
I. W. Dickerson, *Chairman*	December 31, 1921
F. A. Wirt	December 31, 1922
J. B. Davidson	December 31, 1923
Raymond Olney	December 31, 1921
F. N. G. Kranich	December 31, 1922

PAST PRESIDENTS OF THE SOCIETY

	Year
J. B. DAVIDSON	1908
J. G. WYNN	1909
P. S. ROSE	1910
C. A. O'COCK	1911
H. W. RILEY	1912
L. W. CHASE	1913
W. F. MACGREGOR	1914
H. H. MUSSELMAN	1915
F. M. WHITE	1916
E. B. MCCORMICK	1917
DANIELS SCOATES	1918
RAYMOND OLNEY	1919
F. N. G. KRANICH	1920

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"The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings." (From paragraph C 51 of the Constitution.)

Fourteenth Annual Meeting

AMERICAN SOCIETY *of* AGRICULTURAL ENGINEERS

PRESIDENT'S ANNUAL ADDRESS

By F. N. G. Kranich

MY ASSOCIATION with the members of our Society by virtue of the honor bestowed on me last year has brought me in closer contact with the various branches of agricultural engineering than has anything else I have ever had the opportunity of doing.

In this message I shall not review in detail the activities of this society during the past year. I shall, however, endeavor to bring you all to a realization of the valuable work our Society has started and can do.

Every member of this Society, particularly the older ones, knows what has been done. They know about our affiliations with the National Implement and Vehicle Association and the industry as a whole. You all know about our paid secretary. You all know about our journal and what it proposes to accomplish and what it stands for. You are all familiar with the activities that have been going on.

You have all been a part in this past year's developments, and what I of my own self have done or could do is negligible. Each and every one has contributed his share in bringing about the results of which you are all proud. If we have made progress it is because each member has put his shoulders to the wheel and has given a lift.

The splendid support and cooperation from among our members, particularly those on committees working together, has been one of the most gratifying factors of all. This fellowship has permeated the entire institution for good, not alone of the Society, but for the good of each individual.

I cannot help but feel that these associations of our members and friends in our committee meetings, and even at this time of the year in our annual meeting, makes for better men, better engineers, and for better final results. It is after all the associations we have that broaden us. I believe very earnestly and sincerely that every one of you attending this meeting at this time is getting much more good out of it because of these associations.

We get together during our leisure time here and talk shop. We talk the things that we live, those that are nearest to us. We discuss these things with each other and we cannot help but learn from this personal contact with each other. These associations make for enthusiasm which helps us in the work we are doing back home and in that art in which we are working. As Emerson said, "Nothing great was ever achieved without enthusiasm."

I honestly believe that this enthusiasm is due to a fuller appreciation and a greater recognition, not alone by you members but by everybody with whom we come in contact, of the value of agricultural engineering in our economic system.

I think the appreciation, or recognition of what agricultural engineering stands for, is one of the biggest things we have achieved.

Agricultural engineering serves an industry of far greater importance than does any other engineering fraternity. I say this with some thought, not that I discount the value of the work and efforts of others, but I more fully realize and appreciate the greater importance of ours.

It has been a decided privilege to work as I have during the past year with the membership of this Society and with those on the outside for the results we know are coming.

The things that we have accomplished in a tangible way are to me only secondary to that thing which I wish to call *recognition.*

Our Society during the past year has received that recognition which we have so long sought. We have received it in several ways: First, through our associations with the implement manufacturers, who are the builders of farm equipment; second, through the personnel of the men who have joined our Society this past year. I want you all to look over the list of members, as it stands today, and see if anywhere, or in any other institution there can be found such a list of representative men who so thoroughly cover every phase from the teaching clear through the practical side of agricultural engineering.

Our work in the Agricultural Equipment Standards Committee, the chairmanship of which your president has the honor of holding, is also a recognition that should be noted. That committee has many representatives who are members of our Society. Its work is progressing slowly, but after we get it started and in action, the results will be far reaching and for the good of the industry we represent and agriculture as a whole.

Recognition has also been given us in the press, and I am sure that it is the constructive work we are doing in an unmercenary way that affords us this recognition.

This recognition is also apparent when we think of the various meetings of big men in the industry with whom it has been our pleasure to work and have our members address. We have been associated with men representing the highest ideals and with associations representing the very best efforts for good in an industry that is fundamental, and that is, agriculture.

We cannot help but be proud of this recognition, and I am willing to say for my own self that this one thing is to me the most gratifying of all our efforts. It also means that we are coming into the light of things by the aid of this recognition, working toward an end which means advancement in the science and art of what I believe to be the most basic engineering effort in existence.

We may at all times be crossed by the activities of other bodies of men that may seem to conflict. We may find others encroaching or at least endeavoring to on what we feel to be purely agricultural engineering. We need have little fear as I see it of this because of the personnel of our organization. In no other engineering organization that I know is there such a body of men as we have—men who represent the industry as a whole, men who are in sympathy with agriculture and its development, and last, but not least, men who thoroughly understand the theory, the function, and field operation of farming equipment such as tractors, plows, threshers, and all the rest of the machinery so necessary to successful agriculture.

Our fourteen years of existence has given us a fund of knowledge that cannot be duplicated anywhere. Our data is all based on facts gathered by our members who have applied agricultural engineering to actual tests on farms and in farming operation.

We are represented in practically all the agricultural colleges in America. What greater influence could be found for the good of the industry? Members in the profession are spreading this gospel of agricultural engineering in their respective localities. Regardless of how high we stand, our state colleges stand at the top in this line and receive the recognition that is due them in this phase of engineering.

Even in the United States Department of Agriculture we now have within a bureau a division of agricultural engineering. The advisory committee of this division is composed of our members. Even at the head of the division is a very active member of our Society.

The work that this division of the federal government is planning is a correlation of the efforts of the colleges, together with that of our Society, which we know is going to help this big problem of agricultural engineering as a whole, and when I say "help" I refer not to any individual or not to any individual society, but for the good of that great body of men represented as the American farmer.

Our thorough understanding and sympathy with the problems of the farm-equipment manufacturer fits us well to work with him. The personnel of our Society as individuals, as a part of these manufacturing institutions, as officers in these institutions, even as presidents of many of them, all working hand in hand toward a goal, which means results, is as gratifying to you all as it is to me.

The work of your standards committee, and in fact all the committees, relating to or cooperating with this parent standards committee, is bearing fruit. The things we are doing and the reports of the standards committee, which is being published in the last Journal, is to all of you a pretty good reason for our existence.

The need for this work in the industry we represent is recognized. The steps we have taken to bring about this recognition have been slow, but I feel very sure the plans for the future that we now have, and which our new president is endorsing, are going to bear fruit far in excess of our most humble expectations.

There is another thing I wish to bring out here and I believe should get more recognition, and that is that agricultural engineering is really an art and a science. It has been said very often that there is no such thing as engineering in agriculture. I take issue with all such claims.

I am very sure and I know you will all support me that the names of McCormick, Deering, Deere, Oliver, Dain, Dingee, and many others that I might mention, stand for as much, if not more, in the history of our nation as do the names of men that you may think of that have worked in other professions.

This to me is a fact that we should learn and we should talk about in spite of all that is said to the contrary for there is engineering in agriculture and much of it.

I feel very sure that these men have contributed to those things in our country's development which have made the others possible. By the efforts of these men in producing agricultural machinery, they have made it possible for so many of us to live in the city and so few of us on the farms. By their efforts they have made it possible for us to live as well as we do. It is this recognition of these men, who have actually worked at agricultural engineering, although in those days unrecognized and even today to some extent without recognition, that makes for this greater agriculture of which we are all so proud.

Our Society deals with the phase of engineering that is to the speaker far more important than any other branch of engineering that is today being practiced. It deals with those things that are absolutely basic and fundamental.

The engineering work in irrigation and drainage is of inestimable value. To make arid land produce food by the application of irrigation is wonderful. To drain wet lands and make them garden spots of food production is part of the work of the agricultural engineer.

Then there is the work of those men devoting their time to land clearing which is to give us millions upon millions of additional acres of fertile, tillable land upon which the farmer may produce food.

The work of those men who devote their time to farm structures, whether it is the home with its lighting and its modern sanitary equipment, or a barn with its modern equipment, or a silo, or a corn crib, or any farm building, should get the recognition of us all. It is these things that make for economic food production. It is these things that make farming more a pleasure than a task.

And who will dare say that these things are not agricultural engineering, or that they are even secondary to other engineering efforts? This is a part of the work in which our Society deals. It deals with agriculture which is the foundation of a nation.

Nations rise and fall in proportion to their agriculture increases and decreases. Agriculture increases and decreases and becomes a factor only as fast as the agricultural engineer is enabled to develop equipment for work on the farms. In other words, the history of every nation is nothing more or less than the history of its farm equipment, its agricultural engineering developments.

Far be it from me to make any suggestions that are radical departures from what we have been doing but a closer cooperation between the council members and the officers of the Society is desirable.

A closer relation between the activities of the committees with a common purpose in mind should be encouraged. A closer relation with the manufacturers in handing their technical matters should also receive much consideration. Another thing that deserves some consideration should be the reliability and accuracy of the things we publish under our name. It should be borne in mind that they are read by a large number of people, and it should also be remembered that as an influence for the future, these things should be very carefully selected and based on facts as we find them.

As I said before, this Society today contains the greatest fund of knowledge and the most authentic data on agricultural engineering that may be found anywhere. As time goes on, therefore, the more care that is exercised in bringing out future articles on this subject, the more we will be contributing in the way of facts to the literature on the subject.

I also believe that the activities of our educational committees should be enlarged. I believe under this heading we should embrace publicity. In other words, we should refrain from "hiding our light under a bushel."

We have no selfish motives. In fact, all our work is based on doing good for the industry, which after all means for agriculture, which is represented by the farmer.

It may be a little out of order, but I am going to take this opportunity to express my appreciation of the splendid work that has been done by your secretary, Prof. J. B. Davidson. I do this because his influence in this Society and in the industrial world stands out far above that of any other individual that it has ever been my pleasure to know. His thorough understanding and keen sense of business judgment has been a factor, not alone in this past year's activities, but also in those long past dating from the origin of this Society.

I wish at this time also to express my sincere appreciation for the help that every member of the committees has afforded, that every member of the Society has contributed to the welfare of the Society, and to the Council which has laid down a path on which we shall proceed and which will lead to a greater recognition for doing the greatest good to an industry serving the most fundamental of all industries, that of agriculture.

RESEARCH IN AGRICULTURAL ENGINEERING

BY R. W. TRULLINGER

Mem. A.S.A.E., Specialist in Rural Engineering, Office of Experiment Stations, U. S. Department of Agriculture

THIS report summarizes the more important features of work in agricultural engineering research which has been completed or in progress during the past year, more especially at the state colleges and agricultural experiment stations and incidentally at some other public and private institutions in this country and abroad and formulates some general recommendations as to procedure in future research work.

A great deal of work related to agricultural engineering has been in progress, but a review of projects and of data already submitted indicates an apparent lack of the research spirit in a great number of cases. This is probably largely due to circumstances. A striking feature of the work is the fact that a large part of it has apparently been conducted either by or in cooperation with some other agricultural division to meet immediate needs in the solution of a specific problem. This, together with the demands for popular information, has resulted frequently in the mere application of old well-established engineering principles to some perhaps new agricultural problem, or in more or less emergency testing work of little permanent value, to meet the immediate requirements of the specific problems in hand. Thus the advancement of the engineering itself has often not been given the consideration it merits.

In short, there has not been nearly as much effort to increase the basic knowledge of agricultural engineering in this country as has been the case with other branches of pure agriculture. There are, however, some well marked exceptions not only in this country but abroad.

Research work in subjects classed as agricultural engineering have included the following:

1. Materials
2. Farm Power and Equipment
3. Irrigation
4. Drainage
5. Farm Structures
6. Roads and Bridges
7. Water Supply, Sewage Disposal and Sanitation
8. Miscellaneous

MATERIALS

The work on materials has consisted mainly of pure research. The work on alkali-proofing cements at the Wyoming

Experiment Station has proceeded to the point at which some definite basic principles are being laid down. The work on roofing materials at the Iowa station appears to have been mainly a comparison of different types of materials. While this does not appear to be research as far as the materials are concerned, it can in a way be classed as research, if the ultimate intention is to establish definite rules for the use of certain roofing materials for certain definite conditions.

Considerable work has been done on timber preservation at the Iowa, California, Pennsylvania, Minnesota, North Carolina and several other state stations. It is difficult to determine the exact status of this work although some of it is undoubtedly research in that its ultimate purpose is the establishment of methods and basic principles of procedure for the state conditions.

Considerable work on materials which is of interest to agricultural engineers has been in progress at institutions not of an agricultural nature, such as the U. S. Bureau of Standards, the Lewis Institute of Chicago and the U. S. Bureau of Mines. There is apparently hardly a building material which has escaped the scrutiny of the Bureau of Standards. (The cooperative project on concrete drain tile has yielded some noteworthy basic information.) We are also indebted to the Bureau of Standards for considerable basic information on metals, particularly steels, semi-steels, cast-iron, brass and bronze, which are used in the manufacture of farm machinery. Data on woods for this purpose are also available and a report was recently issued on the treatment of harness leathers. The work on cements and concrete at the Lewis Institute needs no comment other than to say that the basic principles established not only in the past year but also in previous years at that institution on the proportioning, mixing and placing of concrete are striking examples of the results of true research. It is to be noted that a number of our engineering schools have also conducted some similar work which is of interest to agricultural engineers.

Owing to the agencies at present engaged in research on materials, it would seem that there is little more that can be taken up to advantage by the state experiment stations in connection with structural building materials. However, there is an open field for more research work on metals and woods used in the construction of farm machinery.

FARM POWER AND EQUIPMENT

The subject of farm machinery as considered here is very broad and includes not only cultivating and harvesting machines but motors, motor fuels, and power and power-driven appliances in general. It is perhaps the biggest branch of agricultural engineering, has probably seen the most costly experimenting, and from the standpoint of actual research, seems to have been the most neglected.

Many reports of so-called experimental work with farm machinery are available and much of such work is in progress at the state colleges and experiment stations, but frequently such work is conducted entirely by or under the supervision of agronomists. The work in the long run usually resolves itself into simple comparative tests of different types and makes of machines and leaves us in the position of using the best of merely what is available.

Aside from the work done by Dr. E. A. White, that by Fischer in Germany and perhaps a few others, there has been very little research conducted on plows since Thomas Jefferson figured out a curve for a moldboard plow, although there has been a lot of costly experimenting. Perhaps such work is not needed but if so, then why all the different types and makes of moldboard plow on the market? We know in a general way what plow to use for certain type of soil but there are many plowing conditions under which no plow gives entire satisfaction. There are certain rules of thumb about plow adjustments for suction, side draft, etc., but what is the basis of these rules other than fit and try. For instance, the recent tractor trials at Lincoln, England, brought out the fact that plow designers have not as yet put out implements which take into account all the requirements of mechanical traction. We ought to know more about plows, that is, something definite and basic. Undoubtedly plow manufacturers would welcome basic information on plows which would save them costly experiments.

Numerous tests of tillage and tillage machinery have been in progress during the past year but in the majority of cases under the supervision of the agronomy departments, thus making the machinery of secondary importance and merely a means to an end. Such tests have been in progress at the Kansas, North Dakota, Oregon, Ohio, South Carolina, South Dakota, and California stations in particular. The Deutsche Landwirtschafts Gesellschaft has also been active in this respect. On the other hand, a step in the right direction are the studies of the draft of farm implements at the Iowa, Montana, and Missouri stations, and of the power required for plowing at the California station. Such studies, if carried far enough, should begin to indicate facts of considerable basic importance in design and manufacture.

There is perhaps more known in general and less in particular about tractors than any other farm machine. A recent specification sheet listed some 314 tractors of some 220 different makes on sale in the United States alone. They cannot all be right and it is believed that no one knows whether any one tractor or type of tractor is the optimum of efficiency.

The need for research work on tractors to provide some definite and well-established working principles to be used in design and manufacture is reflected, both in the large number of different makes for sale and in the tractor inspection laws which have come into effect in certain states, notably Nebraska. This need was also brought out strikingly at the recent competitive trials of tractors at Lincoln, England, under the auspices of the Royal Agricultural Society of England in cooperation with the Society of Motor Manufacturers and Traders. The official report of the trials expressed doubt as to the desirability of the competitive element in technical trials of tractors until design and construction have reached some definite standard. It is to be noted that machines of American manufacture were active in this competition. Undoubtedly many tractor manufacturers have conducted considerable research as is evidenced by their success. But it is believed that many others have learned only by very expensive experiment and are still in the dark in that they have learned mainly what not to do and very little of what to do.

Most of the work on tractors at the state colleges and experiment stations has consisted either of comparative or competitive tests of different makes or of economic studies. Research in to the economics of tractors is undoubtedly a great importance. Its weak point at present is that it must be based on experience with the tractors available and not always on tractors designed and constructed on the basis of firmly established basic facts. It is conceivable that two neighboring farmers may obtain satisfactory results from one design of tractor and unsatisfactory results from another design of the same rating, thus making their economic reports contradictory. Consequently, the results of economic studies of tractors may frequently be of questionable value. In spite of this, considerable helpful data have been secured by the Iowa, Pennsylvania, Kentucky, Florida, South Dakota, Nebraska, and several other stations on the economic use of tractors, most of which will serve as a basis for future research in design and construction.

Special engineering studies of tractors have been in progress at the Iowa, Montana, Indiana, California and Nebraska stations. It is believed that the work at these stations more nearly approaches research than that of any other station. The Iowa station has taken up motor cultivation and such matters as traction equipment. It is to be noted in this connection that the Institute National Agronomique of France has entered into a somewhat extensive research on tractors, which is apparently intended primarily to aid manufacturers in the production of tractors satisfactory to farmers. The Society for the Encouragement of National Industry in

France is also interested in and is assisting in this work. France has realized the lack of basic knowledge of the tractor and has indicated an apparent intention to place future manufacture of these and also other farm machines on a sound research basis.

About the same general principle applies to work on other types of farm machinery at the colleges and stations. With a few exceptions, most of the work has consisted merely of demonstrations of old principles. A few notable exceptions are the plow draft tests at the Iowa station and the milking machine investigations at the Illinois, Iowa, South Dakota, New York, and California stations. Studies of labor-saving machines and fertilizer distributors are also in progress at the Iowa station and of horsepower at the Oregon station.

Attention may well be drawn to an example of methods of research in agricultural machinery employed by the National University of Buenos Aires in Argentina. The work is started by conducting power utilization distribution tests of an agricultural machine. For instance, tests of a series of grain binders showed that 16.5 per cent of the driving power was utilized by the sickle, 7.1 per cent by the reel, and 42.2 per cent by the canvas elevator. Tests of materials are conducted simultaneously, the purpose being to establish basic principles for the materials, design, and construction of a binder giving the highest all-around efficiency for the conditions imposed. Reports have been received describing similar work on threshers and corn shellers. In short, it is the desire of that institution to know something about how these machines should be built rather than to limit their work to obtaining a knowledge of the comparative values of available types.

Farm motors, including tractor engines, need considerable development, especially in view of the motor fuel situation. The U. S. Bureau of Standards has recently been engaged in considerable research on internal-combustion engines, with particular reference to carburetion and ignition and has established a number of fundamental principles relative to points which have heretofore been the subject of much argument. Such work is also in progress at the Kansas and Indiana Engineering Experiment Stations. The work of the Florida Experiment Station and the U. S. Bureau of Mines on fuels for internal-combustion engines is also noteworthy. The U. S. Department of Agriculture is engaged in research on the production of straw gas for internal-combustion engines. It should be noted that the British Ministry of Agriculture is preparing to establish research on all farm machines.

IRRIGATION

Considerable research on irrigation has been in progress at the state stations during the past year. This subject has had the advantage of years of study and has apparently had ample support. The research spirit has prevailed in irrigation resulting in the putting forth of considerable basic information. The irrigation investigations division of the U. S. Department of Agriculture has as usual been quite active, although apparently somewhat limited as to appropriations. Irrigation investigations have also been conducted during the past year at the California, Nevada, Utah, New Mexico, Colorado, Oregon, Montana, Arizona, Nebraska, Oklahoma and Idaho stations. California has perhaps been the leader in amount and scope of such research. Special studies have been conducted on methods of irrigating certain crops, such as alfalfa, rice, vegetables, vineyards, orchards and small fruits, special attention being paid to soil moisture and duty of water. Duty of water and soil moisture studies have also been in progress at the Oregon, New Mexico, Idaho, Nebraska, and Utah stations. The Colorado station has continued its work on the measurement of irrigation water, particular attention being paid to current meters and the venturi flume. The Montana station has also conducted work of this nature. Evaporation and ground-water movement experiments were conducted at the Colorado, New Mexico, Utah, Oklahoma, and Arizona stations. Studies of alkali and the reclamation of soils made alkaline through the excessive use of irrigation water were conducted at the New Mexico, Utah, California, and Arizona stations. Seepage studies were conducted at the Montana station. Irrigation pumping plant investigations were under way at the California, Nebraska, Utah, and Arizona stations, and in this connection the California station conducted work on the manufacture and use of concrete pipe for distribution of pumped irrigation water. The Oregon station has undertaken studies of the feasibility of irrigation with a view to improving the distribution and use of irrigation water and the state irrigation water laws. The Irrigation Investigations Division has, in addition to other activities, issued three important reports, one on spillways for reservoirs, one on the capillary movement of soil moisture and one on the flow of water through concrete pipe. The two last reports are especially typical of true research. In addition that division has engaged in research on current meters which has resulted in the design of a new and efficient meter.

DRAINAGE

The research work in drainage, while perhaps not so extensive as that in irrigation, has been none the less typical of true research. Most of the state stations have conducted research of one kind or another in drainage and some special reports have been issued by the Drainage Investigations Division of the U. S. Department of Agriculture. Two of these, one on the flow of water in drain tile, and the other on the flow of water in dredged drainage ditches, are especially typical of true research. It is to be noted that the French National Academy of Sciences has also reported similar studies on the flow of water. The work of the Iowa Engineering Experiment Station on drainage and drainage structures is also particularly noteworthy as being typical of true research in drainage.

Drainage studies were in progress during the past year at the California, Colorado, Oregon, Indiana, Arizona, Ohio, Missouri, Iowa, Minnesota, Montana, New Mexico, and Alabama agricultural experiment stations. The extent of this work in irrigated areas indicates the growing interest in drainage of irrigated lands. The work in Alabama consisted mainly of the usual swamp and overflow land reclamation which, while not research as a whole, usually entails considerable incidental research. The work at the Indiana station on the effect of drainage and soil moisture on soil acidity, at the Ohio station on the loss of plant food in drainage water, at the Missouri station on water penetration, evaporation, and run-off, and at the Minnesota station on the movement of soil water are typical of true research in drainage in the more humid sections. The work at the California, Arizona, New Mexico, and Oregon stations on the drainage and improvement of wet and alkaline soils are typical examples of research on the drainage of irrigated lands. The Colorado station has entered the drainage field with a project on the drainage requirements of crops and drainage factors for Colorado conditions.

FARM STRUCTURES

The subject of farm buildings and fences, or more generally speaking farm structures, received considerable attention at the state colleges and stations during the past year. While considerable of this work was mere demonstration, there was a large amount of work which may be classed as research. Almost every state did some work on silos, but research on silos was limited to the Iowa, North Carolina, Michigan, Missouri, Guam and perhaps a few other stations where studies were conducted of silo wall treatment, silo capacities and general design, based on local conditions.

Research on poultry houses received the usual attention. The New Jersey, Kentucky, California, Utah, Indiana, Maryland, Washington, and Idaho stations continued work on their comprehensive poultry house projects, taking up such special questions as artificial lighting in its relation to egg production and improvement in design for local conditions.

Studies of the design of self-feeders for hogs were conducted at the New Jersey, Ohio, Pennsylvania and Arkansas stations. It may stretch the imagination to class such work as research, yet it is evident that these stations had in mind the laying down of basic principles to aid the animal husbandry departments in their work of hog fattening. Closely related to this work was the work at the California station on the design and construction of feed lots. The Nebraska, California, and Iowa stations continued their studies of hog-house design. The Iowa station also conducted general studies on equipment for livestock feeding and management and on farm structures in general. A feature of the Iowa work is the study of the efficiency of barn ventilating systems. The Indiana station has also had a rather comprehensive project in operation studying the representative types of farm buildings in the state in an effort to lay down basic principles for the state conditions. The California station was engaged in studies of the design of beef and dairy barns and also of houses or hutches suitable for use in raising rabbits. The Oregon and California stations engaged in studies of equipment and structures for the handling, storage and preservation of manure. The work of the French Institute National Agronomique on farm structures is also noteworthy, especially that recently in progress on structures to meet the emergency conditions in the devastated regions. The analytical methods employed by the French engineers may well be given consideration.

ROADS AND BRIDGES

Practically no research work was done on roads and bridges by the state agricultural experiment stations, as this work is for the most part handled by the highway commissions of the different states and by the U. S. Bureau of Public Roads. No information was secured regarding research by these institutions on the subject other than that contained in their publications. Further mention will not be made of this branch of the subject except to include the more important publications in the data references, and to note that the Chief of the Bureau of Public Roads recently indicated the growing need for research in highway problems.

WATER SUPPLY, SEWAGE DISPOSAL AND SANITATION

The subject of water supply, sewage disposal and sanitation has received very little research treatment. This also includes lighting, heating, and ventilation. This is one of the subjects in which it is believed we have offended the most by attempting to teach without basic knowledge. Only a few public institutions seem to have recognized that fact. There is abundant literature on the subject with new additions coming in every day, yet practically none of it contains anything new. An instance occurred recently in which a state board of health recommended procedures in water purification which had been described by the Federal Government some eight years before, and subsequently through necessity materially modified.

A number of our public institutions in response to popular demand are continually putting out literature descriptive of methods and apparatus for the disposal of sewage, the purification of water and other sanitary processes, frequently without any apparent substantial basis other than perhaps inadequate experiment.

The U. S. Public Health Service has sounded a warning in this connection, and has condemned a number of the practices which have been recommended by other institutions without a knowledge of basic facts. That Service has had a project on residential water supply and sewage disposal in operation for some years, and only recently has it begun to lay down basic principles.

The Missouri, Montana, Michigan, New Jersey, and Idaho stations, the New York State College of Agriculture, the Iowa, Kansas, Indiana, Oregon, and Washington engineering experiment stations, and a few of the state boards of health, especially those of Minnesota and Ohio, have apparently been taking steps along the same line. The New Jersey station is making a special study of the biology of sewage filters. The Wisconsin station seems to have continued its comprehensive project on the disposal of creamery sewage and the Michigan station has taken up a study of dairy sanitation.

The need for research on this subject is reflected in the attitude of some of the foreign agricultural institutions, especially those in Holland, Germany, France, and in some of the tropical protetorates. A project of this nature was recently begun in the Dutch East Indies by a comprehensive study of the gases formed in septic tanks and the relation of gas formation to the design of systems which purify sewage, the purpose being purely and simply to establish basic principles. It is evident that while plenty of mechanical principles are available for use in rural sanitary engineering, there is a need for research to establish basic working relations between sanitary and mechanical principles to meet specific classes of conditions.

MISCELLANEOUS

Considerable research of a miscellaneous nature has been under way. Idaho, Oregon, Minnesota, and Wisconsin stations and perhaps a few others are engaged in conducting comprehensive land clearing investigations, and the Idaho station is investigating the utilization of logged-off lands. In this connection a very neat piece of pure research was conducted and recently completed by a private explosive manufacturing company at the suggestion of the States Relations Service of the U. S. Department of Agriculture, on the removal and utilization of pine stumps from logged-off lands in one of the southern states. Of course, this company was primarily interested in the use of explosives for the removal of stumps but the researches showed that the stumps after removal could be distilled and made to yield products of sufficient value to pay for the removal, distillation equipment and all expenses, and yield a new revenue on the whole project, in addition to leaving the land cleared ready for cultivation. The basic principles of this process were established and preserved and are now available for practical use. The Ohio and Arizona stations conducted work on the use of dynamite in the preparation of soil for crops and the Wisconsin station on the use of dynamite in tree planting and T.N.T. for general blasting.

The South Dakota station continued its work on ice-making on the farm, the Kansas station its milling investigations project and the Iowa station the study of soil erosion and preventive measures therefore.

This review shows that in spite of circumstances tending to discourage research, there has been considerable pure research in agricultural engineering at the state agricultural experiment stations and other institutions during the past year. It is known that many of the state stations have not only been seriously handicapped through lack of funds for research work, but also through lack of suitable personnel. Many of the more capable research engineers have given up research work to take better paid positions in other lines. Such a situation is a serious one from the standpoint of the permanency of agricultural engineering accomplishment.

Every phase of agricultural engineering should be based upon the results of careful research to give both satisfactory and permanent results. It is not within the province of this report to outline methods of procedure in individual research projects, but it seems advisable to call attention to some of the important points brought out in a recent editorial appearing in the Experiment Station Record (Vol. 43, No. 4) on research projects in agriculture. It is pointed out that a project in agricultural inquiry is first of all a constructive scientific undertaking which aims to advance science and through it the art. Its purpose is "to find out and learn how," and thus to understand the purport of results obtained. It deals with things that are fundamental, aiming to disclose the underlying principles or conditions of relationship and seeking to develop basic facts and establish their universality. Originality in research implies going outside of what is known or practiced and injecting something new in purpose or procedure. The scientific method of advancing knowledge is the substitution of detailed and verifiable results for broad, unproved generalities derived from practice or from inadequate experiment and spectulation. A research project should have a definite aim and should be progressive in its conception and its conduct, proceeding in a systematic and orderly way from one essential point to another. Owing to its nature it is necessarily restricted in scope. It always looks toward completion and should be planned with this in view. It is recommended that wherever possible, future work in agricultural engineering be planned with these points in view.

It has apparently been the desire of the Society to combine the subjects of research and data into one committee. While they are two separate and distinct subjects, yet they are closely related and dependent upon each other. Research yields basic working data and general data is indispensable in research. This Society has long been talking about a data book. One of the main aspects of research is to determine the purport of data at hand. There is a large amount of data available of one kind and another related to agricultural engineering.

There is appended a list of selected references to agricultural engineering data obtained in the course of conducting the rural engineering section of the Experiment Station Record. These references have been selected on the basis of their research value and should be added to the list of references submitted in the report of the data committee last year.

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THE FARMER'S ENGINEERING PROBLEMS

By J. R. Howard
President, American Farm Bureau Federation

ANYBODY that runs a farm or heads an organization like the American Farm Bureau Federation and builds it from the ground up is entitled to be called an engineer.

Whenever anything occurs connected with our organization or with any farming problem, I inevitably turn in my mind to my Iowa farm. I cannot get away from it for fifteen minutes of any day of my life or in any phase of the varied activities in which I engage. I sometimes wish I could and sometimes I am glad I can't, so when the invitation came to address the agricultural engineers, I turned to that Iowa farm. I wondered what I knew or what I had on that farm that would concern an engineer or an agricultural engineers association.

I began to think of the barns and the fact that I wanted, as soon as I can get rid of my present job and go back, to build a new dairy barn, and I immediately saw where I hitched up with engineering. Then I thought of how I was going to build another silo, and I wondered if it would be possible to improve either in location or design on either one of the silos which I have; and there was an engineering problem. I thought of some of the machinery which I have on the farm and some new pieces which I would like to have, and there was an engineering problem. I thought about hauling that machinery out from town in the wagon or wondered whether I should get a truck; and there was an engineering problem. And everywhere I turned, whether to buildings, or tile drainage, or machinery, or livestock—livestock is animal husbandry because it takes barns and equipment to take care of it—I ran into an agricultural engineering problem, and I at once made up my mind that this body of men holds a very important place in the agriculture of America—very much more so than I had thought until the invitation came to meet with you.

The matter of tractors was suggested by your toastmaster. It chances that I have a tractor. Sometimes I am glad of it, I am delighted with it, it is exactly what I want and maybe in five minutes I will wish I had never heard of a tractor.

There has been a very great increase in the number of tractors within the last two or three years due, as you know, to the necessity of pushing the work on the farm more rapidly because of scarcity of labor and because of the high price of feed. I am unable to keep a horse on the farm without using at least four acres of ground every year to raise the feed which that horse eats and it is a question whether the horse is worth it or not compared with the tractor. It has been a question; it is not a question now. With the present price of machinery and the present price of feed, the horse has it. We need not think otherwise for a moment but the present conditions are not going to prevail always. Tractors must come down to the level of other commodities or feed must come up to its proper level. Perhaps there will be an action in both directions. In that connection, let me say that the fuel problem is one which every farmer thinks about. We are all concerned about the oil supply.

I was very much interested recently in a publication or an article in one of our farm papers in which it stated that every bushel of corn could be converted into five and a half gallons of alcohol and the by-products sold for enough to pay for the expense of manufacture, and that every gallon of that alcohol was equal in power to one gallon of gasoline. Whether that be true or not, I could not say. The man who wrote the article is one of the best informed farmers in the state of Illinois. If that be true, corn must come up or gasoline must come down in either event solving the power problem to some extent. There are some problems, of course, in the use of alcohol as fuel. It must be made more volatile than it is, it is generally conceded, and it must be denaturized by some substance that is so like the alcohol itself that the denaturizing substance cannot be removed before it comes into the farmer's possession.

The president of one of the large city clubs called on me today and my mind went back to the farm. We were talking about the general prices and economic conditions which are confronting the farmers at this time. We did some figuring in our office recently on the price of some certain commodities. One of those was the price of hides and leather products. We tried to figure out whether it would be possible to get a wagon strong enough and a team big enough to haul enough hides to market to pay for a set of harness, and we did figure out conclusively that there is not a man in Chicago—at least, we don't think there is—who, if he had hides to market at this time, would be able to carry a sufficient number of pounds of hides across the street to pay for one shoe—just one moderate priced shoe. Before the war or during the war, that was not quite the case. At the price at which hides sold two years ago, a man could carry enough across the sreet to buy a pair of shoes but now he cannot carry enough to buy one single shoe.

The price of farm commodities has gone down out of all proportion to the retail price of the manufactured articles. What I told you of shoes is true of all kinds of fabrics and practically every other commodity. You men who are interested in machinery may well take note of those facts, and rest assured that unless there is a change in the buying power of the farmer's dollar, there will not be as much machinery sold next year as has usually been sold to the farmers of the country.

I haven't heard of any definite price schedules on machinery. All I have heard is that the price cannot be reduced. Since there are no reporters present, let me tell you confidentially that there will not be much machinery sold if that be true, unless, of course business revives so that the purchasing power of the farmer's dollar is greater than it is now.

Take on the matter of transportation, for instance, the farmer for years fought railroads rather to his own detriment. He fought for lower rates and lost sight of service. The reaction came and it has come with a vengeance that it is going to concern very vitally every business in this country. You judge the farmer's prosperity, I presume, by the price of commodities on the Chicago market. You forget that the farmer does not receive the Chicago quotations for that which he sells. He receives the Chicago quotations minus the carrying and sales charges, and that carrying charge on grain alone from the average farmer in the grain belt—and that would be in the vicinity of Western Iowa or Minnesota or Northwestern Missouri—penalizes the farmer on the recent rate advance at least ten cents a bushel on every bushel of grain which he sells.

I well remember the conditions which confronted agriculture in 1894 or 1895. That was when corn went to ten and eleven cents a bushel. I had earned my first money during that time or just a year or so preceding. I had gotten together a couple of hundred dollars and bought some lumber and built a corn crib and I speculated in corn at ten and eleven cents a bushel. I knew the condition of those farmers from whom I bought that corn very well and I know the conditions of the farmers in that same locality today, and the condition is infinitely worse today than it was in the days of that ten and eleven-cent corn. Why? Because the cost of production is so very much higher now than it was then.

Half of the farms in the best agricultural states are in the hands of tenants. The tenant is usually a fellow who, like myself, began working by the day or by the month on a farm. Finally he got a little money together and bought a team of horses and some machinery, and probably some second-hand machinery at that, and rented a farm. He did not have capital enough to buy the necessary feed and supplies to go through the first year, and being a beginner, he could not rent the best farm. He had to prove his worth before he could get on a good farm, hence, his progress was slow. Finally, if he had the right stuff in him, he would get together a few hundred or two or three thousand dollars. If his ambition was to become a land owner, he would put his small earnings as a renter into a farm, making only a small payment, and the previous owner would take a back mortgage. That is the condition at the present time and has been for years.

These men who have recently bought their farms and have only paid a quarter or a third of the purchase price—and there are thousands and tens of thousands of cases like that—or the renter who is just starting out and has insufficient capital, are in a serious condition. I was out home two weeks ago and talked with some neighbors of mine who are renters—men who had good equipment of machinery and horses, and some cattle last spring—and they tell me they are forced to sell everything they have and then they cannot pay their debts and they are going to have to go to work by the month or go to the city to get employment. I will say without any fear of successful contradition that more than one-fourth of the farmers of this country today cannot pay their debts, so serious is the situation.

I do not blame all of that, of course, to transportation. Part of it is due to transportation. I am not blaming the railroads, they were entitled to a raise and we conceded they should have it, but we feel they got, probably at that time, a little more than their just desserts, and we feel that if agriculture is to continue to develop in this country, there must come very soon a better balance or adjustment between the farm interests and the other interests of this country.

If I was supposed to talk about tractors, I got off of my subject. The tractor has come to stay, there is no doubt of that in my mind. The problem of the tractor manufacturer is to make it not as cheap as possible for a cheaply made machine made cheap at the expense of durability and service, is false economy always, but to make it as durable and as simple as possible and designed to meet the hard strains which a tractor must bear.

The difficulty with the tractors—I am speaking now from my observation of my neighbors, not my own experience—is that just in the rush season when they need that machine more than at any other time, something goes wrong with it and they have to send and get a garage man to come out, and the average automobile mechanic does not know much about a tractor because there seems to be a vital difference in the mechanism of a tractor and that of an automobile. They are made for very different purposes and the automobile expert is not a tractor expert, hence the farmer does not get very good service.

I don't know whether you ever run into that proposition or not. Then, if anything is wrong, it is necessary to send it to the factory or maybe get a man to come out from the factory to put those parts in place. If the tractor becomes an absolutely successful and reliable tool, it is going to be because it is made as simple as possible to get service out of it and every part made as accessible as possible so that the farmer can do a good deal of the repair work himself, for he cannot depend upon high-priced expert work. If he does, he will soon discard the old tractor and the tractor company will have a bad reputation in that community, so it is to your interest as engineers to make those tractors as durable and as simple as you can, and then as tractor manufacturers or as truck manufacturers, go just as far in standardizing those machines as you possibly can. I would like to see all of our leading farm machines standardized. I am aware of the inconvenience that the dealer would experience for a short time, because he would have to keep the various lines of repairs until the old machines now in the hands of the farmers are cast aside which would be five or ten years, but when that time is gone, there would be a very great advantage in standardization.

Now the truck business and the tractor business is in its infancy and you have a chance to begin that standardization without the excuses for non-standardization which implement manufacturers are now making, and I urge you by all means to standardize as rapidly as you can.

Everything which you as engineers have to deal with comes from the soil. If it does not come directly from the farm, it comes indirectly from the farm. If it were not for the farm, you could not produce. There would not be factories or transportation or merchandising or labor were it not for that farm service. If by any chance the surplus from the farms of this country should decrease ten or twenty-five per cent, there would be a proportionate decrease in the number of freight cars and freight trains which run on the roads; there would be a proportionate decrease in the number of men employed in the factories in this country, and there would be a decrease in all kinds of production. According to the law of supply and demand, that would mean probably an increase in the price of those commodities.

The farmer wants labor well and usefully employed. He wants trains to move and factories to run and he knows in order to bring those things about he must increase his production and maintain that increased production. You men are vital agencies in assisting us to bring about that increased production which is essential to your interest and our interest and the interest of this whole great American nation of which we are a part.

FACTORS INFLUENCING THE DRAFT OF PLOWS

By E. V. Collins

Mem. A.S.A.E. Assistant Chief, Agricultural Engineering Section, Iowa Agricultural Experiment Station

AT THE LAST annual meeting of the Society, Prof. J. B. Davidson gave the results of a series of tests to determine the influence of speed upon the draft of a plow. The conclusions were that increasing the speed from two to four miles per hour increased the draft for the different conditions represented in the tests from 16 to 25 per cent.

This presents a disadvantage or at least an argument against high speed plowing. Other arguments are that greater damage will result to the plows if hidden obstructions are encountered and that it is not what we might term "standard practice."

On the other hand, the lighter weight tractors cannot deliver their full drawbar power at a speed of two miles per hour, unless the footing is excellent.

These arguments are merely mentioned because of their influence upon our lines of research.

The tests reported by Prof. Davidson at the last meeting were all made with general-purpose bottoms, so naturally the next step was to compare the draft of various types of bottoms as influenced by speed. It appeared reasonable that a bottom approaching the breaker type when pulled at, say, four miles per hour, might do the same quality of work, and with no greater draft than a general-purpose bottom when pulled at two miles per hour.

Objectives:

1. To compare the draft of various types of plow bottoms as affected by speed.

2. To determine the power required to cut the furrow slice as compared to the power required for turning and pulverization.

Along with these two main objectives, tests were made to determine the effect of varying the depth of plowing and the effect of dull shares. The equipment used was an Oliver No. 11 sulky plow with stubble, general-purpose, breaker, slat and No. 222 bottoms, and a Vulcan tractor plow with stubble, general-purpose and speed bottoms.

The slice cutter used in these tests is a device built to cut the furrow slice loose without moving it. A heavy blade is bent to a right angle and supported on a wooden frame so as to cut 14 inches wide and up to 8 inches deep. A rolling coulter was used in connection with the vertical part of blade. Small wheels were attached to the side on the land to regulate depth. (See Fig.1)

The rear trucks of the Moline-Universal tractor were used and a low platform attached. This made it possible for one man to operate both the tractor and dynamometer with ease. The right rear truck wheel hugs the furrow wall, making it possible to keep the width of furrow uniform.

The Iowa dynamometer was attached directly to the drawbar of tractor.

METHODS OF TESTING:

One bottom only was used in all tests because it made the change of bottom simpler and also made it possible to secure higher speeds. The width of cut in all cases was 14 inches, and the length of tests 50 feet. All tests to be compared were taken at the same starting place and represented parallel furrows. The starting places were selected with a view to uniformity of conditions. The speed was determined by means of a stop watch.

Tests were eliminated for the following reasons: Excessive variation in depth, failure to get the time, and the failure to scour. These account for the missing points on the accompanying graphs.

FIELDS USED:

Field A was sweet clover sod. It was a clay loam and in

Fig. 1. The slice cutter in use

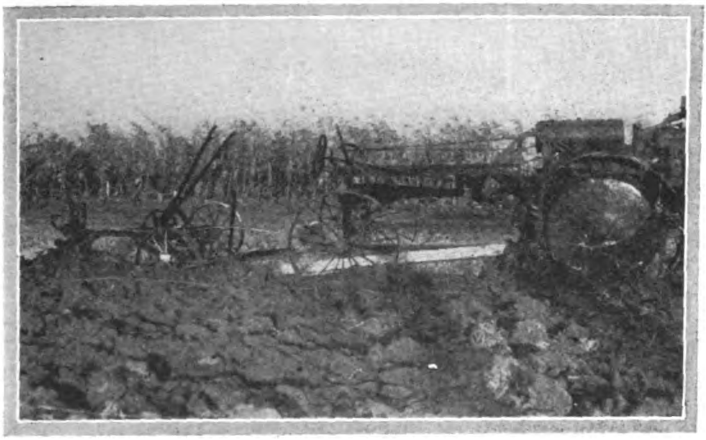

Fig. 2. The tractor fitted with low platform under rear truck

good plowing condition as regards moisture. It was plowed August 14. Four starting points were used.

Field B was red clover sod. It was a sandy loam, and was too dry to do good plowing, and turned up quite lumpy. It was plowed September 21. Three starting points were used. At station No. 2 the ground was especially dry.

Field C was wheat stubble. It was a Carrington loam and one end of the plot was in good condition as regards moisture, while the other end was too wet. There was considerable difficulty in scouring in the wet portions. This plot was plowed October 6, 8, and 9. Three starting points were used.

Field D was Sudan grass stubble. It was a sandy loam and was in good condition as regards moisture. It was plowed between October 22 and November 5. Only one starting point was used.

Field E was blue grass sod, unpastured. It was a sandy silt loam and was in good plowing condition as regards moisture. It was plowed November 10 and 22.

In the tests to determine the draft of various types of plows as affected by speed, each of the three bottoms for the Vulcan plow were tested at various speeds in Fields A and C. The depth in each of these tests was as near 8 inches as could be secured. As would be expected, this varied somewhat with different bottoms and it was found necessary to make corrections in the data to compensate for these variations in depth. The results are shown graphically in Fig. 3, Graph A4 representing the fourth station in Field A and C2 representing the second station in Field C.

Each of the five bottoms for the Oliver plow were tested at various speeds in Field B. A depth of 7 inches was maintained as near as possible. The results are shown graphically in Fig. 4. Graph B2 is of interest because of the small increase due to speed. It is my opinion that this is due to the fact that the furrow turned up in lumps and there was no pulverizing action after the soil was first broken loose.

Attempts were made to compare the general-purpose and breaker bottoms in Fields C and D. In Field E (blue grass sod) the slight advantage noted was in favor of the general-purpose bottom.

In the tests to determine the power required to cut the furrow slice as compared to the power required for turning and pulverization the slice cutter was used in Field C but we were unsuccessful in getting the plow to scour when turning the cut slice. It was noted, however, that *the draft of the slice cutter did not increase with the speed.*

In Field D the slice cutter was used again and no difficulty was experienced in getting the general-purpose bottom to scour when turning the cut slice. The aim was to make the plow run just a trifle shallower than the slice cutter, so that it would not drag on the bottom or cut more soil. The slice cutter pulled slightly harder than the plow itself so this

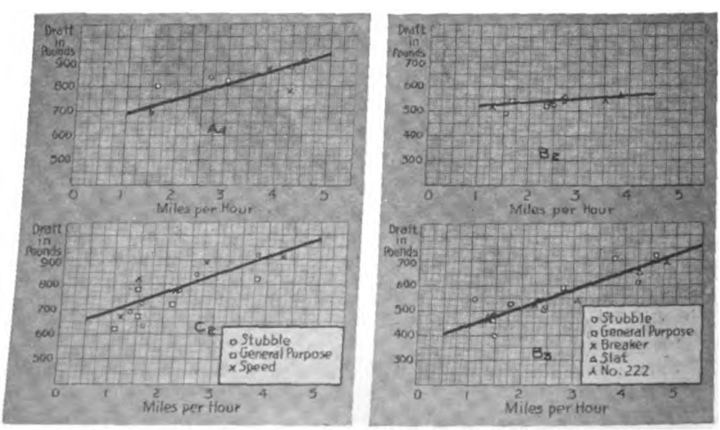

Fig. 3. (left) Influence of speed on draft of three Vulcan bottoms; Fig. 4. (right) same for five Oliver plows, tests at four stations

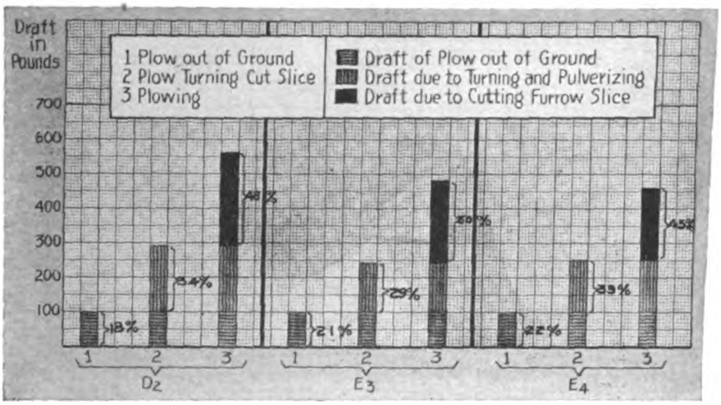

Fig. 5. Distribution of draft into plow chassis loss, cutting, and turning and pulverizing in different fields and with different bottoms

could not be taken as the true measure of the power required for cutting. Also the shape of the blade is different from that of the plow. To arrive at the draft required for cutting the furrow slice, the draft required to turn the cut slice was subtracted from the draft required to plow. In the same way the draft of the plow out of the ground was subtracted from the draft required to turn the cut slice in order to determine the draft required for turning and pulverizing. These tests were made at speeds of about 2½ miles per hour.

The results were as follows:

Draft of plow of ground..............18 per cent
Draft due to turning cut slice..........34 per cent
Draft due to cutting slice............48 per cent

The slice cutter was also used in Field E in connection with both the general-purpose and breaker bottoms with the following results:

Bottoms	Draft of plow out of ground	Draft due to turning	Draft due to cutting
General Purpose	22%	33%	45%
Breaker	21%	29%	50%

As would be expected the breaker bottom required a smaller per cent for turning, while the general-purpose required less for cutting. The breaker having a greater angle to the share throws more pressure against the landside and rear wheel and also supports a longer section of furrow slice. These results are shown graphically in Fig. 5.

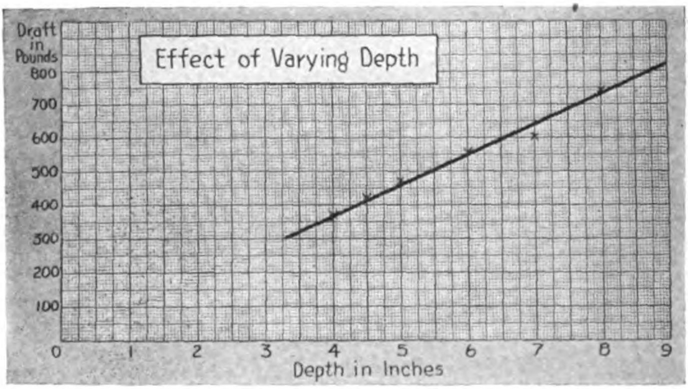

Fig. 6. Tests showing relation of depth to draft used to correct for small variations in depth

A test to determine the effect of varying depth was made in Field D. Tests were made at 4, 4½, 5, 6, 7, and 8 inches. The results would indicate a uniform increase for these depths. In this case, the increase was about 92 pounds per inch of depth. The results are shown graphically in Fig. 6. This test was used as a basis for corrections to compensate for variations in depth as previously mentioned.

In tests to determine the effect of dull shares, a share was dulled by grinding the edge until it was ⅛ inch thick. Another was touched up with a file to make it as sharp as practical. Both shares were in good "form" except for the edge on the dull share. When tested in Field D (sandy loam) the difference in draft was almost negligible. In Field E (blue grass sod) a maximum of 14 per cent advantage was

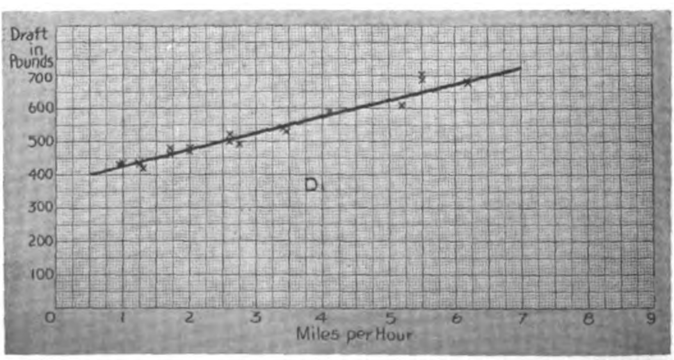

Fig. 7. Test of Oliver general-purpose bottoms in Field D. Shown because of close grouping of points

noted in favor of the sharp share.

Our observations on scouring might be termed "by-products" of the tests.

I believe the current opinion is that plows scour better at high speeds, at least that was my opinion. There was a spot in Field C about five rods long on one side where extreme difficulty was encountered in getting the plows to scour. High speeds were tried with no better results.

In one end of Field D, there was a narrow strip of corn stubble, and it was noticed that the plow would not scour through this at speeds about four miles per hour, while at lower speeds there was no difficulty. This was tried repeatedly to make sure of this point.

Fig. 7 has no direct bearing on the foregoing tests. This run was made with the Oliver general-purpose bottom in Field D. It was to be compared with another run made with the breaker bottom. Being unsuccessful in getting the breaker to scour the curve is shown because the points come nearer to a straight line than any which came to the observer's attention. The depth was exceptionally uniform.

CONCLUSIONS

1. The type of bottom does not materially influence the draft.

2. An increase in speed will produce about the same increase in draft with any type of bottom.

3. The increase in draft due to speed is confined to that part of the total which is required for turning and pulver-

Fig. 8. A sample of the plowing done at six miles an hour in the course of the draft tests

izing. This varies with the speed from less than one-third to about one-half the total draft of plow within a speed range of two to four miles per hour.

4. Variation in depth is probably the greatest source of error in plow tests of a comparative nature.

5. Under some conditions of plowing, a sharp cutting edge is of little importance.

6. Under certain conditions high speeds may cause failure to scour.

DISCUSSION

QUESTION: What is the difference between the speed bottom and the general-purpose bottom?

MR. COLLINS: It is not as steep a plow. The stubble bottom would work best at, say, two miles per hour and the other would do better work between that and three miles. After you get up to three miles the speed plow would lay the soil over all right, but if you run the speed plow at low speeds the edge of the furrow would not be tucked under. This is a new bottom developed by the Vulcan plow people.

QUESTION: Does it more nearly approach the breaker bottom?

MR. COLLINS: No, it is more like the general-purpose bottom, but the moldboard is shorter and has less pitch to it. It avoids the throwing of dirt at high speed. I have not said anything about the quality of work on these tests because that was not the thing we were after. It is hard to judge the quality of work on some. We took the stubble bottom first and ran it a mile and a half an hour. We ran the next one three miles an hour, the next four and a half miles an hour, and we did not have a very nice job of plowing as you can realize. There was not a good opportunity to judge. We wanted to find out if we could get rid of this increased draft at high speed; that was the primary object.

QUESTION: What type of soil did you have in the B-2 field?

MR. COLLINS: Sandy loam.

QUESTION: Is the depth the same?

MR. COLLINS: The depth was seven inches in this field. We ran this in the same way, that is, we put on one bottom and ran it at different speeds and then put on the next.

QUESTION: How deep had that ground been plowed previously?

MR. COLLINS: I think about the same depth; it has been plowed eight inches deep. This chart shows that with the different soil conditions you are going to have a different rate of increase in speed. Some of the men who have tried tests on the effect of speed concluded there was very little increase. I can realize under certain soil conditions you will get a very slight increase where the moldboard has very little to do. The share cut breaks it loose and there is no more pulverizing done by the moldboard.

QUESTION: Do you have data on maximum speeds at which each of those bottoms will do good work?

MR. COLLINS: No, as I said, we did not try to determine the quality of the work. I would not undertake to say anything about the quality. Take a stubble bottom or a breaker bottom, for instance, and in ground that does not hold together like sod, it does not make much difference how far you throw it. We found that in sod, using the general-purpose bottom, it did not make much difference whether you went fast or slow because it would leave a ragged job of plowing. It does not throw sod as bad as it does the other. It will strike the other furrow and lay. I do not say that the general-purpose bottom will do anything like the work that a sod plow will in sod but the effect of speed on the general-purpose bottom in sod was not what I anticipated. I supposed you could throw it over in big chunks and do a worse job than at ordinary speed.

QUESTION: Did the slice cutter cut the horizontal and vertical slice?

MR. COLLINS: Yes.

QUESTION: You ran it through first, loosened up the slice and then ran the plow through to lift and turn it over. That was merely an L-shaped blade to cut the slice, was it not?

MR. COLLINS: Yes, the vertical part of the blade ran down to cut the vertical part of the slice. There was a coulter there, too, to cut the trash in the furrow. It was attached directly to the bottom of the sled.

QUESTION: How did that test compare with where you cut and turned the furrow in the same operation?

MR. COLLINS: The slice cutter pulled harder than the plow itself. You have a straight blade there and you have to put additional weight on the slice cutter to make it stay in the ground.

QUESTION: Was the draft of the slice cutter subtracted from the work you did?

MR. COLLINS: We subtracted the draft to turn the slice after it was cut from the total required to plow. For one thing, our coulter gets no relief on that, that is, the soil is not turned away from the coulter on the slice cutter; it has friction all along. In a plow you turn the dirt away and relieve the cutting edges.

QUESTION: You had a sliding friction instead of a rolling friction, didn't you?

MR. COLLINS: We had a sled in the furrow and wheels on the land. This would be a good illustration: When you want to slit a strap of leather, you pull apart on the two izing. This varies with the speed from less than one-third to about one-half the total draft of plow within a speed range of two to four miles per hour.

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MR. COLLINS: It is not as steep a plow. The stubble bottom would work best at, say, two miles per hour and the other would do better work between that and three miles. After you get up to three miles the speed plow would lay the soil over all right, but if you run the speed plow at low speeds the edge of the furrow would not be tucked under. This is a new bottom developed by the Vulcan plow people.

QUESTION: Does it more nearly approach the breaker bottom?

MR. COLLINS: No, it is more like the general-purpose bottom, but the moldboard is shorter and has less pitch to it. It avoids the throwing of dirt at high speed. I have not said anything about the quality of work on these tests because that was not the thing we were after. It is hard to judge the quality of work on some. We took the stubble bottom first and ran it a mile and a half an hour. We ran the next one three miles an hour, the next four and a half miles an hour, and we did not have a very nice job of plowing as you can realize. There was not a good opportunity to judge. We wanted to find out if we could get rid of this increased draft at high speed; that was the primary object.

QUESTION: What type of soil did you have in the B-2 field?

MR. COLLINS: Sandy loam.

QUESTION: Is the depth the same?

MR. COLLINS: The depth was seven inches in this field. We ran this in the same way, that is, we put on one bottom and ran it at different speeds and then put on the next.

QUESTION: How deep had that ground been plowed previously?

MR. COLLINS: I think about the same depth; it has been plowed eight inches deep. This chart shows that with the different soil conditions you are going to have a different rate of increase in speed. Some of the men who have tried tests on the effect of speed concluded there was very little increase. I can realize under certain soil conditions you will get a very slight increase where the moldboard has very little to do. The share cut breaks it loose and there is no more pulverizing done by the moldboard.

QUESTION: Do you have data on maximum speeds at which each of those bottoms will do good work?

MR. COLLINS: No, as I said, we did not try to determine the quality of the work. I would not undertake to say anything about the quality. Take a stubble bottom or a breaker bottom, for instance, and in ground that does not hold together like sod, it does not make much difference how far you throw it. We found that in sod, using the general-purpose bottom, it did not make much difference whether you went fast or slow because it would leave a ragged job of plowing. It does not throw sod as bad as it does the other. It will strike the other furrow and lay. I do not say that the general-purpose bottom will do anything like the work that a sod plow will in sod but the effect of speed on the general-purpose bottom in sod was not what I anticipated. I supposed you could throw it over in big chunks and do a worse job than at ordinary speed.

QUESTION: Did the slice cutter cut the horizontal and vertical slice?

MR. COLLINS: Yes.

QUESTION: You ran it through first, loosened up the slice and then ran the plow through to lift and turn it over. That was merely an L-shaped blade to cut the slice, was it not?

MR. COLLINS: Yes, the vertical part of the blade ran down to cut the vertical part of the slice. There was a coulter there, too, to cut the trash in the furrow. It was attached directly to the bottom of the sled.

QUESTION: How did that test compare with where you cut and turned the furrow in the same operation?

MR. COLLINS: The slice cutter pulled harder than the plow itself. You have a straight blade there and you have to put additional weight on the slice cutter to make it stay in the ground.

QUESTION: Was the draft of the slice cutter subtracted from the work you did?

MR. COLLINS: We subtracted the draft to turn the slice after it was cut from the total required to plow. For one thing, our coulter gets no relief on that, that is, the soil is not turned away from the coulter on the slice cutter; it has friction all along. In a plow you turn the dirt away and relieve the cutting edges.

QUESTION: You had a sliding friction instead of a rolling friction, didn't you?

MR. COLLINS: We had a sled in the furrow and wheels on the land. This would be a good illustration: When you want to slit a strap of leather, you pull apart on the two pieces. If you cut straight down with your knife, it cuts harder than where you pull the two pieces apart as you cut. That would be my explanation. Only in two of the fields was I able to get the plow to scour after the slice cutter. You do not have good scouring conditions after you cut the slice loose.

(Slide showing slice cutter) The rolling cutter is here. The knife comes down eight inches below the sled and over here is the back of the other sled runner. That runs into the bottom of the furrow to obtain depth and width. It was hitched so that this runner would hug the furrow and give uniform width. We had a weight on it holding it to the ground the uniform depth. We also had considerable suction on the blade.

QUESTION: Did you get the same amount of pulverization where the furrow slice was cut by the slice cutter previous to turning?

MR. COLLINS: Yes, I think about the same.

QUESTION: Do you think the slice cutter has considerable suction? Will it materially pulverize the slice?

MR. COLLINS: The blade was only two inches wide. The bottom edge was a little dirt crumpled, but the furrow slice would be continuous.

QUESTION: What was the shape of the lower knife, the same as the shape of the plow?

MR. COLLINS: It went straight across the furrow. The knife went straight down and then a square corner straight across was made. It does not give the shape of the plow. I realize that you could not expect to compare that favorably with the plow—the draft I refer to—because you get no relief from your cutting edges and I think the other is a more fair way to define the draft due to cutting by subtraction.

It was difficult to get a satisfactory test there and get the two depths out of the depth of the slice cutter running and the plow so that it would be satisfactory. In each of these cases I was able after several attempts to get them to run at the right depth.

QUESTION: Did you finally check the drawbar pull of that outfit the way it is attached to the plow?

MR. COLLINS: No, the draft of this outfit was generally a little heavier than the total draft of the plow so we went at it the other way, subtracting the power required to turn the slice after it was cut from the total required to plow.

QUESTION: If you had a properly shaped plow bottom, do you think the subsequent preparation of the ground would be reduced any by plowing fast?

MR. COLLINS: I doubt if you could make a farmer believe that. Of course there would be quite a difference, but a great deal depends on the condition of your soil as to just how it is going to be left. I do not feel in the spring they will be able to tell which plow did which furrow. There will be a little gap because the next furrow was not run anything like that speed. There is no question but what the different types of bottoms will do different classes of work. The point we want to determine is whether there is a difference in draft due to the different types of bottoms and whether we could get any indication that a bottom could be designed for high speed with as little draft as the ordinary plow at ordinary speed. I am satisfied that a plow can be made to do good work at high speed, but the tests we have run would indicate that you must expect a considerable increase in draft.

MR. KRANICH (president of the Society): Mr. Collins' talk was very interesting, and particularly so from the fact that the increased speed means increased power. I wonder if after all the work that is done—the quality of work which will take more power—isn't worth the additional expense? Another thing I thought about was the statement made by Mr. Collins that this was fall plowing and the soil was not very well pulverized. In fact, the picture Mr. Collins showed appeared to be a very rough job of plowing, but as someone has said, for fall plowing the farmer rather prefers to plow with the least expense and leave it a little rough because he feels that the ground in the spring of the year, after alternate thawing and freezing, will of itself disintegrate and make a pretty good seedbed. It will look considerably different after the snow leaves it and the frost is out of the ground than it does in the fall. There are a good many factors that are going to be difficult to determine really and one in particular is the quality of the work.

JAMES A. KING (Mason City Brick and Tile Company): In that connection a number of years ago we were making a number of comparative tests with plows speeded to work at two and one-half and four miles an hour. We tried the general-purpose bottom, the stubble bottom, and the tractor gang plow at those two speeds of two and a half and four miles. Every farmer that took a look at the two jobs expressed the opinion that the four-mile job was nowhere as good as the two-and-a-half-mile job. It threw the soil and there would be a big gob of dirt here and an open space there, and then another big gob of dirt, much on the principle of a fish net. It made an irregular job of the lapping of the furrows. That was the experience we had some eight or nine years ago.

O. B. ZIMMERMAN (experimental engineer, International Harvester Company): Undoubtedly we are up against a very serious problem here, as we all know, with such a large series of variables, in attempting to analyze, differentiate, and find out the effect of each one.

One of the most serious problems in ascertaining the exact results mathematically is the fact that where a tractor has gone over the land that we are trying to analyze, especially in mass data, we have a disturbance of the soil, caused by the lugs and wheels, which influences the securing of very correct data in regard to plowing with tractors. I have noticed that particularly in watching the tests we have been carrying out at Hinsdale. Ofttimes data which is recorded with a Gurley dynamometer will indicate a falling off, for example, of the draft relatively with respect to speed when you change from two miles to three miles an hour. You can see very well that the influence of the lug action at the higher speeds disturbs the ascertaining of accurate results to an extent which has to be corrected unless you can operate the plow on absolutely unaffected soil. That is a point I was very anxious to find out about Prof. Collins' data—whether all of the cuts were made in soil which had not been affected by wheel or lug action of any kind. That influence was particularly noticeable in some of the tests made at Ottawa Beach at the time of the meeting of the Society of Automotive Engineers in Michigan last summer. I noticed the tracklaying type of tractor pulling plows at variable speeds. At the lower speeds the influence of the tracklaying type of tractor on the ground was not noticeable. When you walked along beside the tractor the disturbance did not penetrate deeply, but when it got to the higher speeds the entire surface was sheared by the action of the lugs. Naturally the draft data taken from the drawbar was that of power required to turn over this soil without the actual cutting, since part of that work of shearing and disturbance had already been done by the lugs.

Mr Hoyt: To what depth was it disturbed by the lugs?

Mr. Zimmerman: To the full depth of the cut, the shear line took place right at the bottom of the furrow. It made a deep impression on me that we would have to be exceedingly careful in the analyzing of data when we were in soil where the lug action did grip the soil in shearing or did disturb it to a large extent. That shows that we have really two very vital problems in tractor plowing, one of which is the plow action in which we must secure at the maximum sensible disturbance of soil, the minimum sensible amount of power, and on the tractor we have to design the wheels in such a way as to reduce the minimum amount of soil disturbance. That is where our big problem lies. The two are distinctly opposite problems. I am satisfied that in the tractor industry we have not as yet given sufficient attention to the getting hold of the soil with the minimum disturbance of the soil. By minimum disturbance I mean minimum sensible packing and minimum crushing and breaking up, because the object of the lugs is to get a grip and to give us a possibility of exceeding the resistance which we are trying to overcome with the plows.

MR. HOYT: Do you think that is an important factor in practical work?

MR. ZIMMERMAN: I think it is very important in both factors, because until we know what the power is and what the controlling engineering theoretical data is of the undisturbed soil, we cannot well solve the tractor problem. Our first problem is to analyze theoretically and practically the soil disturbance and see what can be done by shaping the moldboards and other factors of the plow to give us the minimum amount of power and the maximum soil disturbance. When we have done that we should take up a study of the lug action, irrespective of the plow, to get a maximum drawbar pull. Putting those two together we can make a thoroughly sensible analysis of the tractor problem.

J. B. DAVIDSON (professor of agricultural engineering, Iowa State College): In connection with Mr. Zimmerman's remarks, the significant feature of Mr. Collins' observation is the fact that the type of plow bottom does not materially affect the draft. There are a good many men here who have been in my classes and you know I argued that it cost in power to pulverize the furrow slice; that is, if you used the stubble bottom you would expect the draft to be higher than if you used the general-purpose bottom, and likewise still higher if you used a stubble bottom in place of a breaker bottom.

The observations have not worked out that way, and as you stop to analyze the thing you see why it does not work out that way. In the first place, in the breaker bottom you have a long section of the furrow slice and you are carrying that on a plow bottom—on the share and on the moldboard—and you are pushing it along. You have a great deal more weight, fourteen inches wide, so many inches deep and greater length, and you are pushing that along on top of the plow bottom. You would expect the resistance to be greater even if you had dry friction. In reality you do not have dry friction; you have something between dry friction and liquid friction, and liquid friction varies with the amount of surface in contact. I suspect in analyzing Mr. Collins' result you would find that with the soil full of moisture the breaker bottom will pull heavier than when the soil is dry, and as you think of it, it is a thing that you might expect. I believe it might be possible to take advantage of that principle and change the plow bottoms so we would have this draft as Mr. Zimmerman suggested. Maybe we want an extremely short movement to carry as little of the furrow slice as possible. True enough we don't carry it all vertically, but we carry it part vertically and part is used in shoving it over. The breaker bottom may not be the lightest draft bottom. Practical men have told me they have known that for a long time.

MR. COLLINS: In connection with the effect of scouring on high speed, I would like to ask Mr. Zimmerman if they have had any experience along that line. My observation was we had some difficulty in scouring at high speed. It was not what I expected.

MR. ZIMMERMAN: We have analyzed that, that is, we have argued about the question a good deal and we are thoroughly satisfied when you get below one mile an hour the draft increases abnormally with the speed, so that while we have no direct data on it, I would say roughly that the curve of resistance drops down and rises when you go for considerable miles.

HENRY GREEN (International Harvester Company): My field experience has been with the horse plow that, if you have scouring difficulties, run a little shallower and speed up. That is the general impression among most farmers. Possibly a little shallower plowing brings you into a little different strata of soil. That is likely the reason for it, but the general impression among all farmers is when you have scouring difficulties go shallow and fast.

PROF. DAVIDSON: With a horse you are limited to less than three miles an hour, but when you get to six miles an hour you have a different speed. Isn't it possible that you have areas of low pressure which result in nonscouring? My observation has been if you go less than a mile an hour you have trouble in scouring.

MR. KRANICH: I saw some tests made in South Bend a year or so ago in which difficulties were encountered in scouring at two and a half miles an hour, whereas when the speed was increased to three or three and a half or even four miles an hour, the plow scoured very easily. That is common. We also found that in taking off the jointer and even the coulter, it has many times absolutely caused the plow to work perfectly when it otherwise would refuse to scour at a moderate tractor speed and it would do as good a job of plowing, apparently, as with them. Mr. Zimmerman brought up a subject that I think is a very important one. Of all of the work we have done on plows, tractors, and tractor work, I think we know less about wheels and lugs than any part of our tractors, and it seems to me that affords a field for work as great as any. The effect of lugs on ground of different kinds is very important. We have nothing to guide us that I think is at all logical.

It is rather surprising to find manufacturers so inconsistent in sending out tractors with lug equipment that is unsuited for certain localities. We find no plan or system of sending out tractors with certain kinds of lugs in certain localities. Each manufacturer sends out equipment of lugs different from every other manufacturer in the same locality. I think that is going to be one of the biggest fields we have that is going to give us different insight on the plowing speed and draft, and I hope that work along that line may be carried on this next season that will open our eyes in another direction.

Mr. Zimmerman spoke about the effect of the tractor wheels on the ground. Perhaps we will have to go back to the cable plowing, where they do not run the tractor on the ground at all, to get the results of the plowing independent of the effect of the wheels. The quality of work that the plow does is in a big measure also effected by the hitch. We have seen at the various demonstrations, the quality of work of the different manufacturers, working side by side in apparently the same soil, differ one hundred per cent, due entirely to the fact that they had an improper hitch. It makes for bad work, not alone with the plow but the entire outfit.

MR. ZIMMERMAN: Has the American Society of Agricultural Engineers taken up the question that is really vital to every one, as to what actually constitutes good plowing? Unless we know what we are driving at, we cannot arrive. I am quite well satisfied that there are too few of us who really know what we are driving at when it comes to analyzing this question. Of course, we have seasonable conditions that are required.

In the fall we do not care, as has been said here, if there is more or less in the way of lumpiness in the results of our plowing, but in the spring when we are endeavoring to get a seedbed in the fastest possible time, then it becomes another question and I think that our Society should take that up as a vital question, it has been definitely put on the program to get down to basic facts and see what we are actually trying to do with the soil.

O. W. SJOGREN (professor of agricultural engineering, University of Nebraska): The question of roughness or smoothness of the plowing in the fall may hold for localities where they fall plow for corn, but certainly not for Kansas and Nebraska in the winter-wheat belt. There they want smooth plowing in the fall for wheat. They do not do much spring plowing. It depends on the locality.

In regard to the speed, we ran a few tests at Nebraska this fall to determine the effect of speed and depth and various other factors upon plowing. We have not gone far enough to draw definite conclusions. We found with the plows we used—the general-purpose plows—the higher the speed, the more inferior the grade of plowing. The soil would be thrown a considerable distance and would be choppy as Mr. King said they found it. The trash was not as well covered with the higher speeds as with the medium speeds.

MR. KRANICH: I think this is a subject we have all got to take seriously. We have to get down to a basis somewhere that is consistent and reasonable for the protection of the people who farm without endangering their lives or destroying their property.

WM. AITKENHEAD (professor of agricultural engineering, Purdue University): The work we did part of the past summer in connection with tractor lugs was done in exceptional soil, that is, sandy soil but with clay. It made better conditions as to holding because as soon as the lugs cut through the crust the holding power was gone. We found that angle-iron lugs are almost useless. Each subsequent lug cut through the crust of the soil and pushed the piece back. We did this several times. We drew the plow over a measured distance empty, using two plows with an average draft of 1300 pounds. With the 1300 pounds behind the angle-iron lugs we would get as high as 40 per cent slippage. We studied it from that basis. We finally concluded if we saw the track made by a tractor we could pretty nearly tell whether they were good lugs or not. It isn't so much a question of propelling surface in the lugs as holding power of the soil. With any form of lug that made a cut across the width of the rim of the wheel, we had very unsatisfactory results. The holding power was lost. Not because the propelling surface was too small, but we cut with a series of lugs and pushed them back. We found out that the best holding was a spade lug three inches high and three inches wide. With a lug of this kind on the same basis of calculation as with the angle-iron we got to a basis of 3 per cent slippage. The lug that gave the best holding power made practically no disturbance of the soil and I think that designers in making the curvature of tractor lugs must consider that a lug that will slip in and be curved so, when it leaves the soil, the soil will not be sheared, is best. It has been said again and again that the conditions of the farmers are not common. The ground may be sandy and at the same time the crust hard. I saw one of the tractors with extended angle-iron lugs stalled with the empty plow. It stood and chopped. We could plow with the small angles but not with the big ones.

MR. KING: I hestitate to talk about tractors because I retired seven years ago, but I want to go back to what the gentleman over here referred to, the matter of relation between speed and the speed at which the plow is designed to work best. The plows used in the instance referred to previously were designed for tractors which were operating at a speed of somewhere between a mile and a half and two miles an hour. We found they gave the best results at that speed. Increased to four miles an hour we got inferior work. After four years of continuous experience in the field with tractors I have this thought impressed on my memory: That one of the greatest fields for the development of the tractor is a proper synchronization between the particular design of tractor and the particular implement which it draws.

Mr. Collins: Prof. Aitkenhead made some remarks that remind me of an experience I had in Kansas. We had a patch of alfalfa on a river bottom, largely sand. We were plowing that with several tractors. Our experience was that the extension angle-iron lugs were the only thing we could go into that field with and get out. The machines with the spade lugs had to be pulled out with the other machines. We buried them and had to pull them out. We depended largely on the alfalfa plants for the traction. The angle-irons would get hold of it and the spade lugs had nothing to get hold of. That led me to the opposite conclusion from that of Prof. Aitkenhead. I have changed my views a little on account of Prof. Aitkenhead's experience.

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STANDARDIZATION OF FARM WAGONS

By E. E. Parsonage

Assoc. A.S.A.E. Secretary and Manager, John Deere Wagon Works

THE great bulk of farm wagons sold today are designated as Light, Medium, Standard and Heavy, in line with the recommendations I made in 1913 in a paper read before this Society. The rear axle is also branded with the intended carrying capacity as predicted in my paper of that date.

Prior to three years ago there were nine different sizes of two-horse wagons, and all wagons were rated according to the size of the skein. This rating meant nothing to the farmer and was delusive in the extreme because all skeins of different makes have different carrying capacities in a given measurement. That is, one 3¼-inch skein may not have over 60 per cent of the carrying capacity of another 3¼-inch skein, thus the farmers were deluded many times about the capacity of their wagons.

Again, before standardization was made effective, a wagon factory catering to the farmers trade in various territories, was required to build in the 3¼-inch size wagon *only*, forty-eight different kinds of gears and ninety-five different kinds of wheels.

This meant the necessity for building 912 distinct different kinds of 3¼-by-10 farm wagons, exclusive of brakes.

Under the old plan by multiplying the varieties in each different size of wagon demanded by the farmer it was possible to build, to meet all the individual whims and preferences, 4560 different kinds of farm wagons.

Under the present standardized schedule on the new wagon size, that is, one size of wagon branded "Standard," the following only are retained: four different kinds of wagon gears and twenty-one different kinds of wheels, which reduces the variety to five different kinds of wagons in this one size.

At the present time it is only necessary to build 224 different kinds of farm wagons under the standardized schedule.

The standardization of farm wagon equipment has only started. Is there any reason, or even good sense if you please, in furnishing the farmer with 224 different kinds of farm wagons, when the only variable factor encountered in transporting farm produce from the farm to the market is the size of the horses, the variation in the load to be carried, and in the condition of the road over which the load is hauled.

Wagon wheels have been culled to essentially two heights, 40-44-inch and 44-48-inch, both heights taking the same gear construction. Steel wheels for farm trucks have also been standardized to the extent that at the present time only two combinations are required, 28-32-inch and 30-34-inch. Five years ago the truck manufacturers carried something like twenty-five different heights of steel wheels.

One-horse wagons are made very largely today in only two sizes, light and heavy, designated as such, with steel or wood axles, and with only one wheel height, namely 40-44 inch.

The track or tread of wagons and farm trucks has been standardized for the past two years. The more progressive manufacturers have made nothing but the standard auto track (56 inches) since January 1, 1919. Prior to 1918 farm wagons were made in seven different tracks, ranging from 4 feet 6 inches to 5 feet 2 inches.

The standard track was initiated as a conservation measure during the war. This track was selected first because the automobile uses the 56-inch tread and it is commonly acknowledged that the automobile is the track maker. The standard track has been approved by the Secretary of Agriculture, the Department of Commerce, and numerous trade organizations. There are still some few ill-advised manufacturers who constitute the usual minority that invariably work against any economic change that has ever taken place.

Until very recently farm wagons were made in six different widths of track, and the farmer moving from one state to another, or from one locality to another, was forced in most cases to sell his entire transportation equipment at a sacrifice, because his wagons and trucks would not fit the track of the territory into which he was moving.

Prior to 1917 wagon tires were rolled in round edge and square edge stock. Now practically all wagons are made with a compromised tire called the oval edge. Better and more

Order No.1. (Carload of Farm Wagons)

____________ November 1, 1913
____________, Tenn. Order No.__________
Via__________ For shipment at once

Amount	Size	Kind	Wheels	Tire	Remarks.
1	3½x11	1132	40-44	3x¾ R.E.	3x4 reach, 12′ long
1	3¼x10	1130	40-44	3x¾ R.E.	8-inch stakes
3	3¼x10	1130	40-44	2x¾ R.E.	8-inch stakes
2	3¼x10	1130	40-44	2x¾ R.E.	10-inch stakes
3	3 x 9	1128	40-44	2x¾ R.E.	8-inch stakes
2	3 x 9	1128	40-44	1½x¾ R.E.	10-inch stakes
3	3 x 9	1128	40-44	2x¾ R.E.	10-inch stakes
3	3 x 9	1128	40-48	1½x¾ R.E.	10-inch stakes
2	2¾x 8½	1126	40-44	1½x⅝ R.E.	10-inch stakes
2	2¾x 8½	1126	44-52	1½x⅝ R.E.	12-inch stakes
2	2¾x 8½	1126	40-44	3x½ R.E.	10-inch stakes
1	3 x 9	1128	44-52	1½x⅝ R.E.	12-inch stakes
2	1¼x 7	418	40-48	1¼x5/16	
2	1¼x 7	418	40-48	2x⅜	

prompt service to the consumer results from this and other simplifications.

A practical example of what standardization has already done is noticeably and forcefully seen in the comparison I am going to give you of two orders, each for a carload of wagons from the same merchant in Tennessee. The first order is dated November 1, 1913, and the second order is dated July 26, 1920. These orders furnish an excellent example of "before and after taking."

Notice that in the first order, the merchant specifies for thirty wagons of eighteen different varieties. The second order received from the same merchant in 1920 calls for thirty wagons and only four varieties.

Instead of the three months service on the first order the second order was shipped within ten days after receipt of order.

Now from the farmer's standpoint, when he purchased a wagon from this merchant in the case of the first order he probably got what the dealer had left to sell. In the case of the last thirty wagons the farmer bought a wagon specifying rated capacity. The wood stock, skeins and axles were made to stand up, under extreme conditions, with the load capacity branded on the rear axle.

There are still made dozens of different tire widths and thicknesses. The farmer himself, in the past three years, has very largely eliminated the old popular narrow tires, that is, 1½-inch and 1¾-inch widths. However, in some cases there is still a demand for them, and a decided stand should be taken by all parties interested in standardization to eliminate at least the narrow tires that are detrimental to road surfaces.

Order No. 2. (Carload of Farm Wagons)

________________ July 26, 1921,
________________,Tenn. Order No.________
Via________________ For shipment at once

Amount	Factory Number	Capacity in Pounds	Size	Height of Wheels	Size of Tire	Weight
7	No. 329-A	4500	Standard	40-44	3x⅝	1182
11	No. 327-A	3000	Medium South	40-44	3x½	1230
7	No. 323-A	1500	Light	40-44	2x½	935
5	No. 511-A	800	Light One-horse	40-44	2x⅜	485

Our first object then should be to recommend the tire schedule for farm wagons that will not only prevent the injury to the road surface, but aid in preserving it.

Your Society is cooperating with the wagon manufacturers, and I think it appreciates the fact that is so important to all manufacturers, that is, that no schedule of standardization or simplification can be successful unless it takes into full account the interests of the farmer, whose interest in the final analysis must be of first importance.

The manufacturer, distributor and merchant are vitally interested in further simplification of varieties, because it spells for all parties more prompt service, reduction of stocks, better articles for less money, and a vehicle that is suited to the actual load and road conditions versus the old method of catering to every individual's whims and ideas.

In order that we may arrive at still more concrete results, as a representative of the wagon industry I am going to ask your convention to O.K. by resolution and in spirt the following:

(Let me say first that the tire schedule submitted has been approved several times by the wagon manufacturers in convention, and differs only in one small instance from the scientific investigations of tire widths and road surfaces conducted by the bureau of public roads of the United States Department of Agriculture. This one variation comes under the standard wagon.)

"We recommend and sanction the following schedule of tire widths for farm wagons, thickness to be governed by topographical conditions:

	Maximum capacity	Tire width
One-horse wagon	1500 lbs.	Not less than 2", alternate 3"
Light two-horse wagon	2500 lbs.	Not less than 2", alternate 3"
Medium two-horse wagon	3000 lbs.	Not less than 3"
Standard two-horse wagon	4500 lbs.	Not less than 3", alternate 4"
Heavy two-horse wagon	6000 lbs.	Not less than 4", alternate 5"

"That the carrying capacity of all farm wagons and trucks should be plainly branded on the rear axle, to the end that the purchaser will clearly understand the carrying capacity as guaranteed by the manufacturer. That we approve and sanction as economically sound the single standard of track for all horse-drawn vehicles, that is, the automobile track, 56 inches, center to center of tire on the ground.

"That we voice approval of such further standardization and elimination of varieties as will tend to better service and more effective vehicle transportation based upon the continued improvements in road conditions."

Finally, gentlemen, you may be assured that the wagon manufacturer of today is willing and anxious to cooperate along sound economic lines, realizing that standardization in all lines of industry will result in greater production, increased quality and a reduction of the price to the consumer.

TRACTOR TESTING IN NEBRASKA

By Oscar W. Sjogren

Mem. A. S. A. E. Head of the Department of Agricultural Engineering, University of Nebraska

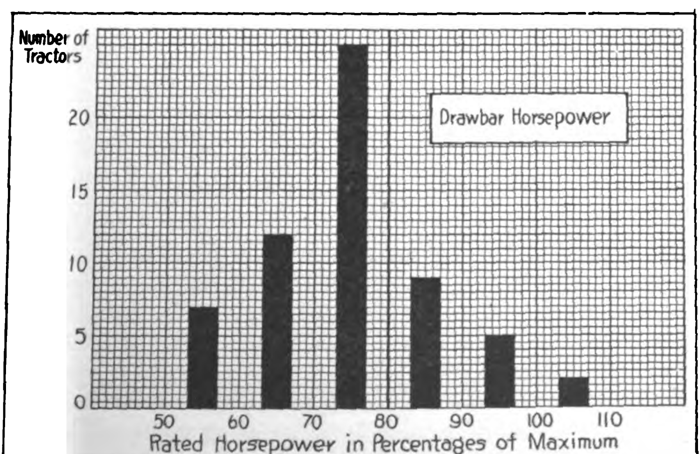
IN PREPARING the outline for this paper I pondered whether or not to go very extensively into the history of the events leading up to the passage of the tractor testing law in the 1919 session of the Nebraska Legislature. I decided that you would be more interested in the results obtained than in the history of the law, therefore I shall not touch upon the passage of the law except very briefly and shall take up in more detail the carrying out of the work under the provisions of the law and the results obtained to date.

The Nebraska Legislature was composed to a considerable extent of farmer members some of whom had purchased tractors that would not stand up or give them more than a few hours' service. The bill was introduced by such a man in the lower house and was followed through the senate by a farmer member who was a large tractor user. To my knowledge there was no effort to block the passage of the law in either house and it is my recollection that it passed practically unanimously. I shall not give you the full text of the law at this time, but if any are interested I can supply you with copies of it. Briefly the provisions are (1) that stock tractor of each model sold in the state be tested and passed upon by a board of three engineers in the employ of the state university; (2) that each company, dealer, or individual who offers a tractor for sale in Nebraska must have a permit issued by the state railway commission, the permit to be issued after a stock model of that tractor has been tested at the university and the performance of the tractor compared with the claims made for it by the manufacturer; (3) that a service station with a full supply of replacement parts for any model of tractor, sold in the state, shall be maintained within the confines of the state and within reasonable shipping distance of customers; (4) and that the enforcing of the provisions of this law shall be placed in the hands of the state railway commission.

No provision was made in the law for financing of the work and as a consequence the funds of the University were drawn upon for the expenses connected with the work which were not at all meagre. Farmers of our state consider this money to be well expended as is indicated by letters and remarks which we have from our people over the state that the reports of the test which they have received or requested have saved them considerable money, in some instances $200 or $300 per farmer. Considering that we have 15,000 tractors in the state and in the next few years fully that many tractors will be sold, it can very well be imagined that an enormous sum will be saved to Nebraska tractor users alone by the operation of the law and issuing of the reports. The reports, however, are not limited to the farmers of Nebraska but are available to farmers of the entire country, and I might say the entire world. Requests have been received from several foreign countries for the reports. As we were anxious to know whether or not the reports were in such form as to be interpreted by the farmers of the state, we sent out a questionnaire to those who had received the reports and every letter that has come back without exception states that the reports have been very valuable and have given splendid information.

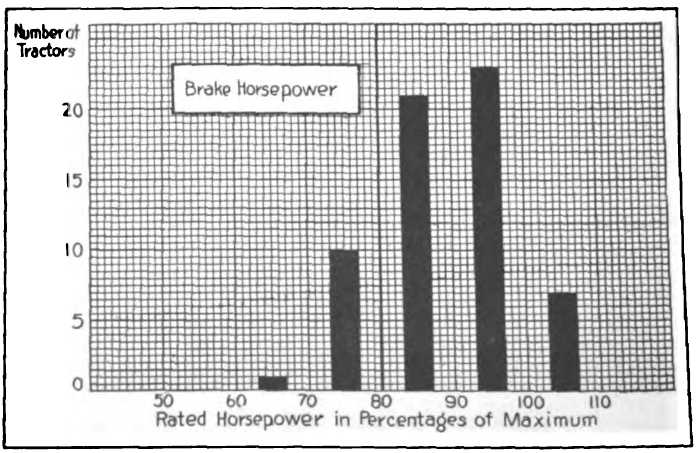
The organization for carrying out the work consists of three members of the department of agricultural engineering, at the University, as a board of tractor test engineers, the members being chosen from that department because of the fact that it has the supervision of the tractor work of the institution and it was thought that the members of that department were most familiar with the tractor situation. A manager of tractor tests was engaged to take active charge of the work and to carry out the details of it. For this position Prof. C. K. Shedd who is well known to most of you was secured and through him is due in no small way the successful carrying out of the work, as he organized the whole and brought it into successful operation.

A large number of meetings were held and rules adopted for carrying out details of the test. Equipment had to be designed and built. The provision as stated in Section 3 of



Drawbar rating practice as shown by Nebraska tests the Nebraska tractor law that the official tests of the University must be compared by representations of the tractor company as to horsepower rating for not less than ten consecutive hours continuous load, fuel used for developing such horsepower, and any other representation such company shall make, presented a problem not heretofore encountered in my tractor testing work. The thought of securing enough land to plow with the tractors which would appear was considered as impossible for several reasons, some being the impossibility of testing tractors under anywhere near approximate uniform conditions of soil and climate through any extended period of time, the impossibility of securing the amount of land necessary, and the large force of men and equipment which would be necessary to carry out this work at such times as land would be available. It was therefore decided to carry out the drawbar testing work on a cinder track using a specially designed dynamometer car for measuring the pull and recording the same for the drawbar horsepower computations. The cinder track was adopted because it was thought that it would be nearer to stubble field conditions under which the tractors operate mostly in our state. It has also thought that cinders would allow of rapid drainage and drying off after a rain, enabling us to get on to the track in the shortest possible time. It was found that this assumption on our part held fairly true, though at times the condition of the track was not what we wished it to be.

The equipment necessary for carrying out the belt tests made it necessary to secure some building where the same could be housed and where testing could be carried out during



Belt power rating practice as brought out in tests inclement weather. There was no building upon the campus suited for such a purpose and it was therefore decided to build a special building to house the belt dynamometer and appliances such as fuel and tools, and offices of the tractor testing force. This building as constructed is 41 feet in width, and 82 feet in length with a 14-foot ceiling. Some mention of the arrangement of this building may not be out of place. The outside walls of the testing shed in which the tractors are housed during the test contain approximately 2340 square feet of wall space. Of this area 294 square feet consists of windows and 232 square feet of door space. This makes a total of 526 square feet of window and door openings, or more than 22 per cent of the wall space, besides this two ventilators in which exhaust fans are installed, are placed in the ceiling above this tractor shed. A Sprague electric dynamometer is housed in a separate room at one end of the shed.

The Sprague dynamometer was decided upon for the belt tests rather than a Prony brake as it was thought that an electric dynamometer would stand up and be more satisfactory under the continued heavy usage to which it would be subjected. Scales were obtained for the weighing of the fuel and a scale stand constructed which would permit the placing of the fuel tank on the scales at the same height as the fuel tank of the tractor insuring the proper pressure upon the carburetor.

Speed counters were secured and rebuilt. A brief description of the speed counter used may not be out of place here as it gave us splendid results and enabled us to get very accurate readings of speed at both ends of the belt, that is, at both the dynamometer and tractor ends at exactly the same instant so that the belt slippage could be closely checked. Electrical connections are so arranged that when the speed counter is applied to the engine shaft and placed in operation electric contact is made throwing in the clutch of the speed counter at the dynamometer and so that the two operate simultaneously. When the counter at the engine is withdrawn the contact is broken and the clutch released. This eliminates personal error, and the speed can be accurately checked. This was used for the inside testing work. Engine speed was checked on the outside testing work by the use of tachometers, and the rate of travel of the tractor was checked by timing it between stations set definite distances apart.

Securing equipment for the outside drawbar testing work presented a very serious problem which we finally solved by the designing and equipping of a specially built dynamometer car or loading machine. This was constructed of a tractor chassis, from which the engine had been taken and in its the Nebraska tractor law that the official tests of the University must be compared by representations of the tractor company as to horsepower rating for not less than ten consecutive hours continuous load, fuel used for developing such horsepower, and any other representation such company shall make, presented a problem not heretofore encountered in my tractor testing work. The thought of securing enough land to plow with the tractors which would appear was considered as impossible for several reasons, some being the impossibility of testing tractors under anywhere near approximate uniform conditions of soil and climate through any extended period of time, the impossibility of securing the amount of land necessary, and the large force of men and equipment which would be necessary to carry out this work at such times as land would be available. It was therefore decided to carry out the drawbar testing work on a cinder track using a specially designed dynamometer car for measuring the pull and recording the same for the drawbar horsepower computations. The cinder track was adopted because it was thought that it would be nearer to stubble field conditions under which the tractors operate mostly in our state. It has also thought that cinders would allow of rapid drainage and drying off after a rain, enabling us to get on to the track in the shortest possible time. It was found that this assumption on our part held fairly true, though at times the condition of the track was not what we wished it to be.

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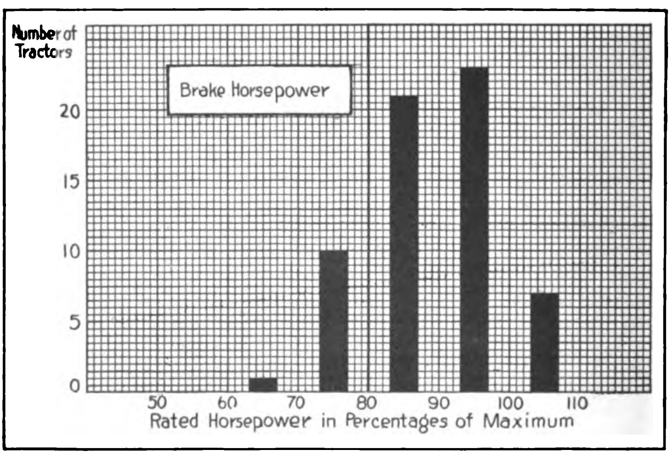

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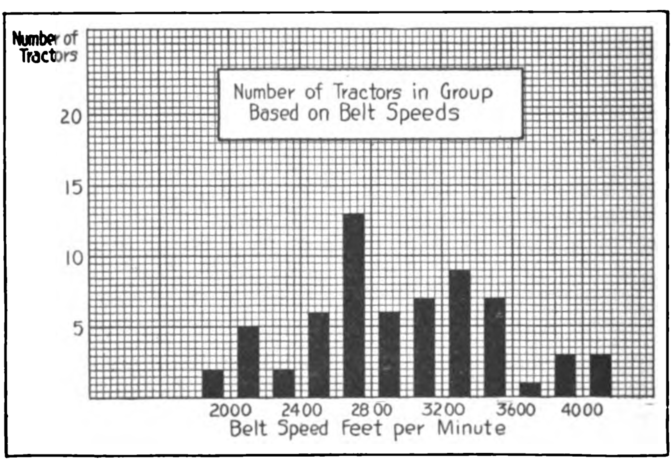
The outline of tests and the order thereof as adopted by the tractor testing board is as follows: (a) Drawbar work from one-third to full load for 12 hours, this test being for the purpose of limbering up; (b) brake horsepower at rated



Range and distribution in belt speed of tractors load and rated speed for two hours, the purpose of this test being to show whether or not the tractor will carry its rated load on the belt, also to show fuel consumption at rated load; (c) brake horsepower test at loads varying from maximum to no load with all engine adjustments as in test (b) for one hour, the object being to show fuel consumption and speed control on varying loads; (d) brake horsepower test at maximum load for one hour, with governor set to give full opening of fuel valve and carbüretor adjusted to give maximum power the object being to show maximum horsepower and behavior of the tractor on the belt and its fuel consumption; (e) brake horsepower test at one-half load for one hour with governor set as in test (b) and carburetor adjusted for most economical operation at one-half load, to show fuel consumption at one-half load; (f) drawbar horsepower test at rated load for ten hours, this test being made on a half-mile cinder track to show whether or not a tractor will carry its rated drawbar load continuously and also to show fuel consumption on drawbar work; (g) maximum drawbar horsepower test, which consisted of a series of short runs with an increase of load for each run until the engine is overloaded or the drivewheels slip excessively; (h) miscellaneous, which may include investigation of work on inclines, turning radius, effectiveness of brakes, or any other feature of the tractor which may require special observation, and (i) tractor is under observation for endurance throughout the complete test as above outlined.

The tractor manufacturer was requested to furnish an ample number of operators for his tractors while being tested. The manufacturer's operator was in charge of the tractor during the limbering up run. This was permitted in order to be sure that the tractor was properly worked in and also to give the university operator an opportunity to become familiar with the machine so that he could properly take it over during the test following the limbering up run. The manufacturer was requested to keep his operator present during the entire test, but he could not make any adjustments or changes except first having permission from the engineer in charge. This order of procedure was carried out throughout the test and was found to work very satisfactorily.

One hundred and three applications for testing tractors were received for the season. Of these sixty-eight appeared for test and thirty-five had their applications cancelled and temporary permits withdrawn. Of the sixty-eight which appeared for test thirty-nine went through without any changes while twenty-nine made changes as follows: four changed their rating, seven failed to make their rating, six changed the rated engine speed, eleven changed some item of equipment, and three withdrew after being on the preliminary test. Of the eleven which changed equipment, two also changed their rating. One of those which withdrew later made a reapplication and appeared and finished the test. These results in themselves I believe speak very loudly for the necessity of a method of testing and rating of tractors as has been carried out under the provisions of this law. These tractors have all been tested under conditions as nearly uniform as it is possible to obtain them by a competent force of men who have been unbiased and unprejudiced.

It may be interesting to compare the performance of the large number of tractors tested and note how nearly they conformed to the recommended standards of the American Society of Agricultural Engineers and the Society of Automotive Engineers. The standards as to horsepower ratings read as follows: "The drawbar rating shall be 80 per cent of the horsepower that the tractor is guaranteed to develop at the drawbar continuously for two hours, the tractor being in good condition and properly operated at rated engine speed. The test should be taken on ground particularly firm to give the tractor a good footing, a firm sod being preferable." "The belt horsepower rating shall be 80 per cent of the horsepower the engine is guaranteed to deliver at the belt pulley continuously for two hours the tractor being in good condition and properly operated at rated engine speed." In this discussion we have the records of sixty-five models and sizes of tractors. The figures from the results show some interesting revelations. The results of the maximum belt horsepower tests are used as 100 per cent and the manufacturers rating is shown in percentages of the maximum power developed continuously for one hour, and shows how nearly this conforms to the 80 per cent standards.

RATED BELT HORSEPOWER IN PERCENTAGES OF MAXIMUM

	60-70%	70.1-80%	80.1-90%	90.1-100%	Above 100%
Number of Tractors.	1	10	21	23	7

Three tractors were not rated. Thus it is seen that only eleven machines fall within the set standard, while fifty-one machines carry a rating higher than permitted by the standard.

On the drawbar work it was found that except in two instances no difficulty was had in securing the rated drawbar horsepower if the rated belt horsepower was developed. The maximum drawbar horsepower was not carried through any extended period but the rated load was carried for ten hours. The same method of figuring is used here as in the case of belted horsepower.

RATED DRAWBAR HORSEPOWER IN PERCENTAGES OF MAXIMUM

	50-60%	60.1-70%	70.1-80%	80.1-90%	90.1-100%	Above 100%
Number of tractors.	7	12	25	9	5	2

(Five tractors had no drawbar rating)

Thus it is seen that forty-five tractors fall within the standards set for the drawbar rating as compared to only seven falling in this class on the belt tests. Seventeen carry a rating higher than the standard, two of these being rated at more than they can actually develop.

Much has been said about rating tractors based on volmetric displacement and the following figures have been compiled from the results and are all based on the maximum belt horsepower maintained at rated speed for one hour. Of the sixty-five tractors the lowest piston displacement is 9420 cubic inches while the highest is 18,720, the next to the highest being 16,730. The weighted average for all tractors tested is 12, 376 cubic inches. The tractors were divided into classes based on types and numbers of cylinders with the following results:

2 cylinder	horizontal	(10 tractors)	10,950 cu. in.
4 "	"	(10 ")	11,520 " "
4 "	vertical	(42 ")	12,950 " "
6 "	"	(2 ")	13,868 " "
1 "	"	(1 ")	18,720 " "

A classification as to bore of cylinder gives the following:

Bore of cylinder in inches		
3 to 4	13 tractors	13,400 cu. in. displacement
4⅛ to 5	28 tractors	13,240 cu. in. displacement
5⅛ to 6	9 tractors	11,440 cu. in. displacement
6⅛ to 7	8 tractors	11,630 cu. in. displacement
above 7	7 tractors	11,390 cu. in. displacement

BELT SPEED

A very great variation exists in the belt speeds, in feet per minute, of the different tractors as indicated by the following:

Less than 2000 ft.	2 tractors
2000-2199	5 "
2200-2399	2 "
2400-2599	6 "
2600-2799	13 "
2800-2999	6 "
3000-3199	7 "
3200-3399	9 "
3400-3599	7 "
3600-3799	1 "
3800-3999	3 "
Above 4000	3 "

The figures obtained in the test permit analyzing the problem in still greater detail from different angles but I believe that those presented herewith are sufficient to indicate that the work has at least brought out some data upon which no comparative figures have been available and I will leave it to you to determine whether or not this work which has been done at a great expenditure of time, money and effort, is really worth while.

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2	cylinder	horizontal	(10 tractors)	10,950 cu. in.
4	"	"	(10 ")	11,520 " "
4	"	vertical	(42 ")	12,950 " "
6	"	"	(2 ")	13,868 " "
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3400-3599	7 "
3600-3799	1 "
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REPORT OF THE STANDARDS COMMITTEE

THE interest aroused during the year in the standardization of farm equipment is unprecedented in the history of the industry. The demand for standardization is constantly increasing; it is a fact also that at the present time this demand comes largely from the manufacturers, and least of all from those who obviously need it the most—the farmers. This greater interest apparent the past year is unquestionably due for the most part to the coming into existence of the Agricultural Equipment Standards Committee, which was created during the latter part of 1919 by a joint committee representing the American Society of Agricultural Engineers and the National Implement and Vehicle Association, officially, and the Society of Automotive Engineers, unofficially, to coordinate the farm-equipment standards work of all engineering and commercial organizations, to avoid duplication of standards, and to encourage and foster the development of new standards.

The activities of the standards committee for the year have been confined largely to getting new work on standardization under way. The process of getting standards developed to the point of final adoption is at present necessarily a slow one, on account of the comparative newness of the work and the comparatively recent establishment of the cooperative arrangement with the National Implement and Vehicle Association mentioned in the preceding paragraph. With certain changes in the constitution and by-laws of this society, which will be included as a part of the recommendations of this report, it is anticipated that such provision will result in more effective organization and functioning of the standards committee and will facilitate the consideration and adoption of standards by the society as a whole.

For the purpose of this report the present status of standards work will be divided into three parts: (1) Standards now ready for final adoption by the society (2) standards in process of development, and (3) standards work in contemplation. It should perhaps be explained at this point that there is indeed no prospect of the standards committee getting out of a job, at least for many years to come; the manufacturers are making urgent demands on the committee to develop standards of all sorts, and it is with the idea in mind of speeding up the work that the recommendations of this report are made.

I. PROPOSED STANDARDS READY FOR FINAL ADOPTION

1. Standard belt speeds, in which it is proposed to include five standard speeds—1500, 2600, 3000, 3250, and 3500 feet per minute.

2. Standard tractor and plow hitches, which include height of vertical hitch on tractor and lateral adjustment for plows of two, three, and four bottoms.

3. Farm wagon standards, including the standard automobile track of fifty-six inches and tire widths for wagons of various capacity ratings.

II. STANDARDS IN PROCESS OF DEVELOPMENT

1. A standard code for testing and rating the belt and drawbar power of tractors.

2. A standard manger form for dairy barns.

3. Standard rating for litter carrier capacities and dimensions.

4. Standard rating for capacities and power requirements of ensilage cutters.

5. Consideration of the standardization and elimination schedules of the National Implement and Vehicle Association with the view to approving those schedules and to making further recommendations for definite standards. Work is already under way in connection with the left-hand plow and the disk harrow blades schedules.

III. STANDARDS WORK IN CONTEMPLATION

1. Standard specifications of farm equipment steels.
2. Spraying machinery standards.
3. Standardization of lug equipment for tractors.
4. Standard code for rating the capacity and power requirements of grain threshers.
5. Standardization of sizes of tubing for stall and pen frames, pen fillers, gates, etc., in dairy-barn equipment.
6. Standardization as affecting ventilating equipment of farm buildings.
7. Nomenclature for farm equipment.
8. Standard width of rows of intertilled crops as affecting drills and cultivators.
9. Specifications for belting.
10. Lumber, oil and miscellaneous material specifications.
11. Disk harrow blades—diameter, thickness, curvature, punching and materials.
12. Rolling coulters—diameter, punching and materials.
13. Standardization as affecting plow bolts.
14. Standard rating for manure spreaders.
15. Standardization of fence posts, wire fencing, fence wire and bale ties.

The preceding list of proposed standards by no means includes everything in the way of standardization activities contemplated by the standards committee; it merely outlines some of the more important things that should have the attention of the committee as soon as it is possible to get to them. A list of things that could be standardized to the advantage of all concerned—manufacturer, dealer, and farmer—to be complete would indeed be a long one; its name is Legion.

In making recommendations for changes in the constitution and by-laws of the society, the standards committee would recommend first of all a complete recasting of the constitution and by-laws along the lines of some of the older engineering societies. Especially would we recommend such changes as would result in greater activity of the council in the government of the society and the conduct of its affairs.

As affecting the effectiveness and functioning of the standards committee and adoption of proposed standards by the society as a whole, we make the following recommendations:

1. At present the constitution provides for standing committees as follows: Research, standards, data, drainage, irrigation, farm sanitation, farm structures, farm building equipment, farm power, farm power machinery, farm field machinery, roads and manufacture of agricultural products. Our recommendation is that these thirteen committees be reduced to two—standards and research, provision to be made as required for sub-committees or divisions of these to committees, the scope of which will include everything comprehended in the activities of the eleven other committees. The organization of the standards committee on the basis of several sub-committees of which the chairman, at least, of these sub-committees shall be members of the general standards committee, will have the following advantages: (1) It will make possible better coordination of standards work; (2) it will result in the appointment of men best fitted to undertake particular lines of standard work as chairman of the various subcommittees; (3) it will delegate responsibility for getting results to a larger number of individuals; (4) it will give the chairman of the general committee more time for matters of organization, planning, coordination, etc., of the work of the committee as a whole; and (5) it will permit of undertaking a larger volume of standardization work at one time, that is, of getting a greater number of investigations of proposed standards under way.

2. As at present provided for in our constitution it requires from one to two years for the final adoption of a standard. While this provision has its advantages in some respects, it does seriously hamper the cooperation of this society with the other organizations represented on the Agricultural Equipment Standards Committee in so far as the final adoption of standards is concerned. We therefore recommend that the constitution at least be amended in such a way that our methods of adopting standards will not interfere with the activities of the Agricultural Equipment Standards Commit-

tee, and yet at the same time will avoid hasty action in adopting standards that have not proved their worth or practicability.

3. This committee further recommends that the constitution of this society provide for a constitution committee as one of its standing committees which will not only be empowered to revise or recast our present constitution, but will edit, revise, or formulate proposed amendments from time to time.

Respectfully submitted,
STANDARDS COMMITTEE
Raymond Olney, Chairman

K. J. T. Ekblaw	M. A. R. Kelley
Geo. W. Iverson	G. B. Gunlogson
O. W. Sjogren	F. M. White

THE DESIGN OF FARM ELEVATORS

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THE object of this report is to present information on the following points with reference to the design of farm elevators:

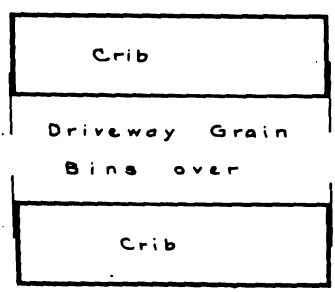
1. Some of the different types of buildings that have proven practical for storing ear corn and small grains.
2. The maximum depth and thickness ear corn may be piled without danger of spoiling under average conditions.
3. The percentage of air spaces or openings in corn crib walls.
4. The pressures exerted by ear corn and the small grains in confinement.
5. Methods of building out rodents.
6. Floor construction in cribs and granaries.
7. The various types of shelling trenches.
8. Schemes for ventilating cribs.
9. The usual precautions for preventing rain or snow from blowing into crib.
10. Location of the farm elevator.
11. Ways of drying out corn in crib.

The modern farm crib and granary is generally referred to as a farm elevator. The modern farm elevator is of comparatively recent design. Its development has been evolutionary in character and the various stages in its progress are marked by corresponding development in the methods of handling corn and grain. In the early days when grains were shovelled by hand from wagons the height of the bin or crib was naturally limited to the height a man could conveniently shovel. The old pioneer type of crib usually consisted of a simple shed roof structure standing by itself in some exposed position. When more storage room was required another crib was built alongside it with enough space between the two for a driveway and both were covered with the same roof. This driveway furnished the man who was unloading corn protection from the winds and storm which, in many cases, was badly needed as the farmer was often compelled to shovel off his load by lantern light after the evening chores were done and the evening meal was over. This sheltered driveway also provided a convenient place for housing vehicles and farm implements. With the advent of power-driven conveyors there occurred a radical change in the design of cribs and granaries. The height was no longer controlled by the height to which a man could shovel, therefore, cribs were built higher to obtain greater economy in construction. Bins for grain and cribs for corn were included under one roof so that one conveying system would serve to handle all of the farm grains, effecting further economy in construction.

Probably the most common plan for a farm elevator consists of a double crib with driveway between and with bins for small grain over the driveway. In the driveway is located the dump or pit and the legs and conveyors for elevating the corn and grain. The cribs are rectangular, semi-circular, or circular in form. Quite a number of types of farm elevators of different plans have been perfected. These include the following:

1. A circular structure with a crib for corn in the lower section and with storage for grain in the upper part.

2. A rectangular structure with two driveways and three cribs. (Fig. 2.) By this arrangement more corn and grain



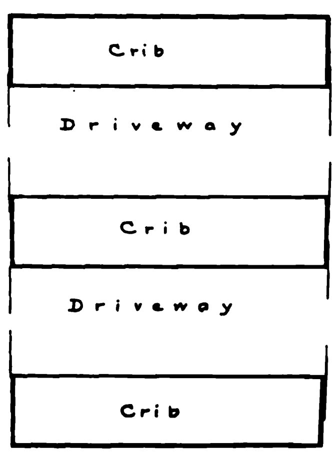


Fig. 1, at top and left. Plan and photograph of a common type of farm elevator

Fig. 2, right. Design giving greater capacity per unit can be handled by one conveyor system.

3. A cross-shaped structure with two driveways at right angles to each other. (Fig. 3.) This type of crib has little to commend it.

The circular form is especially suited to masonry struc-

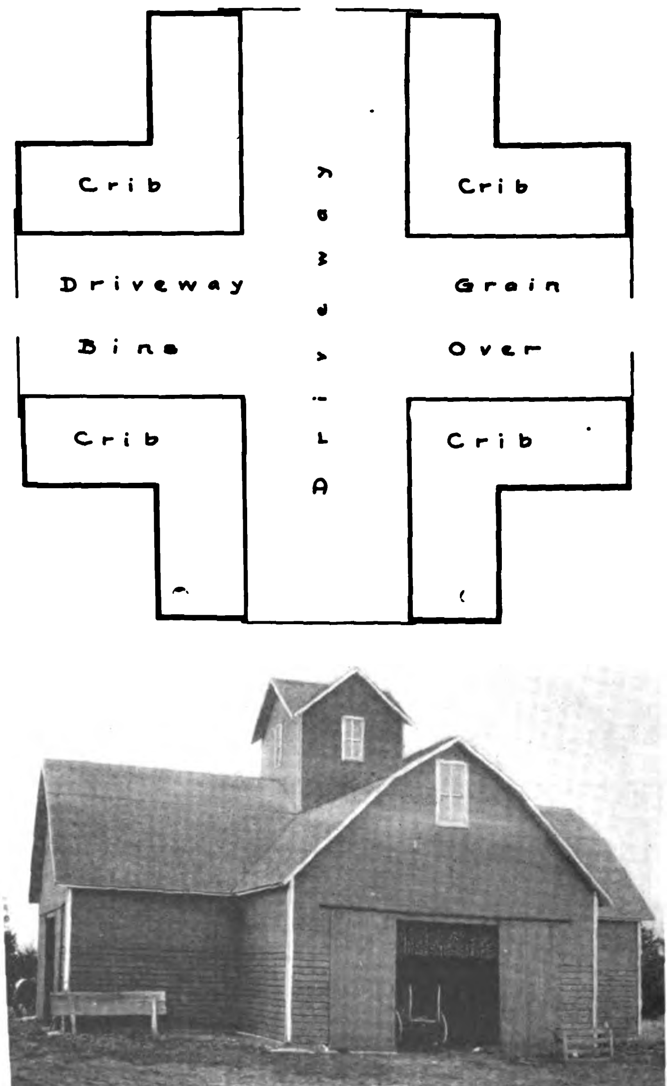


Fig. 3. Plan and photograph of a cross-shaped farm elevator having two driveways intersecting at right angles. The driveways occupy an excessive amount of space in proportion to storage capacity

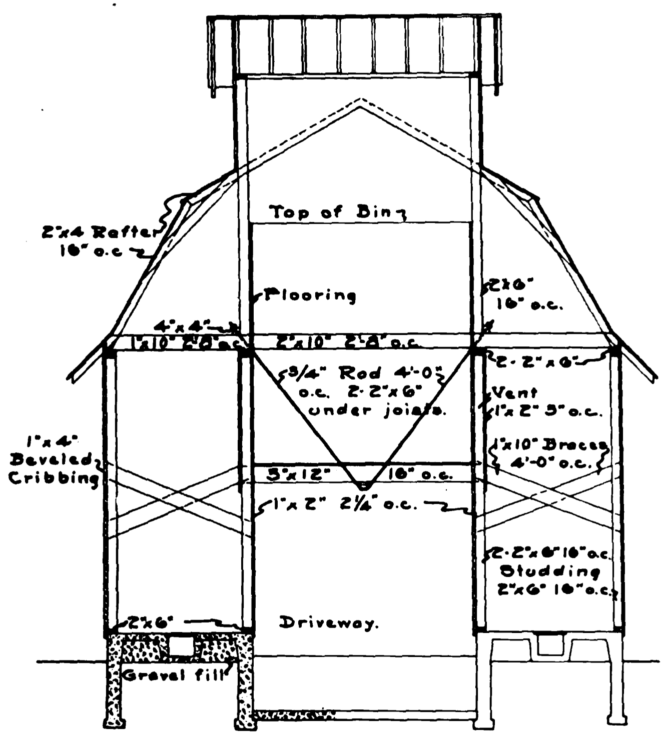


Fig. 4. Section of a modern frame farm elevator with double crib and grain bins over driveway

tures as this shape makes it easy to reinforce. There is also an economy of materials as a circular structure will enclose a greater volume for a given amount of wall space than any other form. Circular storages are used singly, in twos, or in groups or batteries.

A modern frame farm elevator is shown in section in Fig. 4. This section shows a crib 30 feet wide made up of double crib 8 feet 6 inches wide with a 13-foot driveway. A grain bin which may be made 14 feet deep (for oats) is placed over the driveway. The floor of this bin is partly supported by ¾-inch rods, spaced 4 feet apart, which runs to plate height at the sides of the bin. Studdings are two-by-six's spaced 16 inches on center. The bin walls are stiffened by tying across with two-by-ten's at plate line. The bin may be partitioned and made into smaller bins or room for grinder as desired.

The gable ends of this structure are strengthened by tying with a plate made of one 2x6-inch and one 2x12-inch member.

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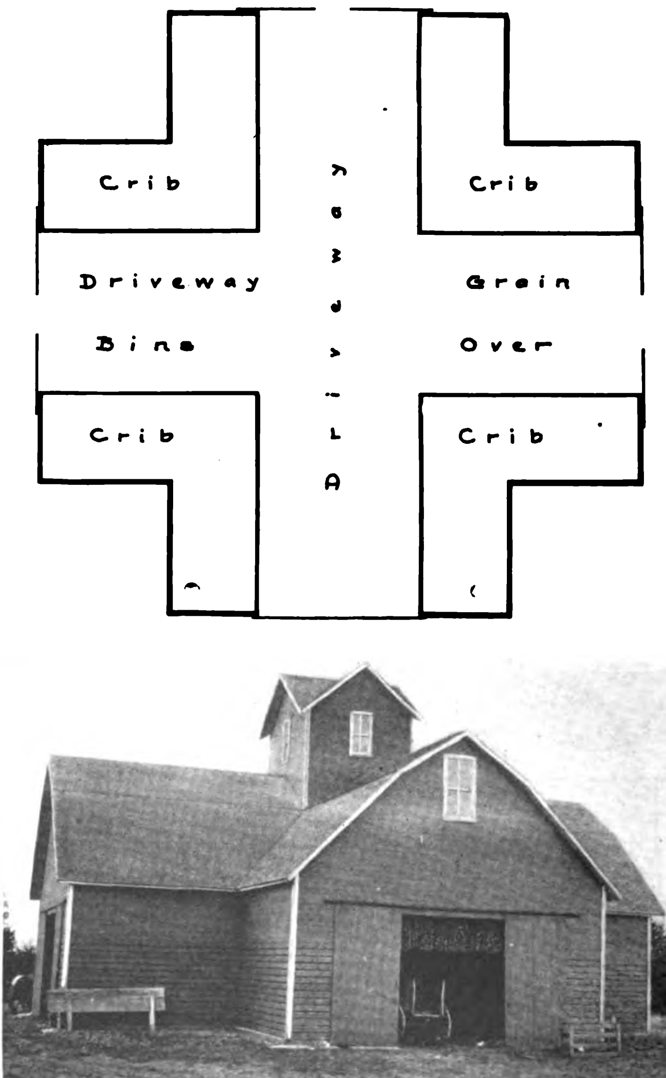

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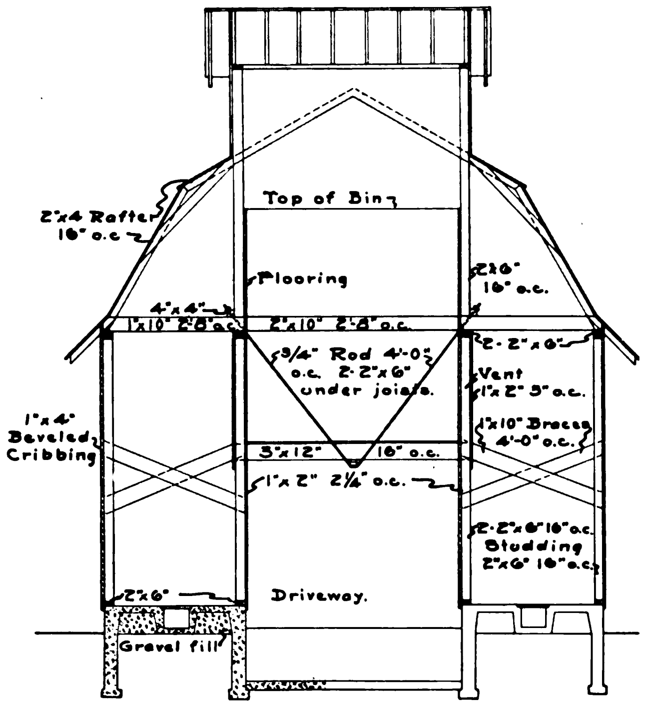

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The gable ends of this structure are strengthened by tying with a plate made of one 2x6-inch and one 2x12-inch member.

The studding from lintel over door or floor are 2x6 inches with two of these replaced by two-by-ten's. These two-by-ten's are spaced two studding spaces, or 2 feet 8 inches on each side of center. Two-by-four studding 16 inches on center are used above the plate.

The crib bins are 8 feet 6 inches wide with 2x6-inch studding 16 feet long. The side walls are tied together by means of 1x10-inch diagonal bracing spaced 4 feet on center placed about seven feet above floor which allows head room under.

Shelling trenches are shown which serve for sheller drag or a means of ventilating when necessary to dry soft corn. Ventilating flues are made next to the small grain bin by placing cribbing boards or lathe on crib side of studding.

One of the most recent developments in the masonry farm elevator is a structure made of concrete staves. (Fig. 5.) Staves used for this purpose are similar to those used in the erection of silos with the exception that each is provided with two openings for ventilation. These openings are each 4 inches wide and 9 inches long and have four ¼-inch rods embedded in the concrete in such a manner that they pass through both openings forming a grating for excluding rodents. The staves are 2½ inches thick, 30 inches long, and 10 inches wide. The cribs of this installation are semi-circular in plan, making this structure oblong in shape. Its dimensions are 20 feet by 30 feet 10 inches. A driveway 10 feet 8 inches wide runs through the center. Storage bins for grain are provided over the driveway. A bucket elevator conveys corn and grain to the cupola from whence it is distributed in the bin desired.

Steel hoops similar to those used on silos serve as reinforcement. The ends of the hoops are rigidly secured to the heavy reinforced concrete door jambs up to the top of the driveway doors. Above this point the rods are carried continuously around the structure. As the lateral pressure of small grain is greater than that of ear corn, additional reinforcement for the bins was provided in the form of steel channels and "I" beams. These are shown directly over the doorway in the illustration.

A five-pound channel on the outside wall is bolted to an "I" beam on the inside. Three such pairs are located on each bin wall over the driveway doors. As a further precaution against possible spreading, the channels on opposite sides of the structure are tied together with steel rods. The channels are also bolted firmly to the corner studs of the grain bin walls.

It was found on observing the width of cribs that the thickness of corn in the crib varied for different communities. It ranges from 5 feet to 9 feet 6 inches or over in width. In the eastern part of the Middle West, where smaller crib

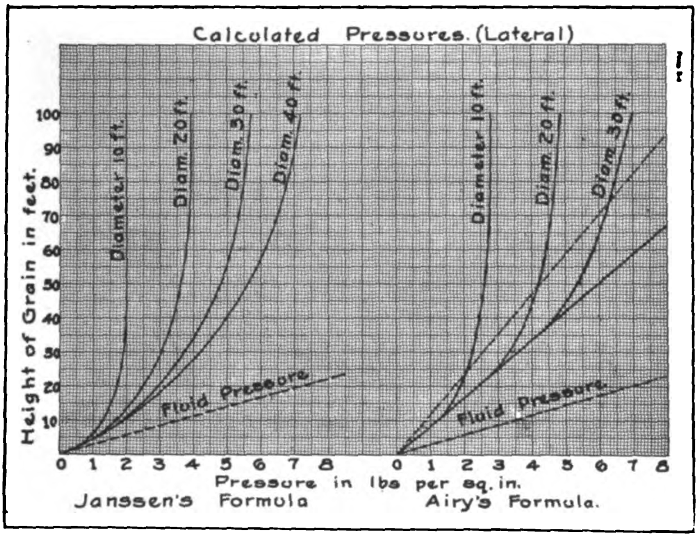


Fig. 6. Graphs of Janssen's and Airy's formulae

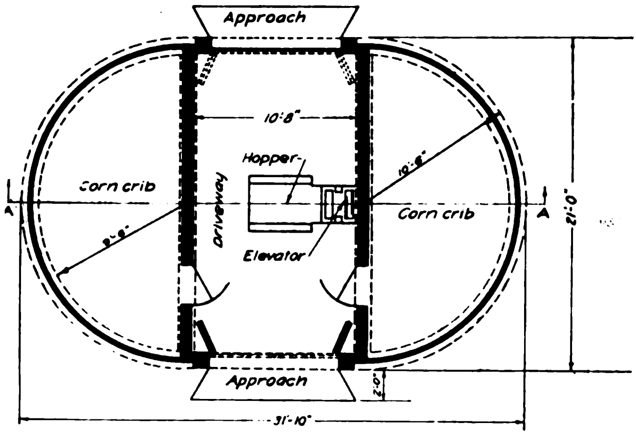
capacity is required, the width varies from 5 feet to 7 feet 6 inches, while the greater width is found in the corn belt. This greater width is satisfactory in a normal year. It is unsatisfactory, however, for soft corn and artificial heat or other means must be used to dry the corn.

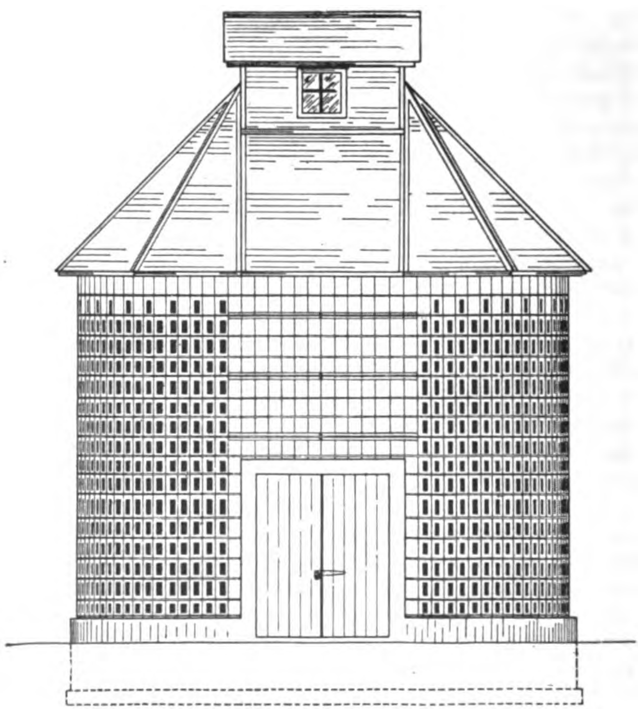
The openings in crib walls vary from 10 to 50 per cent or more. The old cribs built with outside covering with 1x10-inch or 1x12-inch vertical siding allowed very little air from the outside. In no case would the cracks between boards exceed ¼ inch. The driveway side of these cribs was enclosed by 1x2-inch or 1x3-inch strips spaced not over ⅜ inch apart. This spacing was usually about ¼ inch, or about 10 per cent.

The modern double cribs of the Middle West are enclosed with bevel cribbing usually 1x4-inch stock. This cribbing, with about 3¼-inch face, is spaced ¼ to 1 inch apart. Closer spacing of ½ to ⅝ inch may be made which will discourage rats. This would slightly reduce the percentage of openings but still give a greater percentage than found in the older cribs. In masonry cribs the amount of air space varies from 20 to 50 per cent of the wall area. In general, it is well to provide at least 20 per cent openings under average conditions.

Only a limited amount of data is available on the pressure of ear corn. A thesis "Lateral Pressures on Corn Crib" conducted by two senior students, V. W. McClung and Harry Hall, of the agricultural-engineering department at the Iowa State College, in 1916, gave as conclusions:

(1) "Ear corn represents more of a solid than a fluid or semi-fluid."





FRONT ELEVATION

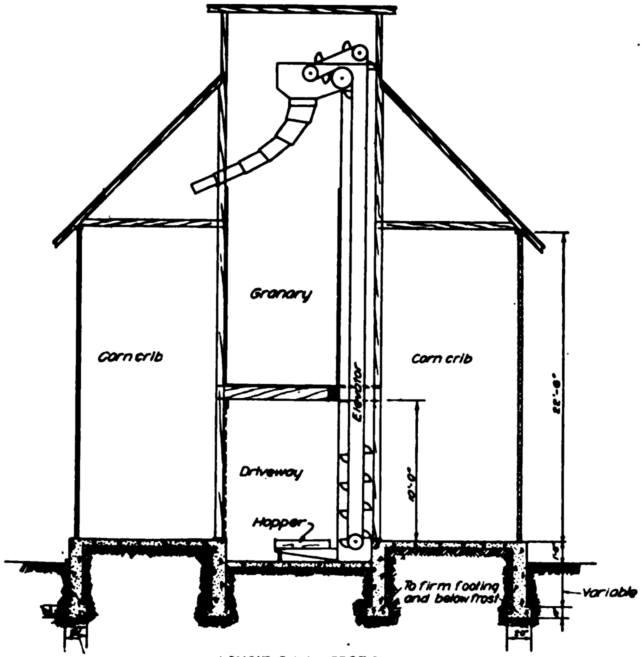
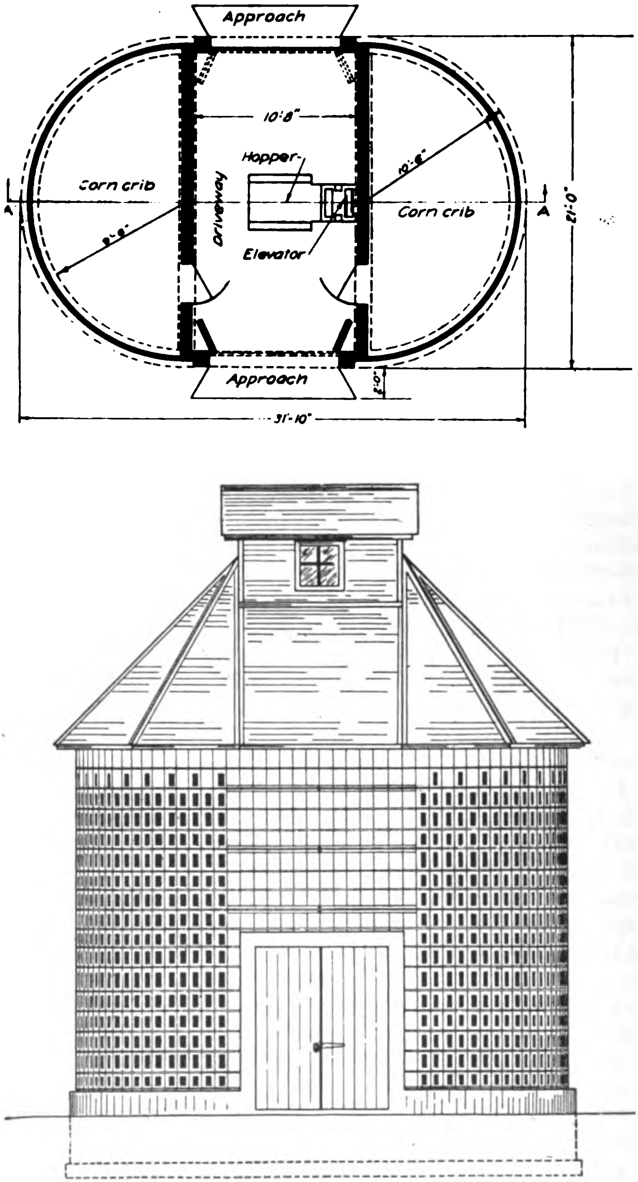


Fig. 5. A concrete stave farm elevator with semicircular cribs and bins for small grain over driveway



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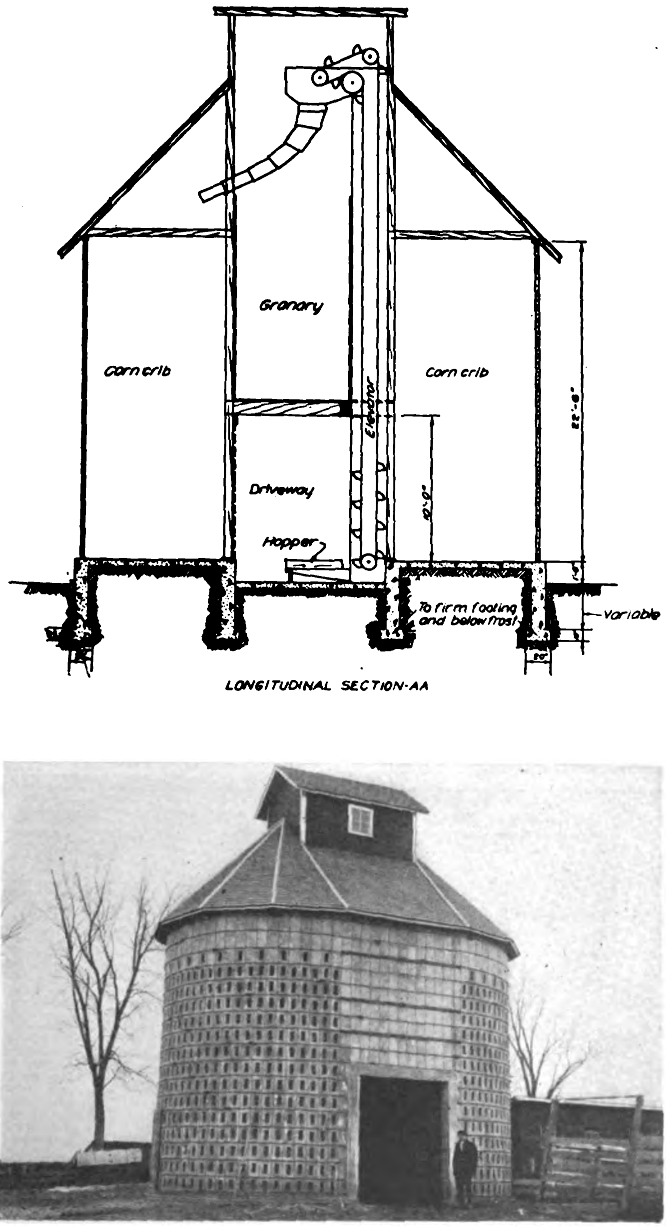

Fig. 5. A concrete stave farm elevator with semi-circular cribs and bins for small grain over driveway

(2) "Lateral pressure is about one-fifth of vertical pressure downward."

(3) "Corn tends to wedge together and hold it perpendicular, sort of locking rather than flowing as wheat or the smaller grains."

The crib on which observations were made was a lath stave fencing crib, 8 feet in diameter and 8 feet high.

It is doubtful if pressure due to ear corn in confinement exceeds 10 pounds per square foot per foot of depth. Cribs designed on this basis have not shown any indications of failure.

Several formulas have been developed for calculating the pressure in grain bins: (1) Janssen's Solution and (2) Airy's Solution. The results of these two methods agree very closely with experiments.

Since these formulas are lengthy and involve considerable calculation, they will be illustrated by graphs. The graphs of the two formulas—Janssen's and Airy's—are shown in Fig. 6 for lateral pressure for wheat. These agree closely in shape, the Janssen's formula pressures being less than those from Airy's calculations.

Some experiments have been conducted to verify these calculations. One conducted by J. A. Jamieson in 1900 on a full size bin in an elevator on the Canadian Pacific Railway, West St. John, North Dakota, is shown in the graph on the left in Fig. 7. The bin was of timber crib construction, 12 feet by 13 feet 6 inches in size and 67 feet 6 inches high. Manitoba wheat weighing 49.4 pounds per cubic foot was used. The calculated pressures from Janssen's formulas are

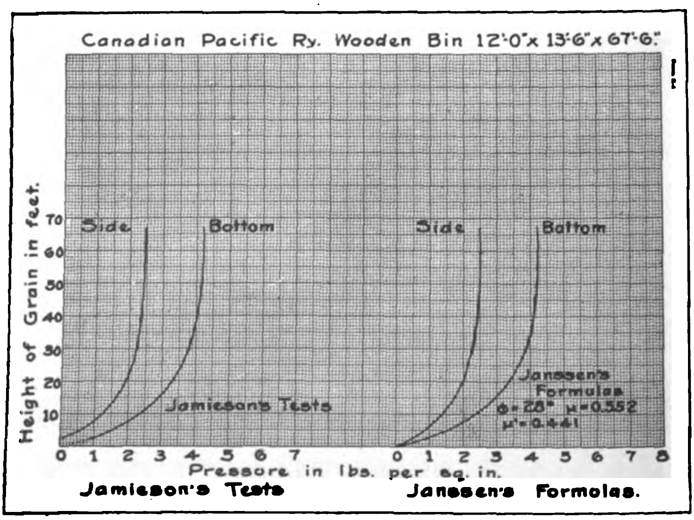

Fig. 7. Comparison of formula with test results

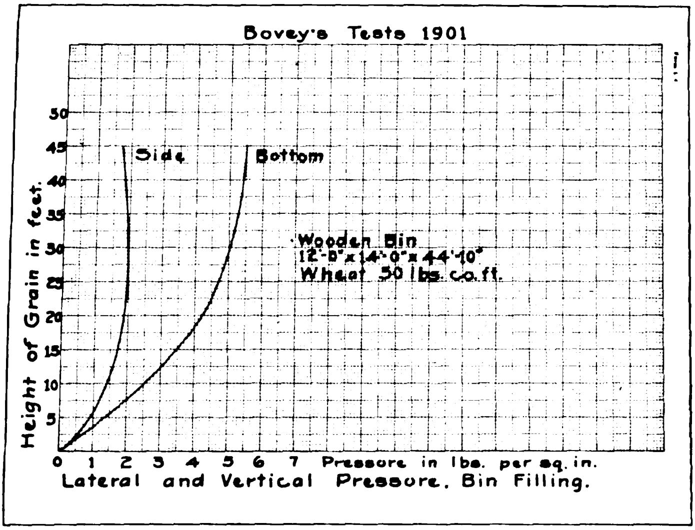

Fig. 8. Tests made as bin was being filled with wheat

shown on the right in the same figure. It is to be noted that the curves are identical in shape and are close in value.

The results of another test made on a bin while filling by Prof. Henry T. Bovey, McGill University, Montreal, in 1901 are shown by graphs in Fig. 8. This bin was of wood construction, 12 by 14 feet in size. The height above centers of diaphragms on which pressures were determined was 44 feet 10 inches.

A set of graphs showing the percentage of wheat carried by bin wall and floor is shown in Fig. 9. These graphs are the result of Jamieson's tests on a model wooden bin 12 feet by 12 feet by 6 feet 6 inches for wheat weighing 50 pounds per cubic foot.

Jamieson in further tests found that corn weighing 56 pounds per cubic foot will give approximately the same pressure as wheat. Peas weighing 50 pounds per cubic foot will give approximately 20 per cent greater pressure than wheat, while flaxseed weighing 41.5 pounds per cubic foot will give 10 to 12 per cent greater pressure than wheat.

Since a cubic foot of wheat is heavier than the other grains, except peas, a bin designed for wheat will safely carry all loads for shelled corn, and oats which are lighter. In designing bins for peas or beans add 20 per cent for strength of bin walls, and for flaxseed add 12 per cent.

The weights of a cubic foot of loosely filled grains in measures are as follows:

	Pounds
Wheat	49
Barley	39
Oats	28
Corn	44
Beans	46
Peas	50
Flaxseed	41
Tares	49

It is believed that all farm elevators which are designed with grain bins for the light-weight grains should have a safety line prominently painted on the inside of the bin and continuous around the wall for either wheat or shelled corn. A careful observance of this would prevent a large number of bin failures.

The following conclusions were drawn from the experiments mentioned in this section and others:

1. The pressure of grain on bin walls and bottoms follows a law (which for convenience will be called the law of "semi-fluids") which is entirely different from the law of the pressure of fluids.

2. The lateral pressure of grain on bin walls is less than the vertical pressure (0.3 to 0.6 of the vertical pressure, depending on the grain, etc.), and increases very little after a depth of 2½ to 3 times the width or diameter of the bin is reached.

3. The ratio of lateral to vertical pressures, k, is not a constant, but varies with different grains and bins. The

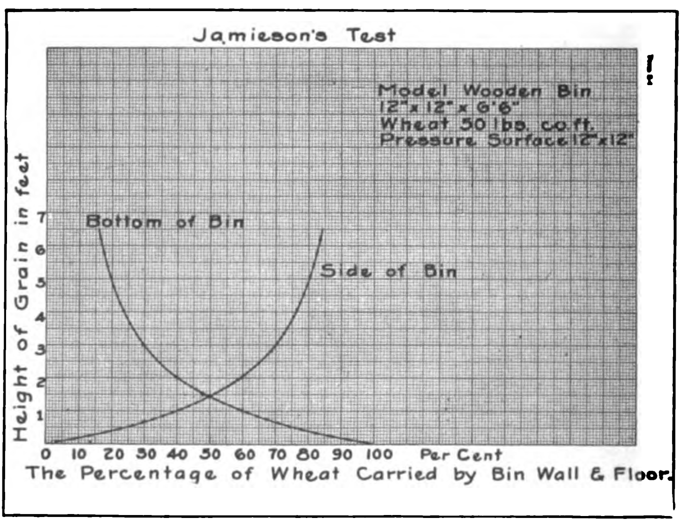

Fig. 9. Load carried by bottom and wall of wheat bin

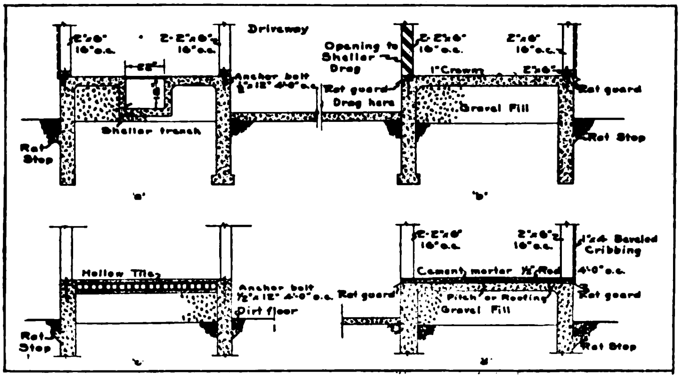

Fig. 10. Concrete floors and foundations for cribs

value of k can only be determined by experiment.

4. The pressure of moving grain is very slightly greater than the pressure of grain at rest, maximum variation for ordinary conditions being probably 10 per cent.

5. Discharge gates in bins should be located at or near the center of the bin.

6. If the discharge gates are located in the sides of the bins, the lateral pressure due to moving grain is decreased near the discharge gate and is materially increased on the side opposite the gate. (For common conditions this increased pressure may be two or four times the lateral pressure of grain at rest.)

7. Tie rods decrease the flow but do not materially affect the pressure.

8. The maximum lateral pressures occur immediately after filling and are slightly greater in a bin filled rapidly than in a bin filled slowly. Maximum lateral pressures occur in deep bins during filling.

9. The calculated pressures by either Janssen's or Airy's formulas agree very closely with actual pressures.

10. The unit pressures determined on small surfaces agree very closely with unit pressures on large surfaces.

11. Grain bins designed by the fluid theory are in many cases unsafe as no provision is made for the side walls to carry the weight of the grain, and the walls are crippled.

12. Calculation of the strength of wooden bins that have been in successful operation shows that the fluid theory is untenable, while steel bins designed according to the fluid theory have failed by crippling the side plates.

The information of this section (pressure of small grains) was secured from the book, "Design of Walls, Bins and Grain Elevators," by Milo S. Ketchum, second edition 1913.

The rodent menace costs the farmers and grain men in the

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It is believed that all farm elevators which are designed with grain bins for the light-weight grains should have a safety line prominently painted on the inside of the bin and continuous around the wall for either wheat or shelled corn. A careful observance of this would prevent a large number of bin failures.

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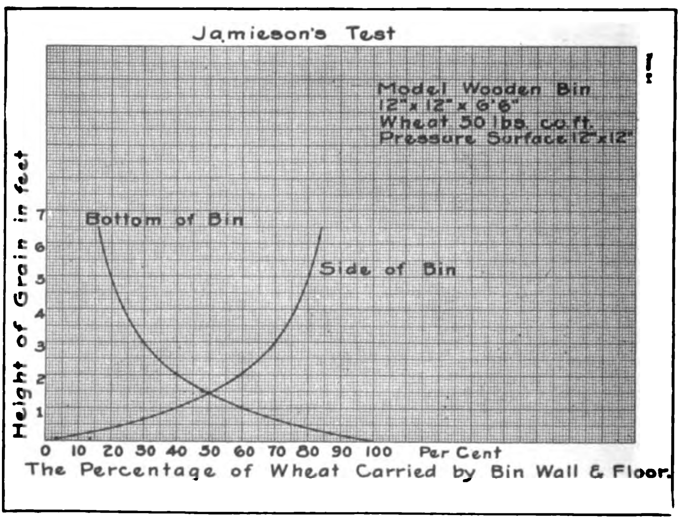
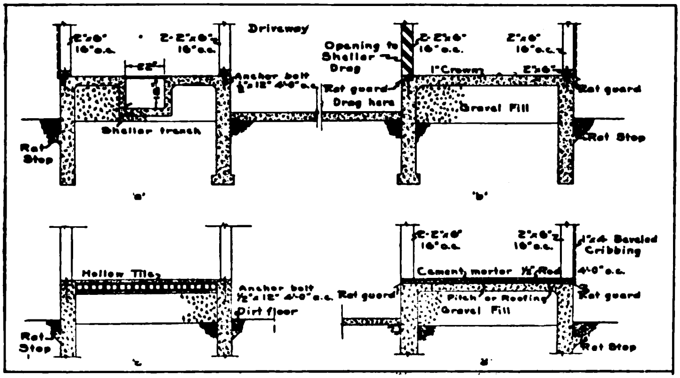


Fig. 9. Load carried by bottom and wall of wheat bin



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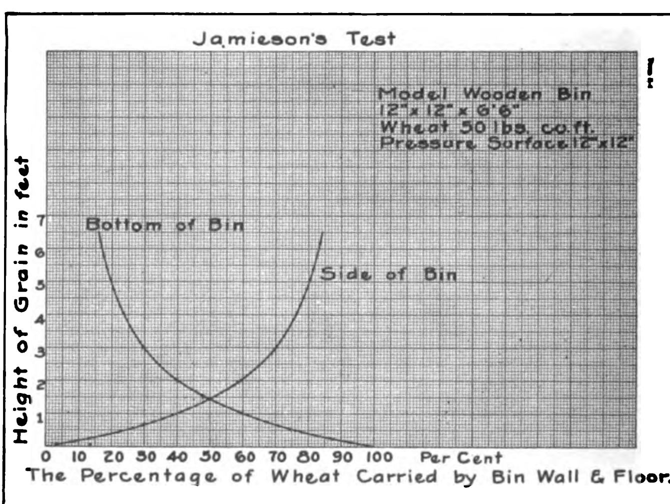

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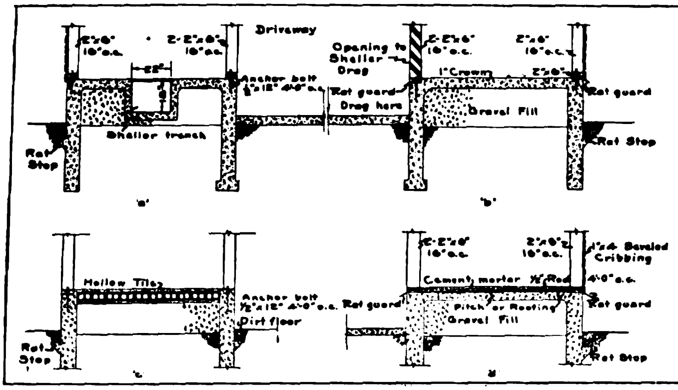

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The information of this section (pressure of small grains) was secured from the book, "Design of Walls, Bins and Grain Elevators," by Milo S. Ketchum, second edition 1913.

The rodent menace costs the farmers and grain men in the

United States millions of dollars each year. It has been estimated that each rat destroys from $2.00 to $4.00 worth of grain in a year and the rat population is assumed to be at least equal in numbers to the human population. This waste may be reduced by discouraging and building out these pests. This may be accomplished by using concrete for foundation walls and floors and placing the floor some distance—18 to 24 inches—above grade. Modern construction and the shelling trench have encouraged this height of floor above grade. This makes it more difficult for rodents to enter a crib because they must climb or jump up to enter.

Rat guards may be used to stop rodents from climbing. These are shown in Fig. 10 "b" and "d." A piece of galvanized sheet metal is set under the wall plate and extends outward and downward for three or four inches.

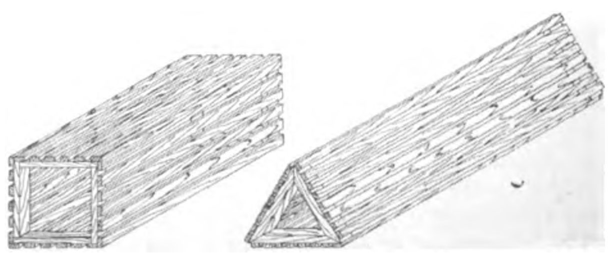
A further precaution against rats burrowing is made by extending a step footing or building a ledge of concrete 4 to 6 inches outward from the foundation wall. A rat in burrowing will become discouraged and give up when meeting an obstruction of this kind. (Fig. 10.)

The shelling trench should be screened with heavy hardware wire cloth which should be placed on a hinged frame that closely fits the opening. This door may be opened for access of cats or ferrets.

In the cement stave type of crib rats are kept out by the ¼-inch rods which run lengthwise through the openings. Some concrete block cribs have wire mesh embedded in the concrete which effectively prevents rats and mice from crawling in through the openings provided for ventilation.

While wood has been used for crib floors it is not permanent and will not stop rodents. The more permanent floor made from concrete is advised. This may be made with sheller trench as shown in "a," Fig. 10, or of solid concrete with fill under or a combination tile and concrete fill.

The floor construction for small overhead grain bins is



Figs. 11 and 12. Shafts and ducts for drying corn

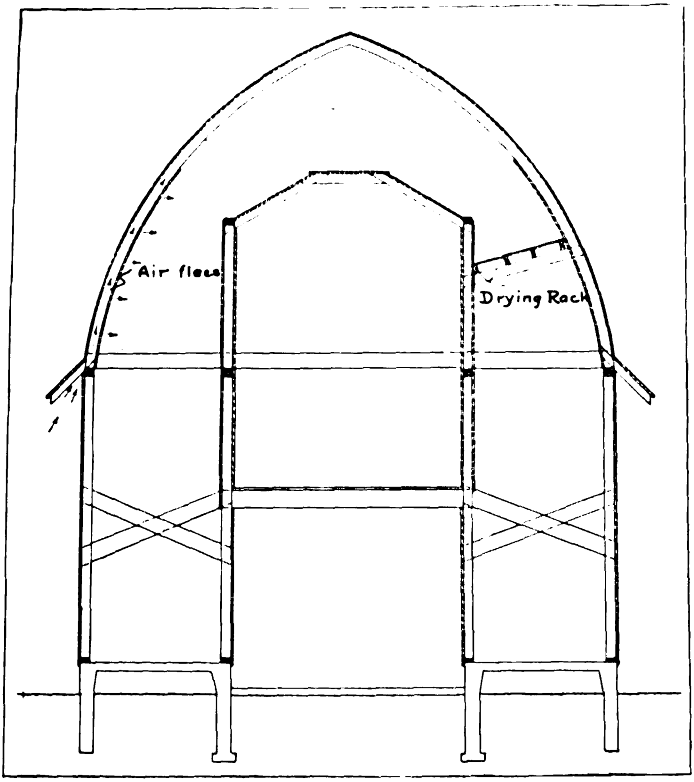


Fig. 13. Rack under roof for first drying of corn

made by using matched flooring over joists as shown in section Fig. 4.

The shelling trench may be made either as shown in "a" or "b" Fig. 10. The former consists of a rectangular or square trench extending from end to end of crib. It is large enough to receive the sheller drag. The depth is usually 18 inches with a width of 20 to 24 inches. The disadvantages are the difficulty in placing the drag in the trench and the harbor made for rats if not thoroughly guarded. A large part of the corn will fall directly into the trench. It also serves as a ventilating duct.

The provision for a drag along the inside of the crib as shown in "b" Fig. 10 is extensively used for shelling. The boards are removed from the outside. The drag may be moved from one crib to the other without resetting sheller. Furthermore, it may be used for removing ear corn for feeding purposes.

Its disadvantage is the difficulty of making it rat proof. Rats will climb up on vehicles or implements and jump to these openings.

For ventilating corn cribs the cupola or aerators placed on the roof will allow the air to pass out from cribs and bins. The air will rise upward through the grain to replace the air removed.

Louvre windows may be placed in gables of cupola or gables of crib for air circulation. These should be screened on outside with small mesh hardware cloth to keep out sparrows.

Additional ventilation may be secured by utilizing the sheller trench for an air passage and placing vent shafts (Fig. 11) over this at intervals. The natural draft or a forced draft and heat may be used. Another means of allowing air to circulate through the mass of corn is placing vent ducts (Fig. 12) across the crib. These ducts are made the width of the crib and they are placed horizontally across through the corn. This opens the interior of the crib to air circulation.

Under ordinary conditions rain and snow will not enter a well-built crib. It is advisable, however, to provide a slight crown in the floor for any moisture accumulating from rain, snow or soft corn to flow out. Provision is made in "a" Fig. 10 by raising plates by shimming up with slate or pieces of hollow block. This allows moisture to pass out and at the same time protects the plate from decay or fungus growth.

In "b" Fig. 10 the inside is set in or partially embedded in the concrete floor. The plate should be treated with creosote as a protection. The outside plate is shimmed up with slate or tile.

In states where blizzards are prevalent the top 2 or 3 feet of the crib is made tight so that snow will not blow on the corn after it settles.

A method recently adopted of placing a drying rack under the roof by a materials company has merit and should be recognized. This consists of a grating (Fig. 13) built between roof and small grain bins. The corn is allowed to remain on grating for several days which serves as a dryer. The heat from the roof and air passing up through rack will remove considerable moisture before corn is finally dropped into bins. This permits the corn to dry on the rack from a few days to a week before the corn is dropped to bins below. Another claim is the corn may be gathered a week to ten days earlier by using this dryer.

GOTHIC ROOFS FOR BARNS

By W. Kirkpatrick
Mem. A.S.A.E. Manager, Farm Buildings Department, Gordon Van Tine Company

ECONOMIC considerations have prompted or made necessary the evolution of the barn roof, of which the gothic type is a recent manifestation. Improved timber working machinery, problems of transportations and availability and the adoption of modern hay unloading tools are the principal factors influencing design in barn roofs.

In a study of the gothic barn roof we may confine our inquiry largely to the rafter member that gives the roof its contour and is its chief substance. Other factors of this roof are as in the older and better understood types, except that inflexible roofing of existing kind may not be applied ordinarily to gothic roofs having rafters less than twenty-seven-foot radius.

Two distinct types of gothic rafters are contemporary. The older type is a rafter commonly formed by assembling two or more pieces of 1x8-inch lumber, laminated by nailing. The members composing this rafter are worked to the specified radius before being assembled. This rafter in position in the roof, presents its convex surface and greater cross-section dissention to overhead stresses. We are not presenting data in detail of this style rafter, for the reason that it is not in favor with builders because of the laborious way in which the rafter members must be prepared. Power-driven saws are not commonly available on the job for cutting the rafter members to conform to the rafter radius and the hand labor involved is of a kind and amount distasteful to mechanics. We find no published analysis of the stresses and resistance for this roof, but from casual examination we are inclined to believe it furnishes as commonly designed, the necessary rigidity and ability to bear snow and wind loads. It would seem that the excessive labor expense and loss of material coincident with this construction has been cheerfully incurred by many builders because of the pleasing proportions of the finished structure. Now that the same contour is obtained by bending rather than sawing, interest centers in the so-called bent rafter method of forming the gothic roofs.

The superior appearance in popular regard, of the gothic roofed farm building, and the laborious way in which the old-style gothic rafter was constructed, caused builders to experiment with the bent and laminated rafter. The bent rafter because of alleged economy of material and labor is the one now usually employed.

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The word "gothic" applied to a style of architecture is a misnomer. The Goths created no architecture of their own. However, the use of the term to designate comprehensively the medieval architecture of north and western Europe of the period 1150 to 1500 A.D. has been so general that the pointed roofed barn no doubt will be known as the gothic.

We find no archetype for the gothic. The term is applied broadly to forms of the semi-circle, or those having a radius of two-thirds or more of the greatest breadth of the resultant arch.

There are two methods in common practice in determinating the pitch of gothic barn rafters. The first employs a radius equal to 0.666 of the greatest breadth of the span. Zero or pivotal point of the radius is in plane with the junction of plate and rafter, as in Fig. 1.

The second method employs a radius pivotal at the perpendicular at 0.75 of the span and on the horizontal in the plane 0.125 of the arch span below finished plate level, as in Fig. 2. The roof pitches and areas resulting from the two radii used are only slightly dissimilar.

Many of the factors influencing barn roof construction of the gable or gambrel type do not occur in the gothic. In ordinary barn roof framing, available timbers are of specified dimensions to which, for practical reasons, builders are confined. The gothic barn roof as commonly constructed is peculiarly free of interior roof bracing timbers, and its resistance to stresses depends to a marked degree on the resistance of the rafters which are fabricated of random lengths of

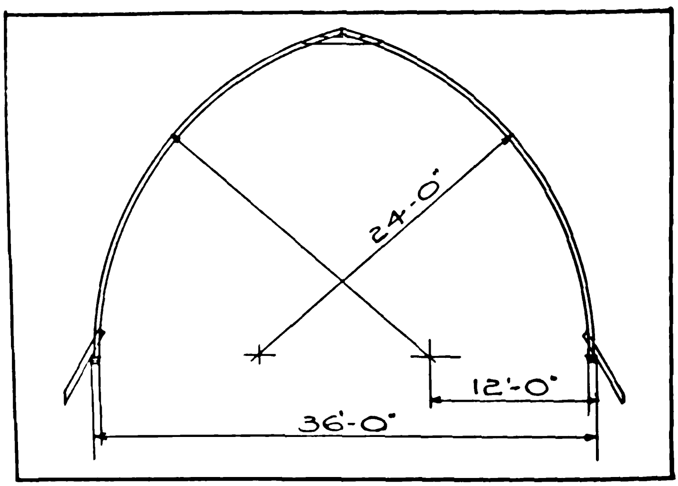


Fig. 1

sound lumber three-fourths of an inch thick. It is apparent then that the rafter may, without undue waste of material, conform to any radius within limits prescribed by convenience, appearance and factors of safety.

From a barn loft utility or operation standpoint, the more pointed roof shown in Fig. 2 presents a benefit that escapes casual scrutiny. The area of little value for storage in a barn loft is that bounded by the roof and a horizontal line drawn ten feet below the ridge. The loaded hay carrier requires from ten to twelve perpendicular feet in which to function, but it is the loft area below the carrier load level that is of most value. In practice the specified upper area of the barn loft is little utilized for storage, so that it would seem best to restrict this area when opportunity presents. In Fig. 2 the loft area confined by a horizontal line drawn ten feet below the ridge is approximately thirty-two feet less than a corresponding segment in Fig. 1. Taking 448 cubic feet as the measure of a ton of partly settled hay, a difference in radius and pitch as noted in Fig. 1 and 2, is equivalent to a hay ton for each fourteen lineal feet of barn loft. To visualize this comparison better and get its practical significance, we may consider a gothic roof as projected in Fig. 1 as furnishing an excess of a little utilized area equivalent to five hay tons in a barn thirty-six by seventy feet.

The span of the gothic barn roof varies with the horizontal cross section of the barn at outside plate level. It is being applied to barns of from sixteen to fifty feet in width. As no standard ratio of radius to span has been laid down, it is not possible to fix definitely the cross section dimensions of rafters for roofs of varying spans. Barns of twenty feet or more width are usually equipped with hay unloading machinery with a maximum lift of about 2000 pounds. The usual hay load on carrier and roof is about 500 pounds but infrequently it is much more, and 2000 pounds of loose hay has been raised from the wagon, elevated and deposited in barn mow at one operation. As there is opportunity under exceptional conditions, for the operation of hay unloading tools to put a 2000-pound hay load on the barn roof, it is then necessary to employ rafters of sufficient strength to carry such loads even in barns of smaller size, that if not subjected to hay carrier loads, could employ lighter rafters.

Bent and laminated gothic barn rafters are commonly constructed of four or five pieces of 1x3 or 1x4-inch sound lumber, S2S, of any kind generally employed in barn frames. Unsurfaced boards, because of greater frictional resistance, would be preferable if they could be obtained in five-eighths or three-fourths-inch thickness. Experiment discloses that per pound of nails used in laminating rafter members, the large nail secures most rigidity in the rafter. As the rafter member cannot be less in its greatest cross section dimension than that can be nailed without splitting, the minimum breadth then is that approximating three inches. Gothic rafters for barns less than thirty feet in width are commonly four pieces ¾x3 random lengths breaking joints two feet or more, well nailed and bolted three feet on center with three-eighths bolts, washered at both ends. These rafters are placed two feet on center on the plate. For barns of thirty to thirty-six-foot breadth, the rafters are commonly five ply ¾x4, on barns of thirty-six to forty-foot breadth. The facility with which the gothic rafter can be proportioned to the stress is noticeable.

In the central states, architects' plans for bent rafter gothic roofed barns were first published in 1916. The pleasing appearance of these barns brought them quickly into favor, so that while a comparatively new design, there are many of them built. Such barns of this type as have been built, having rafters projected as in Fig. 2 and subjected to wind and working stresses for a period of from one to five years, give indication of more than average permanence.

In the experiment of actual construction there have been obtained some interesting data in regard to bent wood construction. The force exerted by three-fourths-inch thick lumber to resume its original position when bent as slightly as occurs in gothic rafters when the radius employed is twenty-one feet or more, is negligible and may be disregarded as a factor in fractional stress analysis. The greater the

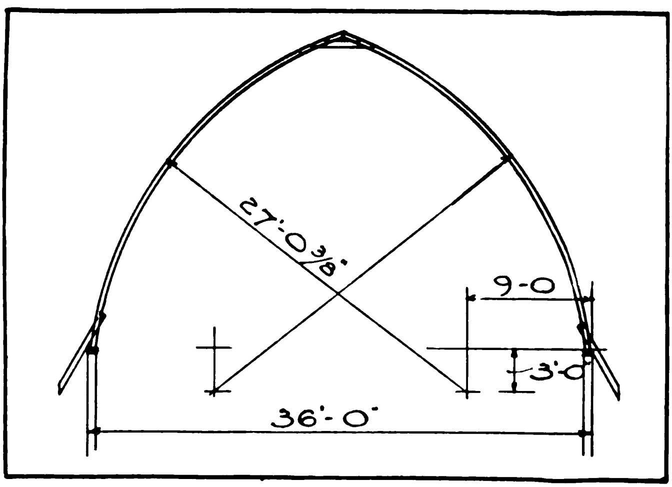


Fig. 2

moisture content of the board the more adaptable it is to a bent position and the more readily its fiber fixes in the changed position.

The theoretical efficiency and economy of the multiple member rafter is borne out by stress experiments and the further consideration that the narrow board usually can be had at less cost per board foot.

PRESERVATIVE TREATMENT OF WOOD IN FARM STRUCTURES

By E. C. Mandenberg

Mem. A.S.A.E. Engineer, Barrett Company

THAT the practice of wood preservation on our farms is the most immediate step towards timber conservation is not to be questioned. Forty-six per cent of the lumber used annually in the United States finds its way into farm buildings. Consequently, it is of the utmost importance that the designers of farm structures not only control the factor of durability in design and specifications, but realize their own responsibility for the proper utilization of timber and its conservation.

The subject of farm structures has been treated in different papers read before this body and in articles which have appeared in Agricultural Engineering. In the previous discussions the location, plans, specifications, and bills of material have been discussed thoroughly but the matter or proper utilization of species and of prolonging the period of service of the material used in construction of farm structures has not been given the thought it rightfully deserves.

It is a well-known fact, perhaps not generally understood by all users of wood in its various forms, that the different kinds of woods vary greatly as to their lasting qualities, and this is particularly true when timber is placed in situations where conditions are favorable for decay to set in and progress. Such commercial woods as heart cypress, the cedars, chestnut, redwood,white oak, fatty or close-grained dense pine resist decay naturally, but it is not always possible to obtain these woods in rural communities and where they are available the price the farmer has to pay is prohibitive. Such species as are available to the farmers usually contain more or less sapwood, have wide annual growth rings, and are not durable timbers.

The sapwood of all species of timber is readily broken down by fungi (wood destroying organisms) when exposed to the weather or where in contact with the ground, concrete, metal, or timber. This natural tendency of woods used in structural work to decay can be retarded for considerable periods if the timbers are properly creosoted and this can usually be accomplished at a relatively small additional increase in the initial cost. In fact the species of wood which decay most rapidly are most easily cresoted by methods available to every user of timber.

It is not for me to discuss the different types of structures which are built on the farms of the country. Our state agricultural colleges are fast solving this problem. When a farmer wishes to build a new farm building he goes to his county agricultural agent and tells him what he wants, how many head of stock of the different breeds he wishes to accommodate, or what other use he wishes to make of the buildings, etc. The county agent in turn communicates with the agricultural engineering department at the state agricultural college or the agricultural extension specialist and the blue prints, bills of material, and specifications are sent out.

All too frequently the construction details and bills of material call for timber, species and grade, which are not readily available to the average farmer.

For example, the bills of material frequently specify No. 1 white pine for hog house floors when any cheaper grade of timber of any available species could be used with economy, if properly creosoted, and the cost of cresoting the less durable woods plus labor is often less than the difference in cost between the durable species which are not readily available and the less durable grades which are easily obtained. The ordinarily fast rotting species of wood properly creosoted will give a longer period of service and a lower annual maintenance cost than the more durable kinds.

The forms of timbers used in farm buildings and to which nonpressure treatments with refined coal-tar creosote can be economically and advantageously applied are shown in the accompanying outline.

Refined coal-tar creosote can also be used to stain the outside of all buildings and the deep rich brown color which it imparts blends well with farm surroundings.

The farm woodlots usually contain species of timber which are ideal for any rough building timbers which the farmer is called upon to use. In most localities portable mills operate and the logs cut on the farm woodlot can be sawed to any bill. Prof. R. S. Hosmer, head of the forestry department at Cornell University, recently said, "A woodlot properly managed is a bank that never refuses the farmer's draft. Every farm has constant need for wood, and a woodlot is not only an asset to the property, but, when wisely used, helps to conserve the Nation's timber supply.

"A good share of the material needed for construction, for repairs to vehicles and implements, and for fencing as well as for fuel, can be obtained from the woodlot. This saves money that would otherwise be paid for high-priced lumber.

"Treatment with preservatives will lengthen the life of wood and also permit the use for construction purposes of many species which otherwise could be used only for fuel."

This use of timbers grown on the farm woodlot not only cuts down the cost of the farm structures very materially but aids the great conservation movement which is sweeping over the country. Unless our timber resources are conserved and put to the best use, posterity will be without timber. All too frequently the farm woodlot does not pay because of improper management. Valuable large logs are cut up into fuel wood, when systematic thinnings could be made and the first two or three cuts of each tree sawed into timber and the tops used for fuel. Such thinnings would remove the mature trees and improve the quality of lumber to be sawed later from the trees left standing, by giving them a better chance to grow and develop straight boles.

The specifications for farm structures should be so drawn. and the blue prints made to show, that all timbers placed on the ground or in contact with masonry as well as all stringers, joists and braces are creosoted at points of contact. Hog and chicken house floors should be creosoted to make structures more sanitary and to control the insects and pests which are found in great numbers in these structures. In this connection U. S. D. A. Farmers' Bulletin, No. 801, entitled "Mites and Lice," states that "both lice and mites are found in practically every locality where poultry is raised. Where present in any considerable numbers both lice and mites reduce egg production and hinder growth and reduce the quality of flesh of all classes of poultry. Refined creosote oils are recommended for control."

White ants or termits cause serious damage to timbers and this can be prevented. Farmers' Bulletin No. 1037, "White Ants," states that poles, posts, construction timbers, and other wood in contact with the ground should be treated with preservatives to render the wood more resistant to attack by termites. Of the more superficial methods of preserving timber, brush or dipping treatments with coal-tar creosotes have proved most effective."

All timbers used in farm structures can be creosoted by the open-tank process which has been described in previous papers read before this Society. This requires a small outlay for equipment. In lieu of the open-tank method, the surface treatment can be applied. Two brush or spray coats are recommended and the refined creosote should be heated to not to exceed 175 degrees Fahrenheit. All materials should be air-dried and completely framed before creosoting.

The word "creosote" covers a multitude of sins and the consumer going to a dealer and asking for creosote oil may actually get a product which has little or no preservative value. The engineers and designers should accept a standard refined creosote oil specification and have the state agricultural colleges analyze the various wood preservatives which are offered for sale to the farmers of any state and then recommend only those which, in addition to being chemically effective, are physically fit. Then some educational work must be carried on to educate the users of timber by timely talks in widely circulated periodicals.

The engineers on the agricultural extension forces can assist materially in this educational work by publishing bulletins on the preservative treatment of farm timbers, by illustrated slide lectures, and by writing "copy" for the bulletins circulated monthly by the county agents of their state.

The writer has been cooperating with specialists on the staffs of the agricultural colleges and it has been repeatedly suggested that projects be drawn up along the lines of a community creosoting tank. In other lines such community projects have been worked out successfully. The writer is interested in such a project and would appreciate suggestions and ways and means of cooperating where such a project is workable.

The following statistical data in connection with the subject of wood preservation is of interest:

1. Original forest area of the United States is 822 million acres.

2. Original stand 5200 billion board feet.

3. Over two-thirds culled, cut over, or burned.

4. Left today—

137 million acres virgin timber
112 million acres culled or second growth timber
133 million acres partially stocked
81 million acres practically waste land

We have 463 million acres today of all sorts and stand amounts and about 2214 billion board feet of merchantable timber. In other words, three-fifths of the original timber is gone.

5. Cutting and loss annually equals 56 billion board feet, of which 40 billion is cut from virgin stands and 16 billion from second growth.

6. All told we are taking 26 billion cubic feet from our forests and growing only 6 billion cubic feet.

7. In thirteen Central States, the valuation of farm buildings in 1900 was $1,700,000,000, in 1910 was $3,300,000,000 and in 1920 was $12,200,000,000. In the same thirteen states where there are 3,375,000 farms, 13 per cent, or 300,000, expect to build new houses; 24 per cent, or 550,000, expect to build new barns; 10 per cent, or 245,000, expect to build new hog houses; 5 per cent, or 110,932, expect to build new corn cribs; 4 per cent, or 90,000, expect to build new granaries; 7 per cent, or 166,000, expect to build new machine sheds, and 23 per cent, or 545,000, expect to build new miscellaneous structures. These figures were compiled by "Successful Farming" in 1920.

FORMS OF TIMBER USED IN FARM BUILDINGS

1. Farm House
   - (a) Sills
   - (b) Stringers (points of contact)
   - (c) Studs (" " ")
   - (d) Foundation posts
   - (e) Basement planking
   - (f) Porch columns, stair stringers, and flooring
   - (g) Shingles
2. Barns
   - (a) Foundation posts
   - (b) Sills
   - (c) Stall floors
   - (d) Feed alleys
   - (e) Feeding troughs
   - (f) Studs (points of contact)
   - (g) Joists (contact with masonry)
   - (h) Shingles
3. Implement Sheds
   - (a) Sills
   - (b) Posts (points of contact)
   - (c) Shingles
4. Sheep Sheds
   - (a) Posts
   - (b) Gates
   - (c) Fence boards
5. Poultry Houses and runs
   - (a) Roosts
   - (b) Floors
   - (c) Entire inside
   - (d) Posts
   - (e) Base boards
6. Hog Houses
   - (a) Floors
   - (b) Skids
   - (c) Shingles (where used)
   - (d) Entire structure inside and out for sanitation and to save painting
7. Hog Pens
   - (a) Posts
   - (b) Gates
   - (c) Fence boards
   - (d) Feeders
8. Animal Shelters
   - (a) Posts
   - (b) Gates
   - (c) Fence boards
9. Corrals
   - (a) Posts

(b) Gates
(c) Boards

10. Silos
    (a) Staves
    (b) Doors
    (c) Chute
11. Granaries and Corn Cribs
    (a) Floors
    (b) Joists
    (c) Posts
    (d) Studs (points of contact)
12. Well House
    (a) Curbings
    (b) Floor
    (c) Studs (points of contact)
13. Fencing
    (a) Posts
    (b) Gates
    (c) Braces
14. Bridges and Culverts
    (a) Stringers
    (b) Floors
    (c) Railings and posts.

ARTIFICIAL HEAT FOR ANIMAL SHELTERS

By K. J. T. Ekblaw

Mem. A.S.A.E. Engineering Editor, National Farm Power Publication

WHETHER the heating of animal shelters by artificial means is desirable is a debatable question. However, wherever a difference of opinion exists, there is an opportunity for making a decision one way or another. In this paper no attempt will be made to arrive at such a decision, but a few ideas and their practical application will be presented for what value they may possess.

Nature certainly did not calculate that wild animals, existing in regions of cold would need anything in the way of artificial heat; but the conditions which Nature took into consideration have been changed by the process of domestication of certain of these animals. It may be that ultimately it will be found that domesticated animals will thrive better without artificial heat, but it does seem that in the present state of their development a little artificial heat, applied under proper conditions, may be beneficial. It has apparently been proved that heat is detrimental to the thrift of poultry except in the chick stage. Sheep that have been brought up under unusual protection suffered severely when exposed to unusual cold and most sheep raisers believe that the only shelter should be from rain, snow and wind.

In Bulletin No. 152 on "Swine Houses," issued by the Iowa Agricultural Experiment Station, Prof. John M. Evvard, one of the foremost authorities in America on swine, makes the following statement:

The newly farrowed pigs especially demand protection. Early pig production is impossible without warm shelter. Stock hogs thrive best when they are not compelled to shiver from cold and thus burn up feed which would otherwise be converted into tissue. The wintering sow makes use of a warm sleeping bed. In truth all classes of swine demand reasonably warm shelter if maximum returns are to be expected."

This statement summarizes admirably the needs and reasons for keeping swine houses warm. Of course in warm climates, such as obtained in the southern states, the sun's heat combined with bodily heat of the swine themselves is sufficient to meet requirements. Proceeding north, however, into states where the length of winter and the intensity of the cold becomes greater and greater, the need for a more adequate provision against cold becomes evident. Through the states of Ohio, Indiana, Illinois, Iowa, Missouri, Kansas and Nebraska, which comprise in the main the great "Corn Belt," and in which are grown and fed the enormous number of swine utilized by the packing industry in its operations, the winter is sufficiently long and severe to bring hardship upon unprotected swine.

Something more than natural heat is necessary. Artificial heat, which can be produced and controlled regardless of the severity of weather conditions, renders the swine raiser independent of the latter. The heat supply can be governed to meet requirements, and thus there need be no wastage.

Swine house construction, on farms where attention is given to swine raising, is rather substantial. The house itself is almost always of a single story with a rather low roof. The walls, if of wood, are usually double, sometimes with an additional thickness of building paper between the layers of boards. The construction of masonry swine houses, using a hollow clay or concrete block, is becoming increasingly common. Precautions are taken to render the construction of the building as close and tight as possible, consequently there is a minimum of heat loss. Most houses are constructed so as to front toward the south and this side is well supplied with windows to obtain the full effect of the warmth of the sun's rays and to utilize them for as long a period as possible. Tables have been prepared by the United States Department of Agriculture (Farmer's Bulletin No. 438) indicating the proper location of windows to get the greatest benefit from sunshine.

In general construction, and therefore in amount of heat lost from the walls, swine houses may be considered similar to factories. Both possess simple but substantial wall construction, and both have a large proportion of the walls consisting of glass. The coefficient of heat transmission is given by Green as the same for a double board wall and for a 12-inch brick wall, being in each case O. 31 B. t. u. per square foot per hour per degree difference in temperature.

In general, it is of course not necessary to maintain in a swine house a very high degree of temperature; in fact, 60 degrees may be considered a reasonably satisfactory temperature for swine, for even with the somewhat inadequate provision against cold given them by Nature, they are to some degree resistant to severe weather conditions.

Since there are no strongly voiced objections to heating swine houses and since practically all authorities approve of it and general practice favors it, the questions that come up are those of decision as to the most satisfactory type of heating systems and how such a system and the operation of it will accommodate itself in the general conduct of farming operations.

To answer the last question first, it may be said that on farms where swine raising is of consequence, the swine require regular attention for feeding, dipping, cleaning the house, etc., and the small amount of attention which a heating system requires can easily be incorporated into the regular duties of the attendant. The amount of heat required is not exceedingly great so that a comparatively small system will suffice. Then, too, most swine raisers feed cooked ground feed to swine, and do not consider the work in connection with this to be at all onerous, so that no objection to the duties of caring for heating system can be legitimately raised. It may be possible in many cases to combine efficiently the processes of heating and feed-cooking so that a single heater may be made to serve two purposes.

From a consideration of the conditions involved, it seems that either a steam or hot-water heating plant would fill the requirements most satisfactorily. A warm air system is not entirely practicable because of the greater difficulty of heat distribution, for most swine houses are long low structures and an economical and efficient arrangement of ducts for transmitting the heated air cannot very well be devised.

To illustrate the application of heating principles to swine houses, if standard steam system will be designed for a typical structure and a layout of the design shown.

The house illustrated is what is commonly known as the "half-monitor type," the design of which has been perfected by Prof. William Dietrich, formerly of the Illinois Agricultural Experiment Station. The pens are arranged in two rows, one on each side of a central passageway, which may be made wide enough for a horse-drawn wagon to pass through. The house is always built to front to the south to get the maximum sunlight, and both rows of pens are arranged so as to receive sunlight. In the monitor wall, double-hung sash are located the entire length of the building, and ventilation on warm days, or whenever necessary, is made possible by controlling the opening of these windows. The typical house, as illustrated, is 22 feet wide, 6 feet high at the eaves both front and back, and the high studs in the monitor wall are 14 feet long. The length of this particular building is 48 feet, though of course its capacity can be changed as desired by changing its length.

The well-known Mills rule will be used in calculating the amount of radiation required:

$$\text{Feet of radiation} = \frac{v}{200} + \frac{w}{20} + \frac{g}{2}$$

V = volume in cubic feet

W = exterior wall surface, including roof, in square feet

G = exterior glass surface in square feet

In this particular house,

V is approximately 8500 cubic feet

W is 2016 square feet

G is 264 square feet

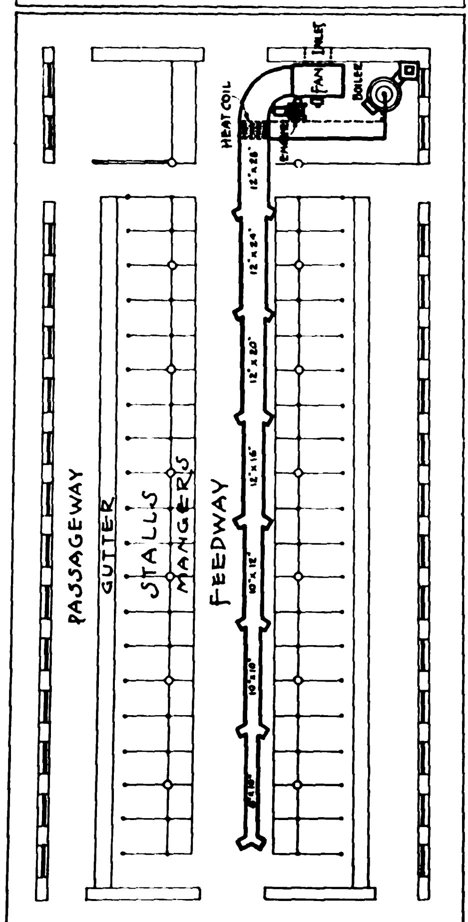


Fig. 2. Plant view of a steam heating system in a typical dairy barn, worked out in accordance with principles laid down in the paper

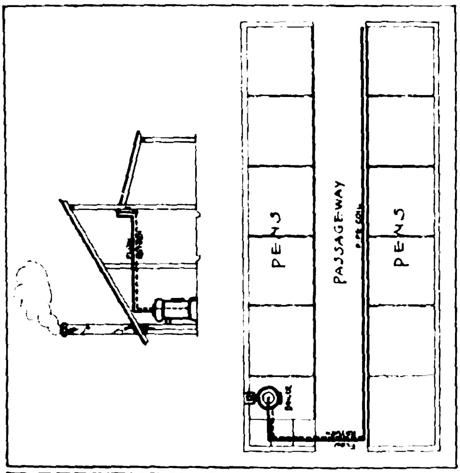


Fig. 1. Suggests arrangement for heating plant in a swine house

Substituting these values in the preceding formula, it is found that the required feet of radiation is 284.9. Since the Mills rule contemplates a difference between inside and outside temperatures of 70 degrees while but 60 degrees is considered in the swine house, the amount of radiation actually necessary is but six-sevenths of that indicated by the Mills rule, or 235 feet. As a check on this calculation a determination of the actual heat loss may be made and from this the radiation can be figured. Using 0.31 and 1.0 as values of heat loss coefficient for the walls and glass respectively, the following is obtained:

$$2016 \times 0.31 \times 60 = 37500$$
$$264 \times 1.0 \times 60 = 15840$$
$$\text{Total heat loss per hour in B. t. u.} = 53340$$

Since the condensation of one pound of steam liberates 970 B. t. u., and since one foot of radiation condenses approximately ¼ pound of steam per hour, the radiation necessary is

$$53340 \div \frac{970}{4} = 222 \text{ feet}$$

which approximates the result obtained by rule.

It is obviously impractical to use ordinary radiators in a structure of this type; much better distribution of the heat can be obtained by using ordinary pipe coils connected directly with the boiler and extending the entire length of the building. From a table of data on wrought iron pipe given by the manufacturer, it is found that one foot of 1½-inch pipe has a radiating surface of 0.50 square feet. To provide 235 feet of radiation, 470 feet of pipe is required, or the equivalent of 10 pipes each 47 feet long. Consequently our heat coil would consist of these ten pipes properly connected with return bends.

The location of the coil may be made wherever it is most convenient. At the rear of the house, on the upper part of the rear wall, might be a satisfactory place, but perhaps a more advantageous location is just below the windows of the monitor wall. This location would aid in the better distribution of the heat.

The smallest boiler manufactured would be large enough to take care of the necessary 235 feet of radiation. Referring to the catalogs of two of the largest manufacturers of heating apparatus, it is found that the smallest boiler has a rated capacity of 300 feet of radiation. This size would then be amply large and would have a reserve capacity for emergency conditions.

In most of the well-known European dairying centers—the Channel Islands, Scotland and England, the Netherlands, Denmark—a deeper appreciation of animal comfort is found than is prevalent in America. In the old country it is quite common to find the cattle housed under the same roof that shelters their human caretakers; and any comfort in the way of heat is shared by both. American ideas of the propriety of housing conditions are, however, essentially different from those of Europe, and cattle are consequently isolated and sheltered in separate structures. With this change in conditions, though Americans feel fully the need of heat in their own habitations, they seem to forget that backs other than their own might become cold, and it is indeed the rare exception to find any sort of a stock shelter supplied with artificial heat.

In pioneer days, shelters of any kind, whether for humans or animals, were not built exceptionally well. Later, as conditions became better, more substantial residences were the rule, and now the improvement has extended to the stock shelters as well. The modern dairy barn, from the standpoint of construction, is almost all that could be desired; it is roomy, solidly and substantially built, and possesses beauty and simplicity in an architecture all its own.

Heating a dairy barn is a proposition that may appear of doubtful value, but nevertheless it has been practiced with good results in a number of large estates that could afford to make the experiment; the Wisconsin Agricultural Experiment Station also advises that if it is possible to maintain the interior temperature of a dairy barn at about 50 degrees Fahrenheit, milk production will be increased and will be more easily kept at a maximum. This is an entirely logical conclusion, considering the cow as a machine, and her feed as raw materials and fuel: The less that need be used as fuel to maintain the body temperature the greater will be production.

One advantage which would accrue from the installation of a heating system would be a possibility of its use in heating drinking water for cows during the winter months. In order to produce large quantities of milk cows must drink large quantities of water. The New Jersey agriculture experiment station states that a cow giving 12 quarts of milk per day needs 36 quarts of water, and the assimilation of the nutritive elements of one pound of corn is required to raise the temperature of the water from freezing to the normal body temperature. It is easily seen that with a herd of forty cows, the cost of warming sufficient water is a considerable item, and it is recommended that use be made of a heater for the sake of economy. When water is warm the cows will drink much more of it and the digestive condition of the animal will not receive the chill and shock as is the case where the water is icy cold.

An up-to-date dairy barn, such as is found on dairy farms throughout the country, is a structure of brick, or stone, and wood; with concrete for floors, mangers and, very often, walls; sometimes the entire structure is built of fireproof materials, with masonry foundations, walls, piers and floors, and with steel arches supporting a roof of metal or asbestos shingles. Every provision is made for strength, reasonable durability, sanitation and for convenience in operation, so that the installation of some means of providing for the maintenance of a moderate degree of artificial warmth completes the list of requirements for an exceedingly efficient factory.

The particular dairy barn which will be used for purposes of illustration is of the type that is quite commonly used, known as the "plank frame" type in contradistinction to the "timber frame" type. The walls may be of double boards or masonry, the mow floor is of matched flooring, and since in the winter time the mow is piled full of hay, the heat loss through the mow floor is practically negligible.

The barn, as shown, is 36 feet wide and 80 feet long. Barns of this type have been built 200 feet or more in length. The ceiling, which constitutes the mow floor, is 9 feet high. Stalls are provided for 38 cows with additional enclosures to be used as calf or bull pens. An abundance of light is provided through 30 windows, each holding four 14 by 16-inch panes.

For the purpose of illustration, the essentials of a design of a steam-heating system will be briefly outlined, with the boiler located in one of the end rooms and with the pipe coils hung on the interior posts above the mangers.

The following data is calculated from the dimensions of the barn and windows given above:

Volume	25820 cu. ft.
Exterior wall surface...........	2088 cu. ft.
Exterior glass surface..........	240 cu. ft.

Using Mills rule for the determination of the amount of radiation required,

$$\text{feet of radiation} = \frac{25820}{200} + \frac{2088}{20} + \frac{240}{2} = 350$$

This is based upon the assumption that the building is to be heated to a temperature of 70 degrees with an exterior temperature of zero degrees. However, as has been previously stated, the desirable temperature in a dairy barn is about 55 degrees, and it is entirely reasonable to assume that the heat from the bodies of the animals themselves will account for an increase of 5 degrees; so that a temperature difference of 50 degrees is what should really be considered, which will reduce the radiation by $\frac{70-50}{70}$, or 2/7, making it 250 feet instead of 350.

Using 1½-inch pipe, which affords 0.5 feet of radiation per foot of length, it is readily seen that a total of 500 feet of

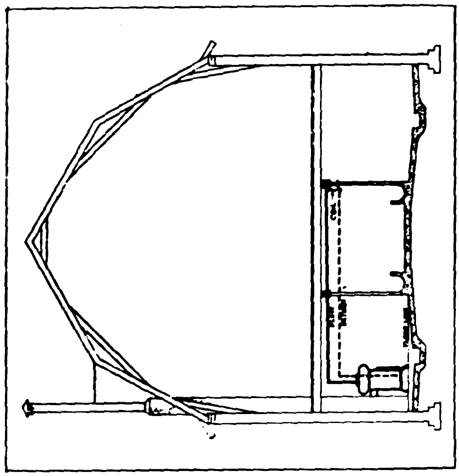


Fig. 3. Cross section of dairy barn showing location of steam pipes

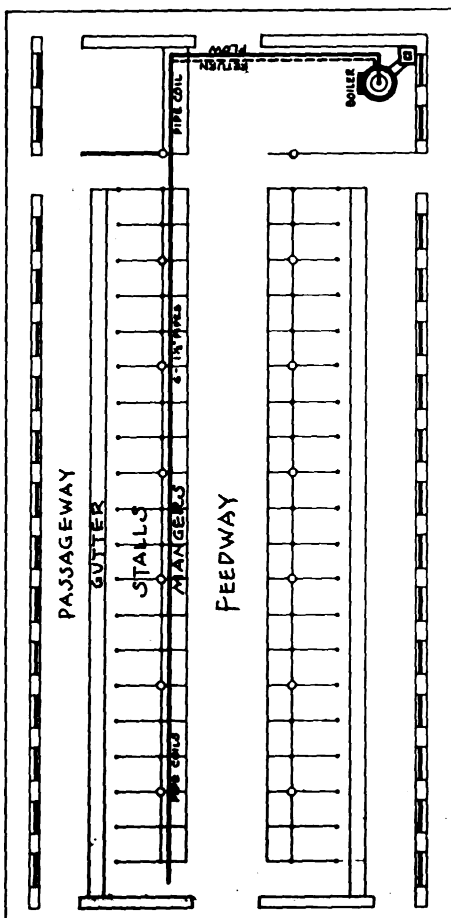


Fig. 4. Plan view of dairy barn provided with combination of warm air heating from steam coil and forced draft ventilation

pipe will be needed. Six pipes 80 feet long, properly connected by return bends, together with the pipes connecting the coils and the boiler, will furnish the radiation required. As in the swine house, the smallest size of boiler manufactured will be amply large to meet all requirements, besides furnishing enough additional steam for sterlizing milk utensils, for heating water for cleaning purposes, etc. The layout of the system is shown in the plans. For the purpose of avoiding danger from fire as much as possible, the boiler room should be plastered or lined with brick, and great care should be taken to avoid the collection of any kind of litter near the boiler.

In systems of ventilation that are generally considered in connection with farm buildings, circulation of air is caused either by increase or reduction in pressure by the force of the wind or by expansion due to heat. The former is of course unreliable and variable, and the latter being the feeble force is likely to be destroyed by badly constructed flues, by uncontrolled wind currents, or by friction. A positive method of producing a certain circulation of air is to employ a fan or blower of some character, operated by mechanical power, which would be strong enough not to be affected by adverse influences.

Since in a system of this kind the air is taken from some source by the fan and distributed by the force of the fan through a system of pipes, it will be a very simple matter to combine with the ventilating system an excellent heating system, using the air as a medium for the transmission of the heat. The same distributing system, and the same motive power can be used, the only additional provision that is necessary being that for warming the air before it is distributed.

To exemplify this method of combined heating and ventilating, a system will be designed for the dairy barn previously described.

According to King, who based his determinations upon actual tests, the amount of air required by animals is as given in the following table:

Kind of Animal	Cubic feet of Air Required per minute
Horse	70
Cow	60
Hog	23
Sheep	15

In the barn described, there were stalls provided for 3S cows, with an additional open stall; it would be reasonable to figure on a maximum of 40 head of cattle, requiring $40 \times 60 = 2400$ cubic feet of air per minute, or 144,000 cubic feet per hour, which must be forced through a heater that will raise its temperature to 55 degrees in zero weather, and distributed within the barn.

Carpenter, in "Heating and Ventilation," states that a "heater provided with blower will condense under average conditions 2 pounds of steam per square feet of surface per hour." The heat given up by the condensation of 2 pounds of steam is $970 \times 2 = 1940$ B. t. u. If one B. t. u. warms 55 cubic feet of air one degree, to heat one cubic foot 55 degrees will require one B. t. u., and to heat 144,000 cubic feet 55 degrees then requires 144,000 B. t. u. To furnish this amount of heat, as many pounds of steam must be condensed as 940 is contained in 144,000 or 78.25, and since a square foot of radiation condenses 2 pounds of steam per hour, $78.25 \div 2 = 39.12$, or practically 40 feet of radiation are required. This is equivalent to 80 feet of 1½-inch pipe, or using "Standard" pin radiators made by the American Radiator Company having a heating surface of 10 square feet, eight sections would be required. The size of boiler to heat these sections is the minimum size manufactured, and there would be an ample surplus to take care of extra requirements.

In determining the size of blower required, the first consideration must be given to the speed at which it rotates, for if it be driven faster than 250 r. p. m., it will make an objectionable noise; 200 r. p. m. is better. Experience has shown that 2,000 feet per minute is a desirable velocity for the flow of air through the ducts. If a blower discharges into the open air, with no interference, it will discharge the air at a velocity even greater than the peripheral speed of its blades; but the transmission through coils and pipes reduces this considerably. With this data, the outer circumference of the fan is $2000 \div 200 = 10$ feet, making the diameter of the fan 3 feet 2 inches.

The resistance which the air will meet, in this installation, in passing through the pin radiators and approximately 100 feet of pipe, will be practically the equivalent of 1 inch of water, or 0.5 ounce, and the fan must deliver the air against this pressure.

The driving power for a fan may be a small gas engine, or an electric motor, depending upon which power is best available. The adaptability of either the engine or motor to this purpose is unquestioned. A 1-horsepower engine, or a ¾-horsepower motor should be amply large.

For the purpose of designing the horizontal ducts by which the air is distributed through the building, a velocity of 1000 feet per minute can be allowed; since 2400 cubic feet per minute must be carried the cross section of the duct must be $2400 \div 1000 = 2.4$ square feet. A rectangular duct 12 inches by 28 inches would be installed, with outlets along the sides, and the duct reduced in size as outlet after outlet is taken off from it. The duct is carried along the ceiling of the central passageway of the building, suspended from the joists.

DISCUSSION

RALPH H. FINLEY: I would like to ask why it is that when a hog house is built very close to the ground, heat is always applied at such a height above the floor; a great deal of cold comes in through the floor. In many cases where solid concrete is used, a great deal of cold gets in. Why do they bring the heat in above the animal? Why not let it originate closer to the ground?

MR. EKBLAW: In any heating system installed in a swine house, the distribution of the heat is so even that it is not necessary to bring it in at the ground. If you bring it in above the ground, it will still be sufficient to keep the air within the house warmed with a fair degree of economy. In the installation of an artificial heating system, it is desirable to have the flow pipes high up so that you can get good returns and a good arrangement of the piping system.

MR. IVES: There is one thing we ought to consider in connection with this artificial heating and that is the question of insurance companies insuring buildings in rural districts objecting very strenuously to the presence of flues or fire of any kind around the farm buildings. They sometimes refuse insurance or put the rate up to a prohibitive amount. If we are going into this matter of heating buildings, we should have to educate our underwriters to the point where they would accept that kind of structure.

MR. ASHBY: As I remember it, the Iowa hog house does not have storm windows. It is not necessary to use storm windows why should it be necessary to heat the house? The loss through the windows is the greatest part. It is much cheaper to put in a greater thickness of glass than to put in a heating system.

MR. DAVIDSON: I might suggest that the radiation from that type of house is extreme and cools off fast through the windows.

MR. DICKERSON: I rather think that the idea of putting the heating coils above is a mistake because it is only the pigs that need the heat and it ought to be kept down close to them. The cold comes from the floor and from the foundation walls. A very simple pipe system arranged around the outside of the farrowing pens would be sufficient. I think there is a very serious danger of getting the heat too great, and where the heat is too great the damage will be greater than any benefit obtained. If artificial heat is used at all it must be used very carefully.

Mr. Hewitt: If you are going to heat the hog houses heat them properly. You can get your return in your boiler because it is always at a low point anywhere on the side to that point. It is not necessary to force the boiler. You do not need a great amount of artificial heat in a hog house. In any that I ever saw you do not need but a very small amount of coils around it at a height starting anywhere that you can get a continuous flow of one-half inch in ten feet. As regards insurance, you will find that it raises insurance materially—at least fifty per cent.

Mr. Sjogren: In the system used by hog breeders in Nebraska, they take a pit under the center of the house, place an ordinary hot air stove in there with a sheet-iron shell about it and let the heat come up through a register in the floor. There is a hole in the floor and they have a return at each end. They seem to think it works satisfactorily and economically. It is a cheap installation, but it does the business.

Mr. Hewitt: You get ventilation that way also.

IMPORTANCE OF HEAT IN THE CORRECT VENTILATION OF HOG HOUSES

By W. B. Clarkson and C. S. Whitnah
Director and Associate of Research and Extension, King Ventilating Company

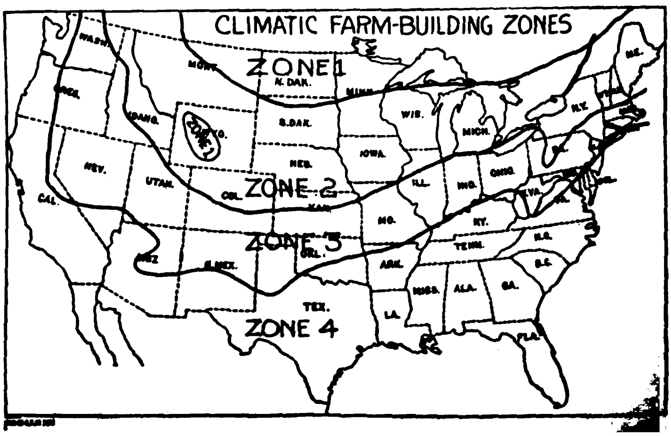
THE modern hog house has a dual purpose: First, to provide proper housing conditions for farrowing purposes; second, to maintain a sanitary home for growing hogs for the balance of the winter.

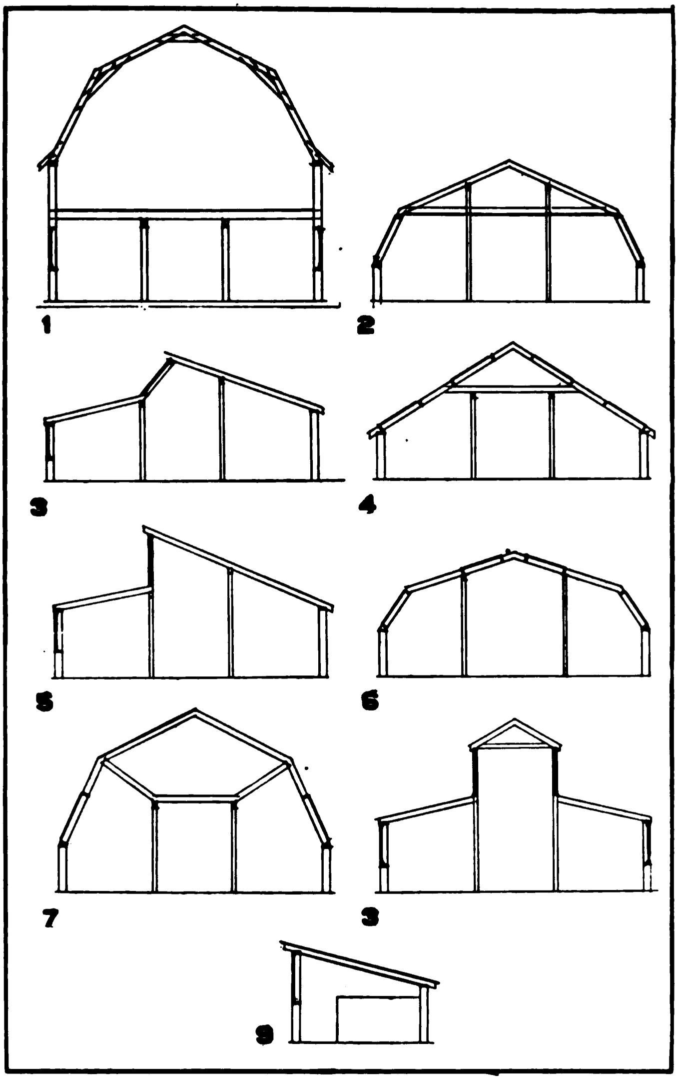
For farrowing purposes it is necessary in cold climates to provide artificial heat, in order to maintain a comfortable temperature. A building properly constructed for each climatic zone, and filled with feeders, may not need artificial heat.

In the last annual report of the A.S.A.E. Committee on Farm Building Ventilation a table was presented, showing that the average 300-pound hog should not be expected to heat more than 240 cubic feet of space in a properly ventilated room.

Analysis of the comparative merits of hog houses shows that there is a correct relation between ventilation, heat and light.

In making comparisons of these factors we have selected nine typical hog houses: (Several other types could be added but these are sufficient to make clear the purpose of this article.) (1) The two-story building with overhead storage; (2) the one-story building with a flat pitch gambrel roof and a ceiling extending across from one hip of the roof to the other; (3) the sawtooth roof; (4) the one-story gable





roof; (5) the half-monitor roof; (6) the same as 2, leaving out the ceiling, but insulating under the rafters with one-half-inch insulation and covered with D. & M. flooring; (7) the same building as 2, but with inclined ceiling on each side extending from hip of roof down to girders and across between the girders; (8) a full monitor roof; and (9) a shed roof.

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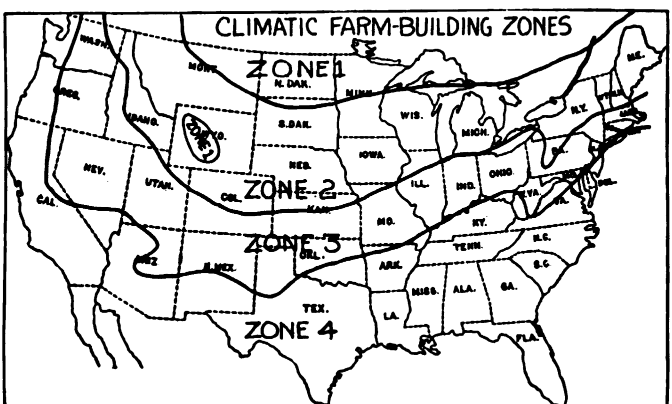

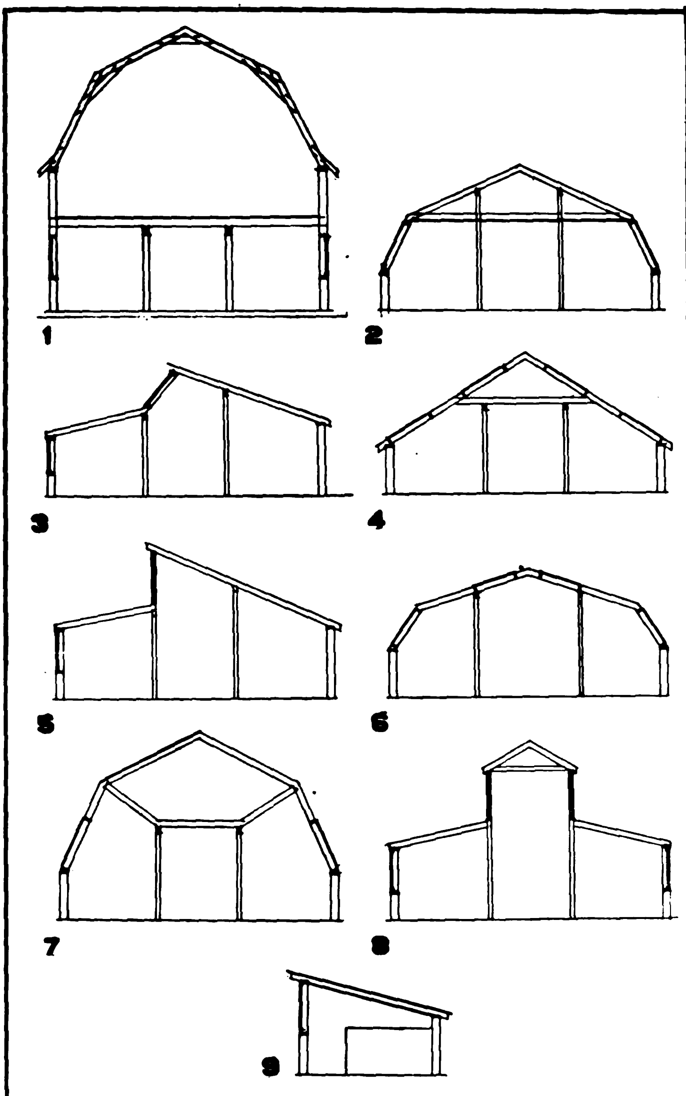

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TABLE I. AMOUNT OF GLASS SURFACE

Type 1	20 windows	9″x10″	6-light sash	100 sq. ft.
Type 2	28 windows	9″x14″	6-light sash	140 sq. ft.
Type 3	10 windows	9″x14″	6-light sash	
	10 windows	9″x10″	6-light sash	90 sq. ft.
Type 4	20 windows	9″x10″	6-light sash	100 sq. ft.
Type 5	10 windows	9″x14″	6-light sash	
	10 windows	9″x10″	6-light sash	90 sq. ft.
Type 6	20 windows	9″x10″	6-light sash	100 sq. ft.
Type 7	28 windows	9″x14″	8-light sash	196 sq. ft.
Type 8	20 windows	9″x14″	6-light sash	
	20 windows	9″x10″	6-light sash	180 sq. ft.
Type 9	20 windows	9″x14″	6-light sash	100 sq. ft.

A cross section of each type is shown for the same size building, 22 feet eight inches wide by 40 feet long, inside measurements, except 9 which is 10 feet eight inches wide and 80 feet long.

To illustrate that heat should be considered in planning the hog house we are showing the relative heat loss from each of these buildings when the windows are placed as is common practice. Table I shows these window areas in each type.

Table II shows the estimated relative loss of heat from each type of building when built according to the following specifications:

WALLS. Studded, framed with shiplap, insulation and drop siding outside the studding; one-half-inch insulation and D. & M. flooring inside.

CEILING. One-half-inch insulation and D. & M. flooring, except in numbers 1, 2, and 7, which require only a tight ceiling insulated with straw or hay above.

TABLE II. RELATIVE HEAT LOSSES IN HOG HOUSES, FIRST ZONE CONSTRUCTION

	WALL		ROOF		WINDOWS				Total
Type No.	Area	Loss	Area	Loss	Wall	Monitor	Skylight	Loss	Loss
1	902	162			100			40	202
2	572	103	260	52			140	70	225
3	850	153	820	164	40		50	41	358
4	672	121	980	196			100	50	367
5	971	175	960	192	40	50		37	404
6	672	121	980	196			100	50	367
7	712	128	404	81			196	98	307
8	1012	182	960	192	80	100		75	449
9	1079	194	880	176	100			40	410

Windows. One-piece sash fitted to frame, with tight stops not made to hinge or slide. Storm windows tightly fitted with not less than one-inch space between glass surfaces.

Doors. Made of two thicknesses of D. & M. flooring, with half-inch thickness of good insulating material between and properly fitted to frame.

These specifications are suitable for houses located in the first zone, as shown on the map entitled "Climatic Farm Building Zones."

Table III shows heat loss in each building when made of materials and construction suitable for third zone and subjected to the low temperatures prevailing in the first zone, to wit: Walls built of matched lumber single thickness, single windows well fitted to casing, single doors and a single thickness matched lumber ceiling in types 1, 2, and 7.

The coefficients of heat loss used in the above computations were as follows: (These are taken from recognized authorities.) This coefficient is the heat loss in B.t.u. per square foot per degree difference in temperature.

	First Zone	Third Zone
Walls	0.18	0.55
Roof	0.20	0.77
Wall Windows	0.40	1.20
Monitor Windows	0.43	1.25
Skylight Windows	0.50	1.50

In types 1, 2, and 7, where the ceilings were assumed to be covered with packed straw or other roughage, the heat loss was disregarded.

A study of these tables shows that a proper consideration of heat and ventilation and the correct size and location of

TABLE III. RELATIVE HEAT LOSSES IN HOG HOUSES, THIRD ZONE CONSTRUCTION

Type	WALL		ROOF		WINDOWS				Total
No.	Area	Loss	Area	Loss	Wall	Monitor	Skylight	Loss	Loss
1	902	496			100			120	616
2	572	324	260	200			140	210	734
3	850	457	820	631	40		50	123	1211
4	672	369	980	755			100	150	1274
5	971	584	960	740	40	50		120	1444
6	672	369	980	755			100	150	1274
7	712	391	404	311			196	294	996
8	1012	557	960	740	80	100		221	1518
9	1079	592	880	678	100			120	1390

TABLE IV. CUBIC SPACE PER HOG

Type	Inside Dimensions	Floor Area	Cubic Space
1	40'x22'8"	906.8 sq. ft.	6346 cubic feet
2	40'x22'8"	906.8 sq. ft.	6640 cubic feet
3	40'x22'8"	906.8 sq. ft.	6813 cubic feet
4	40'x22'8"	906.8 sq. ft.	7026 cubic feet
5	40'x22'8"	906.8 sq. ft.	7586 cubic feet
6	40'x22'8"	906.8 sq. ft.	7620 cubic feet
7	40'x22'8"	906.8 sq. ft.	7766 cubic feet
8	40'x22'8"	906.8 sq. ft.	7857 cubic feet
9	80'x10'8"	853.6 sq. ft.	5546 cubic feet

windows will produce a well-balanced hog house.

Everything else being equal the house that has the least cubic space per hog is the one that is warmest on a cold day. Table IV shows this relation in the several types of houses.

A natural draft system of ventilation should be more efficient in No. 1 because of the double advantage of increased air pressure at the higher elevation and the length of the ventilating flues, which carry the warm light air from the room, thus causing increased and more positive draft. Since No. 1 is the warmest type as shown in Tables II and III, this house provides the best condition for maintaining the proper temperature and makes the best provision for ventilation.

It is apparent that the low flat roof types have some advantage in the matter of light, as shown in Table I, but there are disadvantages to be considered as follows:

1. Snow and ice gather on flat roof windows which must be removed if the windows are to perform the service intended. Climbing on the roof is not an easy job and is seldom done, therefore, much of the value of the glass in a hog house is lost in winter in the first and second zones.

2. Unless carefully installed, skylights are not watertight and always leak more or less in the thawing seasons.

3. Authorities agree that the heat loss through a skylight is greater than through a vertical window.

CONCLUSIONS

1. Windows in the roof of a hog house should be fitted so they are water-tight and covered with storm sash equally well installed, so the frost will not gather on the glass and the heat loss through the glass be reduced to a minimum.

2. In cold climates a properly insulated ceiling over a hog house will reduce condensation and help to maintain a comfortable temperature in the room.

3. The comparative merits for light and for heat and ventilation of the nine types of hog houses under discussion seem to be shown by the above tables.

4. A well-balanced hog house has the proper amount of glass area located to give good light and is designed to retain the animal heat for ventilation.

FARM BUILDING VENTILATION

Report of Committee on Farm Building Ventilation

UNDER the heading of "recommendations" in its last annual report, the committee on farm building ventilation suggested that it was quite important for the committees on farm structures, farm building equipment, and ventilation to work together to produce farm buildings that might be designated as "climatic structures." We suggested that some plan should be devised by which the information secured by each committee can be available at once for consideration by all these committees.

No plan having been devised for this purpose, the committee on ventilation has continued its study of this problem, not knowing what the other committees have done in relation to it.

As a result of the study that the chairman of this committee has given to the subject of "Climatic Dairy Barns," the article on this subject published in the October (1920) number of AGRICULTURAL ENGINEERING is presented as a summary and we submit it as a part of this report.

You will recall that in the last annual report assurances were given that Dr. H. P. Armsby's interest had been enlisted in the work of this committee and through him we expected to reach definite conclusions regarding the heat production of farm animals. We are assured that the results of his findings are now in manuscript form and will soon be published. We have been in correspondence with Dr. Armsby during the past year, and while we are not at liberty to quote him directly, there are certain points that have been brought out in this correspondence which will give hints as to the great value of his manuscript as it relates to farm building ventilation.

The heat production of animals is exceedingly variable, depending upon the size of the animals and their degree of activity and to a very large extent upon the amount and kind of feed consumed by them. There are two quite distinct sources of heat production in the animal body. The first of them is the heat arising from the necessary activities of the animal. On page 711 of Dr. Armsby's book entitled, "The Nutrition of Farm Animals," Tables I and II show under the heading of net energy and expressed in therms (one therm equals 1,000 kilogram calories) the amount of heat thus produced by cattle, sheep, horses, and swine of different weights. On page 625 of the same book (Table 195) there is shown in the last column the amount of heat production caused by the consumption of 100 pounds of dry matter of different feeding stuffs. On page 656 (Table 198) are shown quite similar figures for swine.

To obtain the amount of heat production of animals, it is necessary to add 50.9 therms per hundred pounds of dry matter consumed, to the heat arising from the necessary vital activities of the animal in a state of rest, as shown in Tables I and II above referred to. Dr. Armsby's results will show the heat production of the various sizes and kinds of animals when they are being fed several different rations. Prof. F. H. King states that a cow may eliminate 76,133 B. t. u. per day.

This amount of heat given off by a cow per day would be about the same as if 7.4 pounds of coal were burned in a stove at 75 per cent efficiency. In a barn where 30 cows are housed the heat given off would be equivalent to burning about 225 pounds of coal per day. When 30 head of cattle are housed in a barn for 10 days continuously, the amount of heat given off compares with the heat from a ton of coal burned in the same space.

This comparison is interesting in that it shows, first, the absolute necessity of reducing to a minimum the heat losses through the walls of a barn in a cold climate, if it is expected that the temperature of that barn is to be controlled without the use of artificial heat. Second, it seems entirely feasible to arrange the floor plan and superstructure of the ordinary barn so that it will not be necessary to use any artificial heat added to the waste heat given off by the cows, in order to control the temperature of the room. Furthermore, agricultural engineers will be interested to know that Dr. Armsby clearly demonstrates the necessity for trained agricultural engineers as specialists to solve these problems properly.

Rapid progress is being made in the task of connecting up the producton of heat by animals with the use and waste of this heat for ventilation and by loss through the walls, respectively. In a test of the barn at the Brandon experimental farm Prof. L. J. Smith, then of the Manitoba Agricultural College, obtained a very good record of the conditions of ventilation, temperature and head production, which follows this report.

As a result of correspondence with Prof. J. P. Calderwood, head of the department of mechanical engineering of the Kansas State Agricultural College, we have secured his active interest in our work. A complete report of this correspondence follows this report.

To make observations of air movement which are accurate and thorough is one of the most difficult tasks in connection with the problem of analyzing the ventilation of farm buildings. Some valuable suggestions along this line have been received during the past year from two sources. In the report of the committee on research of the American Society of

Heating and Ventilating Engineers we find the following under the heading of "BEST WAY TO TAKE ANEMOMETER READINGS" "1. The opening shall be divided into equal rectangular areas, no side of which shall be over ten inches long, excepting where this would require more than ten readings, in which case the opening shall be divided into twelve equal areas.

"2. Readings are to be taken in every case in the center of every area.

"3. Readings to be of one-half minute duration, the anemometer being held at the register base or in the plane of the opening.

"4. Where the diffusers are used a total area is to be computed on the basis of the periphery of the diffuser.

"5. The average of the readings are to be considered as the average velocity at the opening. Where negative velocities are found, they are to be deducted in arriving at the average velocity.

"6. In computing volume, the net area of opening is to be taken, the volume to be considered as the product of the average velocity and the net area of the opening.

"7. If the anemometer is held two inches from the register face, no deduction shall be made for the area occupied by the register face."

In answer to inquiries as to the measurement of the flow of air in the testing of ventilators and ventilating systems, the U. S. Bureau of Standards has submitted the following under the heading of "MEASUREMENTS OF SMALL PRESSURE DIFFERENCES:"

"The accuracy attainable depends on the magnitude and constancy of the head to be measured. If the pressure difference to be measured remained constant a vertical U-tube could be used, the head being read by means of a traveling microscope. In most cases the pressure difference varies considerably and it is necessary that the gauge be sensitive enough to show these variations so that we may take an average over a period of time. If the pressure difference is large enough, an inclined gauge may be used. When the pressure difference is small, no entirely successful method has been devised. The difficulty in the use of a gauge of small slope is to make the gauge so that the slope does not change in the course of time. When it is remembered that in the case of a Pitot tube placed in a ventilating pipe, the head will be of the order of 1/25 inches of water, that a slope of 25 to 1 is needed to give a 1 inch scale reading, and that therefore an error of 1/200 of an inch in the vertical height of the gauge means an error of ten per cent in the head, the difficulties are obvious. It is possible in a laboratory with expert handling to get results of value, but the manipulation is very troublesome.

Our advice would be to abandon the Pitot tube entirely. You realize that the velocity varies in the different parts of a ventilator pipe and that twenty or more readings would have to be taken in the different parts of the pipe to compute the average velocity. The wind velocity past the ventilator would have to be constant while these readings were being taken.

If the speeds in the ventilator pipe are not too low, it is possible to use an ordinary anemometer. The ventilator pipe must be horizontal so that the anemometer is vertical. The anemometer is moved slowly back and forth along a diameter for several minutes. Check readings are taken along other diameters. In this way it is possible in many cases to attain an accuracy of five per cent. If comparative readings only are desired, the anemometer may be fixed at the center of the pipe. This instrument cannot be used if the speeds are below 200 feet per minute and is not very accurate if the speeds are below 300 feet per minute.

Beginning early this year the chairman of this committee has been corresponding with the Secretary of the United States Department of Agriculture, emphasizing the importance of the ventilation of farm buildings and the need for research work on this subject.

In reply to our letters the Department wrote as follows: "Considerable work has been done by the Bureau of Public Roads of this Department in the way of ventilating systems in the various barns for which plans have been made, but no investigations have been made, the work having been based on data secured from other sources. The available information on this subject is very meagre.

"We realize the importance of the proposed investigation and believe that a cooperative arrangement could be made with the American Society of Agricultural Engineers to carry on this work. It is thought that this Department might detail a barn architect for about one-third of his time, his salary and traveling expenses to be paid by the Department, which would make it necessary for the American Society of Agricultural Engineers to secure the barns in which the investigations would be carried on, and to provide the equipment as might be necessary.

Carrying out these suggestions, M. A. R. Kelley of the division of agricultural engineering of the Bureau of Public Roads was appointed to spend four months of his time on this work. Mr. Kelley has also been appointed as a member of this committee so that we are able to cooperate closely in this work.

Since this Society has no funds with which to carry on research work, the matter of securing equipment appeared to be a difficulty. However, a circular letter sent to the agricultural engineering departments of the various state agricultural colleges brought offers of the use of a large number of the necessary instruments. It was decided to begin the field work as early as possible in winter and with this end in view a trip was planned into northeastern North Dakota where winter conditions could first be met. Mr. Kelley has succeeded in securing instruments for his work, hence it has not been necessary so far to call upon any of the colleges for the loan of their instruments.

Mr. Kelley accompanied by W. B. Clarkson and C. S. Whitnah have been engaged in field work since December 1, 1920. They have spent the first half of this month in the vicinity of Grafton and Edinburg, North Dakota, where they have made tests in several combination dairy and horse barns. Some very interesting data has been secured which will be published later. On December 17 the party returned to Owatonna, Minnesota, where the work is now in progress.

Particular attention is being paid to the matter of heat losses in the barns that are being tested and we hope by the close of this winter that we will be able to secure much useful data bearing directly on this phase of our research problems.

We desire to make special mention of the work of Francis G. Benedict, director of the Carnegie Institution of Washington, Nutrition Laboratory, Boston, Massachusetts, on the de- Nutrition Laboratory, Boston, Massachusetts, on the determination of the carbon dioxide content of air samples. His work included some actual determinations in a barn at Durham, New Hampshire. As a result of his experience he recommends the use of the Haldane apparatus for CO2 determinations in our research work. A report of these investigations, entitled "Carbon Dioxide Content of Barn Air," is published by the U. S. Department of Agriculture in the "Journal of Agricultural Research" Vol. 20, No. 6, December 1920.

Respectfully submitted,

COMMITTEE ON FARM BUILDING VENTILATION

W. B. Clarkson, Chairman — R. U. Blasingame
Ralph L. Patty — Wm. Aitkenhead

DISCUSSION

MR. DICKERSON: I should like to ask Mr. Clarkson in regard to what he finds the rough average of the velocity of air in the ordinary barn ventilating system in zero weather. That is a question that comes up in any of our problems in figuring ventilating apparatus. I should also like to ask if he has made any study, in connection with these heat losses, of the difference in floors—hog house floors especially. That is one of the questions that comes to me more often than anything else, and I have been told that the Iowa State College tried an experiment of flooring a hog house partly with solid concrete and partly with hollow tile covered with concrete, and that the hogs at least showed a marked preference for the tile floor.

MR. BROOKS: One time there was observed in the menagerie in the Central Park of New York a tendency on the part of some of the animals—even those with the thickest skins, such as the hippopotamus—toward rheumatism. It was an unexpected symptom in an animal such as the hippopotamus, and analysis showed that it was caused by the fact that the animal was imprisoned on a concrete floor. The chill of the concrete was too much for the temperature of the blood of the animal. If we are going to make houses comfortable for animals in this climate it is just as well to remember that it is not only the air they come in contact with, but the floor also, and if we can get some insulation between the animal and the temperature of the earth under the floor, he naturally will like that building better.

MR. CLARKSON: Answering Mr. Dickerson's first question roughly, I would say that a zero outside temperature with a barn temperature of from forty-five to fifty degrees is the average, and the velocity up the foul air flues will generally be around three hundred feet a minute. That will, of course, depend somewhat on the size of the flue and surrounding conditions and it will also depend upon the character of the flue itself. Sharp angle turns, of course, would make a big difference. It is a hard question to answer, but the answer roughly is that in an ordinary flue that is properly made and installed, about three hundred feet a minute would be about the average of the velocity of the air per flue.

In answer to the second question, I will say that the committee as yet has made no studies of hog house floors or of barn floors as to the coefficient of heat loss. It seems to me that is not only very important and perhaps should be gone into right away, but it will be necessary I believe before we can get any accurate or reasonable results to procure a system of thermocouples or something like that, so we can take the actual temperatures of the wall or the floor in either case.

MR. KAISER: I have been in doubt as to the feasibility of having a thermocouple there because a concrete floor or a wood floor may have the same temperature but it would not be apparent. The trouble is the conductivity. When Mr. Brooks spoke of the hollow tile I presume he had reference to concrete hollow tile for buildings as well as clay tile. You can make anything out of it that you can make out of clay tile, and tests made by the United States Bureau of Standards show that concrete has a lower conductivity than the clay tile.

MR. CLARKSON: I think in connection with that, of course, that we all understand that the proper air spacing is going to help not only the floor but the wall by way of insulation, that is, proper insulation. If you will recall the report of the committee a year ago you will remember that we called attention to a barn well in Wisconsin that was made up of clay tile, in which the temperature in the barn—a barn filled with cattle—could not be raised above freezing when the temperature outside was approximately zero. The reason in that case was not on account of the tile, but on account of the work of the masons who laid up that tile. The leakage was through the wall. The wall was a regular sieve because the masons had not done their work properly.

COMPUTATIONS OF VENTILATION TEST DATA IN A CANADIAN BARN, FURNISHED BY PROF. CALDERWOOD

The method of solution of these problems was, first, to use the barn and data of the Brandon Experimental Farm as a means of checking the application of the theory; and second, to apply the theory to other barns submitted. This procedure seemed logical, for the Brandon Experimental Farm Barn was representative of good construction, and furthermore the values recorded in the test data served a splendid means of checking the results of the calculation.

The mathematical calculation in this investigation consisted in determining the amount of heat transmitted through the walls, ceiling, and floor of the barn. The constants for the unit heat transmitted for the various building materials were taken from recognized authorities. In the case of floors and in the absence of definite information as to the construction used, an equivalent of a three-inch concrete floor was assumed. In the case of ceilings, the roughage of feed stored in the loft would materially reduce the heat transmitted but for the case at hand it was assumed that nothing was stored in the loft and that the heat transmitted through the ceiling would be similar to ordinary house construction. (The loft was filled with hay.) No heat other than that generated by the animals were considered. The heat generated per cow was taken at 3172 B. t. u. per hour as suggested by Professor

NOTE: In the actual test of the Brandon Experimental Farm Barn the actual measured air for ventilation exceeded the value found in the above calculations. This would indicate the addition of heat from other sources. Undoubtedly this heat came from the walls. The evening of the test was evidently the beginning of an extremely cold night. The heat thus stored in the walls during the day dissipated itself during the test.

King. In the absence of information as to the number of windows, the glass area of the barn was assumed as ten per cent of the total wall area.

Heating and Ventilating Theory Applied to Brandon Experimental Farm Barn

Dimensions	107½′ x 46′ x 8¾′ (inside)
Walls	24″ concrete (2″ air space)
External temperature	—14.5° F. (average of test)
Inside temperature	+42.4° F. (average of test)
Capacity of barn	65 cows
Animal heat generated per hour	65 x 3172 = 206,000 B.t.u.
Cubic space per cow	650 cubic feet
Heat transmitted per hour through walls of barn during test	84,850 B.t.u.
Difference of these heats or heat available per hour for producing ventilation	121,150 B.t.u.
Percentage of animal heat lost by radiation through walls, etc	41%
Volume of air per hour the unused heat could raise to barn temperature	113,000 cubic feet
Volume of air per cow per hour	1,740 cubic feet

The results could possibly be made more consistent by considering several other items. Thus, my value for the heat transmission through the ceiling is high because I assumed no straw or hay in the loft. One other fact I ignored was that the north wall of the barn was banked. The difficulty that I encountered in this respect was that I could not estimate the effect these items would have on the heat transmission.

I believe that if it were possible to test the Brandon barn for a period of say forty-eight hours or longer at a time when conditions could be maintained constant, that a reasonable check would result in the heat balance as calculated from theory and that secured from the test data.

Conclusions

The results of these calculations suggest the following conclusions:

1. The theory of heat and ventilation can be very effectively applied to barn ventilation and should be considered in the design or installation of barn ventilating systems.

2. The greatest cause for difficulty in barn ventilation is traceable to the large cubic space that is allotted per cow. This should only in rare cases be permitted to exceed 500 cu. ft.;[2] where this value is exceeded special attention should

be given to the construction of the walls for heat insulation.

3. If 500 cubic feet[1] of space per cow is considered standard, little difficulty should be encountered in heating if reasonable construction is applied to the walls of the barn. The walls, ceiling and floor should be as nearly as possible wind proof and the walls should be equivalent in heat insulation to that of a thirteen-inch brick wall; a twenty-four-inch concrete wall with two-inch air space; a twenty-six-inch stone wall; a six-inch hollow tile wall with one-half-inch plaster on both sides; or a frame wall of matched sheeting, studding, matched sheeting, paper and clap-board construction.

DATA BARN VENTILATION TEST AT BRANDON EXPERIMENT STATION FURNISHED BY PROF. L. J. SMITH

BARN DATA

Cattle barn, 50 x 111½ feet outside. Full bank barn north side, built summer of 1917.

Walls: Concrete, 22 inches thick, with dead air space and vertical V-joint inside, total thickness, 24 inches, average distance to ceiling, 8¾ feet.

Gambrel roof with Shawver bents; 2 x 6 rafters; 2 x 8 studs, 18 feet long on 2 feet centres; 2 x 12 floor joist ceiled underneath with V-joint, and with shiplap, two thicknesses building paper and flooring for loft floor.

Capacity of barn, sixty-seven cattle—counting two calves equal to one cow. Cubic space per cow, 700 cubic feet. (107½ x 46 x 8¾ feet inside = 4306 ÷ 67 = 645.8.)

[1]Professor Calderwood's statement that the cubic space in a dairy barn should not exceed "500 cubic feet per cow" is logical, but dairymen are forced to use more space to properly handle the herd so that the one alternative is better insulation to minimize heat losses through walls, windows, ceiling and doors.

Rutherford system of ventilation used with three out-take flues, 2 x 2 feet inside and five intake flues of about half the total area of the out-take flues. Out-take flue area per animal—25.8 square inches.

Control damper of O. T. flue located at bottom of each flue, just above level of stable ceiling. Four air meter readings were taken at each test, two on each side of damper, which was in a vertical position in centre of O. T. flue.

Flue areas at damper—No. 1, 24 x 25; No. 2, 23 x 24; No. 3, 23 x 24 inches.

TEMPERATURES

Outside Barn	Time	Inside Stable, in Center, Half Way Between Floor and Ceiling
	5 P. M.	47
1 degree above	6:30	46 (from recording thermometer)
2 degrees F. below	7	46
7 degrees F. below	8	45

11 degrees F. below	9	43
12 degrees F. below	10	41
13 degrees F. below	11	42
15 degrees F. below	12	42
16 degrees F. below	2 A. M.	40 degrees F.
19 degrees F. below	3	40
20 degrees F. below	4	39½
22 degrees F. below	5	39½
23 degrees F. below	6	40
23 degrees F. below	7	43
20 degrees F. below	8:30	

RELATIVE HUMIDITY READINGS

8 P.M.	42¾-43¾ degrees F.	Relative Humidity
9	41¼-42¼ degrees F.	
11	41¾-42¾ degrees F.	
12	41 -42 degrees F.	
2 A.M.	39 -40 degrees F.	
5	39 -40 degrees F.	

Wind in west; 8 to 10 mi. per hour; weather clear.

SUMMARY

The tests were naturally divided into three periods:

First, when all three O. T. flues were open

Second, when two O. T. flues were open.

Third, when one O. T. flue was open.

The writer did not want the temperature of the stable to fall below 40° F.

The first period, from 6:30 until 10 P. M. showed an average ventilation of 4590 cubic feet per hour per cow, which, allowing 120 cubic feet of air breathed per hour per cow gives a purity of 97.36 per cent which is considerably higher than Dr. King's ideal figure of 96.7 per cent. During this part of the test the outside temperature fell 13 degrees, while that inside the stable fell 5 degrees.

The second period. At 10 P. M. No. 1 O. T. was shut off completely, cutting down the out-take area one-third. This part of the test ran until 5:40 A. M. and, while the temperature outside fell 10 degrees, the inside temperature dropped only 1½ degrees and held steady at 39½ degrees F.; but the second O. T. flue was cut off to test the amount of ventilation, which might be had from the remaining flue.

The average amount of ventilation per hour, per animal, for the second period was 3870 cubic feet which is still better than Dr. King's standard, being 96.9 per cent fresh air breathed.

The third period. Immediately upon closing the second O. T. flue, the barn temperature began to rise, changing from 39½° to 43° Fahrenheit in 2 hours, 20 minutes, during which time the outside temperature dropped from 22 to 23 degrees below zero. The recording thermometer showed that the stable temperature was still on the uniform increase when the test was stopped. During this period the animals were getting an average of 2594 cubic feet per hour, or a purity of 95.4, which is still above the standard of 95 per cent, which is set for animals by many who have made a study of barn ventilation.

The interesting and valuable part of this test is the velocity of out-going air which averaged 711 feet per minute.

Another interesting fact is demonstrated in this test, namely, that the closing of the out-take flues does not decrease the air movement in proportion to the decrease in out-take flue area. The three out-take flues are all 24 x 24 inches inside. The following table shows the amount of ventilation in contrast to the out-take flue area:

No. of O.T. flues open	Area of O. T. flues open	Av. no. cu. ft. air per hr. per cow	Per cent decrease in ventilation
3	12 sq. ft.	4540	0
2	8	3870	14¾
1	4	2597	42 4/5

Intake Regulation. During the first part of the test until 2:15 A. M. intake flue No. 1 was closed, No. 2 was open, No. 3 open, but partially clogged; No. 4 open, and No. 5 open. At 2:15 Nos. 2 and 4 were partially closed, the rest being left as before.

Condition of stable. The inside walls and ceiling of stable were free from frost or moisture, except in several small spots near the inside wall, on the ceiling above the scale, where ceiling was damp. This may have been partially due to the cold air entering from the feed room where the door was open. However, the loft floor was not well covered with feed throughout, which would tend to cause a cold ceiling and also to increase the heat losses from stable.

CLIMATIC DAIRY BARNS*

By W. B. Clarkson and C. S. Whitnah
Director and Associate of Research and Extension, King Ventilating Company

EVERY part of the United States has experienced freezing weather at some time during its history; even the most southern points in Florida, Texas and California have not entirely escaped.

The U. S. Weather Bureau has issued an outline map of the United States showing graphically the lowest temperatures ever observed in the history of the bureau. In the study of this map, one is confronted with some startling records showing the wide extent of low temperature weather conditions during winter.

When it is realized that points so far south as Columbia, South Carolina; Mobile, Alabama; Vicksburg, Mississippi; Shreveport, Louisiana; Waco and El Paso in Texas, are within the zone of a possible zero temperature in winter, we can then understand the importance of a careful study and analysis of the housing conditions for stock in the southern states as well as in the North.

The varying climatic conditions of this vast territory extending from the Gulf of Mexico as far north as dairy cattle are handled is a more important factor in sanitation than the average stockman realizes and the handling of domestic animals for profit is one of the most important and immediate problems confronting the agricultural engineer.

In the necessarily limited scope of this article, we can touch upon the dairy barn only, but what is said of it will apply in a large measure and with equal force under certain modified conditions to all farm buildings where livestock is handled.

In the dairy barn, we find by comparison that the cow, which produces the largest percentage of butterfat per calories of food consumed plus the cost of handling is the animal of greatest profit and in the production and maintenance of such an animal, every surrounding condition ought to be taken into consideration and carefully analyzed for the purpose of utilizing every element of advantage and, as much as possible, eliminating the disadvantages.

The animal husbandry departments in the various agricultural colleges for many years have been developing the science of breeding, feeding and management and the agri-

*This article, published in the October, 1920, number of "Agricultural Engineering," the journal of the Society, is presented as a summary of the 1920 report of the Committee on Farm Building Ventilation.

cultural engineers in their department of the work, must keep pace with this development.

In the study of farm building ventilation and the many problems that confront the student, one of the most important considerations is the minimum temperature likely to be encountered, but in the practice of farm building construction very little thought has been given to the correct planning of the ceiling, walls, windows and doors as these are related to the various climatic conditions during the winter months.

Fig. 1 shows an outline map (revised by U. S. Weather Bureau) of the United States and the southern portion of Canada. It will be noted that on this map, lines have been drawn to indicate the boundary lines between the four zones. The first zone embraces the provinces of Manitoba and Saskatchewan and part of the provinces of Alberta and Ontario as well as parts of the states of Montana, Minnesota and the entire state of North Dakota.

The second zone is clearly defined on the map and it is interesting to note that this line curves down into the state of Pennsylvania, taking in that portion of the state where the temperature in winter reaches a lower degree than in the balance of the state. This section properly belongs to the second zone. It will be noted also that this line is drawn around a section of northwestern Washington and eastern Idaho, which belongs to the second zone. There is a portion of the state of Wyoming, clearly defined on the map, that is first zone territory.

The boundary lines of these zones have been determined a territory where the temperature will drop as low as thirty

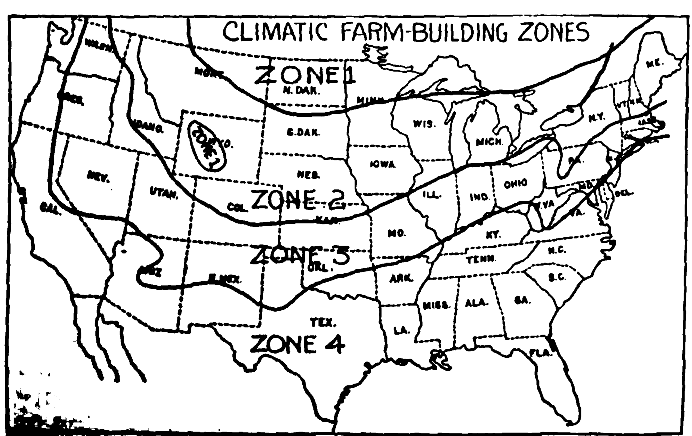


Fig. 1

degrees below zero during the winter months. A sustained temperature as low as minus twenty degrees is not an unusual occurrence in the southern portion of the first zone with a drop of fifty degrees in the northern portion of that zone. In the southern portion of the second zone, we find that a sustained low temperature from zero to twenty degrees below is not unusual.

The territory embraced in the third zone by the same analysis will experience a sustained low temperature between zero and ten degrees above. The northern portion of the fourth zone, especially on the western side, quite often experiences storms or blizzards in which the temperature extends below zero and in this territory a good barn is a profitable investment.

In the dairy barn the heating plant is the herd of cattle housed therein. Each cow is a radiating unit of that plant. The B. t. u. of heat given off by a dairy cow must be as the calories of food and water consumed is related to her bulk and the amount of her milk flow. The proportion of food used in the manufacture of milk and that part given off in heat is problematical but we can be sure that if the barn room is kept clean, the air fresh and the temperature of the air controlled at a degree that causes the cows to be contented and happy, it follows naturally that the milk flow will be increased. If, under such conditions, their milk flow increases and there is a proportional decrease in the heat given off, then the most important problem for the agricultural engineer seems to be, *not how much heat* is given off by the cow but to determine *the most efficient use of this heat.*

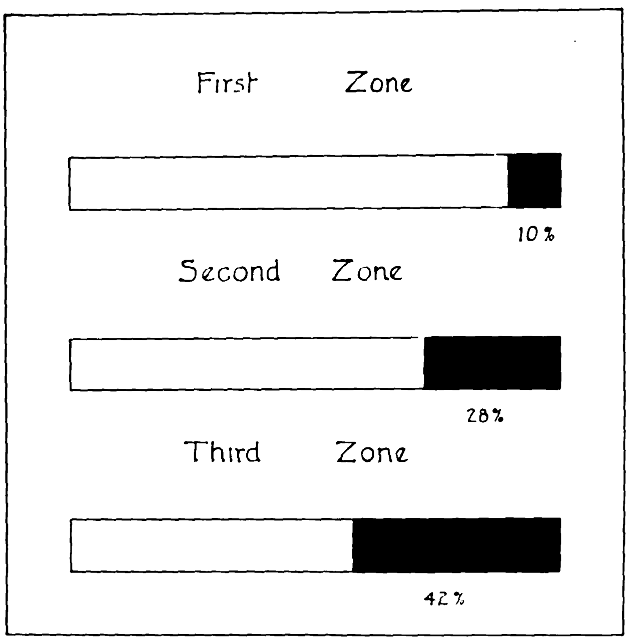
In our observations we have found that in the first zone a temperature of 35 to 40 degrees above zero in the stock room, where all other sanitary conditions are good, is a comfortable temperature for the herd. In the second zone a temperature as low as 40 to 45 degrees will be practical while in the third zone the barn temperature may be maintained at 50 degrees. The barn temperature should never go below 33 degrees Fahrenheit.

The heat passing through the walls, doors and windows of the barn constitutes a dead loss to efficiency during these months of the year when cold weather prevails. In order that this heat may be used to produce sanitary conditions in the barn, the loss of heat through the walls and ceiling must be reduced as much as possible.

Having given proper consideration to temperature conditions where the barn is located and the best temperature for the barn room, our task is to determine the amount of heat given off into the atmosphere by the heating plant, the cow, and then design the barn and the ventilating system to make the most efficient use of this heat.

The amount of heat given off by the cow in a dairy barn must be computed in order to determine what type of barn wall and capacity of ventilating system will make the most economical use of the heat given off. The heat that is given off from the body of the cow, goes into the air and outside through the barn walls and up the ventilating flues.

Pending the receipt of a report, which we are expecting from Dr. H. P. Armsby, giving his computations of the heat generated by the cow through metabolism, the method we have used to determine the heat given off by the dairy cattle is to compute the amount of heat lost through the walls of the barn and the amount of heat used by the ventilating system to provide a circulation of air. The amount of heat lost



DISTRIBUTION OF HEAT.
WHITE PORTION SHOWS HEAT NEEDED FOR VENTILATION IN CLIMATIC BARN OF EACH ZONE.
BLACK PORTION SHOWS THE GREATEST AMOUNT OF HEAT THAT SHOULD BE PERMITTED TO ESCAPE THRU THE WALLS.

Fig. 2

through the barn walls, windows and ceiling may be computed as follows:

$$H = [(W \times K_w) + (D \times K_a) + (S \times K_s) + (C \times K_e)] \times [T - T.]$$

H = heat in B. t. u.
W = window area in sq. ft.
D = door area in sq. ft.
S = side wall area in sq. ft.
C = Ceiling area in sq. ft.
k = coefficient of heat loss in B. t. u. per sq. ft. per degree.
t = temperature inside.
t' = temperature outside.

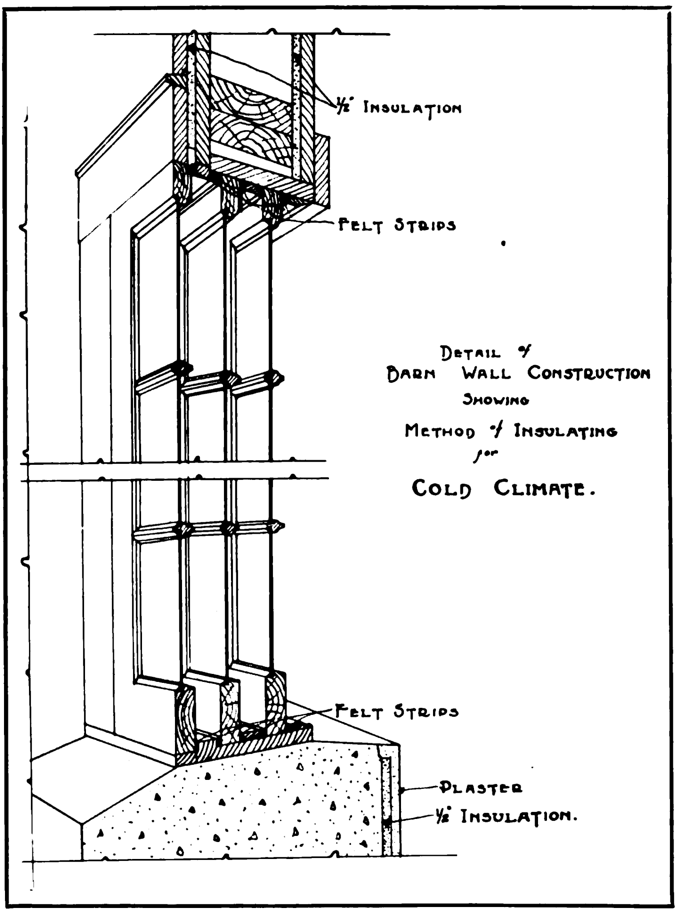


Fig. 3

The amount of heat in the air going up the foul air flue is as follows:

$H = v \times A \times d \times s \times (t - t')$

H = heat in B. t. u.

v = velocity in flue feet per hour.

A = area in flue and sq. ft.

d = density of air at temperature at bottom of flue.

s = specific heat of air.

t = temperature of air at bottom of foul air flue.

t' = temperature outside.

By this method we have arrived at approximate values of the amount of heat given off by dairy cattle.

Tests of temperature conditions in a number of dairy barns show that the amount of heat given off by a herd of cattle is very nearly constant for cattle of a given size in a given climate. This heat comes from the feed of the cows and must be used economically if the cows are to derive the greatest benefit from the feed.

A ventilating system will make the most efficient use of the heat by drawing the fowl air from near the floor it is then taken out at the lowest temperature existing in the barn.

The fowl air flues should be of large enough area to carry out sufficient air to ventilate the barn properly with the flow of air resulting from the circulatory movement of the warm air in the barn and the pressure head caused by the passage of wind across the ventilator.

The heat that is given off by the cattle is also made use of in the ventilated barn because of the increase capacity of the air to carry off moisture.

In order to maintain a standard of purity of 96.7 per cent of air that has not been breathed, it is stated by Prof. King[4] that it will require an air movement of 59 cubic feet per minute, per cow. It will take a quantity of heat to warm this amount of circulating air which will vary with the difference between the temperature in the barn and that outside. In each climatic zone then a certain percentage of the heat is required for proper ventilation. The barn should be constructed so that the heat loss through the walls is within the limit which will leave the heat required for proper ventilation. The chart shown in Fig. 2 represents the relative amount of heat, which is used by a ventilating system that circulates 59 cubic feet of air per minute, per cow and lost through the walls of a barn of proper construction for the different climatic zones.

In such cases the barn room is assumed to have a cross-section 32 feet wide and 8 feet high in which the volume was 600 cubic feet per cow. This represents very nearly an average condition.

Taking as an average value 4000 B. t. u. per hour for the

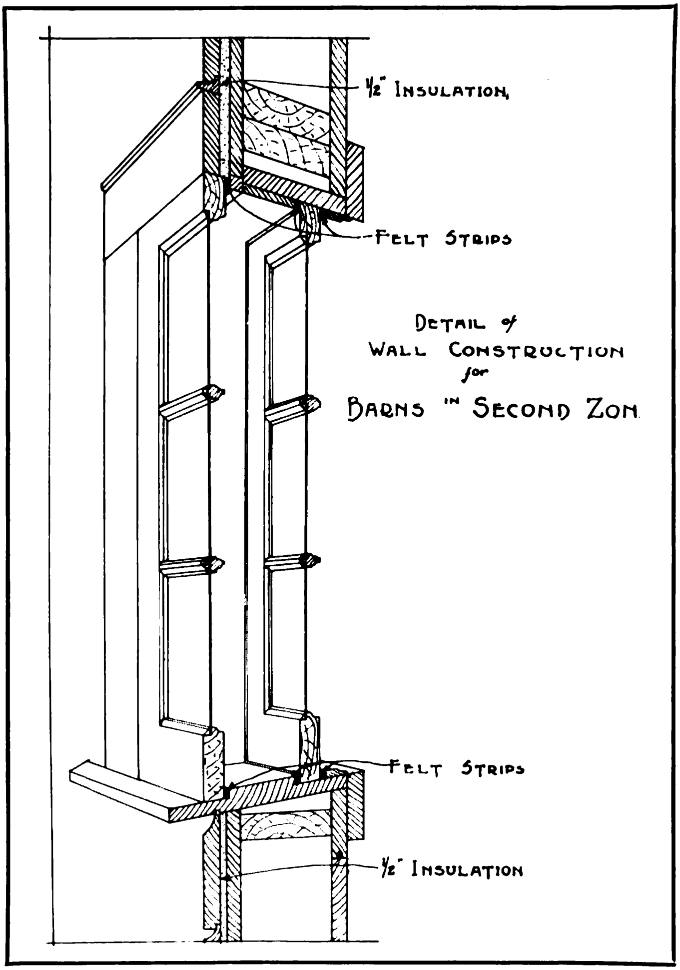


Fig. 4

heat given off by a cow weighing about 1200 pounds, a reasonable weight for Holstein cattle, we find that about ten per cent of this heat is the greatest amount that can be allowed to be lost and maintain a temperature of at least 33 degrees when the outside temperature falls to 30 degrees below zero.

In the second zone we have considered 33 degrees as minimum in the barn and in the third zone a 45 degree minimum, as this represents the condition when the greatest demand is made on the heating plant in the barn in the several zones.

In the light of the data already accumulated in our research work and the first hand study of the actual conditions in various barns in all of these zones, we feel justified in presenting the detailed drawing illustrating the character of the wall which should be provided in all dairy barns, situated in the first zone.

We believe that the barn wall in this zone should have a coefficient of not greater than 16 B. t. u. per hour per degree difference in temperature. Fig. 3 shows a perspective of a

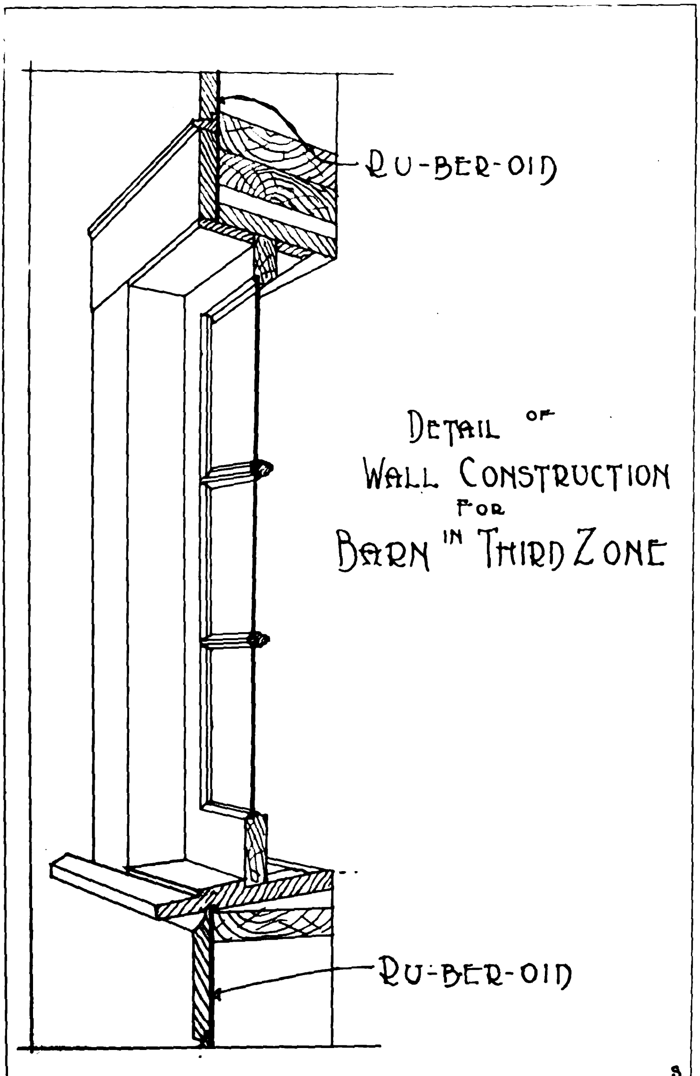


Fig. 5

lumber wall and details of a window, also a perspective of a concrete wall and window detail. We are making no attempt in a limited scope of this article to discuss all of the materials that are available for barn wall construction but have simply taken two of the most popular materials in use as an illustration.

[4]"Ventilation of Dwellings, Rural Schools, and Stables," by F. H. King.

For the barn wall in the second zone, we suggest the character of a wall as illustrated in Fig. 4 and the coefficient for this wall is not greater than 10.43.

We have shown in Fig. 5 the character of a wall most suitable for a barn in the third zone. It is evident that the consideration of heat loss is not as important for a barn in this zone as is the control of air movement through the barn. For this reason the important consideration is to have the walls free from cracks and other air leaks.

We believe that the farmers situated in Oklahoma, the panhandle of Texas, and perhaps all of the northern edge of the fourth zone, will not make a mistake to have the same character of construction as in the third zone barn.

When we take into consideration that the dairy cow is a very nervous individual, and of a temperament that is very susceptible to unusual conditions we believe that the dairymen in the southern states will find it very profitable to erect barns that are built high enough and with a properly installed ventilating system so that the temperature and air in the barn room in winter can be properly controlled, thus affording opportunity to keep the dairy herds comfortable, contented and happy during that portion of the year when the storms and blizzards are prevalent.

LAND CLEARING WITH DYNAMITE

By Arthur L. Kline

Jun. A.S.A.E. Agricultural Service, Hercules Powder Company

THE present time, when there is an apparent overproduction of agricultural commodities, may not seem to be one at which a subject may be most properly discussed which deals with the ways of bringing yet more land under cultivation and thereby increasing the total production of those same commodities. But we all realize that the total production of foodstuffs in the world is much below normal, and that it is only temporarily unbalanced economic conditions which prevent the farmers of the United States from contributing freely to the world's food supply, and thereby continuing to receive a fair share of the prosperity which has been theirs for the past five years; and which should always be theirs. And all those who look forward for more than the next ten years also realize that the natural increase in the population of the United States, especially the growth of the cities, makes it necessary for the government, both state and national, to decide upon and promulgate such methods as will always, or as long as possible, provide adequate acreage of tillable land to supply the nation's food. I say as long as possible, for our present national trend toward manufacturing and industrial life, with the natural and inevitable increase of population, will probably bring us in time to the place where we can no longer grow our own foodstuffs. However, that time is in the very dim future, and will be put off the longer as we are the more active and resourceful in bringing the largest possible percentage of our national area under the cultivation of more and better trained farmers.

So much concerning the interest of land clearing to this convention. It is indeed a very broad subject, but I wish to state in a few words just where dynamite is important in it. In one general sense, otherwise fertile, tillable land is rendered unfit for cultivation by excess water, stones, and plant growth, such as trees, brush, and stumps. Dynamite is used largely, in various parts of the country, to remove these encumbrances. In the rich bottoms of the Mississippi and its tributaries, hundreds of tons are used annually in blasting out ditches to drain off the water, and more to blow out the stumps from the land so drained. In various sections throughout the entire country there are areas in which rocks and stones are so thick as to interfere seriously with profitable farming. Here again dynamite is of value, though to a smaller extent than in ditching and drainage.

But by far the largest and at present most important of the uses of dynamite in land clearing, and the one which I suspect the committee who arranged this program had in mind when they assigned this subject, was its use in the removal of the third of the encumbrances I mentioned, that is, trees and stumps, and especially stumps. Figures from the United States Department of Agriculture in 1918 show approximately one hundred million acres of cut-over land in the southern states, thirty million in the lake states, and eight million in the Northwest, and there will doubtless be much more as more timber is removed. The figures for the lake states are probably somewhat reduced by this time, as lumbering is on the decline there, and of course much of this land will never be suitable for anything but more timber, or for grazing, but there are still millions of fertile acres which must eventually be cleared and produce foodstuffs.

It is in this field that dynamite at present finds its greatest agricultural usefulness. It does not, of course, do the whole thing, nor can it be used without a great deal of hard work. An area of cut-over land which is chosen to be cleared is first cleaned of brush, any second growth valuable for timber is cut and the brush and slashings burned. Then, especially if most of the stumps be hardwood, the field is pastured for a few years, preferably with sheep or goats, in order that the shoots may be kept down. If this is done, most hardwood stumps decay fairly rapidly, especially the smaller fibrous roots, and then the stump comes out cleaner and with less dynamite. Pine stumps decay very slowly, so they can be removed with the others or at any convenient time when conditions are right.

It is commonly accepted, in this last stage of clearing cut-over land, namely, the removal of stumps, that dynamite is almost essential. It is not, of course, the only way they can be removed. You can, as many of the early settlers did, grub out your stumps by hand, and many people use stump pullers without the aid of dynamite, but, as said before and as shown by recent investigations by state and national authorities, as well as the popular verdict, dynamite will either do the work itself or be of material assistance in doing a better job and reducing costs when tractor or stump puller are used.

The Wisconsin Experiment Station classifies the use of dynamite in stumping as follows:

1. To blast them out entirely

2. To crack them before removing either by use of a team, by using block and line with team, or pulling with tractor or stump puller

3. To split them after they have been pulled whole in order to make handling easier.

It will hardly be worth while to discuss at great length the technique of handling dynamite, but I believe that you can readily appreciate that in handling any substance of the nature of dynamite or blasting caps, there would be one, and also, that it would be varied somewhat to produce any one of the results enumerated before. But the basis is of course the same, and the same precautions in regard to the proper handling of the dynamite apply.

After deciding which method you are going to use in removing the stumps, after having carefully considered the kind and the condition of those stumps, then the kind and condition of the soil will largely influence the choice of the dynamite to be used. Dynamite, of course, is made in several grades or kinds and many strengths in each grade, and much depends upon the selection of the proper grade and strength. The kind most largely used for stumping is the ammonium nitrate grade made on a low-freezing formula, and in strengths varying according to conditions from 20 to 60 per cent. In all cases blasting should be done when the soil is wet, and the water in the pores of the soil tends to confine the gases generated by the detonation, rendering the explosive more efficient; and the roots slip out through the wet soil easier. The results are a saving in dynamite and a cleaner job, as there is less earth clinging to the roots, and the hole left in the ground is smaller. The low freezing quality of the dynamite most frequently used makes thawing unnecessary except in cold weather, as it does not freeze until after water freezes. Ordinary dynamites become insensitive at about 40 to 45 degrees Fahrenheit, and their use in this condition, as well as when as when they are frozen, is very inefficient.

The literature published by the manufacturers of explosives, as well as the bulletins put out by the national and various state agricultural experiment stations, is voluminous and readily accessible to everyone who is at all interested in the agricultural uses of dynamite and in land clearing. A few general remarks will give you an idea of the different conditions in which we find stumps that are to be removed, and the rules which in most cases apply. (But even the most experienced blaster will make a few trial shots before loading the charges under many stumps in a field he is not familiar with). In a heavy, wet, clay soil with hardwood stumps that are not well rotted and with pine, a 20 per cent ammonia dynamite will do good work. If properly placed well down beneath the center of load, a charge consisting of the right amount should heave stump and roots out of the ground, splitting the crown into several pieces, without much noise or scattering, and without leaving a large hole or packing of the soil. On a lighter soil, say a loam, possibly a 30 per cent dynamite of the same grade would do the best work, and on a really light soil a 40 per cent. Or if there were not much water present, even a 50 per cent might be necessary in a very sandy soil. The more decayed a stump is, the less resistance it would offer naturally to the force of the explosion, so the lower percentages, or slower dynamites, as we say, with the more heaving effect should be used in these cases. A general rule regarding the amount of explosive to use states that the number of pounds should be the same as the square of the diameter of the stump in feet. Thus a three-foot stump would require nine pounds of dynamite to blow it out. One-third to one-half less is necessary when the stump is only to be split. But, of course, this rule is subject to interpretation and modification according to any number of factors and local conditions.

A few words concerning the means of detonating the charge of dynamite after it has been properly loaded and thoroughly tamped. There is no question that, if a stump can be satisfactorily removed or split up by one charge located under the center and detonated by fuse and an ordinary blasting cap, that method is the most economical. Electric blasting caps cost about three times as much as ordinary caps and fuse.

But they are much safer and more convenient to handle, and there is no possibility of a delayed explosion, which is the source of most of the accidents in stump blasting. The down stroke of the plunger on the blasting machine generates an electric current and detonates all charges or none; if none, you can disconnect the lead wire from the machine and safely go back over your circuit to find out what may be wrong. Aside from the safety factor, the other important advantage is that it permits the simultaneous firing of several charges under the same stump. This is especially advantageous under very large lateral or semi-taprooted stumps, where one charge under the middle would only split the stump and leave the roots still very firmly fixed. Or if enough explosive could be put far enough below the center to blast out stump and roots, or even loosen them, the crater would be altogether too large. And it is also of value in removing large roots of a stump which has been burned to the ground. In this case there is almost no resistance at the center, and separate charges under each root could not be detonated simultaneously by fuse and cap, so that the combined effect would be dissipated in a number of separate explosions. But all could be connected and detonated at the same instant by electric caps and firing, and better results obtained with less dynamite.

It is quite impossible to give, on this occasion, accurate figures of general application concerning the cost of clearing land. It will be valuable, however, for everyone who contemplate using dynamite for any purpose to know that its price per hundred pounds decreases when bought in larger quantities. This price, when bought in lots of ten tons, a minimum carload, or more, is $3.25 less than the ton-lot price, and $5.75 less per hundred pounds than the less-than-ton price. And the same thing is true of caps, fuse, and electric caps. It is also true, in land clearing as in other things, that the larger the scale on which an operation is conducted, the lower its cost, if efficiently managed. So far there has been little of this large-scale work done in land-clearing, though there has, of course, in what is known more strictly as reclamation work. The reason is, I suppose, that land clearing could struggle along as the individual settler's own proposition, while the reclamation had to be done by the Government on a large scale, or not at all. But the farmers are beginning, in this as in other things, to get together and cooperate, especially in their buying.

It will not be long before there are more than the present few individual operators who will undertake land clearing operations on a large scale. Some will go into it as contractors, as the few at present in the field will hardly be able to supply the demand for their services which will soon come about. More will take over large acreages and clear them for their own farming, and doubtless secure large and deserved profits. Of course, labor has been expensive and hard to get, but that condition ought soon to improve. And there are power boring machines, improved devices for piling stumps, and other means which render the work of gangs trained in the art of land clearing very efficient indeed. Improvements are constantly being made in machinery for pulling stumps after they have been split and loosened with dynamite, and quite recently an entirely new idea in the way of stump pullers has been completed.

All of the manufacturers of explosives are aware of the service they can render American agriculture by spreading information concerning the more efficient use of explosives in farming as well as land clearing, and are prepared, through their advertising service departments, and cooperation with all agricultural agencies to do a great deal to put these ideas into practice. The company I am associated with would appreciate any opportunity which might be offered by the members of the American Society of Agricultural Engineers to cooperate with them along this line.

DISCUSSION

QUESTION: What is this new machine for stump pulling that you mentioned in your paper?

MR. KLINE: The reason I did not go into that is because it has just recently been developed. It is known as the Bissell stump puller. I have read descriptions of it, although I have not seen it. A large steam donkey engine is mounted on a tracklaying tractor and there are two drums on which the cable is drawn. The cable is spread out in a large loop from each end of the machine in the form of a figure eight. The engine is sufficiently strong to contract this loop by winding the cable on the drum so as it tightens up against the stump it pulls it over. When it has pulled the stump over, it tightens against the next in line. The pull from both sides tends to counteract any pull that might be exerted on the tracklayer, so it practically is an operation for pulling stumps toward a common center. The tracklayer and engine are strong enough to pull out what few stumps may remain close up to the end of the machine. The tracklayer is also of service in moving on to the next location where the process is repeated.

I have seen that same idea worked out in a little different way with a large steam tractor which was mounted on exceptionally wide wheels to give additional traction. They tied one end of the cable to a large firmly rooted stump, laid it in a sort of arc and then tightened that by moving the tractor forward. As the cable tightened up and straightened out, it tipped over the stumps it came up against and gradually tipped them over until it was entirely straightened and then the cable was thrown to the other side and the process repeated.

QUESTION: Was that after the trees were loosened with dynamite?

MR. KLINE: There is not sufficient force in the cable laid in the arc to tip anything except a well-rotted stump. Hardwood stumps after lying in the ground ten or fifteen years can be tipped over easily.

R. W. TRULLINGER (Office of Experiment Stations, United States Department of Agriculture, Washington, D.C.): It might be interesting to the members if Mr. Kline could review the work done by the Hercules Powder Company in one of the South Atlantic states recently on the removal of stumps and their distillation.

MR. KLINE: That work was done by Mr. James of our company and was largely experimental, but it was quite largely done for our own interests because, as it proves practical, we shall go into it on a larger scale. Pine stumps, especially those of the South Atlantic states, are very rich in pine tar and turpentine and resin products, so it is profitable to combine the land clearing and distillation processes. That has been gone into largely from a private standpoint. I am not familiar with any of the exact figures in the case, but I do know that a very complete experiment was made to find out the most efficient way of removing these stumps and also the most efficient way in which they could be distilled and the utmost value in the way of pine tar products gotten out. The result has been entirely satisfactory. I have nothing more on that subject except to say that it was a very complete experiment both in the way of removing stumps and in their most profitable distillation.

D. P. WEEKS, JR. (drainage engineer, Dakota Engineering Company, Mitchell, South Dakota): Are there any available costs on that experiment?

MR. KLINE: We have published a booklet on that if anyone cares to have it.

L. F. LIVINGSTON (secretary, Marinette County Land Clearing Association, Wausaukee, Wisconsin): I happened to see the Bissell land clearing machine while in operation and Mr. Kline's description was a little faulty in that the figure-eight loop that he explained proved to be an absolute failure. If you can follow the line of a cable as it is being tightened up, you can see that that cable as it is pulled along the side of a stump will be naturally inclined to move up towards the top of the stump and the great majority of stumps were just lifted out of the ground and were not tipped over. Most of the roots were not entirely loosened; therefore, about eighty per cent of the stumps had to be gone after the second time. That idea was thrown aside and the Bissell machine as it stands today has two drums back to back and they use a 1⅛-inch cable running out on each side of the machine. That is hauled out by horse. They use individual chokers which are placed on the stumps by men. Five men are used on the side. The machine draws this cable in to itself. It goes down through a field and leaves a windrow of stumps behind it. The main object of the machine is to clean up, as it goes through, as much land as possible so that the farmer can go in and go to work.

I don't know whether you know it or not, but actual experiment has shown us in the upper part of Wisconsin that from fifty to sixty per cent of the labor of clearing is not removing the stump, but in getting rid of the stump after it is out of the ground. From forty to fifty per cent of the labor and cost puts the stump on top of the ground and from fifty to sixty per cent takes care of it after it is out of the ground. The main idea of the Bissell machine was to leave seventy per cent of the ground entirely free of stumps ready for cultivation after the machine has passed through. The machine costs in the neighborhood of $15,000 and it takes from twelve to sixteen men to operate it. It has not proven practical up to the present time although it is a wonderful advancement beyond anything at present.

I would like to ask you a question, Mr. Kline, in connection with your statement in regard to brushing. Have you any information in connection with windrow brushing as opposed to piling brush?

MR. KLINE: The windrow brushing is the more simple means of getting the brush into one place, but when it comes to burning it isn't as satisfactory as piling. You have to contrast the advantage of less labor of piling your brush against the advantage of much better and more efficient burning.

MR. LIVINGSTON: Do you know of any places where sheep and goats are used, actually and practically used, in cleaning up the brush?

MR. KLINE: It is done very little. It ought to be done but especially in Wisconsin it is not practised at the present time.

MR. LIVINGSTON: I have heard it talked about and have seen newspaper articles on it for the last six years, but I have failed yet to find a place where it has actually been practical to use either sheep or goats as a means of clearing land.

MR. KLINE: Where the sheep and goats are not used, it is necessary to cut the brush and shoots from the stumps with an ax. If they continue to grow, the stumps do not decay at all.

MR. LIVINGSTON: You made the statement that a hardwood stump could be tipped out of the ground readily after it is ten years old. The top of a hardwood stump in our country when six years old is generally so rotten that it is a dynamite job and not a stump pulling job, because the cable will cut off the top. If it is ten or fifteen years old, a half stick of dynamite will take a fifteen or thirty-inch stump and tip it out.

MR. KLINE: I suggest they be left for a few years in order to let the smaller fibrous roots decay. What do you think of my estimate of the saving to the farmers, Mr. Livingston?

MR. LIVINGSTON: The work was gone over by John Swenehart, professor in charge of land clearing work at the University of Wisconsin. He took our figures and the figures at which dynamite was sold by the retail dealers before we came into the county, and he estimated that the actual saving in cash to the farmers through their quantity buying was $45,000 in the cost of their material alone. For the benefit of those present, I might say that we went in there and had fifty-seven educational meetings in the upper part of the state, in Marinette County, and secured orders for land-clearing material, stump pullers and dynamite, the idea being to group the farmers' orders so we could make carload shipments into the various towns. Each man could take his material out of the car thus saving the cost of rehandling and any interest on the money tied up in the investment. We placed fourteen carloads of dynamite in the county in that way.

On top of that $45,000 saved in the cost of material alone, through our educational meetings one statement was made which I am willing to back up. We estimate through our figures and through what our farmers have told us that the average man using explosive wastes one-third of his material.

MR. KLINE: I have no doubt you are right. Everything in Wisconsin would indicate a large loss in that.

MR. LIVINGSTON: Our aim has been first to get the man his material, and after he has got the material teach him how to use it in the most safe and economical manner. Prof. Swenehart estimates the value of the educational work that we have done in the neighborhood of $100,000.

We have over twelve hundred farmers in our association and the association is financially backed by a twenty-five cent membership fee from each farmer which does not pay for the postage. The rest of the money comes from the bigger interests in the county—newspapers, bankers, and the land companies—and I will say that they have certainly been fine to us. They have not tied any strings to their money. They say, "You get the land cleared and that will advertise our county and will come back in returns to us in other ways." We cleaned up 18,000 acres this last year. That is three times greater than any other quantity of land in any other county in the United States, and it has been done through cooperation all the way through.

JAMES A. KING (Mason City Brick and Tile Company, Mason City, Iowa): What has been the cost per acre?

MR. LIVINGSTON: I don't think there is any such thing as cost per acre. Every acre of stumps is an individual problem by itself. Mr. Kline spoke of the rule of the thumb in connection with the amount of dynamite to put under a stump. He qualified that statement, however, so I will not say anything. Every stump is different from every other stump and every acre of stumps is different from every other acre of stumps. The soil is of different moisture content, so any man who tried to make a statement of the cost of clearing, unless he goes out and goes over that individual acre and counts the stumps and looks them over and sizes up what it is going to cost, cannot tell you what it will cost. There is no such thing as an average cost of clearing the land.

We found that eighty per cent of the dynamite we bought was twenty per cent dynamite.

MR. KLINE: Wasn't that part of your educational campaign?

MR. LIVINGSTON: From an economical standpoint, even though our soil is a light soil, the twenty per cent dynamite, if the soil is damp, will do as good work as forty per cent or thirty per cent dynamite and the saving to the farmer is well worth while.

MR. KLINE: I should have been glad, had I the time and had I not been trying to give an article on the general aspect, to have gone a little further into this Marinette County work. That was very interesting, and Mr. Livingston could have given a very interesting talk on that work up there because it is a practical illustration of the value of large scale land-clearing work carried out through individual settlers.

MR. WEEKS: No doubt many of you have seen the article in a recent issue of the "Engineering News-Record" giving the method of clearing by erecting a pole with a pulley on it and a hoisting drum. After the stump is loosened by dynamite, the hoisting drum draws the stump from its position in the ground and finishes the pulling that the dynamite has not completed, drawing the stump to the pile for burning. The pile may vary in size according to the circumstances. A new pole is erected for each pile and the pole that has been erected is burned with the pile of stumps.

It certainly gives me an inspiration to see the interest shown on the land reclamation subject. I have watched with considerable jealously the development of the American Society of Agricultural Engineers, and I have been afraid at times that the subject of land reclamation, either by land clearing, drainage, or irrigation, would be ground up in the wheels of power machinery or would meet an untimely death in the beater of the threshing machine. I think this is just the beginning of a series of articles on land clearing.

MR. LIVINGSTON: The gentleman who spoke in regard to using a gin pole referred to the same method of stump pulling that is used in the Pacific Northwest entirely. I was raised out there and they use a donkey engine and a gin pole. They have an automatic release on the end of the cable which they hook on to a stump. The stump is pulled in and dropped on top of the pile. The man does not go near the release after he hooks the stump on the end of the cable.

We have tried to apply that to lake state conditions, but the donkey engines are so heavy that there are no stumps in Wisconsin, Michigan, and Minnesota that are big enough to hook on to. What is necessary is a machine which will embody the same principles as the donkey engine of the Pacific Northwest and the tracklaying tractor similar to the Bissell machine. However, the Bissell machine is a different scheme. I think in the near future there will be a machine on the market which will use that same gin pole principle. Because poles are more scarce in this country than they are out in the Pacific Northwest, I think it will be an arrangement made out of structural steel, and the pile will be made underneath the end of it.

WALLACE ASHBY (Meadowlands, Minnesota): The country I am working in is swamp land. It has been drained out. The timber owing to the swampy condition is small timber.

Our experience has been that hand work has been more satisfactory than stump pullers or dynamite, although under some conditions we use both. The small trees we have are mostly poplars, spruce, and stuff like that. They grow eight or ten inches in diameter. We take them standing. A gang of men go in and are spread out, a man every ten or fifteen feet, sometimes two men working together. They cut the roots around one side of the tree and then push it over and the tree falling pulls out its own roots. The larger trees have to be cut up. We sometimes cut them up into four and eight-foot lengths, haul off the marketable timber and burn the rest. That is rather a crude and backwoods method and it may be that in the course of time we will get a better method and do it by machinery but up to now we have been using hand labor on the bulk of that work. The trees are small and surface rooted. We have used dynamite and stump pullers where the stumps warranted.

APPLICATION OF THE LAW OF VARIABLES TO THE DESIGN OF DRAINAGE OUTLETS*

By David Weeks

Mem. A.S.A.E. Drainage Engineer, Dakota Engineering Company

An explanation as to what the law of variables is is perhaps desirable before considering its application to drainage problems.

Suppose a thousand men were picked, and the mean height of the thousand men taken by dividing the sum of all their heights by the number of men. If the men were divided into groups, there would be comparatively large groups that varied from this average but a small amount, while as the variation became larger the groups would become smaller, and at the extremes there would be a few dwarfs and one or two giants. This illustrates very well the law of probabilities.

Take for illustration the old problem that is given in most of the algebras, that of flipping a coin. With a single coin there is an equal chance of obtaining either a head or tail, and the probability of either occurrence is indicated by the fraction one-half. If now you flip six coins, the probabilities of different combinations work out as follows:

All heads	1/64
Five heads, one tail	6/64
Four heads, two tails	15/64
Three heads, three tails	20/64
Two heads, four tails	15/64
One head, five tails	6/64
All tails	1/64

If these probabilities are platted as ordinates upon an "x" axis which is divided into six equal parts the typical probability curve shown in Fig. 1 will be the result.

The Army School of Artillery Fire uses such a curve in showing where their shots will probably fall. They divide their base line into eight equal parts and figure that 25 per cent of the shots will fall in the first space to the right or left of the "y" axis, 16 per cent in the second space, 7 per cent in the third space, and about 2 per cent in the fourth space upon the neutral axis. The resultant probability curve is shown in Fig. 2.

The general equation of the probability curve takes either one of the two forms:

(1) $y = Ke^{-h^2x^2}$

(2) $y = hd \times \pi^{-\frac{1}{2}} e^{-h^2x^2}$

e = a base in the Naperian system of logarithms

*The first part of the report of the Committee on Drainage.

K = a constant

$$h = \frac{1}{2d \times \Delta}$$

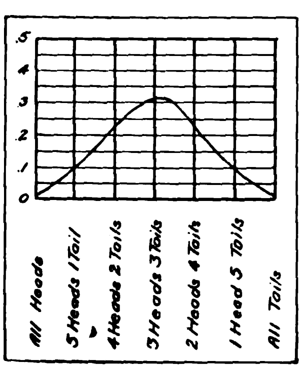
A full discussion of this general curve may be found in "The Method of Least Squares," by Mansfield-Merriman, published by Wiley & Son, or in the "Adjustment of Observations," by Wright and Hayford, published by D. Van Nostrand Company. Allen Hazen has used this method of probabilities in a paper entitled "The Storage to be Provided in Reservoirs," published in the 1914 Transactions of the American Society of Civil Engineers. He has also written a paper which is published in "Engineering News-Record," January 6, 1916. Thorndike Saville has an article in "Engineering News," Vol. 76, No. 26, published late in 1916, the subject of which is "Rainfall Data Interpreted by the Laws of Probability."

Although proper interpretation of rainfall data is only a beginning in the solution of a complex drainage problem, it might be well to reproduce here the meat of Saville's paper with a view to discussing later a similar treatment of the practical drainage problem.

Quoting from the work of Mansfield-Merriman, Saville gives the basis of his studies as follows: "In measurements of equal precision the most probable values of observed quantities are those which render the sum of the squares of the residual errors (variations) a minimum." The arithmetic mean is the most probable value, therefore, of a series of observations of equal weight.

For the purpose of illustration, Saville makes an analysis of the rainfall at Hartford, Connecticut, for a period of forty-seven years using the following as a basis:

Z = Most probable value of a term in a series of observations



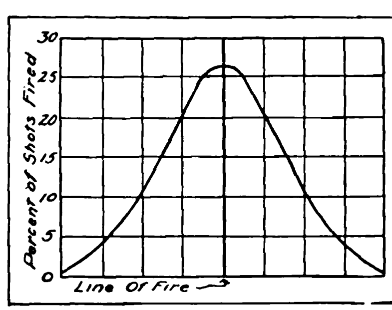


Fig. 1 at left
Fig. 2 above

n = Number of observations
M = Any observation
v = Variation of a single observation from the mean
r = Probable error of a single observation
R = Probable error of the mean

$$Z = \frac{\Sigma M,}{n} \qquad r = 0.6745\sqrt{\frac{\Sigma v^2}{n-1}}$$

$$R = \frac{v}{\sqrt{n}} = 0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}}$$

The quantity $\sqrt{\frac{\Sigma v^2}{n-1}}$ is called the standard variation, and the ratio of the standard variation to the mean, that is

$$\frac{n\sqrt{\frac{\Sigma v^2}{n-1}}}{\Sigma M}$$

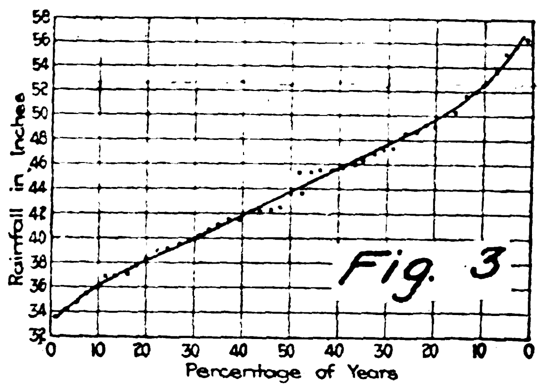
is called the coefficient of variation. The coefficient of variation is used in comparing the rainfall of one section with that of another. In some localities the variation from the mean may be great while in others, for instance on the Atlantic Coast, the variation is very small.

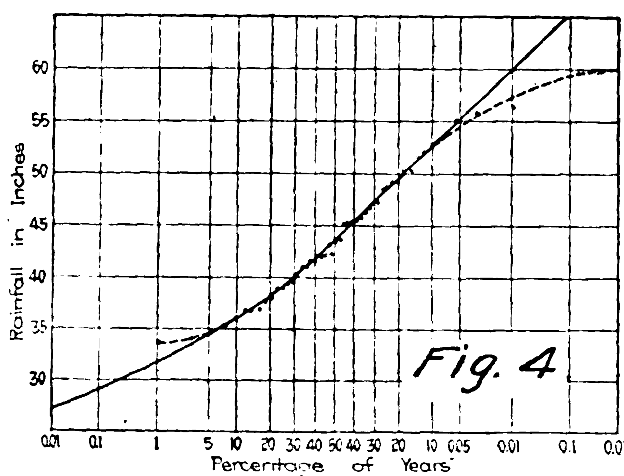
Fig. 3 shows each of the observations, which are arranged in order of ascending magnitude, platted as an ordinate, while the per cent that each observation is of the total is platted cumulatively as an abscissa. The abscissa 1.06 for the lowest rainfall observation is at the middle of the abscissa distance representing 2.128 per cent which is the per cent that one is of the total number of observations taken. Each subsequent abscissa is found by adding 2.128 to the previous abscissa.

Fig. 4 is the same data platted upon special paper for the purpose of getting a curve that will approximate a straight line. The abscissae intervals are made in accordance with the value of the probability integral. The advantage of a straight line is in predicting frequency of future rainfall occurrence by extending the graph beyond the limits of observation.

Now the application of the theory of probabilities to the economic design of drainage systems is an altogether different thing than the simple prediction of probabilities of rainfalls of given intensities. There are many things that may occur from the time that a drop of rain falls upon some part of a drainage area until it passes beyond the limits of the watershed. There are many things that affect the run-off from a drainage district. These factors have been understood qualitatively for a long time. It is the quantitative effect of each of these factors that is the problem before investigators today. The practicability of applying the fine spun law of probabilities to any particular drainage design is doubtful because of the many estimates that must be made as to the effect of the factors governing run-off aside from the mere variation in rainfall.

E. V. Willard, of the Minnesota department of drainage and waters, in a recent report on the drainage of the Min-





FREQUENCY OF RAINFALL AT HARTFORD, CONN., 1868 TO 1914, INCLUSIVE

Courtesy "Engineering News-Record"

nesota River valley, graded the land in the valley to see how often it was flooded enough to destroy the crops. From the records of transfer in the county offices he then determined the value of the land which was subject to flood every second year, every fifth year, every tenth year, and so on. He then made estimates of the cost of the system of drainage which would provide relief for these various classes and amounts of land and in that way arrived at what he considered the most economical system to construct.

There are two ways of looking at the problem of a systematic application of the law of least squares to the economic design of drainage districts. First, the law might be applied directly to the solution of a particular problem such as the drainage of the Minnesota River valley. I do not know just how Mr. Willard analyzed the problem to determine what lands would be flooded at the intervals of time given above. Such a deduction could be based upon a hydrographic study of the valley. Works on hydrology by Meade and by Meyer give methods of computing water yield from a drainage area from rainfall data and drainage area characteristics. Such methods may be more or less approximate according to the amount of rainfall and run-off data available. Years of maximum rainfall are not necessarily years of maximum run-off. Years of maximum run-off are not necessarily years of maximum damage. Years of maximum water yield are not necessarily years of maximum discharge or maximum damage. Years of high water in which the high stage covers some considerable time during the growing season are the years that will cause crops to be damaged or destroyed.

To what data then is the law of probabilities to be applied? It cannot be applied consistently to annual rainfall except insofar as the annual rainfall indicated the years that have probably been years of damage. A graph with years as abscissae and dollars worth of damage as ordinates could be constructed from a hydrograph in connection with a map with sufficient elevations and stream characteristics to make it possible to determine the stream stage in different portions. With this information the land could be classified and a relation could be established between stage and area flooded. Some deduction must be made as to the relation between height of flood, duration of flood, and amount of damage. The ordinate of the damage graph would be determined by the damage that would result as indicated by the hydrograph during any particular time of the year. A damage graph must be constructed for several different types of construction. The application of the law of variables to the ordinates of the damage graph will make it possible to predict the damage to be expected once in two years, once in five years, etc.

RAINFALL AT HARTFORD, CONNECTICUT (SAVILLE)

Yearly Rainfall —Inches	Variations from the Mean	Variations Squared	Percentage of Total For Plotting
33.64	10.34	106.92	0.0106
34.11	9.89	97.81	0.032
34.78	9.22	85.01	0.053
35.74	8.46	71.57	0.074
36.02	7.98	63.68	0.096
36.88	7.12	50.69	0.117
36.91	7.09	50.27	0.134
37.04	6.96	48.44	0.160
37.68	6.32	39.94	0.180
38.25	5.75	33.06	0.201
38.95	5.05	25.50	0.224
39.16	4.84	23.43	0.245
39.45	4.55	20.70	0.266
39.73	4.27	18.23	0.288
40.17	3.83	14.67	0.309
40.75	3.25	10.56	0.330
41.09	2.91	8.47	0.351
41.53	2.47	6.10	0.372
41.56	2.44	5.95	0.394
42.07	1.93	3.72	0.415
42.07	1.93	3.72	0.436
42.20	1.80	3.24	0.457
42.42	1.58	2.50	0.478
43.60	0.40	0.16	0.499
43.66	0.34	0.12	0.522
45.35	1.35	1.82	0.543
45.37	1.37	1.88	0.564
45.54	1.54	2.37	0.585
45.62	1.62	2.62	0.606
45.83	1.83	3.35	0.627
46.32	2.32	5.58	0.650
46.81	2.81	7.90	0.671
47.13	3.13	9.80	0.692
47.29	3.29	10.82	0.713
48.47	4.47	19.98	0.735
48.71	4.71	22.18	0.756
49.22	5.22	27.25	0.777
49.26	5.26	27.67	0.798
50.25	6.25	39.06	0.819
50.29	6.29	39.56	0.840
51.66	7.66	58.68	0.861
52.00	8.00	64.00	0.882
52.69	8.69	75.52	0.903
53.59	9.59	91.97	0.924
55.12	11.12	123.65	0.945
55.81	11.81	139.48	0.967
56.36	12.36	152.77	0.990

$\Sigma M = 2067.95$ $\Sigma v^2 = 1722.17$

$\frac{\Sigma M}{n} = \frac{2067.95}{47} = 44.00$, the mean $R = 0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}} = 0.6020$, probable error of the mean $\sqrt{\frac{\Sigma v^2}{n-1}} = 6.119$, standard variation.

The difference between the damage where no construction is provided and the type of construction under consideration, will be the interest on the investment. There would be, however, some rather intricate adjustments for reducing this difference in damage to a rational interest basis. Of course the type of construction that will pay the greatest amount of interest will be the proper one to adopt, if the farmers can be made to appreciate these fine points.

This method of analysis, if applied at all, would require an expensive survey and study. It could only be applied to very large projects as the cost would be prohibitive on small ones. As to the practicability of its application to any district much might be said on both sides. As a matter of fact there are too many expensive projects designed and constructed without any analysis. Such an analysis, even if it is based upon many varying factors, would familiarize the designer with all the available data bearing upon the success of the project. It would indeed be a guide to the judgment, and in the end the judgment would be the deciding factor in any event.

The greatest trouble which every drainage engineer meets is the lack of sufficient data upon which to base his ordinary judgment. There are few projects upon which hydrographic measurements have been made. It is necessary as a usual thing to make many assumptions throughout any such analysis; however, an experienced engineer is able to exercise his judgment very skilfully in making these assumptions. Even if hydrographic studies have been made, an estimate as to the change in run-off conditions after construction must be made.

The other phase of the problem is the application of the law of probabilities in the preparation of a table of coefficients to be used by engineers throughout the country on small projects that will not warrant an analysis, or where the engineer is not inclined or prepared to make such an analysis.

The following is a summary of the present methods of selecting the run-off factor for the drainage of lands in humid sections:

1. The application of a flat rate run-off factor over a region of similar characteristics, such run-off factor having been determined by comparing the designed coefficient of successful and unsuccessful projects.

2. The measurement of discharge in constructed outlets from areas of different sizes and characteristics, such characteristics being carefully recorded and made the basis of determinations on projects to be constructed.

3. The determination of run-off from the area before drainage construction, and determining the change that the

completed project might make in such run-off, the run-off determinations in the first instance being made by maintaining gauging station, or by analysis of rainfall and drainage area characteristics.

4. Arbitrary judgment based upon more or less experience.

It is proposed to group all drainage districts studied according to their characteristics. The following grouping is only tentative, but it gives an idea of the method proposed:

1. GEOGRAPHICAL POSITION (CLIMATE GROUP)

(a) North Pacific	(g) East Central
(b) South Pacific	(h) West Central
(c) North Arid	(i) East Gulf
(d) South Arid	(j) West Gulf
(e) Northeast Central	(k) North Atlantic
(f) Northwest Central	(l) South Atlantic

The boundaries of these areas to be determined by rainfall, temperature and general climatic character.

2. SIZE OF DRAINAGE AREA IN SQUARE MILES

(a) 0 — 1	(d) 50 — 100
(b) 1 — 10	(e) 100 — 500
(c) 10 — 50	(f) 500 — 1000

(g) Above 1000

3. RATIO OF ORIGINAL AREA OF WET AND SWAMP TO THE TOTAL DRAINAGE AREA

(a) .00 to 0.01	(c) 0.1 to 1.0
(b) 0.01 to 0.1	(d) 1.0 to 10

(e) Above 10

4. TOPOGRAPHY OF HIGH LANDS

(a) Hilly	(c) Rolling
(b) Very rolling	(d) Gently rolling

5. TOPOGRAPHY OF LOW LANDS

(a) Natural drainage obstructed by barriers—general slope along drainage lines greater than 0.1%

(b) Natural drainage obstructed by barriers—general slope along drainage lines less than 0.1%

(c) Natural drainage obstructed by flatness of land—general slope less than 0.03%

(d) Natural drainage obstructed by flatness—general slope between 0.03% and 0.1%

(e) Natural drainage obstructed by flatness—general slope greater than 0.1%

6. SUBSOIL CHARACTERISTICS

(a) Dense	(c) Porous
(b) Slightly porous	(d) Very porous

7. SURFACE SOIL CHARACTERISTICS

(a) Dense	(c) Porous
(b) Slightly porous	(d) Very porous

8. Ratio Of Greatest Length To Greatest Width

(a) .05 or less (c) 0.1 to 1.0
(b) .05 to 0.1 (d) 1.0 to 10.0
(e) Above 10.0

9. Type Of System

Tile Drainage Systems

(a) With surface inlets
(b) With surface inlets or surface outlets
(c) Without surface inlets or surface outlets

Ditch Drains

(d) Complete ditch systems
(e) Ditch outlets for systems using tile in a large portion of the upper portion of the district
(f) Channel improvement of a small section at the lower end of a drainage area

10. Completeness Of The System. (Per cent of drainage area served.)

(a) 0-10 (f) 50-60
(b) 10-20 (g) 60-70
(c) 20-30 (h) 70-80
(d) 30-40 (i) 80-90
(e) 40-50 (j) 90-100

11. Source Of Bulk Of Damaging Water

(a) Overflow from natural channel
(b) Run-off from adjacent lands
(c) Seepage

(This analysis is not for application to irrigated lands.)

(d) Direct rainfall

The possible number of drainage district types will be classified according to this outline, whereas if no such outline were used there would be as many types as there are drainage districts. It is proposed to treat each type separately at first and later draw conclusions from one set of data to fill in where information is wanting in another type. It might be expedient to limit studies to certain groups with the express idea of filling in between these groups when certain laws governing run-off will be better understood. It is proposed to promote investigation along the following lines:

1. The establishment of current meter gauging stations, weirs, and measuring flumes on selected drainage districts that have been constructed and upon selected drainage areas that have not been touched by artificial drainage.

2. The establishment of rain gauge stations equipped with automatic registering devices for measuring intensities as well as amounts.

3. The securing of statements from a very great number of farmers located in selected drainage districts in regard to dates when their systems have been successful and when they

have partially or totally failed. Full descriptions of the drainage district should accompany each report together with the designed coefficient.

It is proposed to analyze the data thus obtained for any one particular type of district as follows:

1. Select a representative district of the type that has the greatest amount of information available for it.

2. Making use of long standing records of daily and monthly rainfall, compute a hydrograph of yield using current meter and weir data for determining constants of evaporation. Such a hydrograph will not show maximum rates of flow, but will be an indication of maximum rates.

3. Plat a mass diagram of soil storage on the drainage area using data and constants determined in (2) for this purpose.

4. Using the best daily records of precipitation available and constants determined from current meter, weir, and automatic rain gauge, make an estimate cf the dollars worth of damage done each year for which data are available.

5. Plat a graph using for ordinates the damage with years as abscissae.

The law of variables would be applied to the ordinates of this graph just as yearly rainfall was treated by Saville. A table of coefficients for different land values and different costs of the drainage system could be deduced from the results of this analysis. It would be necessary to assume different land values and construct damage curves for each set of values. Using the probable difference in damage between no system and a system of a given cost as interest on the cost an economic coefficient could be selected from the table.

AUTHOR'S NOTE: Acknowledgment is due R. W. Clyde, drainage engineer of the Iowa Highway Commission, for suggestions which have been incorporated in this paper.

RESULTS OF A DRAINAGE INVESTIGATION*

By S. H. McCrory

Mem. A.S.A.E. Head of the Division of Agricultural Engineering, Bureau of Public Roads, U. S. Department of Agriculture, Washington, D. C.

THE committee on drainage sent a questionnaire to two hundred and fifty-seven engineers (during 1920) located in the eastern half of the United States. Replies were received from about one hundred, of whom eighty-two completed the questionnaire.

In computing the capacity of tile drains, the Kutter formula is used by fifty-two engineers, Elliot's modification of Poncelet's formula by thirteen; Poncelet's formula by twelve, while other formulae are used by eight. Several engineers reported that they used two or more formulae. In using the Kutter formula the value of the coefficient, n, used ranged from 0.011 to 0.017. The value most commonly used seems to be $n = 0.013$ and 0.015.

The rates of runoff recommended for use in designing tile drainage systems varied greatly. Ten engineers located in Illinois, Indiana, Iowa, South Dakota, and Wisconsin report that under certain conditions they use ⅛-inch runoff; fifty-eight engineers report that they use ¼-inch runoff; twenty-seven report using ⅜-inch; twenty-one ½-inch, and nineteen ⅝ to 1-inch runoff. A number of engineers pointed out that the rate of runoff varied with difference in topography, soil and precipitation, and that therefore no one rate of runoff could be adapted. In Table I are shown the states from

*Second and last part of the report of the Committee on Drainage.

TABLE I

State	Rate of Runoff Inches per 24 hours	Laterals		Laterals	
		Minimum size Inches	Minimum grade Feet per 100 feet	Average Depth Feet	Average Spacing Feet
Alabama	1/4 to 1/2	4	.1	3	75
Arkansas	1/2	4	.1	3	50- 75
Illinois	1/4	5	.08	3-1/2	75-150
Indiana	1/4	4	.05	3	50-100
Iowa	1/4	5	.1	3-1/2	100
Louisiana	3/4	5	.08	3	80
Minnesota	1/4	6	.1	3-1/2	100
Mississippi	1/2	6		3	75
Missouri	1/4	5	.04	3	80
Massachusetts	1/4	4	.03	3	75
Nebraska	1/4	5	.1	3-1/2	80
New York	1/4	3	.08	2-1/2	
North Carolina	1/4	4	.1	3	80
Pennsylvania	1/4	4	.1	3	75
South Dakota	1/4	6	.1	3-1/2	100
Tennessee	1/4	5	.1	3	80
Virginia	1/2	4	.2	3	75
Wisconsin	1/4	5	.1	3-1/2	80

TABLE II Types of Soils (Subsoil) Depth and Spacing of Lateral Drains

State	Sand clay orig. No.	Depth Feet	Spacing Feet	Silty clay No.	Depth Feet	Spacing Feet	Gravelly clay No.	Depth Feet	Spacing Feet	Clay No.	Depth Feet	Spacing Feet	Sand No.	Depth Feet	Spacing Feet	Muck or Peat No.	Depth Feet	Spacing Feet
Alabama	1	3.50	+ 160	1	3.50	100				2	3.00	75						
Arkansas	3	3.00	70	3	3.00	65				3	3.50	62						
Illinois	3	4.00	150	6	4.00	100	1	4.00	+ 80	7	3.33	90	2	3.75	125			
Indiana	3	3.00	100	1	2.50	-40	1	3.00	80	3	3.00	88	3	3.50	150	3	4.00	138
Iowa	9	3.86	115	10	3.63	100	3	+ 4.00	125	28	3.74	90	5	3.83	158	4	4.40	100
Louisiana				1	2.50	80				1	2.50	80						
Massachusetts	1	3.00		1	3.00		1	3.00		1	2.50	+ 30	1	-3.00	-100			
Minnesota	3	3.75	120	2	3.80	110	1	3.90	125	5	+ 3.63	+100	3	4.00	+150	1	- 4.00	88
Mississippi	1	3.00	150	1	3.00	+ 150	1	+ 3.00	+150	1	-2.25	90						
Missouri				2	+4.00	150				2	2.50	50						
Nebraska	1	+4.00	105	1	3.50	85				1	3.00	65						
North Carolina	2	3.50	110							2	3.00	80						
Ohio										1	2.75	40						
Pennsylvania																		
South Dakota	1	3.33	100	1	3.67	100	1	3.67	100	7	3.14	100	1	+ 4.00				
Tennessee	1	3.75	110							1	3.50	65						
Virginia	1	-3.00	-75		-3.00	75				1	2.50	60						
Wisconsin	3	3.20	90	1	3.00	100				3	3.00	75	3	4.00	140	2	+ 4.50	132
Totals	33	* 3.51	* 110	32	* 3.52	* 98	9	* 3.62	* 114	69	* 3.37	* 85	18	* 3.78	150	10	* 4.26	* 115

* These are weighted averages

Table III Cost of Constructing Tile Drains in the States of Illinois, Indiana, Iowa, Minnesota, South Dakota, Wisconsin, Ohio, and Nebraska

Size of tile Inches	Depth in feet								
	3 feet or less Cents per foot	4 feet Cents per foot	5 feet Cents per foot	6 feet Cents per foot	7 feet Cents per foot	8 feet Cents per foot	9 feet	10 feet Cents per foot	12 feet Cents per foot
4	4.7	7.0	7.9	12.0	16.0	28.0	[illegible]	40.0	
5	4.8	7.0	9.0	12.0	17.7	22.8	[illegible]	40.0	
6	5.1	8.6	11.2	15.6	20.8	[illegible]	[illegible]	[illegible]	
7	6.1	10.0	12.8	16.6	24.9	[illegible]	[illegible]	[illegible]	
8	6.6	10.5	14.2	17.5	21.0	[illegible]	[illegible]	[illegible]	[illegible]
10	9.3	14.6	18.2	24.7	30.1	[illegible]	[illegible]	[illegible]	[illegible]
12	11.0	18.9	19.6	28.4	31.8	[illegible]	[illegible]	[illegible]	[illegible]
14		19.0	24.4	26.1	38.2	[illegible]	[illegible]	[illegible]	[illegible]
15		22.2	27.0	28.7	41.8	[illegible]	[illegible]	[illegible]	[illegible]
16		19.9	27.3	37.6	41.2	[illegible]	[illegible]	[illegible]	[illegible]
18		23.7	32.2	44.1	47.8	[illegible]	[illegible]	[illegible]	[illegible]
20		28.0	38.1	42.7	57.0	[illegible]	[illegible]	[illegible]	[illegible]
22		30.0	40.7	57.8	62.8	[illegible]	[illegible]	[illegible]	[illegible]
24		34.7	48.8	57.4	49.8	[illegible]	[illegible]	[illegible]	[illegible]
26		42.0	47.8	75.7	72.8	122.0	[illegible]	[illegible]	[illegible]
27		36.0	37.7	58.3	57.8	[illegible]	[illegible]	[illegible]	
28		30.0	61.0	78.6	72.7	[illegible]	[illegible]	[illegible]	[illegible]
30		40.5	[illegible]	81.0	78.8	100.3	[illegible]	[illegible]	[illegible]
32			55.8	84.0	85.6	101.0	[illegible]	[illegible]	[illegible]
33		47.4	59.3	93.2	92.3	110.0	[illegible]	[illegible]	
34			46.0	144.0	101.0	[illegible]	[illegible]	[illegible]	[illegible]
36		51.5	67.3	120.3	104.3	[illegible]	150.0	159.1	[illegible]
38				38.4					
40				200.0					
42				42.9					
44				250.0					

which reports were received, the most commonly used rates of runoff, the minimum size of the grade, and the depth and spacing recommended for lateral drains.

Of seventy-six engineers who reported in regard to the use of surface inlets thirty-seven increase the rate of runoff when such inlets are used; twenty-six use the same rate of runoff; seven do not use surface inlets, and the others did not report. When the rate of runoff is increased it is most commonly from 50 to 100 per cent, but there is no uniformity in the practice. Failures due to surface inlets were reported by twenty-four engineers, while fifty engineers had had no difficulties; fifty-two considered them desirable, thirteen undesirable. The failures generally consisted of deposits of silt, sand or trash in the tile.

In designing tile drains seventeen engineers make allowance for pressure head in main drains, while fifty do not.

In answering questions in regard to minimum size of tile used for lateral drains, twenty-eight reported 4-inch tile as a minimum; thirty-nine, 5-inch, and one 7-inch. The largest tiles reported as used for mains were 60 inches in diameter located in Illinois. Other large tile were reported as follows: Iowa and Minnesota, 52-inch, Ohio and South Dakota, 42-inch; Wisconsin, 30-inch. None of the other states reported over 18 inches. The minimum grade used on laterals varied considerably. Most of the engineers preferred at least 0.1 foot fall per 100 feet, but a number of them reported having laid tile with grades ranging from 0.02 to 0.05 foot. While the minimum grade used on laterals ranges from 0.01 to 0.1 foot, most engineers endeavor to secure 0.05 foot fall per 100 feet, if possible. Attention was called to the necessity of securing at least 0.2 foot fall for laterals in the Norfolk and Portsmouth series of soils in the South Atlantic states if satisfactory drainage is to be secured.

Structural failures of both clay and concrete tile were reported. Thirty-one engineers report that they have observed structural failures of clay tile; forty-two report no failures; thirty-seven report structural failures of concrete tile; thirty-five report no failures of concrete tile. Failure of concrete tile due to the action of alkalis or acids were reported from Indiana, Massachusetts, Minnesota, North Carolina, Virginia, and Wisconsin. Information relative to all such reported failures is being obtained.

An inquiry was made in regard to the practice of placing tile drains in old open ditches; thirty-five engineers reported that they had done this; thirty-nine had not. Of those who had had experience sixteen reported erosion; nineteen had had no trouble.

An inquiry in regard to failures of tile drains and the causes of failures produce some interesting replies. Thirty-two reported failures because the drains were too small; fourteen, poor grades; fourteen, faulty laying; ten, too shallow; eight, poor outlets; two, too deep; two, tree growths; three silting; eight, tight soil; eight, miscellaneous reasons.

An inquiry was made in regard to the effect of air circulation in the tile upon crops grown upon the land. Forty-nine engineers considered such circulation desirable; thirteen had used vents to admit additional air into the drain; six of these reported favorable results from such vents, and one unfavorable.

An inquiry was made in regard to the method of payment for engineering service. Sixty reported a per diem basis ranging from $5 to $30 per day; the average of all per diem given was $13.60. The rates most commonly given were $10,

Table IV Cost of Constructing Tile Drains in the States of Alabama, Arkansas, North Carolina, Louisiana, Massachusetts, Mississippi, Missouri, Pennsylvania, Virginia, and Tennessee

Size of Tile Inches	Depth in Feet					
	3 feet or less	4 feet	5 feet	6 feet	7 feet	8 feet
	Cents per Foot	Cents per Foot	Cents per Foot	Cents per Foot	Cents per Foot	Cents per Foot
4	5.3	5.9	7.7	9.7	13.3	
5	5.3	5.9	7.7	9.7	13.3	
6	5.5	5.6	7.7	9.7	13.3	
7	5.8	6.7	9.1	11.5	15.7	20.0
8	5.8	7.5	9.7	12.1	16.3	20.6
10	6.0	7.9	10.3	12.7	17.0	21.0
12	6.1	8.5	10.9	13.3	17.6	22.0

$12.50, and $15 per day. Twelve reported payment on a percentage basis with fees ranging from 4 to 12 per cent, the average being 6 per cent.

An inquiry in regard to the attitude of railroad companies toward the construction of underdrains was made. Thirty-eight engineers reported the railroad companies' attitude as favorable; twenty antagonistic; ten reported that the railroad company required their O. K. on plans before agreeing to the work. In several instances the attitude of the same railroad company was given as different by different engineers, one reporting as favorable and others unfavorable. Apparently the personality of the engineer and county officers who come in contact with the railroad officials has a considerable bearing upon the railroad's attitude toward the project.

An inquiry in regard to the use of drainage trenching machinery was made. Nine engineers reported that trenching machines cost more than hand work; forty-six less than hand work; five about the same; while fourteen were uncertain.

An inquiry in regard to use of vertical drains was made. Forty-five engineers had not used them; twenty-eight had. Of the engineers who had used them eleven reported good results; twenty-two engineers, some of whom had not used them, thought such drains of questionable value.

An inquiry was made in regard to the depth and spacing of drains in different types of soil; the average results obtained for the different states are shown in Table II.

It should be remembered that the figures given are averages and may or may not represent the best practice for the particular state and soil.

An inquiry was made in regard to the cost of constructing drains from the data secured. Table III was compiled for the upper Mississippi Valley states, and Table IV for the Southern and Eastern states. These tables are believed to be fairly representative for 1920.

An inquiry was also made in regard to the effect the cost of tile was having on work. Sixty-seven engineers reported that the cost of tile was curtailing work; eight reported no difference; twenty-one reported that other difficulties, generally the inability to secure tile, were also interfering with their work. Several reported that the price of labor was also a factor in curtailing work.

The information obtained from the questionnaires has brought out most clearly the necessity for additional research work on factors affecting the design and construction of tile drains. Among the more important are the proper rate of runoff that should be used for the tile drains; the depth and spacing which should be given to underdrains indifferent soils; the best designs for catch basins, surface inlets, drops, outlet protection, etc., and information in regard to the best way of handling construction problems. The day has passed when the engineer can afford to use an extra liberal factor of safety when designing tile drains. When it is considered that there are drains contemplated or under construction, which will cost approximately $50,000 per mile, the necessity for having the drain of proper size will be appreciated. When tile and labor could be secured for about one-third what they now cost the need for extreme care in figuring the sizes of tile was not so great. It is to be hoped that additional studies in regard to the many factors affecting the design and construction of tile drain can be undertaken at an early date. Your committee would suggest the desirability of all interested in this work uniting to outline a program of research which will secure the desired information. If this were done and the work carefully conducted, much more rapid progress would be possible than has been made in the past.

DISCUSSION

MR. PATTY: In connection with Mr. McCrory's suggestion as to the cause of the railroads being antagonistic toward the work, I would like to ask if that might not be due to the particular projects that the different engineers had submitted. One might submit a project that the railroad was favorable toward, and the other might not be so favorable for the railroad.

MR. MCCRORY: The questionnaire gave no clue as to that. There were three instances where men in adjoining counties on the same railroad reported and one reported favorably and the other two as being antagonistic. It seems as if there must be some question other than probably personality and the manner of approach. They are all underdrains and conditions were probably somewhat similar in the two states in which that occurred.

MR. HARRIS: Has any consideration been made of the number of years of experience or observation of the reporting engineers as influencing the report?

MR. MCCRORY: We did not have that information available. A great many of the men that I happened to know reported and many have had long experience in the work. I think we got reports from some of the best men in the United States doing drainage work. Like all questionnaires we get extremes in both directions. In the case of depth and spacing, for instance, I am quite certain that the practice the questionnaire shows in regard to clay soils is not in standard practice, yet the depth is much wider than the men are using. In the question of soil, it is hard to differentiate. Even the soil men would probably not agree on types of soils. When engineers report on types of soils it is pretty hard to tell.

MR. CUNNINGHAM: I might say that the position of our Indiana railroads as a whole is rather arbitrary on the matter of drainage passing under. The point made just now that the personality of the man seeking the permission to cross the right of way is, in a large measure, responsible for the results he gets is well made. Having observed in division engineers' offices such problems, I have seen that some men got what they wanted and some did not.

SURFACE INLETS AND SURFACE OUTLETS IN SELECTION OF RUNOFF FACTOR

BY DAVID WEEKS
Mem. A.S.A.E. Drainage Engineer, Dakota Engineering Company

AUTHORITIES differ regarding the use of surface inlets. Every locality has its special drainage problems. It is a local condition which forms the basis of this article, but one of common occurrence in the glacial regions.

There are many different types of glacial topography. Eastern South Dakota offers a variety of surface conditions, each presenting characteristic drainage problems. On the broad, flat ground moraine in the drainage area of the James River Valley the swamp areas are large, slopes are very flat, and ridges between swamps are less pronounced than the more rugged topography in the region of Lake Traverse in the northeastern part of the same state. The writer is engaged in the design of extensive drainage systems in each of these areas. The need for an entirely different design for each is evident.

High costs of drain tile make it necessary to pay a great deal of attention to economic design. High factors of safety lead to lavish expenditures—the use of the flat rate of runoff must be discarded, and careful analysis made to determine the proper rate of runoff, not merely for the district as a whole, but for each portion of the system.

In the design of outlet systems for an area of about 30,000 acres in Roberts County, South Dakota, we are using a combination of surface outlets and surface inlets with a careful selection of drainage coefficient, to fit different portions of each system according to its characteristics. The general slope of the area is considerable. The surface is rugged, and but for the many obstructions left by the melting glaciers, the area would be naturally well drained. The sloughs of the area are comparatively small but very numerous with high barriers in some cases keeping the greatest floods from continuing in their course toward Cottonwood Slough, and thence into Lake Traverse, which forms the boundary between South Dakota and Minnesota.

Over the entire area there is not a quarter section of land that does not have numerous pot holes. It is planned to give each land owner an outlet for the drainage from his land. The available slope is great, thus reducing necessary tile sizes, but there are a number of deep cuts which will run the labor cost comparatively high. It is expected the net result will be an average cost per acre. The steeper slopes will make it possible to drain a larger area with a maximum economic tile size.

It is expected a more thorough drainage can be obtained by the use of surface inlets, but with the steep gradient available some protection or relief must be provided for the prevention of "blowouts" below. At the same time an increase in drainage coefficient must be made below the inlet. If no surface relief or surface outlet were provided, this increased drainage coefficient must be continued to the outlet of the tile or to its junction with other portions of the system which will again make necessary a reconsideration of the coefficient according to the arrangement of tributary branches and their respective coefficients of drainage. It seems, however, that this would result in an unnecessary expenditure for additional tile size, and it is proposed to reduce the size of tile as soon as the ridge has been passed, using a surface outlet at the point of such reduction in size. The system will virtually serve two purposes: First, the surface water will be taken off as soon as possible, using the surface of the ground wherever the slope is sufficient instead of trying to carry it all in the tile. As soon as the surface flow has ceased, the tile will be at work lowering the water table in the soil and furnishing outlets to farm systems. Such a design will mean a coefficient larger than is usually applied through the ridges, and a coefficient smaller than is usually recommended for portions of the system where there is no obstruction to natural runoff.

The accompanying illustration (Fig. 1) shows the profile of one of the lines which has been staked out, and the location of the inlet and outlet. Below the surface outlet on this particular system there arises a situation which is common to a great many of our problems in South Dakota. In other states since the beginning of drainage the same situation has caused a great deal of litigation; that is, the matter of damages to lower lying lands. In this instance the outlet to the drainage could easily have been obtained at the point where the surface outlet is placed, but it was decided that a small tile should be carried on, to carry the dry weather flow, while the water table is being lowered in the swamps above. A surface outlet was therefore placed where shown to give outlet to the system while working full capacity. Under the laws of South Dakota as in many of the other central states, owners may drain their lands in the general course of natural drainage, throwing the water upon lower lying lands, but usually where damage can be actually shown such damage can be recovered. It was with a view of preventing such trouble that the smaller tile was carried on down the slope. Had surface conditions warranted, a regular outlet would have been designed with a surface inlet below, into the small tile. It will be noticed that the hydraulic gradient is carried to the surface of the ground at the outlet which is low enough not only to take the surface water from the slough, but also

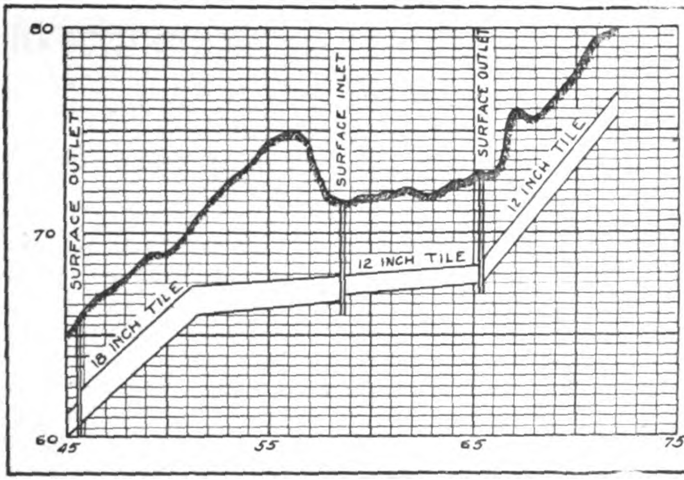


Fig. 1. A large runoff factor is necessary through a ridge while the coefficient may be reduced where part of the flow can be carried over the surface

much of the gravitational water in the soil.

The same reasoning in selection of drainage coefficient can be applied to open ditches but with an additional purpose. The bottom width of open ditches should be wider through the ridges and in this kind of topography than through the sloughs or ground with a slope favorable to natural drainage. In most economical designs it is expected that during exceptional periods the land will be flooded as it would not pay to construct systems to properly care for conditions occurring only at rare intervals of time. Now consider one of these occasions when everything is flooded. There is a certain flow down the valley which together with the flow in the ditch must all be carried through the ridge. If the ditch through the ridge has sufficient capacity, the duration of flood will be shortened, and the resulting damage less. Deep cuts are harder to maintain than shallow cuts. It is harder to get machinery in for cleaning out, or reconstruction, so the importance of larger capacity through the deep cut is evident.

Topography is a very important factor to be considered in the selection of a runoff factor, and where the system is a tile system, the use of surface inlets, surface outlets, and a careful selection of the runoff factor may mean more thorough drainage with an actual saving in cost.

NOTE: Since the preparation of the foregoing, many engineers have been consulted on its merits. Some of them fear the legal results of using farm lands over which to carry surplus water that the drainage system is not designed to carry; others are very much interested in the proper application of the principle involved. All agree that if properly applied the method has many uses and possibilities.

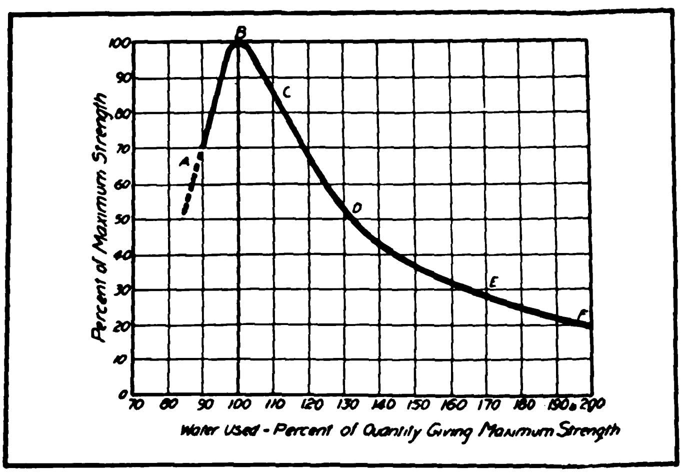
EFFECT OF WATER ON STRENGTH OF CONCRETE

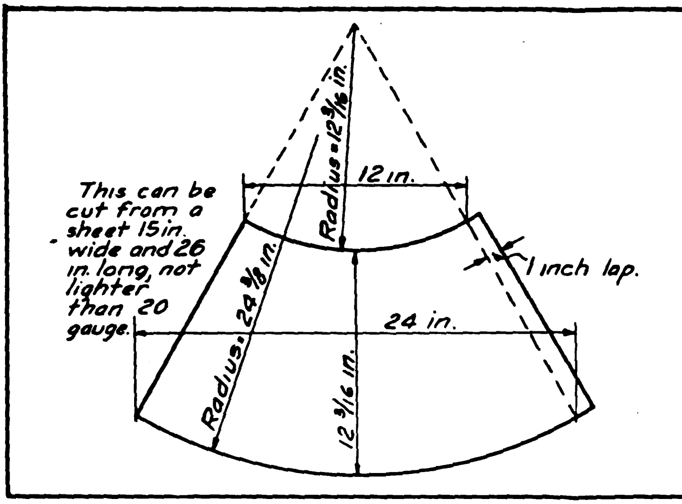
By W. G. Kaiser

Mem. A.S.A.E. Agricultural Engineer, Cement Products Bureau,
Portland Cement Association

TESTS recently conducted at the structural material research laboratory, Lewis Institute, Chicago, prove conclusively that the amount of water used in making concrete bears a direct relation to the strength of the resulting concrete. Among some engineers there exists the erroneous impression that the amount of water used in a mixture bears little if any relation to the final strength. In the tests mentioned, it has been fully proven that the quantity of water used is of the very greatest importance and that too much water is fully as bad as too little. Results of the tests made at Lewis Institute are shown graphically on the accompanying curve. (Below.) The point B on the apex of the curve indicates the maximum strength obtained when the proper amount of water is used. This amount is given as 100 per cent. It will be noted that the addition of 10 per cent more water than the quantity required for maximum strength reduces the strength of concrete by about 15 per cent. Thirty per cent too much water diminishes the strength by one-half. In a like manner the strength of concrete falls very rapidly when there is insufficient water.

In practice it is seldom possible to produce concrete of a consistency which will give maximum strength, as the mix-



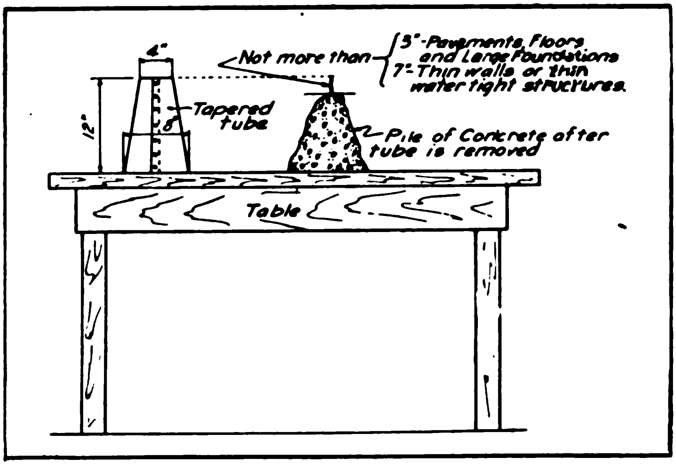


A piece of metal of this shape will, when rolled up, make a tapered tube needed for the slump test.

ture would not contain enough water to make it readily workable under average conditions, especially in thin wall sections. Since the addition of a little extra water will produce a mixture that is workable, there has been a natural tendency to use too much water on some jobs, particularly where concrete is placed between forms and allowed to harden there. In the manufacture of concrete block where the mold is removed immediately, there is sometimes a tendency to use too little water.

A simple method of determining the proper consistency for a given concrete job is known as the slump test. It is now being specified and used by many engineers engaged in concrete construction. The apparatus for making the test is very simple and inexpensive. All that is required is a sheet metal tube 12 inches high, eight inches in diameter on the bottom and four inches in diameter on the top. This tube is placed on a table or some even surface with the large end down and filled flush with the concrete for which it is desired to determine the proper consistency. The concrete in the tube is thoroughly settled by agitating it with a pointed iron rod. The tube is then lifted off at once, care being taken to raise it vertically. As soon as the tube is removed, the concrete will of course slump, the amount depending upon the amount of water in the mixture. After one or two minutes have elapsed, the height of the pile is measured and the slump determined by subtracting this height from the original height of the pile, which in this case would be twelve inches.

For floors, foundations, posts, and similar work the slump



The slump test illustrated here is a safe one for determining the right amount of water to use in concrete.

should not exceed three inches and for thin walls and thin watertight structures, it should not be greater than seven inches. In case of thin walls some of the strength of the concrete is sacrificed to secure a smooth and even surface.

The amount of water which will yield the proper consistency with the average mixture is six gallons of water to one sack of cement, or, stating it in a different way, one and one-half gallons of water to one cubic foot of concrete in place. The correct amount, of course, varies with the character of the aggregate as well as with the proportions used. Some aggregates like sand stones are of a porous nature and will absorb considerable water, while others are practically non-absorbant. Some aggregates may contain considerable moisture before being introduced into the concrete mixture. This is particularly true of sand.

In general a good rule to follow is to use as little water as possible, which after thorough mixing, will produce a workable mixture suitable for the kind of work for which the concrete is intended. This will encourage the man at the mixer to keep the batch in the machine longer and produce stronger concrete.

MENTAL TESTS FOR PREDICTING SUCCESS IN AGRICULTURAL ENGINEERING

By H. E. Burtt
Professor of Psychology, Ohio State University

and F. W. Ives
Mem. A.S.A.E. Head of the Department of Agricultural Engineering, Ohio State University

TWO YEARS AGO the Ohio State University inaugurated the psychological test with a view to determining before the mid-semester examinations if possible the mental capacity of all entering students. It was thought that by giving the so-called "nut test" to students for a period of say three years, and in the meantime comparing the results of the mental tests with the actual performance of the student in the class room, that it would be possible to give entrance examinations of this sort and eliminate the probable failures at the beginning rather than at the end of their first semester. The advantage of such a test is at once apparent as, if successful, it would relieve now overcrowded class rooms and laboratories of much "dead timber."

The college of engineering instituted at the same time tests for indicating possible professional tendencies, with the thought in mind that after a few years of the tests, with careful comparisons of class work and so far as obtainable success in the profession after graduation, it would be possible to predict success or failure in some degree before the student had wasted several years of more or less fruitless study.

After a consultation between the head of the department of psychology and the dean of the college of agriculture arrangements were made by the authors of this paper to conduct similar and more searching tests on the senior students majoring in agricultural engineering, as a research in the possibility of developing more exact methods for predicting success in agricultural engineering. Such methods when finally perfected will be valuable in vocational advice and selection of students in the department of agricultural engineering. Thus it is hoped that it will be possible for the sophomore advisors to guide a student into a line of work that he seems most fitted for without the guessing that is the rule now. It is important in such work to proceed empirically, comparing efficiency in various tests with efficiency in vocation. It seemed probable that seniors in the college of agriculture could be estimated with reference to their ability fairly accurately. Accordingly mental tests were given to about fifty seniors in June 1920 and the estimated success compared with tests scores. Further tests were given to forty seniors in

December 1920. These latter were all majoring in agricultural engineering.

Three instructors in the department of agricultural engineering rated these students for probable success in this vocation. The ratings were made on a linear scale (Table 1). One of the instructors rated all fifty men for probable success in agricultural engineering, although many of these men were not specifically enrolled in that course. The other two instructors rated only the men who were specializing in this field.

The ratings were recorded in millimeters. In order to make these different ratings comparable, it was necessary to transform them into a standard form. One instructor might rate all his men high and another might rate all his men low, and in comparing the two it would be the relative standing that would be of importance. Accordingly the ratings made by each instructor were averaged and the standard deviation obtained. Then that instructor's ratings were transformed into terms of standard deviation so that the final rating meant that the instructor graded his men for example two-tenths of the standard deviation above the average. These heterogeneous ratings could then be averaged into a single score for each student.

Twelve tests were given in all by means of mimeographed blanks. The procedure occupied about one and one-half hours. It is difficult to say what any mental test measures, but there were in the twelve used four in which the emphasis was upon the processes of attention, one of learning, one of association, one of memory, two of reasoning, one of ingenuity, and two of the ability to follow directions. Examples of the five tests which were ultimately retained are given in Table II.

Each test in the group was roughly correlated with the vocational score to see whether the person who scored well in that test was rated high in the vocation and vise versa. On the basis of this preliminary correlation, seven tests were discarded as being insensitive to this vocational variable and five were retained. With these five correlations were computed by a more accurate method ("partial moments") which involved the products of deviations of the measures from their average. The tests were also intercorrelated and the technique of partial correlations employed ("See Yule's "Statistics"). It was then possible to weigh each test in proportion to its correlation with the vocation and its independence of tests. A regression equation was then derived. This is a linear equation in which each test score is multiplied by a constant. This equation gives the best possible weighting of the various tests from the standpoint of predicting vocational success with this group of data. The equation was then transformed slightly so that the original test scores could be put into it directly.

The regression equation obtained was $V = .004\ (.0311) + .019\ (0321) + .039\ (0541) + .015\ (1302) - .023\ (1403) - 1.878$, where figures in brackets refer to scores in the five tests. Five original test scores for each man were then weighted according to this equation to obtain a single score. These final scores are given in Table III together with the average vocational score as well. These final weighted scores are the ones which would be used with people of unknown ability in order to predict probable success in agricultural engineering. The vocational scores are arranged with the men rated highest at the top of the column. The corresponding combined test scores, it will be seen, tend to distribute similarly with the large positive values toward the top of the column. The correspondence is not perfect but by no means random.

If the correlation between these columns is computed by the usual methods this degree of correlation corresponds theoretically to the distribution given in Table IV. For illustration let the successive rows represent ability in combined test score and successive columns represent vocational ability. The table then reads as follows: Suppose 1000 people

TABLE I

Showing Method of Making Ratings on a Linear Scale

Please rate all of the following persons, with whom you are familiar, as to probable success in this vocation. Imagine all the persons engaged in this work whom you have ever known divided into five groups of equal size, a highest fifth, a next highest fifth, a middle or average fifth, etc. Place a cross in the proper column after each person's name to indicate in which fifth he will be found AFTER HAVING HAD SUFFICIENT EXPERIENCE TO READ HIS MAXIMUM EFFICIENCY. If he stands high in a given fifth, place the cross toward the right side of the column and vice versa. In other words the greater the vocational ability the farther to the right of the page the cross should be placed. If in the case of any individual his success is apt to be determined by other factors beside ability, e. g., personality, laziness, etc., please take a special note of this fact.

	Lowest fifth	Next Lowest fifth	Middle fifth	Next Highest	Highest fifth
Jones, John	....	....	....	....	....
Brown, Frank	....	....	....	....	....
Albery, John	....	....	....	....	....
Smith, Clyde	....	....	....	....	....
Mortgan, Sam	....	....	....	....	....
Stone, Thomas	....	....	....	....	....
Miles, James	....	....	....	....	....
Wells, Frank	....	....	....	....	....
Evan, Lyle	....	....	....	....	....
Myers, George	....	....	....	....	....

TABLE II

Five Mental Rating Tests

0311

26	52	39	24	53	37	16
						f
14	33	18	47	12	21	56
d				b		
49	44	59	29	55	31	42
35	20	11	50	15	46	27
		a		e		
58	41	28	38	57	34	48
30	23	54	45	19	13	40
					c	
17	32	47	25	51	43	22
9						

0321

atchdeerfeg hhiajvkel mbneoepng rmsatnuyv
there have been many
waxtytzeambpctdse ftgoh idjekvlimsneo
attempts to devise

0541

2. Write the missing number: 6% of $240 is the same as 4½% of.... (320)

3. 60 pounds of camping outfit are carried. A B and C share the load in these proportions: 2 parts to A, 1 part to B and 1 part to C. How many pounds does each carry? A 30 lbs B15 lbs C15 lbs

1302

emosu	mouse
eeggor	George
cehrry	cherry

1403

1. Vowel that is in triangle but not in circle or rectangle. (E)
2. Smallest number in circle and rectangle but not in triangle. (5)

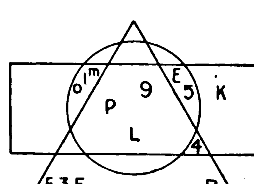


TABLE III

Final Scores From Mental Rating Tests

Name	Vocational Score	Combined Test Score
D.S.W.	149	511
J.C.N.	132	665
W.E.S.	112	456
J.F.D.	108	247
L.M.F.	103	-007
G.W.K.	946	841
E.A.S.	89	075
W.L.D.	83	-156
H.J.R.	76	941
J.L.H.	76	-232
C.H.C.	72	533
H.C.B.	60	110
A.W.B.	48	476
C.A.H.	47	294
G.B.A.	44	-312
B.O.	28	-172
W.M.M.	04	483
A.D.S.	0	642
W.S.M.	0	449
R.J.S.	-04	-601
G.A.D.	-04	-118
C.E.G.	-04	-380
T.C.K.	-04	084
C.W.S.	-04	-356
G.M.B.	-12	536
J.C.D.	-17	017
E.D.L.	-32	086
E.J.W.	-36	-056
W.R.G.	-39	378
R.O.R.	-32	263
R.E.H.	-60	-740
S.R.S.	-64	347
P.R.L.	-84	297
R.L.S.	-112	-734
K.L.E.	-112	265
H.A.R.	-116	-481
B.M.D.	-117	-236
L.A.K.	-120	-175
T.G.A.	-121	156
H.F.L.	-132	013
V.G.B.	-188	-262
S.G.	-192	-550

took the tests and we selected first the 100 with the highest score (i. e. the highest tenth of the group) then the 100 next in rank (i. e. the second tenth), etc. Suppose we likewise divided them into ten groups on the basis of vocational ability—a highest tenth, a second tenth etc. Then of the 100 people who were highest in test score, 32 would be in the highest tenth in vocational, 19 is the second highest vocational tenth, etc. Of that 100 who were next to the highest test group, 19 would be in the highest vocational 10th, 16 in the next highest, etc.

Instead of predicting what per cent of people would fall within certain vocational limits, the table may be used equally well to predict the *probability* of an individual success. For example, if an individual gets a test score which is in the highest tenth of a standard set of such scores, the chances are 32/100 that he will be in the next highest 10th, etc. Thus, if a student's test score is known the table makes it possible to predict his chances for success in agricultural engineering as indicated.

For convenience it might be desirable to condense the table in some manner as the following: Let the best three tenths in vocation be arbitrarily called "good," the next three tenths "average," the next three-tenths "poor," and lowest tenth "very poor." Then of 100 scoring in the tests:

1st tenth—65 will be good, 24 average, 10 poor, 1 very poor, in vocation, 2nd tenth—49 will be good, 32 average, 17 poor, 2 very poor, in vocation, 10th tenth—6 will be good, 19 average, 43 poor, 32 very poor.

Thus if the lowest 10th in test scores were refused admission to this course of study, there would be 6 per cent good agricultural engineers ruled out but along with them 32 per cent very poor ones and 43 per cent poor ones. The result

TABLE IV
Distribution of Arrays of Successive Tenths of a Group When r = .50

Tests Score		1st tenth	2nd tenth	3rd tenth	4th tenth	5th tenth	6th tenth	7th tenth	8th tenth	9th tenth	10th tenth
1st	tenth	32	19	14	10	8	6	5	3	2	1
2nd	"	19	16	14	12	11	9	7	6	4	2
3rd	"	14	14	13	12	11	10	9	8	6	3
4th	"	10	12	12	12	12	11	10	9	7	5
5th	"	8	11	11	12	11	11	11	10	9	6
6th	"	6	9	10	11	11	11	12	11	11	8
7th	"	5	7	9	10	11	12	12	12	12	10
8th	"	3	6	8	9	10	11	12	13	14	14
9th	"	2	4	6	7	9	11	12	14	16	19
10th	"	1	2	3	5	6	8	10	14	19	32

of drawing the lines at any arbitrary point can be easily determined.

The above study should be considered only preliminary. It is based on only forty-two cases and with many of these only one vocational rating was available. The regression equation was worked out to predict this variable that was rated and is consequently dependent on the reliability of the rating.

The correlation obtained in the present instance is higher than that generally found between academic variables and intelligence. The supposition is that agricultural engineering requires special aptitudes as well as intelligence. The correlation is not as high as that sometimes found in the industrial field. It will be possible to increase it by devising other tests to include in the equation. The effect of this would be to increase the values in the upper left portion of Table IV and decrease those in the upper right.

It is suggested that the present seniors in agriculture be given these five tests which were retained in the first equation as well as some others which it is desirable to try out, that those men be rated and correlations worked out as before in order to improve the reliability of the regression equation and, if possible, to increase the magnitude of the first correlation.

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of
AGRICULTURAL ENGINEERS

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F. M. White	1916
E. B. McCormick	1917
Daniels Scoates	1918
Raymond Olney	1919
F. N. G. Kranich	1920
E. A. White	1921

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Fifteenth Annual Meeting

AMERICAN SOCIETY *of* AGRICULTURAL ENGINEERS

THE PRESIDENT'S ANNUAL ADDRESS

BY E. A. WHITE

AGRICULTURAL engineering, "the art and science of engineering as applied to agriculture," is receiving an ever increasing recognition as one of the most potent, constructive and vital forces shaping the destiny of our agricultural developments. It has long been recognized that engineering developments are one of the chief characteristics which distinguish American agriculture from that of other nations, but the realization that these engineering forces may be logically grouped under one great standard, agricultural engineering, has been slow in coming, especially on the part of the general public. However, a rapid growth is not essential to the ultimate establishing of a fundamental fact in human society. It is far more important that progress in this direction be substantial rather than rapid. As was so ably elucidated by Ex-president Kranich in his address to you last year, our most notable achievement in the year 1920 was the recognition the Society obtained from various sources. It is a pleasure to report that due to the enthusiastic cooperation on the part of the officers, committee chairman, committee members and others the past year has again brought increased recognition of the importance of agricultural engineering. It can now be said that agricultural engineering is established and that this Society is recognized as the logical clearing house for this particular field of knowledge.

Increasing recognition brings increased responsibilities. Our field is broad. We touch farm operations and farm life at many points. In fact the whole farm situation is so saturated with engineering applications that it is impossible to give a comprehensive treatment of our agricultural problems without dwelling at length upon this subject. The future looks bright for this organization. The opportunity for service is ours. Past accomplishments furnish the best evidence that the obligations which come with opportunity will be met.

There is not time to review in detail the work of the past year. In fact, with the Journal appearing every month, this is neither desirable nor necessary. However, there are a few outstanding developments to which I wish to call your attention.

The first of these is the formation of the Reclamation Section. Reclamation work has long been recognized as of national importance. Various organizations have been developed which devote their attentions to various phases of this field. These organizations have notable achievements to their credit, but so far as I am informed ours is the first technical society to accord official recognition to reclamation work as such. At present the Reclamation Section embraces the fields of land clearing, drainage, and irrigation. If there are any other lines which should be included they will be welcome if the case is properly presented.

The formation of the Reclamation Section will furnish a substantial stimulus to the more efficient utilization of our natural resources. We must not allow present conditions to blind us to the fact that this nation should develop every acre of land on which food can be economically produced. A large acreage of fertile land still awaits the magic touch of the drainage engineer. Desert areas are still dormant awaiting the irrigation water which will cause them to bloom and produce. The clearing of the cutover land in Wisconsin alone has been described by Dean H. L. Russel of the Wisconsin college of agriculture as a bigger undertaking than the digging of the Panama Canal. The organization of our Reclamation Section will form a clearing-house for information on these large problems and afford a rallying point for the men in this profession.

The College Section was also organized during the past year. This affords the agricultural engineering departments of the land grant colleges a point of organized contact with the work of the U. S. Department of Agriculture which has already resulted in giving coordination and stimulation to research and teaching work.

Agricultural engineering work, both in the U. S. Department of Agriculture and the land grant colleges, needs more substantial financial support then is now accorded to it. You have but to examine the financial reports of these institutions to realize the truth of this assertion. The organization of the College Section will afford another means of bringing this need to the attention of the public.

At present there are four distinct groups represented in the Society, viz., reclamation, college, farm buildings and farm operating equipment. The organization, of two of these groups into sections logically brings up the question of the desirability of organizing the two remaining groups into sections. It is my opinion that such action would be desirable but I gladly leave the final decision in this matter to the superior judgment of the members of the Society.

Our relations with other organizations have been most pleasant and profitable. These contacts promise to be of increasing importance.

We have had the honor of most substantial cooperation from the National Association of Farm Equipment Manufacturers, especially in standardization work. Members of a large number of firms represented in this organization have given freely of their time and counsel. The secretary, H. J. Sameit, has been ever ready to aid our work and offered many constructive suggestions. The organization has turned over a number of problems for solution, furnished financial support, and with the single injunction "find the facts." We are indeed fortunate in having this connection so firmly established.

The National Drainage Congress graciously recognized the work we are doing in the Reclamation Section and there are unmistakable evidences that our Society will be able to cooperate with this great organization to the benefit of both.

The officials of the American Farm Bureau Federation have on numerous occasions given voice to their belief in the desirability of standardization work. Just last month this organization took definite steps towards action in this direction and accorded this Society the honor of requesting it to be officially represented on a committee to further standardization work. It is an opportunity to get further action in a field where we are vitally interested.

Committee work must ever form the backbone of this organization. The officers are responsible for the appointment of committees and to a certain extent for the assignment of work to be done but the officers cannot carry the load alone. Fortunately there is an increasing sense of the responsibility which a committee appointment carries on the part of our members. The point I especially wish to call to your attention is that there has not been developed a form of committee organization which has stood the test of subsequent developments. In organizing the committees for the past year your officers knowingly did some experimenting with methods of committee organization. The results have been gratifying. The problem has been whether to have a large number of independent committees or to appoint a general chairman for a certain field and have him develop and direct a number of subcommittees. The experience to date indicates that fewer major committees with the required number of subcommittees produces better results. However, there are cases where work is retarded by this method because of the roundabout course required to get action. It is a problem which will be solved in time but on account of its vital relation to Society progress I felt that the members should be fully informed of the situation.

Your president would feel that he had been remiss in regard to his duties if he did not take advantage of this opportunity to discuss very briefly future possibilities. In the midst of the stress of readjustment the future looks bright for agricultural engineering. Close students of agricultural development are unanimously agreed that we have passed the pioneer stage and are now entering the business stage of farming. Profits can no longer be taken largely from the increase in the value of the land but must be realized from farm operations. Can we as agricultural engineers visualize what this means?

In the future more attention will be paid to costs of production. In this program farm machines and the more efficient use of power will play a leading part. It is a situation made to order for the engineer.

Along with this business development in agriculture there is certain to come a demand for better living conditions on the farm. Farm buildings of the future will not simply be built; they will be designed and erected with a view to utility and beauty. They will contain modern equipment, with the farm home brought up to date. Here is another great opportunity for the agricultural engineer.

While there is much debate today as to whether we have an overproduction of foodstuffs at home or an underconsumption abroad the reclamation engineer, whether engaged in irrigation, drainage, or land clearing work, can continue serenely on his way firm in the belief that the day is coming when this foresight will be recognized as having been fundamental to our national development. He is adding new wealth in the form of potential food production.

So let us strive to be constructive in our work, serving present needs in an efficient manner and building for the future on a firm basis with a confidence and enthusiasm in keeping with the great field of agricultural engineering. Let us so labor that future generations may rise up and call us blessed.

RESEARCH IN AGRICULTURAL ENGINEERING—1921*

IN THIS report an attempt has been made to summarize the outstanding features of agricultural engineering experimentation, investigation, and research completed or in progress during the past year at the state agricultural experiment stations, certain other state and federal institutions, and certain foreign agricultural and engineering institutions.

Unfortunately certain factors enter into the preparation of such a report which tend to result in the omission of numerous important features and to make absolute accuracy in the statement of certain others quite difficult to attain. This is especially true of cooperative projects where the work has been reported under some department of the station other than the agricultural engineering department. Again many projects are being conducted wholly on state funds and may be omitted from reports to the Office of Experiment Stations. Furthermore, it has been found very difficult in a number of cases to obtain complete or comprehensive statements from the officials of state institutions. All in all numerous omissions and inaccuracies occur in this report.

What appears to be an unfortunate feature of the work in agricultural engineering at the stations this year, as in previous years, is the fact that much of it has been done in departments other than the agricultural engineering department. Obviously, to obtain the best results, such work should be done at least in cooperation with the agricultural engineering department. Again, the total lack or only partial appreciation of the research or the truly investigational viewpoint is still evident in too many cases.

The work in agricultural engineering during the year included the following general subjects: Farm machinery, farm buildings, drainage, irrigation, farm water supply, and sewage disposal, land clearing, materials of construction, and miscellaneous.

One of the more important features of the farm machinery studies during the year seems to have been the work relating to tractors, of which tractor economics comprised a considerable portion. Economic studies were reported from the Illinois, Indiana, Florida, Missouri, Connecticut, Montana, and New York Cornell Stations. In most cases these studies were conducted on state funds and, with one or two exceptions were handled by departments other than the agricultural engineering department. In view of the fact that somewhat over three hundred different types of tractor are being manufactured and sold in this country today, the question constantly arises as to what of permanent value to agricultural

*1921 Report of the Research and Data Committee engineers' actually results from an analysis of the purely statistical data obtained.

It is believed that this argues the importance of conducting such studies at least on a cooperative basis with agricultural engineers in order that they may be planned and carried out and the results analyzed, with a view to producing basic information of both practical and scientific value. It is to be noted in this connection that the tractor economics studies of the U. S. Department of Agriculture have apparently been placed on such a cooperative basis. These studies, if properly planned and carried out, should yield considerable information upon which to base engineering projects in tractor research.

There seems to be a tendency in the tractor work at some of the stations to formulate what appear to be blanket projects covering a multitude of problems. Of course, conditions and circumstances often influence such cases but nevertheless there is a strong indication of a lack of appreciation of the magnitude of the problem and of the importance of selective judgment in its treatment. A broad subject like tractors which includes a large number of unsolved problems cannot possibly be given comprehensive treatment in one project without a very large personnel and extensive equipment. It would seem better, therefore, to analyze the subject into its important elements and select the most pressing problem, with reference to locality and conditions, for first treatment. The work on this problem should be planned with a certain definite object in view calculated to tie it up with the other tractor problems.

As instances of the growing tendency to exercise analytical and selective judgment in dealing with the tractor problem, attention may well be drawn to the work at the Indiana, Nebraska, Texas, and California stations. The Indiana project might at first glance be considered a mere blanket project since, in addition to the general economic studies, it includes nearly a dozen other definite features. However, this apparent excess volume of the project seems to be the result of an analysis of the tractor situation in the state. There is also evidence that the station has recognized the importance of attacking the elements of the tractor problem in the order of their relative importance, in spite of the volume of its project. This is indicated by the studies on such individual subjects as slippage and drivewheel equipment which has already yielded some significant results. An exhaustive study on this subject was recently completed in Italy and reported by the International Institute of Agriculture at Rome, thus indicating its importance.

While the Nebraska tractor project, operating on state funds, calls for work on tractor testing and rating, and is not considered on the whole as a research project by the Office of Experiment Stations, a large amount of test data has been secured which have been subjected to analysis. Some of these analyses were submitted to the Research Committee for consideration and comment and it was found that on tentative interpretation they yielded certain more or less new basic relations and principles of a general nature, of course, which, if further investigated, it is believed will materially influence standardization in both the design and rating of tractors. It has been recommended that these analyses be made the basis for the formulation of certain definite research projects on tractors which can not be discussed in detail here. There is every reason to believe that the tractor testing work as now carried on, if properly supplemented by careful and exhaustive analysis, intelligent interpretation, and special investigation where necessary should be productive of many new basic principles tending to standardize tractor design.

The California project, while somewhat less comprehensive, is organized more specifically upon research lines with certain definite problems in view. Among these, the problem of motor lubrication has received rather exhaustive preliminary analytical study as a subject of prime importance, and provisions have been proposed to carry the work to completion. A further result of the analysis of the tractor problem at the California station is a project on methods of cleaning the intake air of tractor motors which was submitted to the Research Committee as a study of prime importance. This project has been the subject of considerable discussion by the Committee, and it is hoped that it will serve to standardize all future similar studies.

As a result of an analysis of the tractor problem in Texas, Prof. Scoates has proposed a comprehensive project on tractor engine lubrication to the Research Committee as one of prime importance. This involves a cooperative study with the chemistry department on motor oils and is to be put into operation shortly at the station. This project is of considerable interest in view of similar work at the Iowa and California stations, and the Committee has subjected it to considerable analytical study with a view to making it a standard for similar studies. A striking instance of exhaustive research on this important subject which should be considered in connection with this project has recently been reported by the Lubricants and Lubrication Inquiry Committee of the Advisory Council of the Department of Scientific and Industrial Research of Great Britain. This study dealt with the lubrication of both internal-combustion engines and machinery, and included work with all kinds of lubricating oils comprising both mineral and vegetable oils and mixtures thereof and a number of so-called technical mixtures prepared in the laboratory. Different combinations of gears and gearing were studied. The indications are that for practical purposes a certain amount of deflocculated graphite in mineral engine oils seems to increase their efficiency. The best manner of incorporation of the graphite is a subject for further study.

No reports of other comprehensive tractor studies at the state stations have been received during the year. It is known that considerable tractor work is being done, but reasonable doubt exists as to the existence of any number of well-organized projects of study.

The subject of fuels for internal-combustion engines has commanded considerable attention this year. The fuel studies conducted by the U. S. Bureau of Standards have included such important features as characteristics, economy, and detonation.

Significant results as to the relation between the phenomenon of detonation or knock and timing have been obtained. The engineering experiment station of the Ohio State University has also reported studies of the flash and burning points of kerosene-gasoline mixtures and on the economical utilization of liquid fuel. The fuels section of the Imperial Motor Transport Conference of Great Britain has also conducted some important researches on alcohol as an internal-combustion engine fuel. The work has included especially a comparison of alcohol with gasoline and other volatile hydrocarbons and a study of the effects of mixing alcohol with volatile fuels. The indications are that the lower calorific value of alcohol is almost compensated for by the greater compression at which it can be used, and this property of high ignition temperature under compression is hardly altered by admixture with 20 per cent of benzine or of gasoline itself. The French and Belgian studies of palm oil as a motor fuel in the tropics during the past year are significant and indicate the existence of a new and very effective fuel for tropical use in this relatively cheap and abundant oil.

General tractor studies were conducted during the year in Belgium, France, Sweden, Denmark, South Africa, England, and the colonial possessions and protectorates of Ceylon, Tunis, Java, and India. The Belgian studies were essentially of an economic nature but were planned largely upon the basis of technical considerations. The work in the colonies and protectorates was usually of a special comparative nature and can not be classed as being of a very high order of research.

Work along other farm machinery lines has been varied.

A project on fertilizer distributing equipment has been inaugurated at the Alabama station. This seems to have developed into a very important and somewhat pressing problem in some localities. In this connection it is to be noted that the Deutsche Landwirtschafts-Gesellschaft of Germany has recently completed a very exhaustive study of fertilizer distributors under the intensive conditions of cultivation in vogue in Germany. Dust prevention when handling dusty fertilizers was an important feature considered. A significant preliminary finding was that no single machine is available on the market which meets all of the conditions imposed. The work naturally proceeded into an analysis of what a fertilizer distributor should accomplish under such conditions, and on this basis a study was planned and conducted which yielded the basic principles which govern the design and construction of the fertilizer distributors desired. These are to be placed in the hands of farm equipment manufacturers when the final interpretation is complete. This work indicates the opportunities existing for the development and standardization of machinery of this kind. Thus the possibility is evident that the Alabama project on the subject may be one of far-reaching importance. While its details are not available it is hoped that the plan of procedure has been organized so that the study will not stop with a mere comparison of existing machines.

Studies on the power requirements of farm implements, particularly tillage implements, have been conducted at the New York Cornell, Wisconsin, Nebraska, Montana, Iowa, and Missouri stations. With one exception, these projects have been operating on research funds and all seem to embody certain research principles. In some cases, notably Iowa, Missouri, and Nebraska, the studies are becoming quite comprehensive. This subject was deemed of such importance by the Nebraska Station that a project on the power requirements of tillage machinery has been submitted to the Research Committee which it is hoped will not only tend to standardize studies of this type but will tend to stabilize and standardize the design of certain tillage machines.

The Iowa station has a voluminous farm machinery project in force which includes among other things studies on corn picker-huskers, silage harvesters, small threshers, small silage cutters, grain shockers, shock movers, and silage packers. To the casual observer it might appear that a great deal of the work under projects of this type would consist merely of miscellaneous testing, and in the past this has probably been true to a considerable extent. But there is now a growing tendency to organize these studies so that on careful analysis the data obtained is susceptible of interpretation which invariably uncovers numerous new and unsuspected basic relations as well as certain misconceptions and omissions. While the work at Iowa on this project, covering so many miscellaneous machinery subjects, has been apparently for the most part conducted on research funds, some of it is believed to be worthy of more careful analysis and planning from the research standpoint than apparently has heretofore been accorded it.

With this in view two projects of proposed research have been submitted to the Research Committee for criticism and comment. One of these is a study of corn planters and corn planting methods adapted to multiple-row cultivation, the purpose of which seems to be the development of corn planters and cultivation along efficiency lines. It may be said in this connection that the development of farm machinery along efficiency lines seems to be one of the most popular and pressing subjects in agricultural engineering at this time, especially in the Middle West. The other project submitted to the Committee is on the power requirements of silage blowers. An analysis of this project by the Committee showed that the subject includes a number of unsolved and very important problems relating to the efficient use of silage blowers.

In this connection a report of similar work conducted at a leading British University was recently presented to the Royal Society of Arts of Great Britain. The studies dealt specifically with pneumatic elevators in theory and practice, and were limited to suction types. The experiments were conducted with grain, husks, and other materials, and included determinations of pressure of air on grain and other materials, grain velocity, efficiencies of vertical conveyors, and efficiencies of nozzles. Mathematical expressions were derived from the interpretation of the data obtained which express the basic principles and relations governing the design and operation of such elevators. This work should be a valuable aid in work similar to that planned at the Iowa station.

The work at the National University of Buenos Aires on hay and silage cutters should also be important in this connection. These studies have been conducted for some time with a view to developing the most rational type of knife for hay and silage cutting, and have so far indicated the superiority of spiral-shaped knives to straight knives. The necessity of establishing a definite relation between the geometric form of the knife, a convenient peripheral speed, and the weight of the frame also seems evident. Studies on corn-harvesting machinery at the University have also been in progress, and have resulted in the development of two types adapted for green and dry corn, respectively.

A comparative study of horse and motor cultivation is in progress at the Mississippi station. While this does not sound like research, it is understood to be operating on research funds, and so must include at least some of the elements of research.

An unique and very interesting project has been apparently finished at the Montana station, dealing with the development of power by use of bulls in a treadmill. Some of the features of this project, such as the development of an automatic slapper, are very amusing, but yet they involve the use of scientific principles, and the project on the whole seems to be a well-planned and executed piece of cooperative scientific work.

A distinct contribution to the causes of and remedies for thresher explosions has resulted from recent studies by the U. S. Bureau of Chemistry on matters relating to the accumulation and redistribution of static electricity in threshing machines. In all cases a continual marked difference in potential was established between the earth and the different parts of the machines studied. Several steel machines showed, as individual units, a greater potential than the earth. The indications are that under favorable conditions the cylinder concaves and grain pan of a thresher will become electrified to a greater extent than other parts of the machine, resulting in the occurrence of sparks during the restoration of normal static balance.

Considerable work has been reported as being in progress during the year on the subject of farm buildings and equipment, including heating and ventilating. The Iowa and Indiana stations appear to have been among the leaders in this work as far as amount of work done and number of subjects studied are concerned. Attention is drawn to this matter since, like the Indiana tractor project, the Iowa and Indiana farm building projects cover a large number of subjects, perhaps too many to be effectively covered in one project. On the other hand, the number of these subjects presented is evidence of the exhaustive analysis which has been made of the subject as a whole, and indicates the growing tendency to select and study the more important elements of the subject revealed by such analysis. The Iowa projects cover such matters as farm houses, general farm barns, cattle barns, dairy barns, horse barns, poultry houses, swine houses, sheep sheds, crop storages, granaries, corncribs, smokehouses, manure pits, machinery sheds, garages, power plants, cattle feeding barns and equipment, silos, and ventilation systems. The Indiana project is equally as comprehensive. A study of ventilation systems has also been in progress at the Wisconsin, South Dakota, Minnesota, and New Hampshire stations, and, of course, the classic work on ventilation of the late Dr. Armsby and his associates at the Pennsylvania station is well known to all agricultural engineers. Materials for stable floors have been a subject of special study at the Ohio State University.

Work on silos has also been in progress at the Michigan, Missouri, and Guam stations. In all three cases the work has been supported by research funds. The investigations at Missouri have been planned to study all conditions affecting the use of the silo, including material of the wall, moisture factors, loss of nutrients, and silo capacities. The Michigan studies have resulted in considerable working data on silo capacities.

The subject of poultry houses has been studied at a number of stations but perhaps most systematically at the Kentucky, New Jersey, Oregon, and Washington stations. The New Jersey studies have been especially comprehensive and have constituted a process of gradual elimination of different designs down to certain definite standard types and equipment. The work at the Washington station is also approaching this stage.

Dairy barns and milk houses have received attention at the Wisconsin, Arizona, and Texas stations. The Wisconsin studies have been quite comprehensive, and the work at Arizona has resulted in the development of an adobe milk house. At South Dakota work on farm barns and dairy barns has been reported which has resulted in quite definite standard principles of design for the state. However, insufficient information is available regarding this work to determine its research status.

A striking piece of research has been reported from the Delaware station on sweet potato storage houses. Unfortunately it seems that this work was conducted entirely by the horticultural division. Nevertheless, it has yielded some valuable basic principles affecting the design of sweet potato storage houses in that locality.

The Minnesota station has started a study on the heating and ventilating of farm homes. In this connection it is well to draw attention to the fact that noteworthy research has been reported from Germany on the heat conductivity of building and insulating materials and heat permeability factors of new structures. In addition the University of Illinois engineering experiment station has studied and reported on the emissivity of heat from various surfaces and is continuing the warm-air furnace research work. The Ontario Agricultural College has reported research work on insulating materials, and the American Society of Heating and Ventilating Engineers has reported studies on the transmission of heat through single-frame double windows. All of these studies taken together should be of considerable importance in connection with studies of the heating and ventilating of farm buildings and dwellings. The importance of the subject of ventilation needs no emphasis. The Research Committee has made no attempt to formulate a project of research on ventilation owing to the projects already in existence. However, the importance of the subject of the artificial heating of animal shelters has been looked into, and it is hoped that a project may be organized on that subject.

The Committee has considered no general farm building project for a number of reasons. One is that a number of such projects are already in existence. But the most important reason is that the subject obviously first needs a more thorough analysis by all the different states and a comparison of notes to see just what elements should be attacked first.

It would seem that the time is ripe for further studies of farm houses, with particular reference to the development and use of new materials of construction. In this connection it is to be noted that the Ministry of Agriculture of England has inaugurated a set of studies on the relative values of farm houses made of monolithic concrete, cob, pise de terre or earth rammed between movable forms, timber, and timber and brick. The main purpose of this work is the development of the use of pise de terre which promises to be a cheap, flexible, and efficient material.

With certain exceptions it is not believed that the drainage work which has been done at the state stations this year as a whole has been of a very high order of research. Of course, the very nature of the subject and general circumstances make it difficult to plan and carry through projects of research. The demand for practical information on the subject seems, however, to have occupied a large part of the time of the men assigned to such work at the stations, and has left relatively little time and funds for research.

In spite of circumstances and conditions tending to discourage research some few noteworthy pieces of work have been done. The cooperative projects in North Carolina on the efficiency of underdrains, run-off from drainage canals, run-off from underdrained land, and action of tile drains on ground water level deserve special mention. These studies seem to have included a special study of soils as a basis for the drainage experiments. Another noteworthy cooperative study is that conducted at the Alabama station on the effect of tile drains in the lime or prairie soils. Two other local cooperative projects have also been inaugurated at the Alabama station on farm drainage and terracing and studies of swamp and overflow conditions. The nature of these studies is not yet available. The Ohio and Minnesota stations are engaged in studies of the depth and spacing of drains, and an interesting study on this subject has just been reported from Germany.

At the Montana station a study is reported as being in progress on different drainage practices followed in the state and their relative effectiveness. This is hardly research, but could be made the basis for such work. The Colorado station seems to be continuing its studies of drainage requirements of crops.

The Oregon station has several projects on the drainage and improvement of wet lands, including "white" lands, greasewood lands, and tide lands. Much of this work involves the removal of excess alkali and the restoration of a fertile structure. Considerable basic data have already been made available from this work. At the California station work is in progress on land drainage by pumping and on the reclamation of certain marsh and alkali lands by drainage.

Work on the drainage of peat and muck soils has been reported from Wisconsin, Minnesota, and Florida. The Wisconsin station has been especially active in this respect. An important feature of this work is the fact established that the settlement of drained peat soils must be considered as an important factor in the design of both tile and open drains. The further reclamation of these soils after drainage is an important complication of this work.

Studies on the cost of trenching, hauling, and laying tile have been reported from Ohio. The Minnesota station has started a correlation of land and crop values with cost of drainage, and has a project in operation on the movement of water in soils. The Kentucky station is engaged in studies of the effect of the initial moisture present on the movement of water in soil. The project at the Missouri station on the investigation of water penetration, evaporation, run-off, and erosion in average Missouri soils should also be mentioned.

Before leaving the subject of drainage, attention should be drawn to a recent study conducted by the Ministry of Agriculture of England on mechanical ditchers for land drainage. The studies so far have been conducted only on a rotating wheel tractor ditcher for digging tile trenches. The significant fact was established that there is little difference between the cost of work by this machine and by hand labor. However, other advantages such as quick completion of work enter in which establish the importance of mechanical ditchers. Work by the Ohio station on the other hand has so far indicated a considerable saving by machine trenching. The same result was obtained in experiments conducted for one year by the North Scotland Agricultural College.

The subject of irrigation is one in which considerable work has been in progress. It has perhaps received more intensive research treatment than any other division of agricultural engineering, and apparently conditions and circumstances have been distinctly favorable for such work. Under the able leadership of the Irrigation Investigations Office of the U. S. Department of Agriculture the work has developed throughout the irrigated West, and the cooperative projects and individual state projects which have been reported in progress are numerous. The majority of these projects have been operating on research funds, which is a very significant fact in itself when considering their research status.

Owing to the large number of such projects in existence of about equal importance, it would be impracticable to attempt to give them any comprehensive review here. However, the California station submitted a very comprehensive project to the Research Committee for consideration on the relation between irrigation head, soil type, and grade in the preparation of land for irrigation, to be conducted at the station. This general subject is already being studied in one form or another at a number of the stations, and seems to be a very important irrigation matter at this time. The Idaho and Oregon stations especially have been interested in such work as has also the Office of Western Irrigation Agriculture of the U. S. Department of Agriculture. It was with the object of attempting to standardize this particular type of study that the project in question was so readily considered by the Committee. It is hoped to make this project somewhat of a standard pattern for such work, although it is realized that this will take time and considerable analytical study.

Attention may also be well drawn to the ground water studies at the Montana, Arizona, Utah, and New Mexico stations, and to the pump irrigation studies at the Nebraska, Montana, Arizona, and Utah stations. The work at the Nebraska, Arizona, and Montana stations, especially on pump irrigation, has been productive of considerable basic working information.

The question of duty of water has been under investigation at the Utah, Idaho, California, New Mexico, Oregon, Montana, and Nebraska stations, especially, and this work is so well known as to need no comment. The U. S. Reclamation Service has also been quite active in this connection.

Numerous alkali land and alkali tolerance studies have also been in progress, notably at the Arizona, California, New Mexico, Idaho, and Utah stations, and the U. S. Department of Agriculture has reported a comprehensive study on the quality of irrigation water in relation to land reclamation. A significant conclusion drawn from this study was that the quality of irrigation water should be judged not only by considering the total quantity of the salts in solution or the proportions of the acid radicals but also the proportion of the sodium to the calcium and magnesium. This is taken to indicate that water to be safe for long-continued irrigation should be relatively rich in calcium and magnesium.

The study of water measurement devices, including current meters and the Venturi flume, at the Colorado station and of weirs at the Montana station should be mentioned, and the evaporation studies at Colorado are reported as being still in operation. Other special studies related to irrigation which have been reported are on the use of concrete pipe in irrigation by the U. S. Department of Agriculture and on conveyance losses of water on irrigation projects by the U. S. Reclamation Service.

The latter study has indicated that 25 per cent is about the minimum loss that may safely be estimated under favorable conditions and that 50 per cent is sufficiently high for the average well-planned project. It was further shown that concrete linings, on account of their high costs, should be resorted to only after all other means of preventing losses have failed.

Noteworthy foreign work has been reported by the Deutsche Landwirtschafts-Gesellschaft on the spraying of fields with municipal sewage. This work has led to the development of three different types of portable spray irrigation apparatus which may be used in the distribution of clarified and partially clarified municipal sewage, especially in furrow irrigation.

Research on the subjects of farm water supply and sewage disposal has apparently been almost nonexistent during the year according to the information available. There are a few exceptional cases which will be mentioned, but it is believed that the majority of such work that has been done during the year has consisted largely of reproduction and very little of creation. There is ample evidence of the importance of unearthing and establishing some of the basic principles of this subject. The Research Committee hoped to formulate a project of research on some phase of it but has failed to do so.

There have been many more or less well meaning but poorly planned and conducted attempts to get at the fundamentals of the subject. There are a few exceptions, however, which may well be mentioned. The study at the New Jersey station on the biology of sewage disposal is unique and stands practically alone in its class as a research project on farm sewage disposal. Its purpose is to determine how sewage may be disposed of with a reduced amount of water and end products containing waste materials in a commercial form. This is a Hatch fund project and unfortunately, it would seem, is being conducted by the Department of Entomology alone. Here would appear to be a wonderful opportunity for cooperative work on an extremely important subject. In a preliminary study of the biology of the sprinkling sewage filter, it has been found that organisms are present in the gelatinous film of a filter which are similar to those occurring in the soil, and which act in the oxidation of organic nitrogen to inorganic forms. This process seems to be a gradual one, starting in the top layer with the zone of greatest activity in the second layer. Here it seems is a distinct step forward to establish a bridge between the results obtained with large-scale filters and the results desired on small-scale absorption or filter systems. Other biochemical facts were established which should be of the utmost importance in a study of farm sewage disposal.

The work at the Montana station on farm sewage disposal in which at least three methods are being studied is perhaps not so comprehensive in plan as the New Jersey project, but is a more distinctly engineering project. This project has been quite productive of information so far, but it is believed it should be continued to a point where interpretation of the data obtained will yield some definite basic principles. It also is believed that a certain amount of cooperation with the Chemistry Department would add materially to the value of this project. The work at the New York Cornell station on the disposal of creamery sewage and the disposal of domestic sewage by subsurface irrigation should also be mentioned. The latter of these projects apparently has been in operation for some time. The Missouri station has for some time been conducting a project on sanitary equipment for farm homes in which unfortunately it would seem the extension features are apparently being considered at the same time. The U. S. Public Health Service has had a most comprehensive project in operation for This has been conducted in cooperation with the U. S. Department of Agriculture. The interpretation of results obsome time on the treatment and disposal of creamery wastes. tained has established numerous basic principles of value. The work at the Minnesota station on farm sewage disposal should also be mentioned. This work indicates the superiority of the rectangular, two-chamber septic tank for certain Minnesota conditions.

The Rothamsted Experimental Station in England has recently reported a remarkable piece of research on the use of straw filters for sewage purification. The indications are that straw when used as a filter gradually removes the nitrogen from the sewage and, as the filter ripens, a straw manure is formed equal in value to the best stable manure. At the same time the sewage is effectively purified. It is concluded that for best results about two pounds of dry straw per person per day is required in the filter. From 20 to 35 days is required for maturity of the straw filter.

Both the Idaho and North Dakota stations have water supply projects. The former consists of a study of the design and installation of farm water supply systems, and does not give outward evidence of carrying the aspects of true research. The latter, however, is a Hatch fund project to determine the suitability of North Dakota waters for drinking and mechanical purposes, and unfortunately is confined to the division of agricultural chemistry.

There are probably other water supply and sewage disposal studies in operation, but these are all which have been reported. It is believed that the time is ripe to get together on this subject with a view to digging out the basic principles involved. It is recommended that future research committees get into touch with the Montana, New York Cornell, and New Jersey stations, the U. S. Public Health Service, and other institutions interested in the subject, with a view to establishing some studies on this subject which will settle the questions relating thereto once and for all.

While the subject of land clearing is an old one, it has developed some new and interesting aspects during the past two or three years, and especially since the signing of the armistice ending the world war. The U. S. Department of Agriculture has shown its interest in the subject by conducting cooperative experiments with the Wisconsin station on the use of explosives in blasting stumps. Salvaged T.N.T. and picric acid have developed into effective explosives for this purpose, as indicated by the Wisconsin experiments. So-called grenade powder and modified versions thereof have also been used with a certain degree of success. The Wisconsin station has also conducted studies on the time of brushing and seeding cut-over land, on the comparative strengths of dynamite required for blasting pine and hardwood stumps on various soil types, and on the comparative value of the different methods employed in the removal of pine and hardwood stumps. A certain amount of similar work has been in progress at the Minnesota, Oregon, and Alabama stations. Of course, a large part of this work consists mainly of comparative experiments. Yet the results are to a certain extent susceptible of analysis and interpretation into basic principles and apparently little more can be asked in view of the nature of the work. The work has resulted in the development of new and improved methods, and it is believed that it can well be carried much further.

Materials of construction as a subject has developed from a minor miscellaneous matter to one of the main divisions of agricultural engineering. Its connection with all other important divisions of agricultural engineering is becoming more and more evident, and its rise to an important division is only a natural result and true indication of progress in the subject as a whole. The preservative treatment of fence posts, timbers, lumber, shingles, and other wooden structural materials has been under investigation at the Alabama, Minnesota, Montana, and Iowa stations especially. The U. S. Department of Agriculture has reported a study of powder post damage to timber and wood products and preventative measures. These have indicated the effectiveness of kerosene and hot boiled linseed oil as preventative measures against this destructive agency. The American Wood Preservers' Association has derived mathematical formulae showing the penetration of creosote into various sizes of sawed and round timbers, and the German Agricultural Society has conducted an investigation of the fundamental principles of wood conservation in order to get at the root of the matter.

The Minnesota station has reported a comparative study of fence posts and an investigation into the effect of structure, time of cutting, and methods of seasoning of white cedar on the penetration of preservatives. The Ohio station is also engaged in an investigation of the relative durability of fence post timbers, and the Iowa station apparently is continuing its project on roofing materials.

A study has been in progress at the New Jersey station on fungi injurious to paint. In this work the purpose is to determine the species of fungi growing on painted surfaces, the environmental facts and conditions, the injurious effects, the relationship of fungi to paints of different composition, and preventive measures. This is a new and unique study, and would seem to be an outgrowth from or an advance on the comprehensive studies of paints and painting conducted for some years by the North Dakota station and the U. S. Bureau of Standards. The U. S. Reclamation Service has also been engaged in a study of water gas and coal-gas-tar paints for irrigation structures which indicate the superiority of tar paint for submerged metal works.

The Iowa station has been conducting a service study of oils, presumably lubricating oils. The Idaho and Wisconsin stations have studied the design, manufacture, and durability of concrete tile for drainage and irrigation purposes, and the Wyoming station is apparently still engaged in its study on the alkali proofing and the preparation of alkali-proof cements. The cooperative project on the action of alkali on concrete conducted by the U. S. Department of Agriculture, the U. S. Bureau of Standards, and the U. S. Reclamation Service is apparently still in existence. All of these studies seem to indicate that the sulphates are the salts most dangerous to concrete.

The U. S. Department of Agriculture has recently been engaged on a study of the water resistance of treated canvas during continuous exposure to weather. Eighteen different treatments have been tested. The effectiveness of lead oleate and Bermudez asphalt in waterproofing mixtures has been especially indicated. Beeswax is superior to all other hard waxes tested.

The University of Illinois Engineering Experiment station has reported a study on the thermal conductivity and diffusivity of concrete, indicating the relation between the conductivity and the proportion of solid material to voids. The Lewis Institute has also reported a study of much interest to agricultural engineers on the effect of storage of cement. Another general study and summary of data is that made by the U. S. Bureau of Standards on strengths and related properties of metals and certain other engineering materials. This work should be of special interest in connection with the development of farm machinery and motors.

As usual there are a few miscellaneous features of agricultural engineering under study which deserve mention. The Alabama station has a project on destructive distillation and one on the effect of grade of terrace and its relation to soil type. The Illinois and Missouri stations and the Ohio State University are also studying the subject of soil erosion and preventive measures. The work at Ohio has recently been centered on such special features as broad base terraces and earth-saving dams. In this connection attention should be directed to a project in soil erosion and preventive measures submitted by the Nebraska station to the Research Committee for consideration. While this project in its original shape was not considered to be research by the Committee, sufficient comment and suggestions were made to serve as a basis for the standardization of projects of this kind. It is believed that soil erosion and terracing studies should be placed upon a definite standard basis with reference to soil type and other conditions, so as to make aimless testing in the subject unnecessary. The importance of the subject needs no emphasis.

Both the Minnesota and Michigan stations have started work on small farm electric light plants. While the status of this work is difficult to determine, it is noticed that the Michigan station has made a brief analysis of the costs which enter into the production of electrical current by gasoline or kerosene. The Ohio State University is also engaged in a study of the effect of oil on the operation of farm electric plants.

Tillage and tillage methods are subjects normally related to the work of agronomists. However, they have such a distinct relation to the development of tillage machinery that it is considered advisable to include them as miscellaneous agricultural engineering matters which are at least of a cooperative nature. In fact, certain cooperative projects are in existence. Studies of tillage and tillage methods have been reported from the South Dakota, North Dakota, North Carolina, Oklahoma, Illinois, Oregon, New York Cornell, South Carolina, Indiana, and Ohio stations. In nearly every case the main point under study is that of depth of tillage. Moisture content seems to be second in importance. The Ohio and North Dakota studies seem to have been especially comprehensive, and the question of subsoiling has been given considerable attention in both projects. The North Dakota results so far are not favorable to the general practice of subsoiling. Recent German experiments on the influence of water content and void space on the ease with which soil may be cultivated have indicated that the common soils are most easily cultivated when they contain hygroscopic moisture only, and that this condition is apparently independent of other physical characteristics. This study would seem to be of particular significance when considering such matters as draft and scouring.

A very important miscellaneous subject which is being studied by the U. S. Department of Agriculture is that of dust explosions. This work, much of which is being conducted in cooperation with the U. S. Bureau of Mines, has yielded some very significant results of far-reaching importance. While it is not practicable to review all these studies here, it is believed that this subject is one to which all agricultural engineers should devote some attention, owing to its close relation to the design of farm structures.

The Research Committee has had a miscellaneous project under consideration submitted by the Iowa station on methods of multiple hitching of horses. This will be a cooperative project with the animal husbandry division. The difficulty of developing a research project on such a subject is obvious, but the purpose is to inject some engineering into multiple hitching and to try to establish some working principles.

From this summary and from the survey made by the Research Committee during the year, four general subjects seem to stand out from the rest as being of prime importance and worthy of immediate and exhaustive research treatment. These are in the order of their importance, as indicated by the survey: (1) Power requirements of farm machinery and its more efficient utilization, (2) farm water supply and sewage disposal, (3) increase of economic efficiency of horse and mechanical power, and (4) determination of standards of design and performance for farm machines and parts thereof.

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RECENT DEVELOPMENTS IN FARM BUILDINGS*

By Fred C. Fenton

Mem. A.S.A.E. Associate Professor of Agricultural Engineering, Iowa State College

DURING the past two years there has been very little development along farm-structures lines. For the most part new farm structures were brought forth in response to a need or demand on the part of the farmers.

There is a widespread interest and, consequently, some development in the construction of the Gothic arch barn frame. Since its first appearance in the Northwest some fifteen years ago it has grown in favor steadily. It is popular because of its pleasing exterior appearance and because it gives a haymow entirely free from interior braces. It may also be adapted to almost any width barn.

These barns were first developed near the lumber mills of the Northwest where the lumber could be cut without much trouble to the curvature of the roof. The ribs or rafters commonly were made by nailing together three or mo-e 1x10-inch boards to form a curve. These boards can be prepared best at a sawmill where a power saw is available. The sawmill in the West made the practice of preparing and selling the boards cut to the proper radius. In the Middle West this type lost favor because of the labor of preparing the lumber in the absence of power-driven saws.

In 1916 the first bent rafters made their appearance. An experiment with the bent rafter conducted at Davis, California, in 1916 is the first one brought to my attention. In this construction the boards are bent to the desired curve instead of being sawed out. The ribs are commonly made of four or five one-by-four's bent and securely nailed and bolted together with joints spaced so that no two will be closer than three feet. The construction of these ribs is simple and the erection also is very easy. All of these barns built in the Northwest seemed to have been strong enough, and the numerous examples of the bent rafter in the Middle West seem to show that this design is also strong enough.

The curve of the roof may vary considerably. A common method is to make the rafters with radius two-thirds of the width of the barn. This makes the top of the roof rather flat. A three-quarter-width radius makes the roof a bit high and peaked. The best design seems to be using a three-quarter-radius from a point three feet below the lines of the top of the studding.

In the absence of experimental data there seems to be two weaknesses in these roofs. Where the radius curva-

*Fifteenth annual meeting paper.

ture is small and the top of the roof is rather flat, there has been a tendency to sag at the middle of the barn. Also this flat portion is not suited to the use of wood shingles. The second weakness is the joint between the bent ribs and the wall of the barn. When no tie is used other than the toe-nailing of the rafters to the plate it would seem to be a very weak point. Ties running vertically from the rib down to the floor joist are used, spaced every eight feet. It is questionable whether these are adequate.

The combination built-up and bent-rafter type in the opinion of some makes a stronger barn. Built-up ribs of three one-by-twelve's sawed to the curvature, spaced eight feet apart, give the barn some rigidity which is lacking in the barn built of the bent rafters entirely. Headers made of 2x4-inch material are set in between the built-up ribs at intervals of four feet for stiffeners. Bent rafters made of four 1x3-inch material are spaced two feet on centers between the heavier ribs.

The weakness at the eaves is overcome by making the ribs continuous from foundation to the ridge, that is, the stud and rafter is one continuous built-up rib of five one-by-four's. This construction eliminates any weakness at the eaves. A later design of the Louden Machinery Company provides for a continuous rib running from foundation to foundation. This eliminates both joints at eave and ridge. The radius of curvature at the peak is twelve feet and the natural slope here is secured by two short rafters spiked to the ribs and braced in the center. F. C. Harris states that in the Louden experimental work it was found possible to bend this lumber to a ten-foot radius, providing a good quality of lumber was used.

Just what will be the most approved design of the Gothic roof will have to be worked out. The shape of the roof is growing in popularity and seems well suited to the type of barn required throughout the corn belt. There is need for some original research along this line.

Right along this line it might be well to mention the experimental masonry arch built at the Iowa station in 1915. The idea was to work out a roof of permanent fireproof nature that could be used on the concrete or clay block barrs already designed. Results of this experiment have been reported before.

This Society has already been interested in the development of permanent construction. Clay blocks for barn-wall construction have reached an advanced stage, and to those following farm buildings there is little new to be presented.

There are two new barn walls of concrete which may be of interest. One is a monolithic construction developed by the Denniston-Sprague Construction Company, Fergus Falls, Minnesota. The wall consists of solid walls strengthened by pilasters at intervals of six feet. The walls themselves are three inches thick and the pilasters are 8 by 8 inches projecting five inches outside of the wall. To prevent cracking and hold the walls together 3/8-inch rods spaced twelve inches apart run continuously around the barn. Each pilaster is reinforced vertically with three 3/8-inch rods.

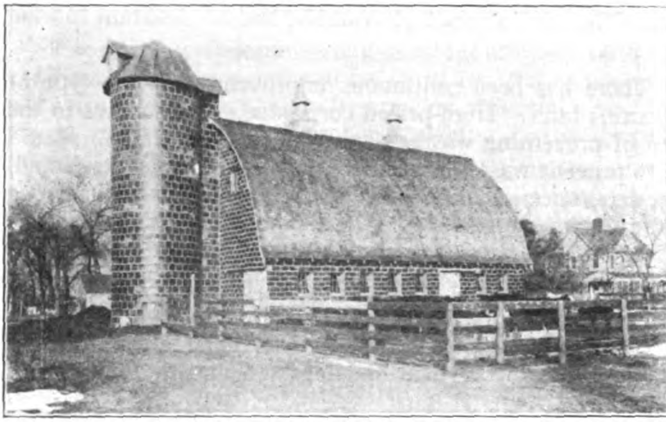
The steel forms used to cast the walls are made under patent by the above company. They are made in sections 24 inches high and 6 feet long of 14-inch gauge sheet steel. These sections are reinforced with angle irons to secure rigidity. The construction of these walls seem to be simple. First, the pilaster forms are set up, then the sheet forms are bolted to them. Bolts extend through the pilasters to hold forms the proper distance apart. Door and window frames are set in at the proper places and the concrete poured. It is recommended that enough forms be provided for the entire barn. Set them all up at one time and pour continuously, but it is believed that two rows or units of forms would be sufficient. They could be raised and the wall poured in sections similar to the method used in silo construction. One complete set of forms for a 36 by 72 foot barn would cost about $1500. They would be practicable only for a contractor or perhaps a group of farmers.

The cost of materials in this wall is low. One barn 36 by 72 feet in size would cost as follows:

160 sacks of cement at 75 cents	$120.00
18 yards of sand at $2	36.00
Reinforcing steel	50.00
Total for materials	206 00
Labor, four men ten days at $4	160.00
	$366.00

Where the farmer could supply the sand and do most of the work a very cheap wall will result. A three-inch solid concrete wall will lose nearly as much heat by radiation as single glass. So this would be a cold wall with large heat loss, and a great deal of frost would form on the inside. For this reason it would be more suited to warm, dry climates where only cheapness and rigidity were required.

Another concrete barn which has attracted considerable attention is the one developed by the Valley Silo Company, Fargo, North Dakota. The designers of this barn state that their object was to secure a barn that would give warmth, dryness, and utmost rigidity and strength. Although this



Gothic arch roof construction on a clay block barn

barn is similar in exterior appearance to the previous one, it is different since it is constructed of blocks and staves made at the factory and hauled to the farm. The staves are like common silo staves, 10 inches wide, 30 inches long, and 2¼ inches thick. The wall consists of two thicknesses of these staves with an air space between. The staves are held in place by piers or pilasters made of cement blocks cast at the factory. The blocks are 5½ by 10 by 13½ inches and provided with grooves on the sides into which the ends of the staves are fitted. Each pilaster is hollow from top to bottom to permit the placing of steel vertically, after which the cavity is filled with concrete. The horizontal joints of staves are set in cement mortar, while the ends are pointed up after being put in place. The corner blocks, lintels, and window sills require special design and are cast to fit into the general scheme.

The barn is easy to erect. The wall is tied down to the foundation by embedding bolts in the green concrete, allowing them to extend up into the pilaster about three stave lengths. Then 9/16-inch wall bolts are inserted into the hole in the pilaster, being long enough to extend from the foundation to a point six inches above the wall. The opening in the pier is filled with concrete, thus tying the two reinforcing rods together. The wooden plate is bolted solidly on the top of the wall, making a solid tie from the upper part of the barn to the foundation.

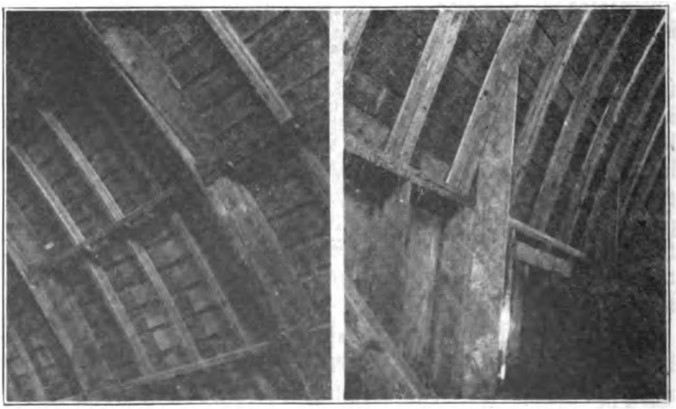
The joists of the hay loft are supported on 4x6-inch timbers which rest on special girder piers set into the pilasters.

The Valley Silo Company states that they have built forty-one of these barns, all of them giving satisfaction. The barn is very warm, with no frost or condensation on the inside. They do not crack or crumble, and are resistant to wind and fire.

There has been continuous improvement in the type of corncribs built. High-priced corn gave great impetus to the idea of preventing waste. The idea of an ideal crib should be to prevent waste of corn from all sources, such as mould, rot, rats, mice and fire. Besides this a crib must be strong and durable.

The Adel Clay Products Company, pioneers in the round tile crib, have lately improved their corncrib block. The former angle cut block had four square openings, furnishing an excellent place for sparrows to nest. The latest block has four long narrow vertical openings too narrow for birds or large rats.

The demand is for rectangular cribs with a driveway through the center and grain storage overhead. Such a crib was built on the Iowa State College grounds out of Adel tile in 1916. The walls were strengthened by heavy concrete pilasters, making a cumbersome and expensive type of construction. But we find the same idea worked out in the new Natco corncrib and granary. Some attempts have been made to build a clay-block corncrib wall with stiffeners or reinforcing, but they have never been very successful. In this crib the tile are made in two units, a 4x8x5-inch ventilated tile and the 5x8x12-inch pilaster tile. Pilasters are placed approximately six feet on centers. Where the crib walls are not more than ten feet high no reinforcing steel is used in the pilasters. But for the higher crib walls both horizontal and vertical steel rods are placed in the pilaster and openings are filled with concrete. The openings in the



Gothic roof framing: bent construction at right, mixed bent and sawed shown at left tile are so small that they are ratproof in themselves.

The crib is well designed and substantial. It presents an excellent appearance and can be built into the combination corncrib and granary with the central driveway, the type which has always been the most popular with the corn belt farmer.

The growth of the concrete ventilated stave corncrib has attracted considerable attention. Built of the regular silo stave 10 inches wide and 30 inches long, it is particularly adapted to the circular construction. The ventilation is furnished by two central openings, 4 by 9 inches in size, in each stave, giving about 20 per cent of the wall area in openings. These openings are filled with four quarter-inch steel rods which run lengthwise of the stave and form a protective grating with openings close enough to exclude rats. The crib is held together by 9/16-inch steel rods so spaced that each stave has two rods to hold it. Some kind of interior ventilator is used to insure proper drying out of the corn at the center.

A combination corncrib and granary may be made out of these two units, using the solid staves for the small grain and the ventilated for ear corn. A roof is put over the two and an elevator installed permanently in the driveway.

Another design secures the combination grain-storage building by putting the grain above the driveway. The corncrib is semicircular in shape, which necessitates some strong beam construction at the driveway to which to tie the rods. The interior studding and the joist above are of wood so this is half concrete and half wood type of construction. The door frames may be made of concrete, and the steel bands tied to this solid concrete post. This is, no doubt, a more rigid structure. The end of the grain bins above is made of solid staves, leaving no wood subject to the weather on the outside.

Still another design is the one using steel beam construction for the driveway studding and the floor joist. Ventilated staves are fitted between the steel joists below and solid staves form the walls for the grain bins above. By using a fireproof type of roofing on this structure we have a very permanent and fireproof crib.

These concrete stave corncribs present a fine appearance. The gray stave with rods and roof painted green makes an attractive color scheme. These cribs are being built in numerous places throughout the corn states and are giving excellent satisfaction.

DISCUSSION BY A. W. CLYDE

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THERE are a few features of the Gothic barn roof and other self-supporting roofs which I wish to discuss even at the risk of being called a "crepe hanger." I have been investigating the strength of such roofs with results that may be rather surprising.

My remarks on the Gothic barn roof will be limited largely to the bent-rafter type. In attempting to determine the strength of this construction it is necessary to make one fundamental assumption, namely, that the several one-by-fours or one-by-sixes can be bolted or nailed together so well that they will act as a unit. This is a doubtful assumption at best and, therefore, suggests that a more liberal factor of safety should be provided than would be the case in other kinds of construction. In other words, it is extremely unlikely that a bent Gothic rafter is as strong as it would be if it could be made in one piece. Bearing in mind this fundamental assumption we can analyze the rafter according to two conditions:

First: As a continuous arch with fixed ends. This condition is not yet realized in actual construction though designs have been made for it.

Second: As a three-hinge arch. This is very nearly the average condition. It is typified by the usual construction where the rafters rest on a plate and are spliced at the ridge with collar beams.

I have made analyses for both these conditions. In each case the construction and loading were taken as follows:

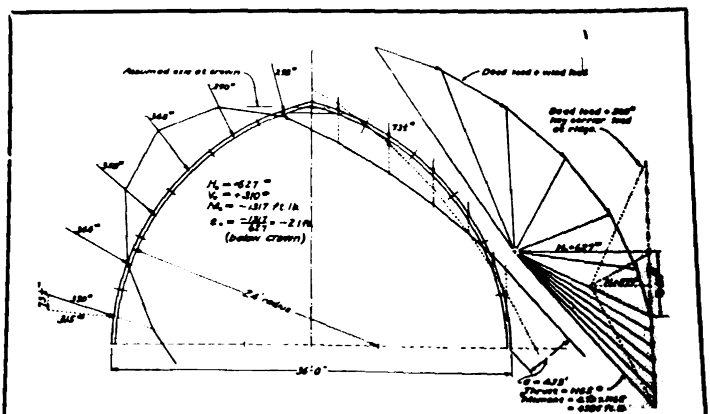


Fig. 1. Gothic rafter considered as a continuous arch with fixed ends, spaced twenty-four inches apart

Span, 36 feet; rafters, five pieces of one-by-four curved to 24 feet radius, actual size 3¾ by 4 inches, spaced 24 inches apart; roof covering, one-inch boards and shingles; wind load, 30 pounds per square foot on vertical surface and decreasing on slopes according to Kidder's handbook; hay carrier load, three hundred pounds at peak on one rafter.

The spring line of the arch or the lower hinges were taken at the eaves, it being assumed that the walls would be braced at this point. The wind was chosen as thirty pounds per square foot or ninety miles per hour because I believe most of us have considered that barn roofs should stand this load.

First condition, continuous arch with fixed ends (Fig. 1). As already mentioned this condition is almost never realized. The analysis was made by the elastic theory as is used on reinforced concrete arches. The method is explained in Turneaure and Maurer's "Reinforced Concrete Construction." The loads on the right are the dead loads, while those on the left are the resultants of the dead and wind loads at each load point. The thrust, shear, bending moment, and eccentric distance at the crown were calculated and the equilibrium polygon and force diagram drawn. To insure accuracy the bending moment and eccentric distance were also calculated at each load point and checked with the graphics. At the spring line on the leeward side the stress due to both bending moment and direct thrust is a maximum, being 5262 + 78 = 5340 pounds per square inch. This is about the ultimate strength of fir.

One half of the force diagram for the hay load is shown by dotted lines. The stresses caused by it are small in comparison to the wind load.

The second condition, the three-hinge arch (Fig. 2).: This is the condition usually existing in Gothic roofs, the joints at the plates and peak not being rigid. Values for the horizontal thrust and the shear at the crown were calculated by moments. Then the equilibrium polygon and force diagram were drawn. The force diagram naturally passes through the three hinges since the hinges offer no resistance to bending. The maximum moment is at point 4, left. The maximum stress is also there, being 7158 + 18 = 7176 pounds per square inch. This is above the breaking point for ordinary lumber. In this case also the hay load is small compared to the wind load.

It is, therefore, evident that a bent rafter made of five pieces of one-by-fours will not stand up under a wind load of thirty pounds per square foot. This is particularly true when it is remembered that the separate pieces cannot be expected to act as a unit when made in the usual manner. There are also splices which weaken the rafter. Further analysis by the three-hinge-arch method shows that a rafter made of eight pieces of one-by-fours (actual size 3¾ by 6½ inches) would be about right for a wind pressure of fifteen pounds per square foot, provided it would act as a unit, and provided the splices in pieces near the outsides were made near the ends rather than near the middle of the rafter where the stress is the greatest.

The strength of the sawed rafter cannot, in my opinion, be computed with accuracy. We will probably have no definite idea of its strength until actual tests are made under loads which are applied like wind pressure.

I realize that this is painting a dark picture of the Gothic roof. It will be of interest, therefore, to see how it compares with other types of construction.

The report of the 1918 annual meeting of this Society contains an analysis by Mr. Strahan of the Shawver frame which is usually considered the strongest of all self-supporting barn roofs. His analysis assumed a heavy wind load (40 pounds per square foot) and the truss taken was quite high. Compression was indicated by the minus sign (—) and tension by the plus sign (+). I have checked over this analysis and find it correct if the Shawver frame would act as a real truss. Mr. Strahan pointed out, however, that the Shawver frame is not a truss at all unless the lower rafters are designed to carry tension. He suggested that a 1½-inch rod be provided to assist them in this respect. But if such a tension member should be provided then the truss in question would fail at the joints long before the wind pressure reached 40

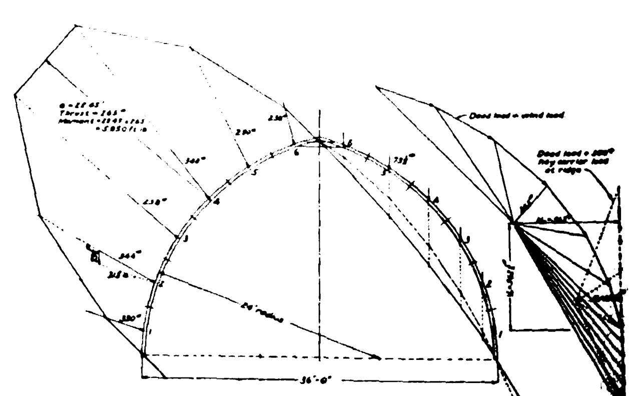


Fig. 2. Gothic rafter considered as a three-hinge arch with pivot points at peak and plates

pounds per square foot. The joints would fail because it is impossible to put enough bolts or nails in them to carry the calculated stresses. For example, the purlin post on the windward side has 36,100 pounds tension. For safe design this requires about thirty-six ¾-inch bolts or one hundred and twenty 40[d] nails at each end. Plainly any such number is out of the question. Any structural engineer will say that in a truss having wood tension members the strength is limited by the joints. Often it is not practical to use a joint which will develop more than one-eighth or one-fourth of the full strength of the timbers.

The report of the 1916 annual meeting of this Society also contains an analysis of the Shawver considered as a real truss. The wind load was thirty pounds per square foot. In these calculations the shear at the crown was neglected. The reaction at the crown should have been at an angle instead of horizontal, giving a horizontal component of 4950 pounds and a vertical component or shear of 6400 pounds. When this correction is made the stresses are entirely changed. Some are increased while others are reversed. The stress in the windward peak post, KJ, becomes 19,250 pounds tension. This might require seventy-seven 20[d] nails where this member is fastened to the collar beam.

I am convinced that the Shawver frame as usually made will not act as a real truss and, therefore, this method of analysis does not represent the truth. Most of its strength is due to its resistance to bending. The joints are a vital part of the construction, yet I cannot recall ever having seen a plan which specified exactly how many nails or bolts should be used. We have been neglecting our plain duty as engineers because we have left the most important part of the construction to the judgment of the carpenter. Information on the lateral strength of nailed and bolted joints may be secured from the following references:

"Engineering News," Vol. 76, page 115

Iowa Engineering Experiment Station, Vol. IV, No. 2

"Structural Details, Design of Heavy Framing," Jacoby

"Practical Structural Design" McCullough

Doubtless most of us consider the wing-joist or braced-rafter type of roof as the least substantial. At least it is weaker than the Shawver. Its strength cannot be calculated exactly. By comparison with the Gothic, however, we can be sure that the lower rafter on the windward side would break near its center long before the wind reaches ninety miles per hour since there is only a single two-by-six at this point.

I regret that so far my work seems largely destructive. I expect to follow it up with more constructive work. At the present time I have come to five conclusions as a basis for further work:

1. We know practically nothing definitely of the strength of ordinary barn roofs. Most of our knowledge may be summed up by saying that many have been built and comparatively few have fallen down. This is no more than carpenters know. Careful analysis shows that none of the common styles will stand up against a wind of ninety miles per hour or a pressure of thirty pounds per square foot.

2. It is not necessary or desirable to provide for any such wind load. Such winds may occur only once in a generation. Furthermore, the ordinary barn frame would not stand such winds even if the roof could. Since little consideration of human safety is involved we ought to come to a more reasonable basis and then make our designs safe in the joints as well as otherwise for the revised loading.

3. The Gothic roof with bent rafters and also the braced rafter need to be strengthened considerably to stand safely a wind of fifty to sixty-five miles per hour or a pressure of about ten to fifteen pounds per square foot.

4. The Shawver frame is not a real truss and should not be analyzed as such. One reason for this has already been given. Another reason is because the purlin is not fastened securely enough to the post to transmit much compression from the lower rafter to it.

5. There is an urgent need for tests to determine the strength of the Shawver and the braced-rafter styles, also to see how well the Gothic bent rafter will act as a unit. Until such tests are made we can only guess at their design and their strength. Probably our guess will be no more intelligent than a carpenter's guess. In such tests the wind loads should be applied perpendicularly to the surface as they actually occur.

NOTE: Since the foregoing was presented, at the 1921 annual meeting of the Society, Mr. Clyde has designed a new type of truss which he believes can be treated as a real truss. It is described in the March, 1922, issue of "American Builder," together with some further discussion of the Shawver frame. A model of the new truss was tested at Iowa State College on February 27, 1922, and its strength found to be fully up to expectations. Plans are being made for similar tests on the familiar types of roofs.

SUNSHINE EFFICIENCY OF HOG HOUSES*

By Frank C. Harris

Mem. A.S.A.E. Director of Agricultural and Industrial Engineering, The Louden Machinery Company

SUNLIGHT in the hog house promotes sanitation, warmth, and dryness—three of the prime requisites for the healthful housing of swine. It seems to have an additional vitalizing influence on animals, particularly young pigs, which is not a direct result of the disinfection, warmth, and dryness. It seems to promote the proper functioning of their bodily organs.

Sunlight is the great natural disinfectant. Bacterial life is found almost everywhere but exists in the more dangerous forms in damp, dark, warm places. A very favorable condition for the development of germ life would be found in the dark, close hog house in which the beds were used continously for a few weeks, and no argument is necessary to show that this is an unfavorable condition for young pigs to live in. Many forms of bacterial life cannot stand strong sunlight and dryness is unfavorable to their propagation. Sunlight is the great natural agent which keeps bacterial life under reasonable control. When admitted to the hog house the sun's rays not only disinfect to a considerable extent the nests, floors, and pens where the hogs are kept, but they also dry up the offal, promote ventilation, and disperse foul odors which swine because of their low stature would otherwise be compelled to breathe.

These considerations are too well understood to justify more than a brief mention here. It is the main purpose of this discussion to consider and investigate the methods of and types of houses best adapted to obtaining sunshine in the hog house at the proper place rather than the benefit derived from it.

As to warmth, experiments conducted in Massachusetts by Mr. Cabot and others with rooms and boxes thoroughly insulated on all sides except one, which was covered with glass, show that more heat may be collected in this way than is ordinarily thought possible. They were able to obtain summer temperatures inside of these boxes during the day in winter weather. This emphasizes the fact that hog houses should be insulated thoroughly against heat loss, and may be constructed to constitute, in effect, sun boxes which will trap a large amount of the sun's warmth. These experiments also suggest that the windows in the hog house should face the sun's rays as nearly perpendicularly as possible throughout

*Fifteenth annual meeting paper.

the day. The sun's rays are as warm in winter as they are in summer but because of the shortness of the day, their slant. and the condition of the earth are reflected away from the earth's surface and much of their warmth is not retained.

Much has been written regarding sunlight in hog houses; tables have been prepared giving the height of a window set at a certain distance from the bed in order to get the sunshine at the proper place on a given date; buildings have been designed to obtain as much benefit as possible from the sunlight. This has all contributed greatly to the development of the best types of hog houses, but there is still a vagueness as to the actual amount and location of the sun spots thrown into the pens by the windows of these types of buildings. This is easy to understand when we remember that the slant of the sun's rays varies with each hour of the day and each day of the year, and there is at the same time a daily and hourly change in angle between the meridian and the position of the sun.

The difference in angle which the sun's rays make with the ground at noon between midwinter and midsummer is approximately 47 degrees. During the farrowing period from February 1 to April 15 the variation in angle with the ground at noon is 27½ degrees. From midwinter, December 21, to February 1, the change in angle is 6 degrees; from February 1 to March 1 the change is 10 degrees; from March 1 to April 1, which covers the equinoctial period and therefore the greatest rate of change in angle, the change is 12 degrees. The change in direction of sun's rays with reference to the meridian is not so important but has some influence. The sun rises on February 1 at a point about 67 degrees east of south at a few minutes after seven o'clock in the morning, while on April 15 it rises 77 degrees east of north at about five-thirty in the morning. The difference in the direction of the sun's rays at sunrise over this period is 36 degrees, and the variation in the time is more than one and one-half hours.

The accompanying drawing (Fig. 1) shows the various points at which the shadow of a point, located as shown by the heavy black circle, would be thrown on the given dates and at different hours of the day, and illustrates the change in the position of the shadow due to the seasonal change in the slant and direction of the sun's rays. The black curves show the path which the shadow of the point would take on various dates and seasons. Heavy lines or curves are shown for midwinter, the equinoxes and midsummer, and for the first days of February, March, and April. The dotted lines are the hour lines upon which the shadow will fall on the hours given. The intersection of the dotted hour lines with the heavy date lines give the position of the shadow on any given date and hour. During each half year the shadow of

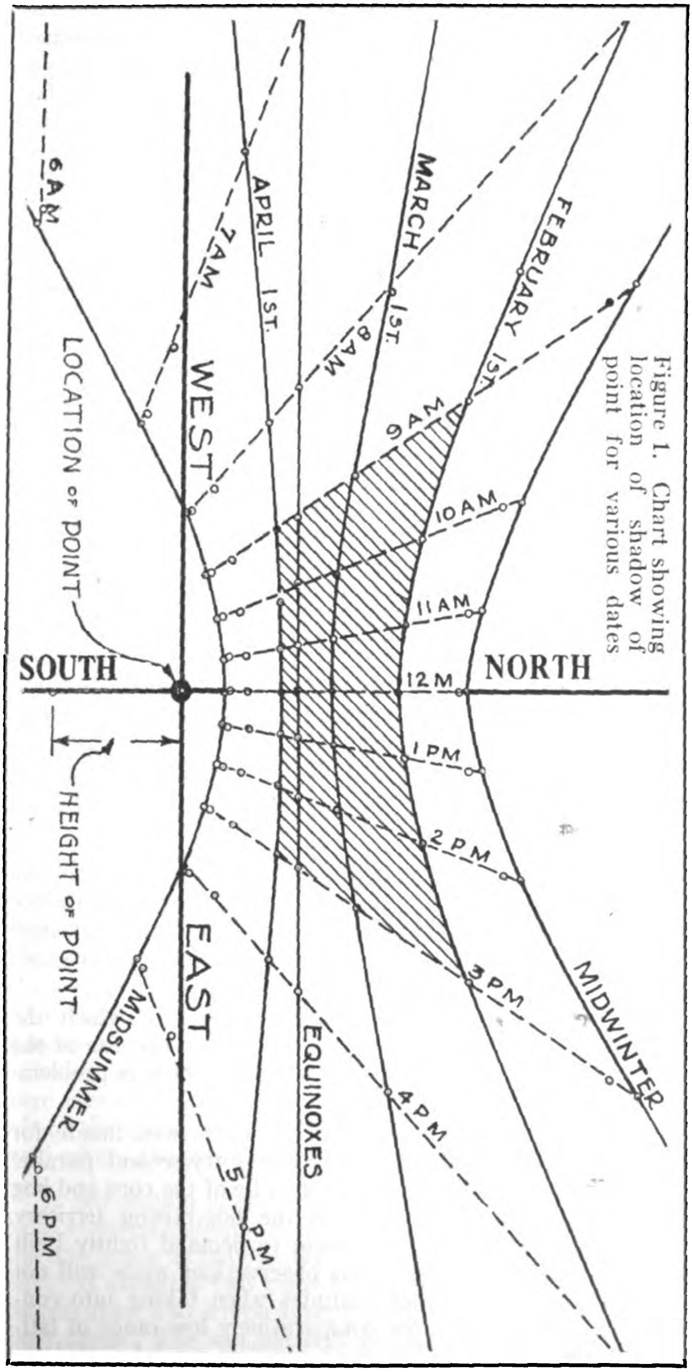


Figure 1. Chart showing location of shadow of point for various dates

the point will fall anywhere in the area between the two outer curves which are those for midwinter and midsummer. The shaded area in the chart covers the various positions of the shadow for the principal part of the day during the farrowing season, which the investigations outlined in subsequent paragraphs were made to cover. The different positions of the shadow of the point shown in the drawing correspond exactly to the sun spot or pattern which rays of light would make by passing through the roof window of a hog house.

The need for exact information is apparent if reliable results are to be obtained. For this reason the drawings which follow were based on astronomical data contained in "The American Ephemeris and Nautical Almanac for 1920" published by the U. S. Naval Observatory. Charts giving the slant, direction, and projections of the sun's rays for each hour and date under consideration were made from this data. The time referred to in each case is sun time which varies slightly from the prevailing standard time in some localities. but is much better for this purpose and is correct for all places.

The investigations were limited to the hours of nine, ten, eleven, twelve, one, two, and three o'clock sun time for the following reasons:

1. The intensity of the sunshine during the middle of the day is much greater than at early morning and late evening.

2. Due to the angle at which the early and late sun's rays strike most of the windows the reflection is great and the effectiveness of the sunshine is reduced until it is of comparatively little value.

3. The oblique rays of the sun passing through the window during the early morning and late evening produce sunlight patterns of large area but of very little value and thus their influence on results would be somewhat misleading.

4. The thickness of the walls and roof in which the windows are placed has a tendency to reduce the size of the morning and evening pattern to a degree which is problematical.

The investigations and sunshine charts were made for 42 degrees and north latitude. The forty-second parallel strikes slightly to the north of the middle of the corn and hog belt and is about the center of the hog-raising territory having a sufficiently severe climate to demand tightly built winter quarters for swine. The observations made will not be greatly amiss for other latitudes when taking into consideration the fact that the comparatively low range of latitude for the United States which requires careful consideration is about 12 degrees. The difference in angle of the sun's rays with the ground on any date is equal to the difference in latitude between any two points under consideration, therefore, the maximum variation in the angle of the rays on the forty-second parallel and at other points in the belt under consideration will be 6 degrees, or one half of the total range.

Six degrees change in angle of the sun's rays, or in latitude, would make a difference in the height of the window at the ridge of a hog house of about one foot when sun patterns were thrown in the same relative position in the building. It should not be forgotten that the severity of the cold in the north makes farrowing in general slightly later in the year, so that the change in season and corresponding change in the angle of the sun's rays during this period will partly offset each other. The change in angle of the sun's rays with the ground at noon is about one-third degree per day. This being true the only difference in window location from that shown in the cross sections accompanying this discussion will be to shift the upper roof windows up to the ridge in the construction of buildings for points five degrees or more to the south of the forty-second parallel, or to move the window down the roof eight or ten inches for locations five degrees or more to the north of this parallel.

Fig. 2 shows a drawing of the sunlight or sun patterns made for a hog house in common use. The building runs north and south. It is a gambrel roofed building of the better types in use at the present time and will illustrate that further inprovement may be made by changing the roof lines and relocating the windows. There are two 2′ 0″ by 2′ 3″ window openings to each pen having only nine square feet of glass per pen, and this is more than many hog houses contain. These sun patterns were obtained by the use of the charts already mentioned. Each window opening was projected obliquely down upon the floor. The projection was made in the direction and slant of the sun's rays upon the hour and date indicated, producing the sun patterns as shown. This example illustrated the general method followed in making the entire investigation. The patterns were carefully drawn and their areas measured by scaling where they were regular in form. A polar planimeter was used where the patterns were irregular or difficult to scale.

A pen section of the building was taken as the unit and basis of investigation. A pen section consists of a section of the hog house as long as the one pen is wide, namely, eight feet. It contains two eight-foot pens, one on each side of central alley, and a typical set of windows, beds, troughs, and floor areas. The sun patterns for one pen section only are shown in the following drawings, but a large floor area must be used since the windows in one pen section generally throw their patterns into another pen section, and in turn receive patterns from the pen section on the other side.

The efficiencies of the various types with regard to admitting sunlight to the proper places in the buildings were calculated by the following method. Sun patterns for all the windows in the pen section were made for nine, ten, eleven, twelve, one, two, and three o'clock on the date under consideration. All these patterns were measured and the total sunshine area divided by number of hours to obtain the average sunshine area for the day. This result was divided by the total glass area in the pen section, the result being the efficiency of the type on that day, per square foot of glass.

The pattern for each hour is taken as the average for the hour beginning one-half hour before and ending one-half hour after the hour indicated. That is, the pattern for nine o'clock represents the hour from eight-thirty to nine-thirty.

Thus, the efficiency basis on which the results are calculated is the average area of sunshine, expressed in square feet, which one average square foot of glass will admit to the

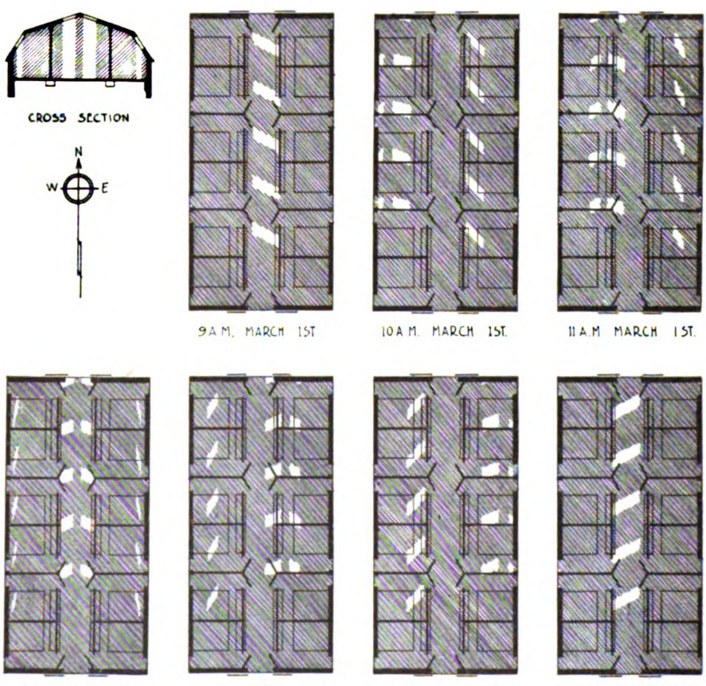


Figure 2. Chart showing sun patterns for a common type of hog house

floor or bed continuously from 8:30 A. M. until 3:30 P. M.

The figures given in Table I made from the sun pattern drawings of the different types show two sets of readings. The first readings were taken on the entire floor of the hog house and were used to calculate the efficiencies with respect to the floor. The second measurements include only the sun patterns or portions of patterns falling on the bed, and give the figures with respect to the beds alone. The results in Tables II, III, and IV, which are based on the data given in Table I, give in the last two columns the efficiencies of the different types for the entire spring farrowing period for floor and bed, respectively. They were obtained by drawing and measuring patterns for February 1, March 1,

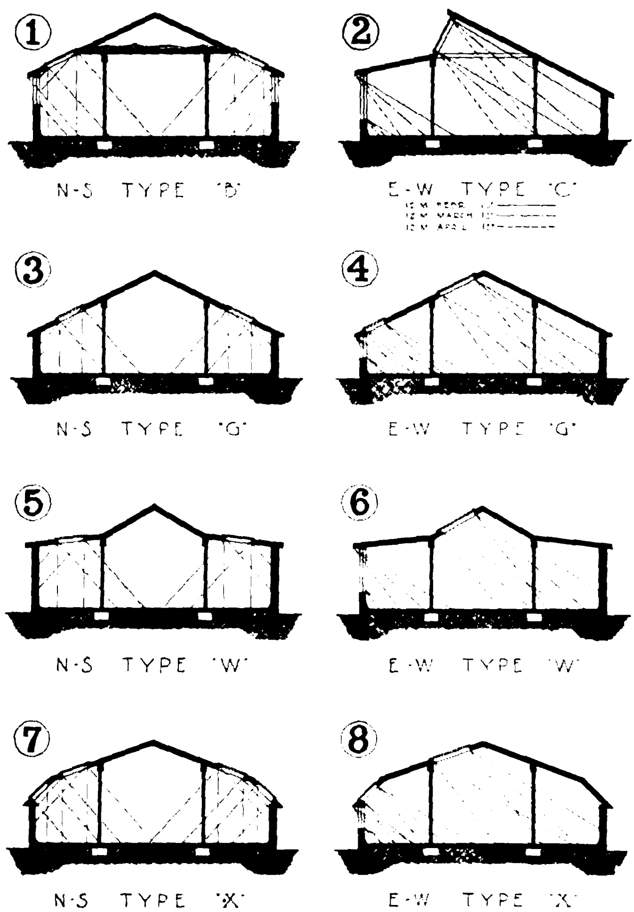


Figure 3. Chart of selected cross sections

and April 1, and figuring the average sunshine area obtained for the three dates using the method described above.

The beds are assumed to be five by six feet, which is small enough to avoid results which would be misleading. In general they are placed on the north side of the pens in north-south buildings and to the west side of pens in east-west buildings. Pens are assumed to be eight feet wide. If six-foot pens are used, however, the results would be comparable. No interference to the sun's rays by paneling is assumed.

Fig. 3 shows the cross sections of a number of buildings designed for special investigation after a careful preliminary study of existing types in common use. North-south types, B, G, W, and X, shown on the left side of the drawing, have their windows arranged for buildings designed to run north and south, while east-west types, C, G, W, and X shown on the right-hand side of the plate have windows arranged for buildings designed to run east and west. B is a north-south type only, while C is an east-west type only. G, W, and X may be used as either type by making proper changes in the window arrangement. These designs embody the best features of the designs studied in the preliminary investigation and a comparison of the sun patterns in Fig. 2 with the sun patterns of these types will show the improvement.

There is a considerable amount of repetition of similar patterns in Fig. 2. For this reason in Fig. 4 only the windows for one pen section were used. Instead of showing the patterns for each hour on the given date on separate floor plans, the patterns for one pen section for all seven hours are shown on a single plan. The patterns produced each hour are outlined with a light line. This method of showing the patterns, while it does not show the sunshine distribution so clearly, requires only one plan for each day instead of one for each hour. A set of sun patterns which will be typical of the entire building, regardless of length, will be secured by this method. The results obtained by studying one pen section from each type can then be compared.

The length of the building is assumed to be indefinite. One pen section at each end of a hog house would have less sunshine than the central areas and, therefore, the efficiencies for shorter buildings would be less, but the same thing is true for all types so that comparisons will not be affected.

Fig. 4 gives the sun patterns for all of the east-west types shown in Fig. 3 for February 1, March 1, and April 1. The floor plans used have five pen sections, or ten pens, but the sun patterns on these plans were made by the windows in the central pen section only. The sun patterns for February 1 are outlined in dotted lines as they would extend outside of

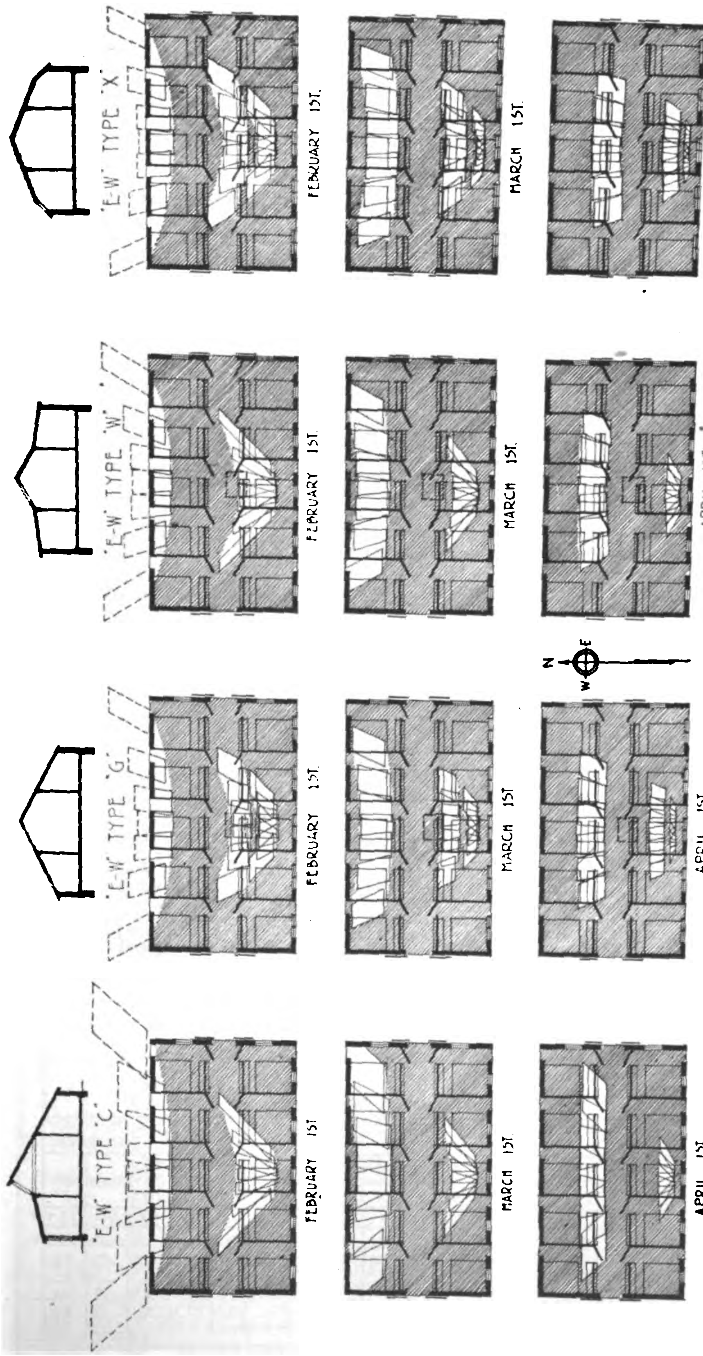


Figure 4. Chart showing sun patterns of all E-W types for Feb. 1st, March 1st, and April 1st

the building if the north wall were removed. The patterns actually strike the north wall and would furnish a considerable amount of indirect or reflected light. A sow lying down along the north wall of a pen, since her body would extend several inches above the pen floor, would catch a larger amount of the slanting rays of sunshine than the pattern indicates.

By March 1 practically all of the sun patterns in these designs strike directly across the beds and give excellent sunshine on the beds. One pattern follows another along the north row of pens in such a way that the warmth which accumulates will keep the beds dry and comfortable.

TABLE II

COMPARATIVE EFFICIENCIES, E-W BUILDINGS

E-W TYPE	UPPER ROOF WINDOW			LOWER ROOF WINDOW			WALL WINDOW			TOTALS			EFFICIENCY ALL WINDOWS	
	SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	TOTAL GLASS	AVERAGE SQ FT SUN ON FLOOR	AVERAGE SQ FT SUN ON BED	FLOOR	BED
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	30	1.02	.39				8½	1.15	.57	38½	40.1	16.6	1.04	.43
G	15	1.04	.42	8	1.38	.38	8	1.07	.66	31	35.2	14.7	1.14	.47
W	15	1.04	.43				8½	1.15	.57	23½	25.4	11.3	1.08	.48
X	15	1.04	.35	8⅓	1.49	.41	8	1.07	.66	31⅓	37.4	14.1	1.19	.45
AVERAGE													1.08	.45

TABLE III

COMPARATIVE EFFICIENCIES, N-S BUILDINGS

N-S TYPE	WINDOW ARRANGEMENT	EAST ROOF WINDOW			EAST WALL WINDOW			WEST ROOF WINDOW			WEST WALL WINDOW			TOTALS			EFFICIENCY ALL WINDOWS	
		SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	TOTAL GLASS	AVERAGE SQ FT SUN ON FLOOR	AVERAGE SQ FT SUN ON BED	FLOOR	BED
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
G	INDIV	11	.82	.25				11	.82	.25				22	18.1	5.5	.82	.25
W	"	11	.77	.21				11	.77	.21				22	15.7	4.6	.71	.21
X	"	11	.77	.20	9	*.68	*.23	11	.77	.20	9	*.68	*.23	40	29.3	8.6	.73	.21
B	REG	20	.66	.21	12	.46	.15	20	.66	.21	12	.46	.15	64	37.5	11.9	.59	.18
G	CONT	22	.82	.15				22	.82	.15				44	36.1	6.9	.82	.15
W	"	22	.77	.25				22	.77	.25				44	31.5	10.6	.71	.24
X	"	27	.75	.21				22	.75	.21				44	33	9.5	.75	.21
AVERAGE ALL																	.73	.21
"	INDIV																.75	.22
"	CONT																.76	.20

* LOWER SLOPE OF ROOF IN N-S TYPE "X"

TABLE IV

EFFICIENCY OF BUILDING SET DIAGONALLY

DIAGONAL OR NE SW TYPE	WINDOW ARRANGEMENT	LOCATION OF BED	UPPER ROOF WINDOW			LOWER ROOF WINDOW			WALL WINDOW			TOTALS			EFFICIENCY ALL WINDOWS	
			SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	SQ FT GLASS	EFFICIENCY FLOOR	EFFICIENCY BED	TOTAL GLASS	AVERAGE SQ FT SUN ON FLOOR	AVERAGE SQ FT SUN ON BED	FLOOR	BED
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
G	REG E-W	S-W	15	.88	.23	8	1.23	.38	8	.91	.41	31	30.4	9.8	.98	.32
"	" "	N-E	15	.88	.22	8	1.23	.36	8	.91	.52	31	30.4	10.3	.98	.33
			SOUTH EAST ROOF			NORTH WEST ROOF										
"	IND. N-S	S-W	11	1.28	.32	11	.30	.17				22	17.3	5.3	.79	.24
"	" "	N-E	11	1.28	.29	11	.30	.17				22	17.3	5	.79	.23
AVERAGE															.885	.28

Table I—Measurements of All Sun Patterns

Section	Type	Date	Position of Window	Area of Glass	Area per Pen Sect.	Area of Sunshine Patterns in Sq. Ft. on Floor and Beds.														Total Area on Floor.	Total Area on Bed.	Av. Area on Floor.	Av. Area on Bed.	Window Efficiency for Floor.	Window Efficiency for Bed.	Eff. for Fl. All W'dows. for Month.	Eff. for Bed All W'dows for Month.
						9 A.M.		10 A.M.		11 A.M.		12 M		1 P.M.		2 P.M.		3 P.M.									
						FL	BED	FL.	BED	FL.	BED	FL.	BED	FL.	BED	FL.	BED	FL.	BED								
E-W	C	FEB. 1	ROOF	30.00		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
N-S	X	APR. 1	ROOF CON ‡	22.00	44.00	0.0	0.0	0.0	0.0	16.0	10.5	19.0	10.0	22.0	8.0	26.0	0.0	29.0	0.0	112.0	28.5	16.0	4.1	0.73	0.18	0.73	0.18
NE-SW	G	FEB. 1	UPPER † RF.	15.00		0.0	0.0	0.0	0.0	12.5	9.5	20.5	5.5	18.5	8.0	16.0	0.0	0.0	0.0	67.0	23.0	9.6	3.3	0.64	0.22		
NE-SW	G	FEB. 1	LOWER † RF.	8.00		19.0	7.0	14.5	0.0	12.0	0.0	11.5	2.5	10.5	7.0	9.0	3.0	7.0	5.5	83.0	25.0	11.9	3.6	1.45	0.45		
NE-SW	G	FEB 1	WALL †	8.00	31.00	24.0	3.0	16.0	5.5	12.5	4.0	9.5	3.5	7.0	4.0	4.0	3.0	0.0	0.0	73.0	23.0	10.4	3.3	1.30	0.41	1.03	0.33
NE-SW	G	MAR. 1	UPPER † RF.	15.00		0.0	0.0	14.5	4.0	20.0	13.2	18.5	5.5	17.0	0.0	14.5	0.0	12.5	1.0	97.0	23.7	13.9	3.4	0.93	0.23		
NE-SW	G	MAR 1	LOWER † RF.	8.00		14.5	0.0	12.5	0.0	11.0	1.0	10.0	4.5	9.5	8.5	8.0	7.0	3.0	0.5	68.5	21.5	9.8	3.1	1.22	0.39		
NE-SW	G	MAR. 1	WALL †	8.00	31.00	16.5	8.8	12.0	7.5	10.0	3.8	6.0	1.5	4.0	1.0	0.0	0.0	0.0	0.0	48.5	22.5	6.9	3.2	0.86	0.40	0.99	0.31
NE-SW	G	APR. 1	UPPER † RF.	15.00		20.5	15.0	19.5	10.5	17.5	1.0	16.5	0.0	15.5	0.0	14.0	0.0	11.0	1.0	114.0	27.0	16.3	3.9	1.09	0.26		
NE-SW	G	APR. 1	LOWER † RF.	8.00		12.0	1.0	10.5	4.5	9.5	3.0	8.0	2.0	8.0	2.5	7.0	4.5	0.0	0.0	55.0	17.0	7.9	2.4	0.99	0.30		
NE-SW	G	APR. 1	WALL †	8.00	31.00	10.5	10.5	8.0	6.0	6.5	4.0	4.0	2.0	2.0	1.0	0.0	0.0	0.0	0.0	31.0	23.0	4.4	3.3	0.55	0.41	0.92	0.31
NE-SW	G	FEB. 1	S.E. ‡ RF.	11.00		21.0	17.0	19.5	0.0	17.0	0.0	15.5	0.0	14.0	0.0	12.5	3.0	10.5	7.0	110.0	27.0	15.5	3.9	1.41	0.35		
NE-SW	G	FEB. 1	N.W. ‡ RF.	11.00	22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	1.5	10.5	6.0	16.0	7.5	2.3	1.1	0.21	0.10	0.81	0.23
NE-SW	G	MAR. 1	S.E. ‡ RF.	11.00		20.0	2.5	17.0	0.0	15.0	0.0	14.0	0.0	13.0	5.5	11.0	8.0	9.0	4.0	99.0	20.0	14.1	2.9	1.28	0.26		
NE-SW	G	MAR. 1	N.W. ‡ RF.	11.00	22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	9.0	7.0	11.0	6.0	23.0	16.0	3.3	2.3	0.30	0.21	0.79	0.23
NE-SW	G	APR. 1	S.E. ‡ RF.	11.00		15.0	0.0	14.5	0.0	14.0	1.0	12.5	1.5	12.0	6.0	10.5	10.0	9.0	8.0	87.0	26.0	12.4	3.7	1.13	0.34		
NE-SW	G	APR. 1	N.W. ‡ RF.	11.00	22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	5.0	10.5	9.0	12.0	10.0	31.0	15.0	4.4	2.1	0.40	0.19	0.73	0.27
NE-SW *	G	FEB 1	UPPER † RF.	15.00		0.0	0.0	0.0	0.0	12.5	6.0	20.5	19.0	18.5	1.0	16.0	0.0	0.0	0.0	67.0	26.0	9.6	3.7	0.64	0.25		
NE-SW *	G	FEB. 1	LOWER † RF.	8.00		19.0	3.0	14.5	0.0	12.0	0.0	11.5	1.0	10.5	4.0	9.0	7.5	7.0	3.0	83.0	18.5	11.9	2.6	1.45	0.32		
NE-SW *	G	FEB 1	WALL †	8.00	31.00	24.0	2.5	16.0	10.0	12.5	11.0	9.5	7.0	7.0	2.0	4.0	1.0	0.0	0.0	73.0	33.5	10.4	4.8	1.30	0.60	1.03	0.36
NE-SW *	G	MAR. 1	UPPER † RP.	15.00		0.0	0.0	14.5	14.0	20.0	5.0	18.5	3.0	17.0	0.0	14.5	0.0	12.5	1.5	97.0	23.5	13.9	3.3	0.93	0.22		
NE-SW *	G	MAR. 1	LOWER † RF.	8.00		14.5	0.0	12.5	0.0	11.0	2.0	10.0	4.0	9.5	2.0	8.0	4.0	3.0	1.5	68.5	13.5	9.8	1.9	1.22	0.24		
NE-SW *	G	MAR. 1	WALL †	8.00	31.00	16.5	5.0	12.0	9.0	10.0	10.0	6.0	6.0	4.0	3.0	0.0	0.0	0.0	0.0	48.5	33.0	6.9	4.7	0.86	0.59	0.99	0.32
NE-SW *	G	APR. 1	UPPER † RF.	15.00		20.5	5.0	19.5	9.0	17.5	2.0	16.5	0.0	15.5	0.0	14.0	0.0	11.0	4.0	114.0	20.0	16.3	2.9	1.09	0.19		
NE-SW *	G	APR. 1	LOWER † RF.	8.00		12.0	0.0	10.5	4.5	9.5	9.5	8.0	7.0	8.0	5.0	7.0	2.0	0.0	0.0	55.0	28.0	7.9	4.0	0.99	0.50		
NE-SW *	G	APR. 1	WALL †	8.00	31.00	10.5	5.0	8.0	6.0	6.5	4.0	4.0	4.0	2.0	2.0	0.0	0.0	0.0	0.0	31.0	21.0	4.4	3.0	0.55	0.38	0.92	0.32
NE-SW *	G	FEB. 1	S.E. ‡ RP.	11.00		21.0	13.0	19.5	0.0	17.0	0.0	15.5	0.0	14.0	0.0	12.5	6.0	10.5	8.0	110.0	27.0	15.5	3.9	1.41	0.35		
NE-SW *	G	FEB. 1	N.W. ‡ RF.	11.00	22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	2.5	10.5	8.0	16.0	10.5	2.3	1.5	0.21	0.14	0.81	0.25
NE-SW *	G	MAR. 1	S.E. ‡ RF.	11.00		20.0	1.0	17.0	0.0	15.0	0.0	14.0	0.0	13.0	1.5	11.0	8.0	9.0	7.0	99.0	17.5	14.1	2.5	1.26	0.23		
NE-SW *	G	MAR 1	N.W. ‡ RF.	11.00	22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	1.0	9.0	7.0	11.0	7.0	23.0	15.0	3.3	2.1	0.30	0.19	0.79	0.21
NE-SW *	G	APR 1	S.E. ‡ RF.	11.00		15.0	0.0	14.5	0.0	14.0	3.0	12.5	6.0	12.0	5.0	10.5	2.5	9.0	5.0	87.0	21.5	12.4	3.1	1.13	0.28		
NE-SW *	G	APR. 1	N.W. ‡ RF.	11.00	22.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	4.0	10.5	2.5	12.0	7.5	31.0	14.0	4.4	2.0	0.40	0.18	0.73	0.23

* BED TO N.W. OF PEN. † E.W. TYPE WINDOWS. ‡ N.S. TYPE WINDOWS.

TABLE V

COMPARATIVE DATA

BASED UPON ONE 8 FT. PEN SECTION

TYPE	DIRECTION	WINDOW ARRANGEMENT	SQ. FT. CROSS SECTION	CU. FT. AIR	EXPOSURE				AVERAGE SQ. FT. SUN		SUNSHINE EFFICIENCY	
					TWO ENDS	SIDE WALLS	ROOF	GLASS	FLOOR	BED	FLOOR	BED
1	2	3	4	5	6	7	8	9	10	11	12	13
B	N-S	REG.	173	1384	346	100	129*	64	37.5	11.9	.59	.18
C	E-W	REG.	173	1384	346	82	216	38.5	40.1	16.6	1.04	.43
G	E-W	REG.	153	1224	306	64	200	31.	35.2	14.7	1.14	.47
G	N-S	IND.	153	1224	306	64	200	22	18.1	5.5	.82	.25
G	N-S	CONT.	153	1224	306	64	200	44.	36.1	6.9	.82	.15
G†	NE-SW	E-W	153	1224	306	64	200	31.	30.4	10.3	.98	.33
G†	NE-SW	N-S	153	1224	306	64	200	22	17.3	5.0	.79	.23
W	E-W	REG.	162	1296	324	98	192	23.5	25.4	11.3	1.08	.48
W	N-S	IND.	162	1296	324	98	192	22	15.7	4.6	.71	.21
W	N-S	CONT.	162	1296	324	98	192	44.	31.5	10.6	.71	.24
X	E-W	REG.	164	1312	328	64	208	31.3	37.4	14.1	1.19	.45
X	N-S	IND.	164	1312	328	64	208	40.	29.3	8.6	.73	.21
X	N-S	CONT.	164	1312	328	64	208	44.	33.	9.5	.75	.21
AVERAGES			165	1320	330	81	189	35.6	29.8	10.0	.87	.30

*STRAW COVERED CEILING, HALF EXPOSURE COUNTED † NOT COUNTED IN AVERAGES

The nearness of the windows to the beds in the pens on the south side of the building makes their sun patterns move slowly and allows the accumulation of heat. On April 1 when the sun is higher the sun patterns have begun to leave the north row of pens and move into the alley, and the patterns in the south row of pens are greatly diminished. The sunlight, however, by this time of the year has become very much warmer and the necessity for sunlight within the building greatly lessened since the building will be kept open and the hogs will be free to run in the sunlight outside. By midsummer when the sun's rays become intense the sun patterns in the east-west types will have practically left the beds and the building can be used for shade. This is a desirable consideration which is not found in the north-south types. The fact that each window in the east-west types produces sun patterns for the entire day is important during the early months.

The concentration of the sun's rays upon the beds results in less sunlight falling upon other parts of the building, particularly in east-west types, and reduces that upon the central feed alley materially. This is probably unimportant as the animals do not occupy nor litter this part of the building, and it is easily swept or washed out.

The patterns for the various north-south types are given in Fig. 5. This figure also shows types G and X arranged with continuous roof windows. Sun patterns are given for February 1, March 1, and April 1. Because of the confusion that would arise due to the overlapping of the sun patterns which would be produced by the windows of pens directly on opposite sides of the central aisle, the windows for the pen in the southwest corner and the one in the middle of the east side were used to produce the patterns in this plate.

A comparison of Tables II and III show the difference between the east-west and north-south types. The last two columns in these tables represent the efficiency for the floor and bed respectively. The figures obtained for all east-west types taken together and also those for all north-south types run close enough together that their averages may be considered as a safe basis for comparison. The average efficiency for the entire spring farrowing period

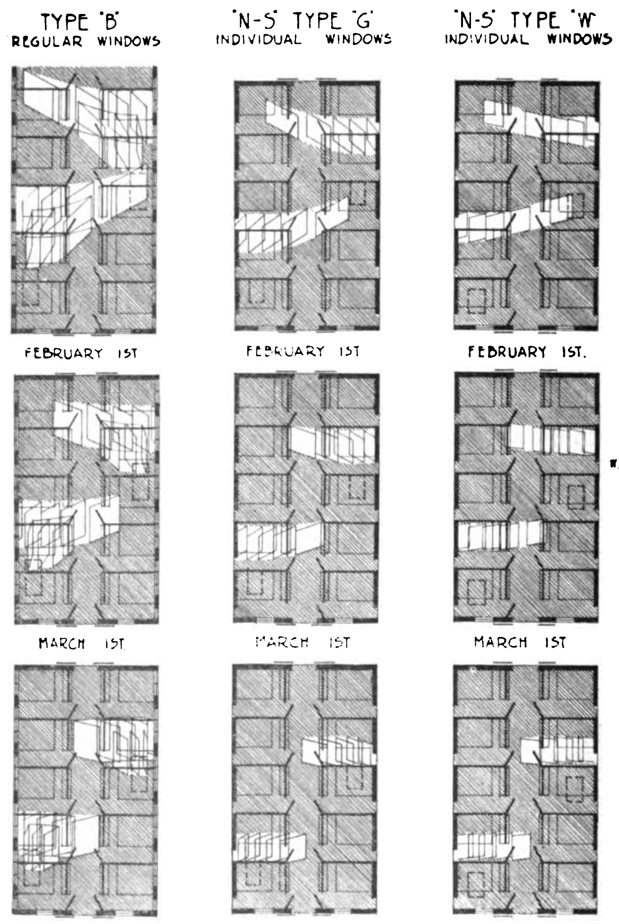
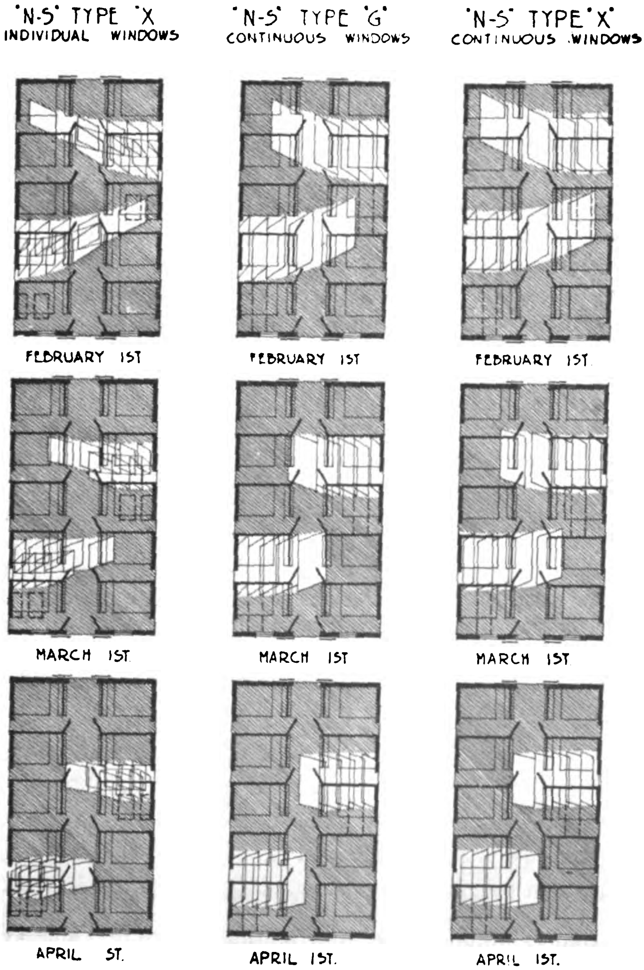


Figure 5. Chart showing sun patterns of all N-

for east-west types is 1.08 for the floor as compared with 0.73 for the north-south types. The comparative figures for the beds are 0.45 and 0.21, respectively. That is, on the average a square foot of glass in a north-south type will admit to the floor of the hog house 68 per cent of the amount admitted by east-west building and only 47 per cent as much to the bed.

The building giving the sun patterns shown in Fig. 2 is similar to type X but the windows are placed at the ridge and the lower slope of the roof is too steep. It is among the better than average buildings in general use. The windows are too high at the ridge of the roof. The total glass area is smaller than most of the types shown in Fig. 3, but this



S types for Feb. 1st, March 1st, and April 1st

should tend to increase rather than decrease the efficiency rating as it is easier to keep a larger percentage of a small pattern on the bed than a large pattern. One square foot of glass on the average in this building will furnish 0.575 square feet of sunshine to the floor and 0.135 to the bed on March 1, as compared with 1.31 and 0.72, which are the averages on that date, for all the east-west types and 0.73 and 0.21 for all north-south types shown in Fig. 4. That is, it will admit to the floor and bed, respectively, 44 per cent and 19 per cent as much as the east-west types, and 79 per cent and 64 per cent as much as the suggested standard north-south types. This indicates that by the careful design of the building 20 per cent more sunlight can be thrown upon the floor and 33 per cent more upon the beds of a north-south hog house, and also that more than twice as much sunlight per square foot of glass may be obtained on the floor, and more than four times as much upon the bed of a well-designed east-west type of hog house than is obtained in most of the north-south hog houses being erected at the present time.

It is sometimes desirable because of the lay of the land, existing buildings or other improvements about a farmstead, or because of the choice of a breeder, to place a hog house in a diagonal position with reference to the points of the compass. Fig. 6 shows the sun patterns made by a type G building set in this position. The three drawings on the left in this plate show sun patterns made by the window arrangement of an east-west building with the windows facing to the south-east. The three drawings to the right are for a north-south window arrangement of type G with separated windows. Measurements of the sun patterns on the bed were made both with the bed to the north-east and to the south-west of the pen. Table IV shows no particular preference for either position of the bed. It indicates that the window arrangement of the east-west type is more desirable than the north-south window arrangement for building placed in this position. The average efficiency of the type placed diagonally is between the averages of the east-west and the north-south types, the figures being:

	Floor	Bed
East-west types	1.08	0.45
Diagonal, E-W windows	0.98	0.32
Diagonal, N-S windows	0.79	0.23
North-South types	0.73	0.21

The figures would be the same as those given in Table IV if the building were run in a northwest-southeast direction, because the relation between the position of the sun and parts of the building would correspond exactly to their relation in the other position.

The window locations have an important bearing upon the effectiveness of the sunshine in the buildings and efficiencies of the various types. When a window is far away from the floor or bed the movement of its pattern across the floor is correspondingly rapid and less warmth will accumulate at any point unless it is followed up soon by another pattern. This occurs in the east-west buildings but not in the north-south types. When the window is near the floor or bed the movement is much less from hour to hour and also

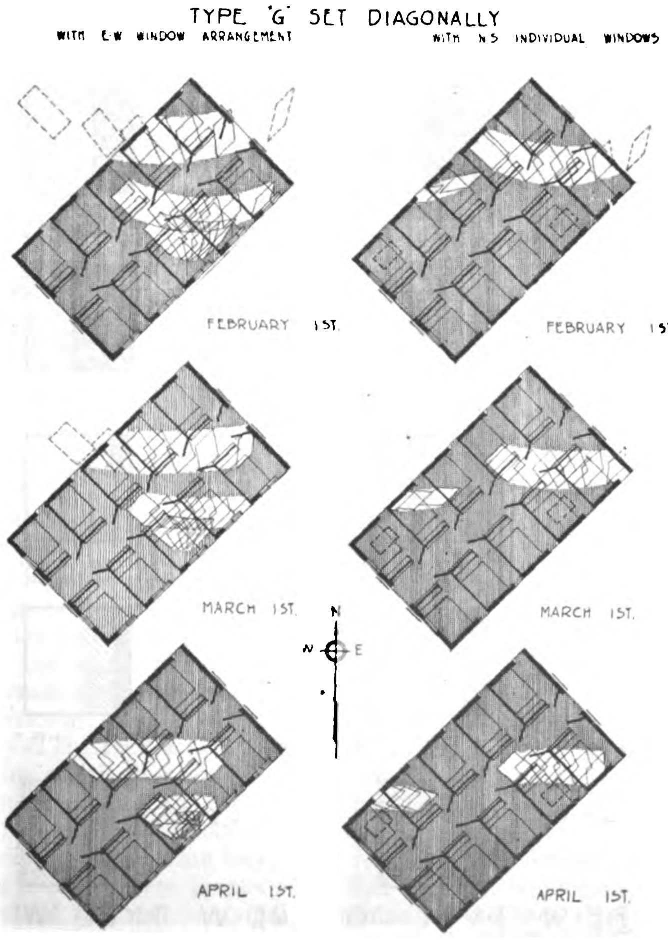
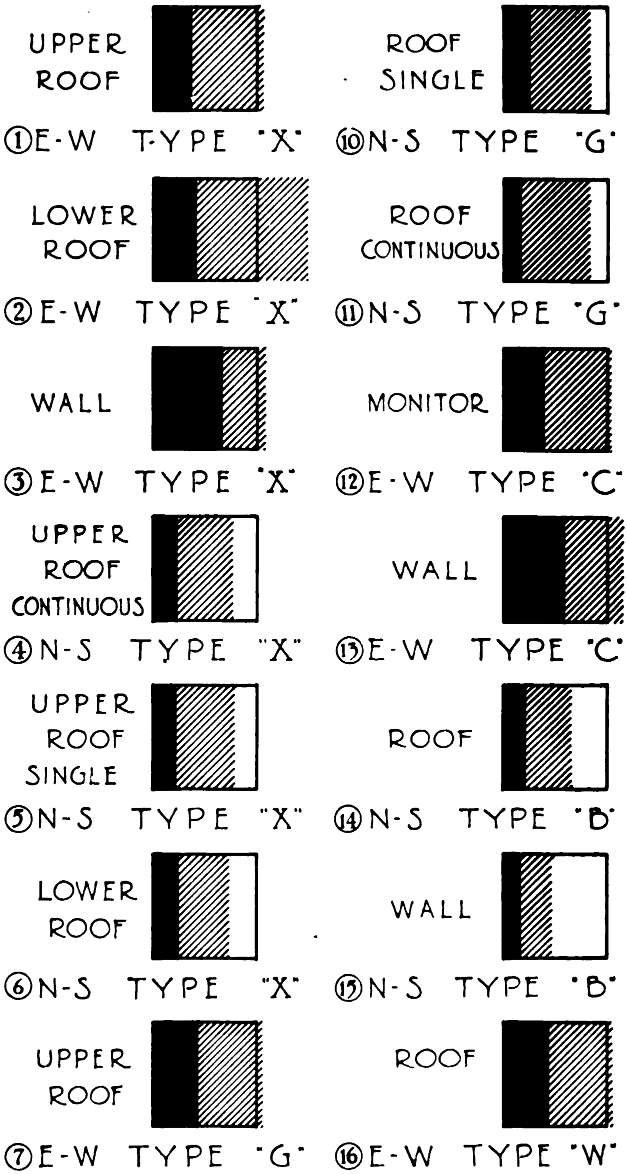


Figure 6. Chart of sun patterns for NE-SW type G

COMPARATIVE EFFICIENCY OF WINDOWS



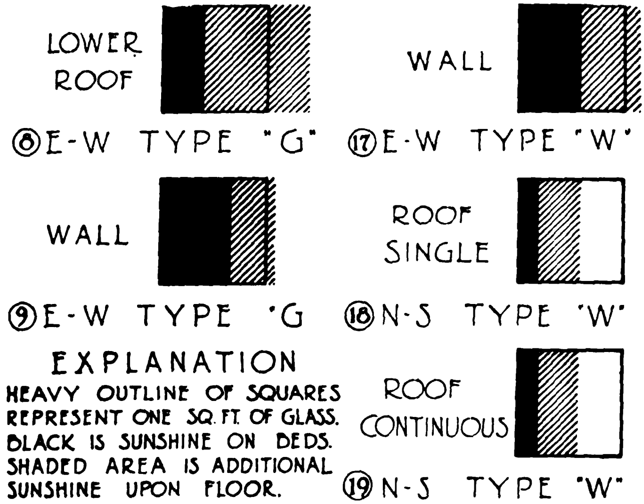


Figure 7. Chart of comparative efficiencies of windows

there is less seasonal change in the position of the patterns. These facts justify the wall windows shown in the south wall of some of the east-west types. These windows should be guarded with wire mesh or be made of heavy wire glass.

In Table 2 the efficiency is in an inverse ratio to the glass area. While there are other features than the glass area which should be taken into consideration in accounting for this, it is logical that there should be a decreasing efficiency with respect to concentrating the sunshine upon the bed when the glass area and, consequently, the size of the patterns is increased. Investigations made by increasing the glass area in some of the types have shown that there would be a slight decrease in the efficiency in such cases.

Fig. 7 is a graphic chart based on the figures in Table I. It gives the comparative efficiencies of the various windows in the different types. Here the efficiencies are represented on the square-foot basis, the black area representing the average amount of sunshine which a square foot of glass in a particular window will throw on the bed during the entire day. The shaded area shows the additional amount of sunshine which that square foot of glass will throw upon the floor, outside of the bed, during the day. The heavy outline which includes the black area in each figure represents the outline of one square foot and is for convenience in comparing areas. These graphs show that the wall windows will average fifty per cent more sunshine on the beds than is shown by other windows. Refer to graphs numbered 3, 9, 13, and 17. Graphs numbered 2 and 8 represent lower roof windows in east-west types and show about the same amount of sunlight upon the beds of these types, but considerably more upon the floor than graphs 1 and 7, representing the upper roof windows.

Graphs numbered 4, 5, 6, 10, 11, 14, 15, 18, and 19 in Fig. 7 representing the windows in the north-south types. Their average efficiency is much lower than the windows of

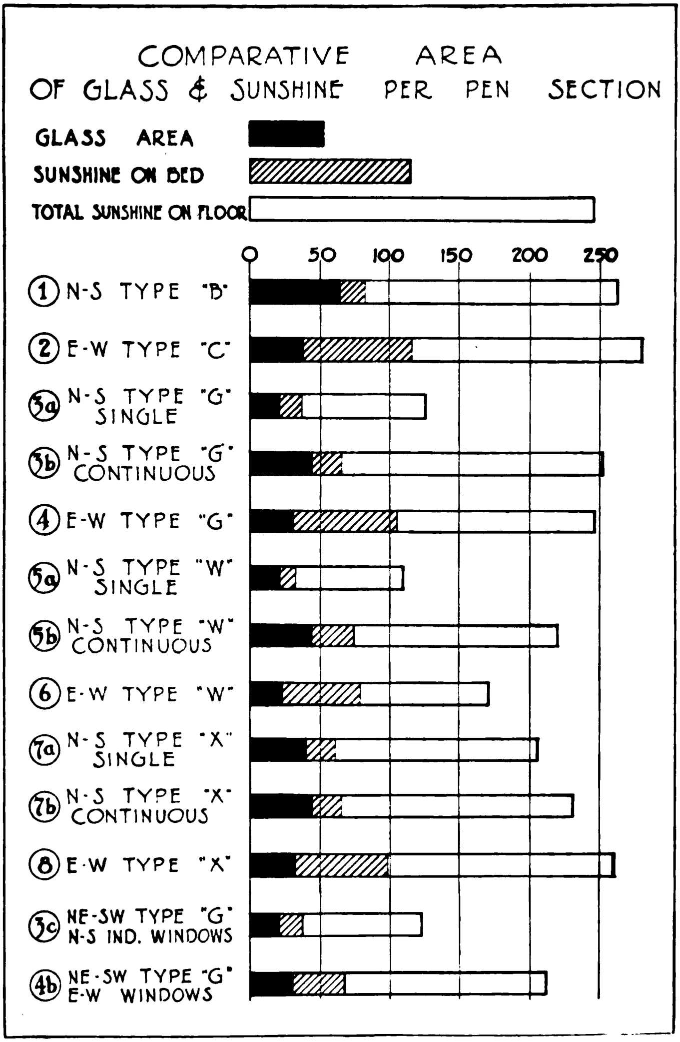


Figure 8. Chart of comparative amounts of glass and total sunshine

the east-west types. These windows were all located along the roof in the position which would give the best sunlight into the beds on March 1. Sometimes this throws the window over one side of the pen and sometimes the other. When properly set for March 1 sunshine upon the beds, however, the February 1 and March 1 pa'terns for these windows fall upon the north or south side of the nest owing to the change in the sun's altitude. Generally the windows over one pen, because of the slant of the sun's rays, throw their patterns into the next pen to the north. Readings made for the north-south types indicate that the amount of sunshine thrown into the pens is about the same for the hottest as it is in the coldest months.

Table III shows very little difference in efficiency between the north-south types which have individual windows and those which have continuous windows. It would appear then that in the north-south hog house the amount of sunshine which a breeder wishes to get into the building would determine the kind of windows to use.

The efficiency of the various types with reference to the amount of sunlight thrown on the beds indicates a less favorable condition than that which actually exists owing to the fact that the beds were assumed to be only about five by six feet in size and there will be a considerable amount of warm sunshine thrown into the pen where the sow or swine can use it although it is not actually on the bed. Sometimes the bed covers the entire pen floor. The use of the combined figures for both the efficiency of the sunshine on the bed and over the entire floor will give a reliable idea of results.

Fig. 8 gives a graphic comparison of the glass areas and the areas of sunshine for the entire floor and for the bed for

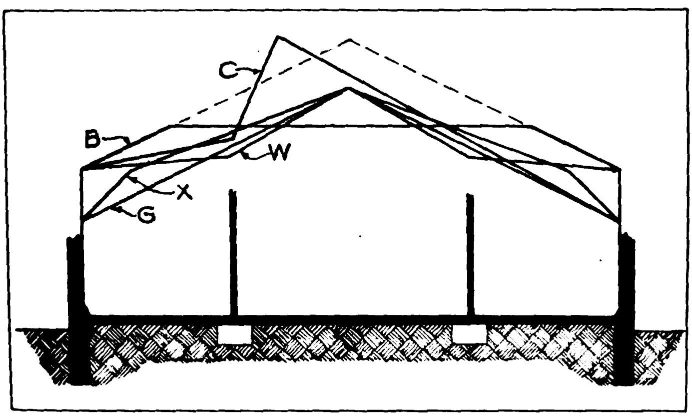


Figure 9. Comparative cross sections of types

all standard types and window arrangements. The black line represents glass area. The shaded and open lines represent respectively sunshine on the bed and on the floor in proportion to the relative areas.

A general summary of types B, C, G, W, and X with the various window arrangements is given in Table V. The cubic feet of air, and the roof, wall, and glass exposure per pen section are given for the sake of comparison in addition to figures on sunshine efficiency. Fig. 9 shows comparative cross sections.

The following conclusions may be drawn from the foregoing study:

1. The hog house properly designed and running east and west will admit twice as much sunlight per square foot of glass, to the beds, as the hog house running north and south.
2. The windows will be less exposed to cold winter winds.
3. The movement of the patterns through the building favors the accumulation of more heat on the nests in east-west types.
4. The east-west building offers better summer shade on the beds.
5. The arrangement of windows in the east-west types should be used when the building is run diagonally with respect to the compass points.
6. Wall windows are justified in east-west buildings because of their high efficiency.
7. The closer the windows can be brought to the beds the greater will be their efficiencies from the standpoints of both the concentration of warmth and control of the position of the sun pattern.

DISCUSSION

MR. KING: It is a mistaken conception that the sun's rays passing through glass have a disinfectant power actually to kill germs. Two years ago I had occasion to take that matter up with a number of the leading bacteriologists of the country and they assured me that sunlight after passing through glass has practically no disinfectant power and that it has lost its violet rays. Its main efficiency in that case is to keep the floor dry and prevent development of germs.

I want to second a thought brought out here that in the design of a hog house we want to consider other features than that of a window, and one of those of special importance is the amount of cubic volume that must be heated by the hogs' bodies as affected by the design of the house. We want to keep that cubic volume as low as possible.

PRES. WHITE: The Society is very much indebted to Mr. Harris and the company which he represents for this exhaustive study, on one phase only remember, of the design of hog houses. I hope you men realize that it is work like this that is putting the foundation under the profession of agricultural engineering. I also believe that this discussion of Mr. Harris' will enable some of us to read this paper which has already appeared in the November number of the Journal with more intelligence.

MR. STEWART: There are a few things we may go astray on. Do we need sunlight to kill the germs or for heating purposes, or just plain sunlight, or all three? From the standpoint of killing the germs, the germ-killing power of sunlight is due mostly to the ultra-violet rays of light which are quite largely intercepted by the glass. Those that do go through the glass are so thoroughly scattered inside of the building that no greater percentage of those rays strike where the sunlight does than strike the rest of the building. If we were to take a picture in that building with a camera, in which we used a screen so as to cut out all light except the ultra-violet rays, you could not detect any sunshine shadow. The ultra-violet light would come from all parts of the building with equal luminosity, showing they are entirely scattered.

So far as the killing power of the sun's rays is concerned, the sunshine pattern has very little to do with it, and it is only the amount of square feet of glass surface perpendicular to the sun's rays.

If we are talking about the amount of heat secured from sunshine, then again the amount of surface the light strikes upon will have nothing to do with the amount of energy received from the sun, but it is only the total square feet of sun's rays measured in a cross section perpendicular to those sun's rays that get within the building, regardless of whether it covers five square feet on the ground or whether it covers only one square foot.

Then, from the efficiency standpoint, we must also consider that the sun's rays in the morning only have a heating efficiency, at nine o'clock about sixty per cent of that at noon, measured in a perpendicular cross section of the rays of light, due to a greater absorption of the atmosphere which the sun's light has to come through.

In addition to that I would say that the use of the term "efficiency" here seems to me a rather unsatisfactory term to use for energy. We have a very definite meaning for the word "efficiency." I believe the proper term to use here would be the word "coefficient." If we want to discuss it as the coefficient of sunshine rather than efficiency, it can be worked out on the basis of efficiency, but then we would need to consider, for instance, in the case of where we had forty square feet of glass area, and an efficiency of one to four, that would mean we would get 160 square feet on the floor.

COMPUTING FUEL REQUIREMENTS FOR HEATING BUILDINGS*

By K. J. T. Ekblaw
Mem. A.S.A.E. Editor, Power Farming Bureau

VARIOUS well-known rules are extant for determining the size, position, and location of the units of different types of heating systems, but the writer has been able to find very little information in regard to methods of determining the amount of fuel necessary to heat certain buildings. Such determination is usually mere guess work and any estimate that may be made generally has as a basis only figures derived from comparisons with actual installations of greater or less similarity; as a result the estimate is at best rather vague and is likely to vary widely from the actual required amount of fuel needed.

In 1914 Prof. E. H. Lockwood, of the Sheffield Scientific School of Yale University, formulated a rule which has a logical scientific basis. It is a complete rule depending on five definite variables: (1) Wall surface of building; (2) heat transfer coefficient for building material; (3) difference between interior and exterior temperatures; (4) length of heating year; and (5) heat units of fuel utilized for warming purposes, depending jointly on kind and quality of fuel and efficiency of heating system.

As a formula Prof. Lockwood's rule is stated as follows:

$$\text{Pounds of Coal Required per Year} = \frac{(m\,W + n\,G)\ (T\text{-}t)\ C}{D}$$

W = total exterior wall surface of building expressed in square feet. Ceilings are included only when space above is not heated. The wall surface of unheated portions of the buildings are not included.

G = total exterior glass area of heating part of building expressed in square feet. This area included the overall dimensions of window sash, and in glass doors the area of the doorway.

m = heat transfer coefficient for 24 hours. These values are standard values determined by Greene's method and as given by him.

Lath and plastered walls clapboarded	4.8
Brick walls 8 inches thick, furred and plastered	5.8
Same, 12 inches thick	4.8
Same, 16 inches thick	4.3
Concrete Walls, 12 inches thick, furred and plastered	6.2

n = heat transfer coefficient (24 hours) for glass

Single glass	25
Double glass	11

*Article which appeared in the July, 1921, number of Agricultural Engineering.

T = average temperature inside building during heating year for a residence. Its value may be taken at from 62 to 70 degrees Fahrenheit, depending on the amount of cooling at night.

t = mean daily temperature outside of building during the heating year. (See accompanying table.)

C = number of days in heating year, or number of days in calendar year that heat is required in building. (See table.)

D = thermal units per pound of coal usually employed in the heating system. For direct steam or hot water, under the conditions and care ordinarily exercised, 50 per cent of the heat value is efficiently utilized. For indirect steam, or hot water, or for warm-air furnace heating, this value is 40 per cent. Careful operation of the heater may increase these efficiencies.

In order to make this formula of general application the writer checked all values carefully and, using the records of the United States Weather Bureau, prepared a table indicat-

TABLE OF HEATING PERIODS

LOCATION	Record Period	Duration of Heating Days	Average Temperature During Heating Period. Degrees Fahrenheit
Abilene, Tex.	1886-1905	104	45.8
Atlanta, Ga.	1879-1905	110	45.0
Bismarck, N. D.	1875-1905	212	23.6
Boise, Ida.	1878-89, 1899-1905	184	37.7
Burlington, Vt.	1873-1905	210	29.0
Cheyenne, Wyo.	1873-1905	224	32.2
Chicago, Ill.	1873-1905	189	33.6
Columbus, Ohio	1879-1905	173	33.6
Denver, Colo.	1873-1905	188	36.6
Helena, Mont.	1880-1905	195	29.7
Kansas City, Mo.	1889-1905	170	32.8
Lincoln, Neb.	1897-1905	174	31.8
Marquette, Mich.	1873-1905	226	24.5
Memphis, Tenn.	1873-1905	113	42.5
New Haven, Conn.	1873-1905	186	33.0
Pittsburg, Pa.	1873-1905	171	38.0
Portland, Ore.	1873-1905	167	42.0
Raleigh, N. C.	1887-1905	123	43.7
Reno, Nev.	1888-1905	174	38.3
San Francisco, Cal.	1873-1905	49	50.0
Seattle, Wash.	1894-1905	185	43.0
St. Louis, Mo.	1873-1905	153	39.4
St. Paul, Minn.	1873-1905	195	26.0
Syracuse, N. Y.	1903-1905	194	32.6
Washington, D. C.	1873-1905	159	38.7

ing the length of heating year and the average daily temperature during this time for twenty-five cities of the United States, located centrally in areas which might be considered representative regional areas so far as weather is concerned. The heating period as given includes the number of days when the mean temperature was fifty degrees or below; this might seem a rather low figure but it must be remembered that this is the average temperature of the day, and that even when no fuel is being burned the interior temperature for various reasons is higher than that outside. The average temperature during the heating period was found by taking the mean of the average daily temperature over a record as indicated.

A practical determination of accuracy of the formula was made in connection with a residence located in New Haven, Conn., the walls of which are clapboarded outside and covered with lath and plastered inside. The residence has a total exterior wall surface of 1750 square feet and a total exterior glass surface of 350 square feet. An average inside temperature of 70 degrees Fahrenheit was maintained, and from the accompanying table of average temperatures it is found that the average exterior temperature during the heating year of 186 days is 33 degrees Fahrenheit. The fuel used was of the grade known as "Yard Pea" anthracite with a heat value of 12,500 B. t. u. per pound. These values, together with M and N, given previously as 4.8 and 25 respectively, were substituted in the formula as follows:

$$\frac{(4.8 \times 1750 + 25 \times 350) \quad (70 - 33)\ 186}{12500 \times 0.50} = 18900 \text{ pounds coal}$$

giving the amount of fuel required as indicated.

During the winter of 1912-1913 the owner kept a careful record of the actual amount of fuel used in heating the house. This record shows a total fuel consumption of 19,000 pounds, which is in remarkable agreement with the value as determined by the formula. It may be mentioned, incidentally, that through careful operation of the heating system the owner of the residence was able to reduce his coal bill materially through the use of the lowest grade of fuel.

The amount of coal required per day in the coldest weather is of importance in determining the size of heater to be installed. The general formula can be adapted, making

T = 68 degrees Fahrenheit

t = the minimum temperature outside

C = 1 day

Then the formula becomes

$$\text{Pounds of coal per day} = \frac{(m\,W + n\,G)\ 68}{D}$$

A COMPARATIVE STUDY OF SOME INSULATING MATERIALS*

By R. R. Graham, B.A., B.S.A.
Associate Professor of Physics, Ontario Agricultural College

By WAY of introduction I wish to explain what I mean in this case by insulating materials. They are substances or materials which are poor conductors of heat, and those that will be referred to are of a loose nature like shavings and cork clippings. Sometimes these forms of insulation are called "fillers" since they are packed into the spaces between two walls of lumber or other materials.

Low heat conductivity is certainly the most important property of a good insulating material, but there are other properties that are very essential, more particularly from the practical standpoint. What I mean may be more clearly expressed by the statement that all good insulating materials are poor conductors of heat by nature but all nonconductors of heat are not necessarily good insulating materials. One illustration will serve to make this point still clearer. Dry good-quality sawdust is a poorer conductor of heat than planer shavings, but no one who is familiar with the behavior of the two fillers in walls under similar conditions would choose the sawdust in preference to the shavings. The shavings win out under actual tests for several reasons: They are very elastic and, therefore, when once packed into a space maintain their position, whereas sawdust having no elasticity very soon settles and leaves large spaces at the top of the walls for the entrance or exit of heat. Then, again, shavings do not absorb moisture so readily as does sawdust, and as dryness is conducive to low conductivity it is very important that the material be a poor absorber of moisture. Furthermore, shavings can usually be secured in a drier and purer form than sawdust and, hence, there is less liability to deterioration and decay in the shavings. There are still other differences that might be emphasized, most of them in favor of shavings.

To summarize, a good insulating material has the following properties: Low conductivity of heat, non-absorber of moisture, elastic (if a filler), pure or free from foreign substances subject to decay or spontaneous combustion, and these not mentioned before, namely, not subject to vermin (rats and mice), convenient to handle and install, durable, odorless (if used in construction of cold storages for perishable and easily tainted goods), and reasonably cheap.

For some time I have been very much interested in the subject of insulation, particularly the phase of it enunciated

*Article which appeared in the August, 1921, number of Agricultural Engineering.

above, as I realized that it was something that would concern the practical farmer more and more as the years go by. Recent applications of insulating materials on farms have confirmed my belief, so I undertook to experiment with several insulating materials, all fillers, in order to ascertain their comparative values as insulators or nonconductors of heat. So far as these experiments have been conducted they show only relative values, not absolute, for the materials tested, but since the question about them from the practical man is usually "Which is the best insulation?" the relative values are the most useful of the two. I had hoped to determine the absolute values before now but sufficient funds and assistance were not available, consequently the work had to be abandoned. The experiments carried out involved a great deal of tedious and painstaking work, but as the results were satisfactory I felt that the task had been worth while. The results in detail would occupy more space than I have at my disposal, and so only a brief description of the method used and a summary of the results obtained with a few comments thereon will be given here.

The method, to describe it briefly, consisted of putting a small metal box containing a known quantity of ice and water in the center of a tight wooden box and filling the intervening space around the inner receptacle with the substance or insulating material that was to be tested, and later determining the amount of ice melted in a given time by the heat that had passed through the material. The tests were made in duplicate for two or three different times with each material tested. The reliability of the method was amply vouched for by the uniformity of results. The two boxes were sealed up tightly while under test. There was always sufficient ice in the inner box to insure a temperature of about freezing, 32 degrees Fahrenheit, throughout the tests, and the room temperature was fairly constant, its temperature being recorded continuously on a self-recording thermometer. The amount of ice (in pounds) melted per hour per one degree Fahrenheit difference between the temperature of ice box and the room was the basis for comparison of the conductivity of the materials tested.

A series of preliminary tests was conducted to find out if the rate of melting of the ice in the inner box depended on the size of the pieces of ice used. As stated above, the cans were filled with pieces of ice and then ice-cold water was added until the cans were completely filled. The tests showed a very slight difference in favor of the melting of the fine pieces of ice. It was eventually determined that if a uniform quality of ice were used and the pieces of ice ranged in diameter from three to five inches and the spaces in the mass of ice were filled with ice-cold water, the meltage was practically a constant factor for any definite temperature. This fact having been definitely decided on the method already outlined was adopted and a long series of tests with several materials was carried out.

The materials subjected to tests were coarse black granulated cork, very fine black re-granulated cork, 8/20 grade granulated cork of natural color, another grade of granulated cork, natural color, used as packing materials for Malaga grapes, planer shavings, forest leaves, sawdust, chopped straw, and excelsior.

The results showed conclusively that the very fine black re-granulated cork is the poorest conductor of heat of all the materials listed above. If we put it at the top of the list and assign it a value of 100, the others occur in the order indicated in the following table:

NAMES OF MATERIALS TESTED	Average Ice in Pounds Melted Per Hour Per 1 Degree F. Difference in Temperature Between Ice Box and Outside Air	Relative Insulating Values, 100 Being the Standard
1. Very fine black re-granulated cork	.00410	100
2. Chopped straw	.00476	86
3. Coarse black re-granulated cork	.0048	85
4. Forest leaves	.0049	84
5. Granulated cork (natural color used for packing material around imported Malaga grapes)	.0049	84
6. 8/20 grade granulated cork (natural color). Looks similar to preceding one but a little coarser in granules and lighter in weight	.0051	80
7. Sawdust	.0060	68
8. Excelsior	.0068	60
9. Planer shavings (loose)	.0068	60
10. Planer shavings (packed)	.0074	55

As I have pointed out, a good practical insulating material must possess other special properties than low conductivity. In reviewing this table then one must bear this fact in mind and not be guided in one's choice of an insulation by conductivity alone. The first one on the list is a very poor conductor of heat because it contains a large percentage of dry air in a quiet condition, but it is black and very dusty, therefore, very disagreeable to handle in any large quantity, and it is also expensive. In my opinion it has no practical value for the farmer. It is better adapted to special lines of insulation in connection with cold-storage construction.

The next, chopped straw, is a good insulation, accessible and cheap on the farm, but unless rats and mice are absolutely prevented from getting into it one could not depend upon it for good results. It has also a tendency to settle in the space it occupies but not so badly as sawdust.

Forest leaves are not very durable as they become disintegrated especially if handled very much. It is very essential that they be dried thoroughly in the sun or in a warm room for some time before using.

Granulated cork, similar to Nos. 5 and 6 in the table, makes excellent fillers, being poor conductors, durable, pleasant to handle, not subject to decay or ravages by rats and mice, and poor absorber of moisture.

Usually sawdust is not pure and dry enough to give good results except in temporary use as packing around ice in ice houses. Other undesirable features of it have been referred to before.

Excelsior is too stringy, hard and stiff, for a good filler. The kind tested was rather coarse. The finer grades would be more satisfactory. It would be difficult to secure it in large quantities.

Planer shavings, although they are at the bottom of the list as nonconductors of heat, make a very satisfactory insulating material for general use as a filler if they are pure, dry, and moderately fine. They are reasonable in cost and quite easy to get.

I would say in summarizing comments on these materials that granulated cork (natural color), planer shavings, and sawdust are the best insulating materials for use on the farm all things considered.

The uses to which these insulating fillers may be put in farm practices are: Packing around beehives for outdoor wintering, protecting water pipes from frost, insulating milk and cream-cooling and water-supply tanks, fillers for refrigerator or small ice-cold storage walls, packing material for fireless cookers, and other uses of minor importance.

Within recent years there has arisen on the farm quite a demand for these insulating materials for the uses just mentioned, particularly for wintering bees outside; granulated cork and planer shavings are used chiefly for this purpose, but some have used leaves, chopped straw, and sawdust with very good results.

A RESULT OF IMPROPER BARN ROOF CONSTRUCTION*

By Ray W. Carpenter

Mem. A.S.A.E. Professor of Farm Engineering, University of Maryland

THE barn shown in the pictures on this page happened to stand in the path of a near-tornado with the disastrous and quite unusual results shown. An inspection of the plans from which the barn was built and of the wreckage of the barn revealed several interesting facts, which it is believed should be of value to designers and builders of farm structures. Especially is this true in view of the fact that this barn was built with a self-supporting roof of the type now being constructed almost to the exclusion of other types. The barn is 36 feet by 66 feet, with 14-foot studding, giving a hay mow of about 90 tons capacity. This mow was almost empty at the time of the accident. It is worthy of mention that this barn was saved from complete destruction by the fact that the sills were securely bolted to the foundation.

Examination of the collapsed portion of the roof showed that the failure was due to two causes, insufficient bracing and extreme carelessness in construction.

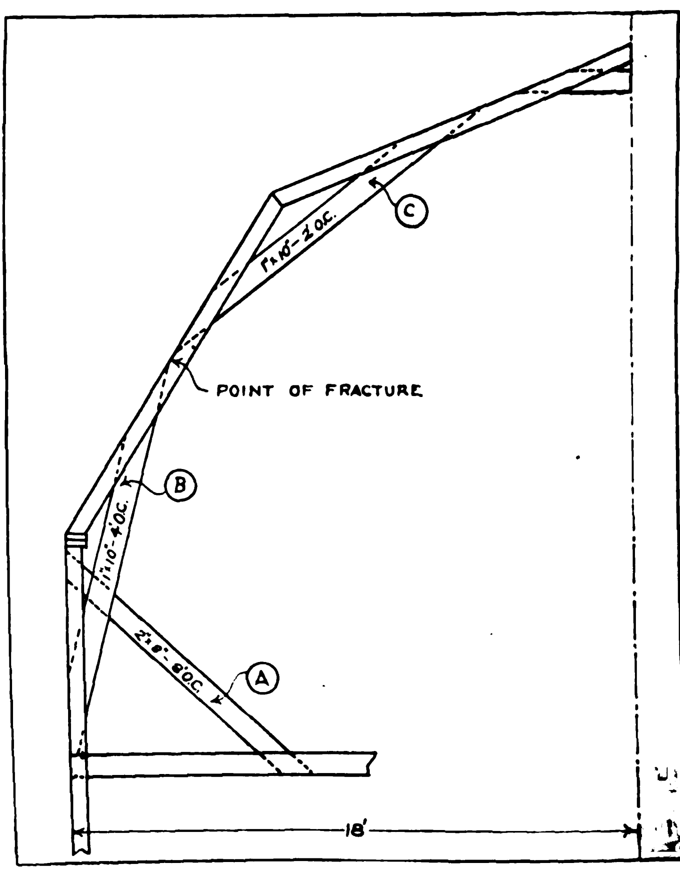
Let us first consider the feature of careless construction. Notice that the picture shows just above the hole in the roof, a long straight crack. This was caused by the fact that the roof sheathing boards had been so cut that the ends of five consecutive boards came upon the same rafter at this point and for the next nine sheathing boards below; the ends of every one came either upon this same rafter or the one just adjacent to it. The joint between any two boards is a weak point. When fourteen such points occur in a group, as in

*Article which appeared in the June, 1921, number of Agricultural Engineering.

Poor design and bad workmanship each had a share making possible the peculiar failure shown here this case, the resulting weakness is great. With a roof 66 feet long and with this faulty construction directly in the center of it, it is not strange that it gave way under the strain of a heavy wind. Any contractor who would allow such a condition to occur is guilty of extreme carelessness.

The details of construction of the roof are shown in the drawing. The upper braces, C, consisting of a 1-by-10-inch piece on each rafter, had remained intact, and apparently possessed ample strength. A crosstie from the rafter joint to the brace would, however, be good practice. The lower braces, B, had failed badly. They were twisted, bent, or broken. Evidently the mistake in the design of this roof had been to consider B as a tension-resisting member, whereas it had been called upon to resist compression. One-inch material of any length is of course almost valueless for this purpose.

In the writer's judgment safe construction would call for



brace B to extend from the floor to a joint with brace C. It should be of two-inch material, and be stiffened by two or three crossties to the rafter and studding. A very effective brace for this point is made of two 1-by-10-inch pieces, one on either side of the rafter. These pieces are blocked apart by two 1-by-8-inch strips which extend to the rafter, thus serving also as crossties. This gives the brace an effective thickness of four inches.

Braces A are sometimes omitted from barns, but this should never be permitted. In the case under discussion they had clearly been of great help. One important function which they perform is to distribute side thrust throughout the structure, instead of allowing them to be concentrated at a few points. Their other function, to prevent the spreading of the walls due to the weight of the roof, is well understood. Spaced eight feet apart, they take up surprisingly little room for the valuable service which they render.

THE RELATIVE CONDUCTIVITY OF MATERIALS USED IN FARM BUILDING CONSTRUCTION*

THE object of this report is to present data on the relative conductivity of various constructions used in farm structures. In order to do this we decided to review all data on relative conductivity of building construction; to select that data on farm building construction and place it in an available form for the agricultural-engineering profession, and to recommend its use by members of the American Society of Agricultural Engineers with the view of adoption as standard practice.

The statement was made a year ago by the Committee on Farm Building Ventilation that "The heat given off by one dairy cow per day was equivalent to 7.4 pounds of coal burned in a furnace at 75 per cent efficiency." Granting this statement we can readily see that the heat given off is enormous. Figured in Illinois coal at 45 per cent burning efficiency, this would be equivalent to 12.8 pounds, or in Iowa corn at 42 per cent efficiency, it would take 21 pounds of corn. Again figured for a seven-day period for a 20-cow dairy barn, it would take about 1800 pounds of coal or 42 bushels of Iowa corn.

This Farm Building Ventilation Committee's report further stated that "The heat loss through the walls of a barn must be reduced if the temperature is to be controlled without the use of artificial heat."

Realizing the importance of convenient conductivity tables and the fact that only a few of the members of this Society have access to large college libraries, the Committee on Farm Structures Design has collected data on conductivity from the leading heating authorities, and recommends an average of the reviewed data as given in the table below, for the use of agricultural engineers, subject to such additions or corrections as may be necessary to make the table complete.

We desire to give credit to the following heating authorities consulted, with particular reference to William R. Jones' tables published in *Heating and Ventilating Magazine*, October 1918 to January 1919, inclusive:

J. H. Kinealy, "Formulas and Tables for Heating," 1899.
R. C. Carpenter, "Heating and Ventilating of Buildings," 1911.
B. F. Sturtevant Company.
N. S. Thompson, "Mechanical Equipment of Federal Buildings."
A. M. Greene, "Elements of Heating and Ventilating," 1913.
Buffalo Forge Company.
William A. Snow, "The Principles of Heating," 1912
C. L. Hubbard, "Power Heating and Ventilating," 1914.
J. M. Harrison, "Applied Heating and Ventilating," 1911.

*Report of the Committee on Farm Structures Design.

J. R. Allen, "Notes on Heating and Ventilating," 1905.
L. A. Harding, "Mechanical Equipment of Buildings," 1916.
James D. Hoffman, "Handbook for Heating and Ventilating Engineers," 1913.
National District Heating Association, Bull. of Jan. 15, 1916.
American Radiator Company.
Frank L. Busey, "Transmission of Heat Through Building Materials," 1914.
Heating and Ventilating Magazine
James A. Donnely.
B. N. Irwin, "Elements of Heating," 1914.
King Ventilating Company.
Engineering Experiment Station, Univ. of Ill., Bull. 102.
Engineering Experiment Station, Penn. State College, Bull. 16.

WINDOWS

Standard Sash	1.09
Tight Sash	1.07
Weather Stripped	0.90
Medium Sash	1.20
Loose Sash	1.35
Double Glazed	0.62
Double Sash	0.62
Single Skylight	1.16
Double Skylight	0.62
Monitor	1.30
Wet Glass	1.10

WALLS

Concrete—Plastered one side	
4 inches	0.82
8 inches	0.59
12 inches	0.46
16 inches	0.39
20 inches	0.33
24 inches	0.29
Concrete—Plain or Reinforced	
4 inches	0.90
6 inches	0.77
8 inches	0.63
10 inches	0.56
12 inches	0.48
16 inches	0.41
20 inches	0.35
Brick—Furred and Plastered	
4 inches	0.33
9 inches	0.27
13 inches	0.23
17 inches	0.21
21 inches	0.19
Brick—Plastered	
4 inches	0.49
9 inches	0.38
13 inches	0.29
17 inches	0.25
21 inches	0.22
Brick—Plain	
4 inches	0.60
9 inches	0.42
13 inches	0.32
17 inches	0.26
21 inches	0.23
Hollow Tile Stucco one side, Plaster one side	
2 inches	0.47
4 inches	0.40
6 inches	0.36
8 inches	0.31
12 inches	0.26
16 inches	0.23
20 inches	0.20
Hollow Tile Plastered one side	
4 inches	0.75
8 inches	0.54
12 inches	0.41
16 inches	0.37
20 inches	0.31
Hollow Tile Plain	
4 inches	0.79
8 inches	0.56
12 inches	0.44
16 inches	0.40
20 inches	0.33
Wood Plain, tight	
⅜ inch	0.86
½ inch	0.78
¾ inch	0.69
1 inch	0.59
1½ inches	0.51
2 inches	0.43
4 inches	0.29
8 inches	0.17
12 inches	0.13

Frame Construction—	
Lath and Plaster, Studding	0.62
Lath and Plaster, Studding, Siding	0.45
Lath and Plaster, Studding, Stucco	0.34
Lath and Plaster, Studding, Paper, Siding	0.31
Studding, Sheathing, Paper, Siding	0.29
Lath and Plaster, Studding, Sheathing, Siding	0.29
Studding, Paper, Siding	0.34
Lath and Plaster, Studding, Sheathing, Paper, Siding	0.23
Lath and Plaster, Studding, Back-plaster, Sheathing, Paper, Siding	0.21
Lath and Plaster, Studding, Shavings, Sheathing, Paper, Siding	0.10
1-inch Board, Sawdust fill, 2 inches; 1-inch Board	0.13
1-inch-Board, Sawdust fill, 4 inches; 1-inch Board	0.09
1-inch-Board, Sawdust fill, 6 inches; 1-inch Board	0.06
1-inch-Board, Sawdust fill, 8 inches; 1-inch Board	0.05
Miscellaneous Wall Construction—	
Sheet Iron only	1.20
Sheet Iron over One-Inch Boards	0.40
Corrugated Iron only	1.50
Corrugated Iron over One-Inch Tongued-and-grooved Boards	0.36

Cement Block, 8-inch	0.63
Cement Block, Plastered	0.55
Cement Block, 12-inch	0.43
Cement Block, Plastered	0.38
Batten Door, Single Board	0.42
Batten Door, Double Boards, Paper	0.26
Mill Door, Outside	0.56
Mill Door, Inside	0.40
Two Single Batten Doors	0.21

FLOORS

Earth	0.20
Concrete	0.31
Flooring on Concrete	0.12
Plank on Asphalt	0.20
Tile on Earth	0.31
Flooring on Tile	0.11
Concrete on Tile	0.30
Flooring, Sleepers, Earth	0.13
Plank on Wood Beams	0.13
Flooring, Joists open beneath	0.29
Double Flooring, Joists open beneath	0.20
Flooring, Joists, Lath and Plaster	0.19
Double Flooring, Joists, Lath and Plaster	0.13
Flooring, Joists, Fill, Air, Lath and Plaster	0.05

CEILINGS

Ceiling Joists, Lath and Plaster	0.45
Flooring, Joists, Wood Ceiling	0.29
Three-inch Plank on Wood Beams	0.30
Flooring, Three-inch Plank on Girders	0.19
Flooring, Joists open under	0.40
Double Flooring, Joists open under	0.23
Flooring, Joists, Lath and Plaster	0.28
Double Flooring, Joists, Lath and Plaster	0.25
Flooring, Joists, Fill, Air, Lath and Plaster	0.10
Flooring, Joists, Steel Ceiling	0.35

ROOFING

Sheet Metal, Unlined	1.30
Sheet Metal, Wood Framing	1.30
Corrugated Metal	1.50
Sheet Metal, Tongued-and-Grooved Boards	0.28
Slate, Wood Lathing	0.88
Slate, Tongued-and-Grooved Boards	0.38
Wood Shingles, Lathing	0.63
Wood Shingles, Sheathing	0.32
Tar Paper, Sheathing	0.44
Tar and Gravel, Roofing, Sheathing	0.26
Roofing, Tile, Lathing	1.12
Roofing, Tile, Sheathing	0.80
Cinder Fill, 2 inches of Concrete	0.80
Cinder Fill, 4 inches of Concrete	0.53
Tar and Gravel, 2 inches of Concrete, 8 inches of Tile	0.38

PORTLAND CEMENT STUCCO FOR FARM BUILDINGS*

By J. E. Freeman
Manager, Structural Bureau, Portland Cement Association

ONE of the oldest methods of finishing building exteriors and interiors is by means of a plaster coat known as stucco. For ages the use of stucco has been common in the Mediterranean countries. Some fine examples of stucco work done by the ancient Greeks and Romans are still in existence. Many also may be found throughout Mexico, Central America and the southwestern part of the United States. Some of the last examples, however, are little more than mud plaster with or without lime, used as exterior finish of the mud block buildings erected by the early Spanish explorers and missionaries. In the sixteenth century stucco was an essential part of the half-timbered houses of England, a type of architecture that still prevails there and which has been adapted to the tastes of builders in the United States and other countries.

Until within comparatively recent times the development of stucco in this country has been slow, principally because of the plentiful supply of lumber and the tendency in the past to build with less regard for durability and fire resistance than is evidenced today.

Early builders used stucco to secure added protection against the elements and more artistic appearance at low cost. The same reasons still encourage the use of stucco and in place of mud plaster or cement, builders now have a stronger, more uniform, and more durable material in Portland cement. As the cement can be obtained practically everywhere and the sand and water with which it is mixed are local materials, Portland cement stucco is available anywhere at small cost; consequently, it is being used more and more as an exterior for houses and all other classes of structures, as well as when renovating old buildings of practically all kinds.

Portland cement stucco as an exterior finish may be combined with almost any style of architecture—the Colonial with its stately columns; the Georgian with its simple lines, the Mission with its plain walls and tiled roofs; the Old English with its half-timbered upper stories. The illustrations in existing structures are sufficiently varied to prove the adaptability of stucco and show many pleasing effects that may readily be secured with this material.

Stucco helps to make warm houses where winters are severe and cool ones in hot climates, because the manner of its use increases building wall insulation. The economy and simplicity of its use make it adaptable to workingmen's

*Fifteenth annual meeting paper.

cottages, large country or city residences, farm buildings, industrial housing developments and many other structures. The intending home builder who carefully investigates and weighs the merits of Portland cement stucco against other kinds of exterior finish, realizes that it will give him more for his money than any other method of treatment and specifies it for his moderate cost city or suburban home.

By adding various mineral coloring materials in proper amounts, many different shades of yellow, red, brown, green and gray can be secured, or by using white Portland cement and white limestone or marble screenings in place of sand, he can obtain a white stucco. Different varieties of sand, marble and granite chips, limestone screenings or other materials may be used in the finishing coat and the surface then treated to expose these selected materials, thus giving choice of many surface effects. Almost any degree of smoothness, roughness or texture is possible, depending on the method used in finishing.

Portland cement stucco is ordinarily made on the job from Portland cement and clean coarse sand mixed with water. It can be applied on either metal or wood lath, or directly on any surface of concrete, brick, tile or other masonry. The rules for such work are comparatively simple and easy to follow. The cost is reasonable and a building with stucco exterior is a permanent source of satisfaction to its owner.

When the exterior of a house or farm building is of clapboards or shingles, danger to adjacent buildings from fires is great. Even when the house exposed is not actually set on fire, heat may do so much damage that expensive repairs are necessary. An exterior of Portland cement stucco greatly reduces this hazard. Sparks and firebrands are harmless. A fire must be intense, close and long continued before the heat will injure the stucco. This reduction in the fire hazard is particularly important in a building that shelters the owner's family and his personal possessions. Such protection has a real money value. If the roof of the stucco finished house is of cement-asbestos shingles or concrete roofing tile, the hazard from nearby fires is still further lessened.

Portland cement stucco properly mixed and applied is practically permanent. No other stucco will so well endure all climatic conditions from Maine, to California. Maintenance and depreciation are negligible. An exterior of clapboards or shingles must be painted frequently and repairs are often necessary. In a few years the cost of painting and repair amounts to more than the total cost of a Portland cement stucco exterior. When the annual charges for maintenance, interest and depreciation are computed, Portland cement stucco will be found by far the most economical exterior finish.

Old buildings can be renovated or remodeled and completely changed in appearance by applying an overcoat of Portland cement stucco. If weatherboarding is in poor condition it should be removed, then furring and expanded metal or wire lath applied over the sheathing to which sheathing paper has previously been fastened. Another method is to fasten the furring direct over the weatherboarding and then apply the metal lath. In preparation of any of these methods the structure should be gone over carefully to determine whether the framework is strong enough and in good enough condition to produce satisfactory results. The stucco brings an additional weight on the framing. Some provision must be made for extending the old window and door frames to correspond with the increased thickness of the wall or else the plaster brought over the old frames in such a manner that a recessed window or door opening is made.

Where new structures are concerned the best procedure to follow is that outlined by the committee on treatment of concrete surfaces of the American Concrete Institute in their recommended practice for Portland cement stucco issued in 1920. Some of the principal points briefly noted are as follows: Stop the stucco above groundline to avoid possible frost action as well as staining from dirt and moisture. Special attention should also be given to details of flashing and drips. Keep the water from getting behind the stucco.

Masonry walls should be clean before stucco is applied to insure bond. Proper wetting of the surface just before applying the stucco is also important, too dry a wall or one completely saturated—both hinder good results. There should be a moderate amount of suction. Concrete or concrete block walls which are somewhat rough and of course texture are ideal basis for Portland cement stucco, because of their similar make-up.

Good bracing of frame walls is important to secure sufficient rigidity. Adequate fire stopping is an important feature in this type of structure in order to develop its full fire-resistive value. A basket of metal lath set in spaces between studs at juncture of floor joists and wall or bearing partition and filled with cement mortar or concrete from the ceiling level to four inches above floor level is a good example of effective fire-stopping.

Proper and thorough mixing of ingredients is very important. Only sufficient water should be used to produce a good workable consistency. Once the quantity of water necessary for proper consistency has been determined by trial it should be carefully measured for each batch thereafter. Fine aggregate should be clean and consist of sand or crushed stone screenings graded from fine to coarse, but passing a No. 8 screen. The colorimetric test with which you are doubtless familiar is a very effective means of determining whether a sand is free from injurious amounts of organic impurities. Hydrated lime should be used in the stucco in preference to lump lime, on account of the difficulty of thoroughly slaking the latter on the job.

Mixtures should be about 1:3. Sometimes for base coats a 1:2½ mix is used particularly when plastering on lath. Hair or fibre may be used in the base coat for plaster on lath, but should be omitted in the finish and intermediate coats.

Second coat should follow first or "scratch" coat whenever possible on the day following; the finish coat should be applied not less than a week after the second coat. The second coat should be protected against loss of moisture by sprinkling for two or three days after application and finish coat should be similarly protected from rapid drying.

The wide variety of finishes possible with Portland cement makes it a useful material for the architect in the development of artistic effects, and is one of the reasons why it is so generally utilized by him in residence construction. It

TABLE OF COLORS TO BE USED IN PORTLAND CEMENT STUCCO.

COLOR DESIRED AND COMMERCIAL NAMES FOR USE IN CEMENT	Pounds of Color Required for Each Bag of Cement to Secure Light Shade	Medium Shade
GRAYS, BLUE-BLACK and BLACK		
Germantown lampblack[1]	½	1
Carbon black	½	1
Black oxide of manganese	1	2
BLUE SHADE		
Ultramarine blue	5	10
BROWNISH-RED to DULL BRICK RED		
Red oxide of iron	5	10
BRIGHT RED to VERMILION		
Mineral turkey red	5	10
RED SANDSTONE to PURPLISH RED		
Indian red	5	10
BROWN to REDDISH-BROWN		
Metallic brown (oxide)	5	10
BUFF, COLONIAL TINT and YELLOW		
Yellow ochre[2]		
Yellow oxide	5	10
GREEN SHADE		
Chromium oxide	5	10
Greenish-blue ultramarine	6	—

[1]Only first quality lampblack should be used. Carbon black is light and requires very thorough mixing. Black oxide or mineral black is probably most advantageous for general use. For black use 11 pounds of the oxide for each bag of cement.

[2]Should contain not less than 15 per cent of the oxide.

is impossible to describe them adequately within the scope of this paper, but they are fully discussed in the recommended practice just referred to.

Where coloring material is added only mineral colors should be used and not over 10 per cent of color by weight of cement should be added. The accompanying table is a guide to the quantities of various colors required for light and medium shades of red, brown, buff, green and dark gray.

The foregoing discussion is, of necessity, only a brief discussion of fundamental features, and a thorough reading of Recommended Practice for Portland Cement Stucco of the American Concrete Institute is recommended to those desiring more detail information. The Portland Cement Association will be glad to supply copies to those of you who de-
"Very frequently hog lots are provided with a mudhole or hog
sire them.

In closing I quote the following from a letter by a Pittsburgh architect in support of the statements as to durability and attractiveness made at the beginning:

"In my practice of 36 years in which time I used Portland cement stucco extensively for exterior surfaces, I am convinced that when the material is properly prepared and applied there is no material superior to it for the exterior surface of buildings. There is permanence as well as architectural beauty. My convictions are well based on the fact that upward of a dozen houses of cement stucco on metal lath construction designed in my office and built under my supervision in the early nineties' are standing today not showing the least distintegration."

DISCUSSION

Mr. Stewart: Can we really expect the cement stucco on wood or metal lath to last for ten years without developing cracks on the flat surfaces along cracks?

Mr. Freeman: In the letter just read from the architect in Pittsburgh those buildings which he referred to as having been constructed in the early nineties (1892 or 1893) were of Portland cement stucco on metal lath construction, and examination made by one of Portland Cement Association's field engineers recently confirmed these statements which the architect made in his letter to the effect that the plastered surface was in practically the same condition as it was when applied. There was a marked freedom from cracks excepting around the coal hole which it might be natural to expect, with coal being shoveled into the building. It depends a great deal upon the character of the framing, the rigidity of the framing over which the lath is applied, as well as upon the care with which the plaster is applied to the lath.

In many cases the tendency might be in applying the plaster on metal lath, not to push it through the lath thoroughly enough. The idea has been that an air space between the sheathing and the plaster on the lath was desirable from the standpoint of insulation, but our investigations would indicate that the tar paper covering over the sheathing is sufficient, and really better insulation than such an air space would be, and if the lath is then applied to pencil rods, that is, quarter-inch rods, as recommended, and the plaster pushed through the lath so it thoroughly covers the lath on the inside, you will have the lath then imbedded completely in the plaster.

DESIGN OF OUTTAKE FLUES FOR STABLE VENTILATION*

By J. L. Strahan

Mem. A.S.A.E. Department of Rural Engineering, Massachusetts Agricultural College

FOR a number of years past it has been considered that the amount of air which should pass through a stable housing dairy cattle in order to maintain a proper degree of purity to the air is 59 cubic feet per minute per head of stock. This is merely another way of stating King's standard that not more than 3.3 per cent of the total amount of air in the room should be once breathed. Such air would contain 16 or 17 parts of carbon dioxide per 10,000, assuming that air coming from the lungs contains about 425 parts and pure air only 3 or 4 parts.

It has also been the practice to attempt to maintain this standard or at least to approximate it by means of a natural draft system which depends solely upon animal heat for its motive power. One of the purposes of this article is to discuss the possibility of attaining this end, and to justify certain assumptions which can be used to derive a formula which will be as simple as possible and still remain an adequate expression for the proper design of outtake flues.

It is a self-evident fact that, with the exception of the latent heat of vaporization, or that heat which holds the exhaled moisture in vapor form, all of the heat produced by stock in a closed room will be used either to warm the air passing through the room or else will be lost through the walls by radiation and conduction. It is reasonable, therefore, to state the heat conditions in formula form as follows:

(1) $H = D\ (.01848\ N\ V + h)$, in which H = total heat produced in B. t. u. per hour,

D = degrees of temperature difference between outside air and stable air,

N = number of cows,

V = volume of air required per cow per hour in cubic feet,

.01848 = B. t. u. required to raise one cubic foot of air through one degree Fahrenheit, or the product of .231 (specific heat of air) and .08 (weight of a cubic foot of air), and h = heat lost through walls in B. t. u. per hour per degree of temperature difference.

This formula may be algebraically transformed into either of the two following forms:

$$(2)\quad D = \frac{H}{.01848 \times N \times V + h},$$

which can be used to determine the limiting temperature

*Fifteenth annual meeting paper.

difference for a given stable that will maintain a given standard of air purity, or

$$(3) \quad V = \frac{H\text{-}Dh}{.01858 \times D \times N},$$

which can be used to determine the volume of air that can be passed through a given stable maintaining a given temperature difference.

The application of these formulae requires that the heat produced and the heat lost be known. To supply this data the following tables are prepared showing, first, the heat produced by dairy cows under different conditions and, second, the value for K, or the rate of heat transmitted in B. t. u. per hour per square foot for walls of various designs.

TABLE 1.—HEAT AVAILABLE FOR VENTILATION PRODUCED PER HOUR BY DIFFERENT BREEDS OF COWS UNDER DIFFERENT CONDITIONS

Breed	Condition	Calories of Heat Produced Per Hour (Armsby and Kriss)	B.t.u. Produced Per Hour
Jersey	Maintenance	306	1214
	20 lbs. milk	509	2020
	30 lbs. milk	571	2266
Holstein	Maintenance	381	1512
	30 lbs. milk	622	2468
	45 lbs. milk	700	2778

The figures in this table are computed from tables given in the paper entitled "Some Fundamentals of Stable Ventilation," by Armsby and Kriss, in the "Journal of Agricultural Research," June, 1921. (This paper was reprinted in the July and August, 1921, numbers of AGRICULTURAL ENGINEERING.)

TABLE 11.—VALUE OF K FOR COMPUTING HEAT LOSS THROUGH WALLS OF DAIRY STABLES

TYPE OF CONSTRUCTION	Value of K
Concrete—12 inches thick (solid)	.30
Concrete—8 inches thick (solid)	.40
Concrete—6 inches thick (solid)	.56
Stud Wall—(ceiled inside, double boarded, and papered outside.)	.25
Glass in windows—1 thickness	1.00
Glass in windows—2 thickness	.50
Stable ceiling insulated by hay in loft (probable)	.15

The figures in this table were computed from tables given in "Heating and Ventilating," by Hoffman, and "Heating and Ventilating Buildings," by Carpenter. Additional data on heat loss through walls are available through the efforts of the research department of the King Ventilating Company and others.

Applying these formulae to a specific case, the results will be somewhat as follows: Let us assume a stable 36 by 80 feet inside measurements housing forty cows, the walls being 8 feet high to the eaves and consisting of twelve inches of concrete to the window sills 3½ feet above the floor, and framed from this point to the plate, using 2-by-6-inch studs ceiled inside, and sheathed, papered and sided outside. The window space provides 4 square feet of single glass area per cow. The stable ceiling is insulated by the hay in the loft above during the cold months of the year. Assume also that the cows are Holsteins producing 45 pounds of milk per day per cow.

Under these conditions, the value of

$H = 40 \times 2778 = 111,120$ *B. t. u.* per hour

$h = (232 \times 3.5) \times .30 + (4 \times 40 \times 1) + (232 \times 4.5) - (4 \times 40) \times .25 + 2880 \times .15 = 957$ *B. t. u.* per hour per degree temperature difference

$V = 3452$ (Armsby & Kriss), or 3545 (King)

Substituting first in formula 2 we have

$$D = \frac{111120}{(.01848 \times 40 \times 3452) + 957} = 31.1 \text{ degrees}$$

From this computation it seems evident that a temperature difference of 31.1 degrees can be maintained in a well-built stable when large cows are kept at a maximum production and the wall space per cow is not above 46 square feet.

If small Jersey cows in low production were kept in this same stable, the temperature difference would be considerably reduced owing to the reduction in the amount of heat produced. It could be determined by using the same formula and substituting the new value for *H*.

$$D = \frac{80800}{(.01848 \times 40 \times 3452) + 957} = 22.3 \quad \text{degrees}$$

In this case the temperature could not be kept above freezing in zero weather without reducing the flow of air and thereby increasing the carbon dioxide content. The flow of air that could be allowed the Jersey cows and still expect them to maintain a temperature difference of 31.1 degrees, or the same *D* as was held by the Holsteins, can be determined by using formula 3. Thus

$$V = \frac{80800 - (957 \times 31.1)}{.01848 \times 40 \times 31.1} = 2220 \text{ cubic feet per hour.}$$

The reduction in air circulation in this case would be equivalent to $3452 - 2220 = 1232$ cubic feet per hour per cow, and would raise the volume of air in the stable once breathed from 3.3 to 5.1 per cent, thereby raising the carbon dioxide content from .167 volume to .248 volume per cent.

From the foregoing computations it is evident that when Holsteins in high production are housed in a stable of this sort it will be reasonable to expect them to maintain a temperature above freezing in zero weather and at the same time maintain reasonable ventilation conditions. On the other hand, if Jerseys in low production are housed, the stable temperature will drop below 32 degrees as soon as the outside temperature goes below 6 degrees above zero if the same rate of air flow through the stable is maintained. The air flow will have to be reduced over 1200 cubic feet per cow per hour in order to keep the inside temperature up. This will have the effect of lowering the ventilation standard a very considerable amount. Instead of 3.3 per cent of air once breathed there will be 5.1 per cent. Instead of 16.7 parts per 10,000 of carbon dioxide there will be present in the air 24.5 parts, an increase of approximately 33 per cent. Just how serious such a condition will be to the cows is questionable. It is probable that they will not suffer sufficiently to warrant the installation of a heating plant to make up the heat deficiency because such a condition will last only as long as the temperature remains around zero, and such will probably not be the case for long periods of time.

It can be shown by the use of formula 2 that small Jersey cows on maintenance alone can maintain a temperature difference of from 15 to 17 degrees in well-constructed stables. This is probably the smallest heat-producing plant that need ever be designed for and it would occur only very rarely. In the large majority of stables the cows will be in part at least producing some milk and therefore additional heat, and it seems therefore reasonable to state that for average conditions 20 degrees will be the smallest temperature difference that will ever occur as a maximum. In other words, any dairy herd will be able to maintain at least 20 degrees temperature difference in a well-built stable. In a large number, perhaps the great majority of cases, the maximum possible temperature difference that can easily be maintained will be above 35 degrees and in some cases will run up to 35 degrees or more. (By maximum temperature difference is meant that which can be maintained compatible with an air flow of 3452 cubic feet per hour per cow unit.) Of course, during cold periods the temperature inside can be kept above freezing at the expense of air purity as has been shown.

This being the case it is not unreasonable to assume that outtake flues may be designed to pass the required amount of air through a stable at a minimum temperature difference of 20 degrees. At smaller temperature differences, the ventilation system need not be expected to operate because air can then be supplied through doors and windows without danger of lowering the temperature of the stable below freezing.

Additional draft caused by wind blowing over the top of the flue should not be counted on to increase the air circulation in the stable over and above what will occur as a result of the maximum allowable temperature difference, because obviously any increase in the rate of air flow through the stable will have the effect of lowering the temperature. If, therefore, it is desired to maintain the temperature difference constant throughout alternate periods of high wind and no wind, it will be necessary to dampen down the flue (decrease its effective sectional area) while the wind is blowing, thus nullifying this effect.

Flues designed to pass the proper amount of air through the stable at 20 degrees temperature difference without the addition of motive power due to a wind over the top, will be efficiently operative at the time when draft producing power is at a minimum. They should be provided with dampers to

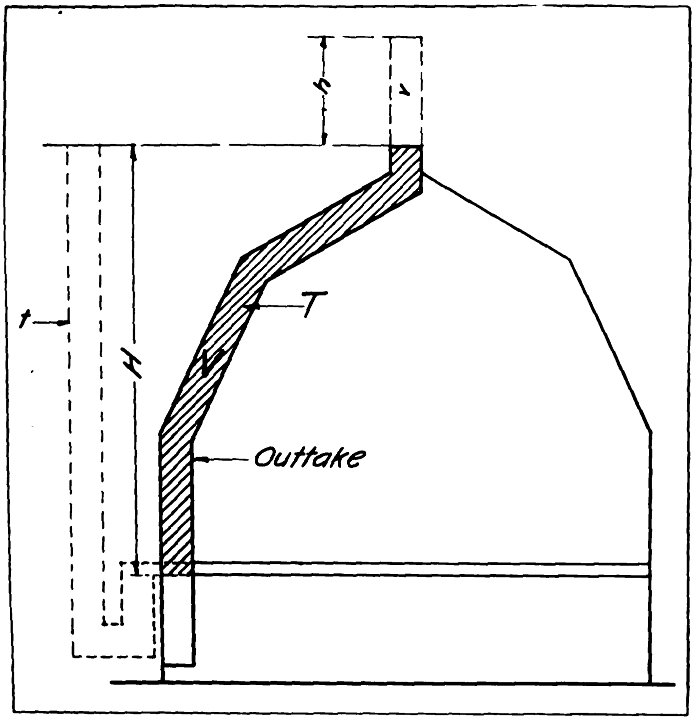


Diagram showing essential dimensions of outtakes reduce their section at such times as the temperature difference increases or the wind is blowing thus preventing an unnecessarily high rate of flow through them.

Having attempted to establish the reasonableness of 20 degrees as a temperature difference to be used in design, let us consider the problem of determining the proper size of flue for a given set of conditions.

In the accompanying drawing let H equal the height of a foul air flue in which, if there were no temperature difference, the column of air would be exactly balanced by an equal column of outside air entering the stable at the ceiling. Suppose now that the air in the flue becomes warmed to a temperature of T degrees, the outside temperature remaining at t degrees. The flue air will expand a definite amount depending upon its absolute temperature before and after warming, and in its rarified condition would require a column equal to h in addition to its original volume to balance exactly the original outside column. In other words, the weight of an outside column of air equal in volume to v would, acting under gravity, through a head equal to h be the force producing an upward flow in the flue, disregarding friction for the moment.

The volumes of these columns are proportional to their heights, therefore,

$$V : V + v = H : H + h$$

Also the volumes are proportional to the absolute temperatures before and after warming. Thus

$V : V + v = 460 + t : 460 + T$

Hence, $H : H + h = 460 + \mathrm{t} : 460 + T$.

(1) Algebraically, $h = \dfrac{H\ (T - t)}{460 + t}$.

The formula to determine the velocity of falling bodies

is (2) $v = \sqrt{2\ g\ h}$

Considering air as the falling body and h in the figure the distance through which it falls, or its head, we can substitute its value in the velocity formula, from which we see that

$$V = \sqrt{\frac{2\ g\ H\ (T - t)}{460 + t}}$$

and $V = 8.02 \sqrt{\dfrac{H\ (T\text{-}t)}{460 + t}}$

We have already seen that 20 degrees will be a reasonable temperature difference for which to design and we can further assume with propriety that in time when the system is first expected to operate in the fall will be when t, the temperature outside, is just about or slightly below freezing. Substituting these values in the formula we have

$$V = 8.02\sqrt{\frac{20\,H}{460 + 30}} = 1.63\sqrt{H} \text{ feet per second, or}$$

(3) $V = 60 \times 60 \times 1.63\sqrt{H} = 5868\sqrt{H}$ feet per hour.

If air were passing through a 12-by-12-inch flue at the rate of V linear feet per hour, then the rate at which air would be drawn from a room through it would be V cubic feet per hour, neglecting friction in the flue. V can, therefore, be stated as the rate of change of air in cubic feet per hour through a one foot square flue, thus

(4) $V = 5868\sqrt{H}$ cubic feet per hour through 12-by-12-inch flue.

It has been customary in the past to assume that the actual flow of air through a flue as ordinarily installed in a barn would be one-half the theoretical flow, although this amount of variation will undoubtedly differ in flues of different shapes, length and construction. Lacking any other definite figures resulting from authentic experimentation, however, and in view of the fact that up to the present this "factor of safety" has proved adequate it will be retained here, and being incorporated into formula 4 makes it read.

(5) $V = 2934\sqrt{H}$ cubic feet per hour through 12-by-12-inch flue.

If the cow capacity of the stable is known, the amount of air to be passed through each hour can be found by simply multiplying the rate per cow by the number of cow units, thus (6) Total air flow per hour$=3452\ N$, where N=number of cow units of stable capacity.

If formula 5 states the rate of change through a 12-by-12-inch flue and formula 6 states the total rate of change required, then obviously the number of square feet of total flue area required can be found by dividing formula 6 by formula 5, thus

(7) $A = \dfrac{3452\ N}{2934\sqrt{H}}$ = square feet of flue area required for the stable.

But it is desirable, in order to simplify later computations, to have this area stated in square inches rather than square feet. This can be accomplished by multiplying formula 7 by 144, thus

$$(8)\ A = \frac{144 \times 3452\, N}{2934 \sqrt{H}} = \text{square inches of flue area required for}$$

the stable.

Bringing this formula to its simplest form it becomes

$$(9)\ A = \frac{170\, N}{\sqrt{H}} = \text{square inches of flue area required for}$$

the stable, in which
N=number of cow units stable capacity, and
H=difference in elevation in feet between the point where the fresh air enters the stable and the point where the foul air leaves the outtake flue.

It is evident then that, in order to use this formula, it is necessary to know only the number of cows or cow units that the stable is capable of housing and the height of the ridge of the roof above the ceiling of the stable in the case of the King system, and above the floor of the stable in the case of the Rutherford system. The results will be a statement of the total flue area required and not of the number of flues. This must be determined by the designer to suit the individual requirements of the case, and inasmuch as these requirements may present almost infinite variations, no definite rule can be laid down. In general, however, it has been found good practice to place flues not farther apart than 30 feet and to have them in opposite pairs, each pair outletting through one ventilator head on the ridge.

The use of this formula should be strictly reserved for cases where the air space per animal housed does not run over 1000 cubic feet, because in such a case there is not sufficient animal heat to maintain the temperature difference designed for. This would exclude calf barns and maternity stables in which the plan consists of a series of box stalls.

DISCUSSION

QUESTION: Was the heat loss indicated just enough air to give that ventilation, or did you allow for any additional leakage?

MR. GUNNESS: The calculations were made on the assumption that air entered the stable at the rate of 3452.

MR. KELLEY: There is one point I observed in regard to the use of the coefficient 0.01848. The direct derivation of this coefficient, of course, is not shown here, for the sake of brevity, but is based upon the unit of using 0.8 as the weight of air at 70 degrees, which reduces to 55 the cubic feet of air that one B. t. u. will raise one degree.

Basing our assumption on 70 degrees removes it entirely from barn temperatures because we seldom experience any such temperature in the barn.

If we use the average of those temperatures (36 to 56 degrees) which we may anticipate in the barn, it reduces the number of cubic feet to a little more than 52, rather than 55.

There is a question for debate in regard to the heat units given off by Holsteins and Jerseys. The heat units given in the table are based not on the total heat production as given in the Armsby article, but on a unit 25 per cent less than the total heat production. If we use the unit of 25 per cent less we get into more difficulty in our interpretation of heat losses from buildings, and if I should use that same factor, I would reduce the heat estimated generated by the animals in the barn and the heat loss through the walls in every case. Even as it is, with the 25 per cent more heat estimated, in six cases I had a negative heat loss, that is, a greater heat loss than was estimated produced.

Now whether we are correct in that assumption or not, I am unable to say. Until we secure further data and further tests on that particular line, of course we cannot determine that.

I wanted to bring out some of the difficulties that ventilation engineers are up against, and upon which the Farm Buildings Ventilation Committee has tried to secure data for agricultural engineers in order to get them a little more tangible information as a basis for design.

MR. STEWART: It seems to me that we haven't had any new contribution in that last equation. I believe we haven't gotten a step further than where King was years ago. If you will substitute for N one animal, and substitute for H in the last equation your height of 30 feet, dividing 170 by 5.5, you get the area of the flues to be 30 square inches flue area required for a cow with a ventilator 30 feet high.

MR. FENTON: One other thing that we get out of that is that a difference in temperature of 20 degrees is much less than that King assumed in arriving at his 30 square inches.

MR. STEWART: If we assume that we can keep the temperature inside above freezing when the temperatures outside are 10 degrees above, we can use that amount of ventilation. Then if we drop the temperature outdoors to zero it means in the same barn we will have to reduce our amount of ventilation to about 2700 instead of 3500. We can work out the ratio in which that has to be dropped entirely by the ratio of the amount of heat that will have to be taken out at temperatures above freezing.

MR. CLARKSON: I think if you will refer back to the report of the committee—I am pretty sure it was four years ago—and if you will note in that report, the report of the test on the A. N. Sweatman barn, near Zealandia, Saskatchewan, you will see that some of your figures will need revising before you get down to the real basis of facts.

FARM BUILDING VENTILATION AND SOME RELATED FACTORS*

By W. B. Clarkson

Mem. A.S.A.E. Director of Research and Extension, King Ventilating Company

As an introduction to the relation which ventilation bears to the whole subject of farm structures, it seems desirable to describe the conditions which led to a study of this question. The greater part of the work that has been done on the ventilation of farm buildings has been done within the past twenty years. During this time the most remarkable advances have been made in recognizing and in solving the problems which the farmer is forced to overcome in order to obtain sanitary conditions in his barn.

The conditions which led to the study of ventilation and building construction in order to obtain sanitary conditions in farm buildings were very practical difficulties, and they are still present in a large number of the animal shelters on the farms of this country.

When one went into a barn filled with animals which was not ventilated the sensation was very unpleasant. The air of the room was foul smelling and oppressive because of its dampness; the floors were filthy and unsanitary; the walls were damp and covered with frost or moisture, and the temperature conditions were very uneven.

When the door of such a barn was opened the foul, damp air rushed out, and because the outside air was colder a cloud of steam was formed by the condensation. This at once suggested that a circulation of air could be used to do away with some of the foul conditions in the barn.

The problem with which we have to deal is the removal of these bad conditions. Ventilation is the principal factor in the removal of foul conditions. Yet the assumption should not be made that ventilation is the complete remedy for all of these bad conditions.

While the subject of this discussion is primarily the ventilation of farm buildings, the fact that other factors are in themselves related to ventilation in the obtaining of sanitary conditions forces us to study them in connection with ventilation.

It was mentioned above that one of the conditions in the barn was the filthy condition of the floor. This problem has been worked on a great deal, and now the flooring of animal shelters is considered a success. A smooth, hard, solid, and nonabsorbent surface has been found necessary and these are the kind of floors that are being built in modern

*One section of the 1921 report of the Committee on Farm Building Ventilation.

dairy barns. However, the obtaining of a sanitary floor is not apart from ventilation because, in order that a floor may be dry, the air must be relieved of the excessive moisture thrown into it by the stock.

Because of the relation of the animal life within the building and the plan and construction of the building itself to the conditions of sanitation, the work of your committee in studying farm building ventilation has divided itself into at least four separate fields. These were discussed in the last several annual reports of this committee, but it seems worth while now to divide them more carefully and to give the report of our progress along these separate lines. These as they appear to us:

1. Relation between the animal life and the condition of the stable air
2. Climatic conditions which affect ventilation
3. The relation of barn construction to sanitation
4. Design of ventilating apparatus

The information that has been published within the past year on this subject is one of the greatest marks of progress that your committee has been able to report for the past several years. "Some Fundamentals of Stable Ventilation," by Henry Prentiss Armsby and Max Kriss, director and associate, respectively, of the Institute of Animal Nutrition, Pennsylvania State College, has furnished definite data showing the production of heat carbon dioxide, and moisture by typical farm animals. (This article was published in the June number of the "Journal of Agricultural Research" of the U. S. Department of Agriculture, and reprinted in the July and August, 1921, numbers of AGRICULTURAL ENGINEERING.) This work was undertaken upon the initiative and with the cooperation of the chairman of this committee, and the results are practical in every way for use in our study of farm-building ventilation and also in the application of ventilation to the individual barn. Without reviewing the subject matter of the article further, it seems advisable to discuss in detail the application of this most valuable data.

The most fundamental basis for judging the sanitation of a barn found so far is the use of the animal heat. The data presented by Dr. Armsby enables us to estimate within very reasonable limits the amount of heat produced by a herd of cattle or other animals that are housed in a stable. This is done by computing the maintenance ration for animals of the size that are in the barn and then adding the heat due to the food consumed in excess to that required for maintenance.

The question which confronts the agricultural engineer is, What can be accomplished with this heat? The answer to this question is that it must, under practical circumstances, keep the barn at a comfortable degree of temperature and provide a motive power for a sufficient amount of air circulation to keep the stable air pure.

Under the heading of the relation of the animal life to the stable air conditions, the question of the most desirable temperature of the stable air for each of the farm animals immediately presents itself. We must admit at the outset that there is a great deal of further research work to be done on this subject. Yet there are certain sources of information available now and it is necessary for us as engineers to use these until further research has been made by those who are interested primarily in animal husbandry.

From a theoretical and pure research standpoint the information bearing on this subject is that for each animal there is a critical temperature at which the production of heat is minimum and at which the utilization of feed for maintenance and production is optimum. It is not known exactly what is the critical temperature for all of the several farm animals and this is another point upon which we have still to wait further information.

However, we are not wanting for a great deal of practical information as to the desirable temperature for the stable air. In order to get the information that is in the hands of the animal husbandry men of today into tangible form, the chairman of this committee sent out during the past year a questionnaire to the animal husbandry departments of several state agricultural colleges of this country and Canada. The questions were on the desirable temperature for dairy barns. The replies came back almost uniformly recommending a temperature of from 40 to 45 degrees in the northern part of the country and from 45 to 50 degrees in the central portion of the United States. The replies came from about thirty of the heads of animal husbandry departments, and can be taken as a sound, practical index of the opinion on the subject today.

It has also been the observation of this committee that from a practical standpoint it is possible to maintain this temperature with a good amount of circulation.

Still another question that arises is the purity of barn air which should be maintained. As stated by Prof. F. H. King, "The real problem with which we have finally to deal is how nearly can we maintain the air of dwellings and stables at the normal out-of-door fresh air purity with practicable economy." This Society has already adopted a standard circulation of air as desirable, but it should not be lost sight of that fresh air is very vital to the health and production of the animals and a larger circulation may still be practicable in some cases. For this reason we should not lose sight of the fact that there is still a great need of research to determine the practical requirements for ventilation.

The other measure which we have at present of the ventilation of the stable is the amount of moisture present in the air of the stable room compared with the moisture in the outside air. Insofar as this is connected with the relation of animal life to the stable air conditions it is through the amount of moisture produced by the animals themselves and with the effect of this moisture on the health and production when it is not removed by the animals has been covered very thoroughly by Dr. Armsby in the article above referred to. As far as we know the effect of this excessive moisture on the health and production of the animals has not been studied from a purely scientific standpoint, and here again the results that we are able to find are from a practical standpoint.

It has been the experience of many livestock owners that the excessive moisture of the stable air is detrimental to the keeping of the coats of the animals in good shape as the excessive moisture causes the coats to shed prematurely. It has also been the experience of dairymen that animals which partially shed in this manner and which had been housed in excessively warm stables in the fall fell off a great deal in production when a cold snap came.

The factors to be considered in regard to climate when studying the ventilation of barns are (1) the minimum temperature likely to be experienced, (2) the temperature at which the ventilating system will be called upon to operate during the greater portion of the winter season, and (3) the temperature conditions which will require the minimum capacity of the ventilating system.

It is at once evident that the division of the country into zones with respect to similar climatic conditions enables us to make a close estimate of these conditions to apply to an animal shelter in any particular part of the country. The United States Weather Bureau has prepared maps, some of them at the request of the chairman of this committee, which show us definitely the temperature conditions that can be expected in the different climates.

The third question, as to the maximum outside temperature at which the system will be expected to operate, is not so easily answered. It has been definitely found that many farmers keep their animals in the barn in the spring when the outside temperature is at least 50 degrees. This means that the capacity of the system must be very large in order to remove the excessive heat and moisture.

The relation of this condition to the ventilation of the building comes under the head of the design of ventilating apparatus, rather than the relation of the climatic conditions. It, therefore, seems best to leave the subject of climatic conditions with these few statements of general summary.

RELATION OF BARN CONSTRUCTION TO SANITATION*

By C. S. Whitnah

Jun. A.S.A.E. Associate Research and Extension, King Ventilating Company

THERE are two distinct reasons why the plan and construction of the farm structures in which animals are housed are intimately related to the ventilation. One is that the ventilating system, if planned at the same time as the building, can be installed so that it will have maximum efficiency and convenience in handling the animals in the building; the second is that the loss of heat through the walls makes the stock room cool off and, if excessive, causes condensation.

There has been some confusion in the past among students of ventilation and the construction of farm buildings about the necessity of warmly insulated walls in order to obtain sanitary conditions in the stable room. This confusion has arisen, largely from the taking of the maintenance of a desirable temperature as the only basis for the need for a warmly insulated wall. It must be remembered that the condensation of moisture on the inside of the wall occurs only when the temperature of this inside surface is lower than the dewpoint of the air.

Aside from the question of the maintaining of a desirable temperature, it has been found necessary to insulate the walls of the room in order to keep them dry and free from frost.

These are primary essentials for the housing of farm animals. The influence of damp walls, frost-covered windows, and dripping ceilings is bad for the health of the animals. If the walls are wet they are bound to be dirty and unsightly and to foster the presence of disease germs and so act to destroy the building. It is true that there is some controversy in regard to the exact values to be applied in some cases, and yet the results that are being obtained by installing radiation in proportion to the amount of heat loss and ventilation, have worked out so successfully that there is no room for criticising this method. It is well known that this has been used in all types of heating and ventilating, except farm buildings.

The practice of heating buildings by artificial heat differs from the application of the estimation of heat loss from animal shelters, in that, in the first case the amount of radiation can be varied to suit the case and in the second case, the

*A portion of the report of the Subcommittee on Farm Building Ventilation presented at the fifteenth annual meeting of the Society, Chicago, December, 1921.

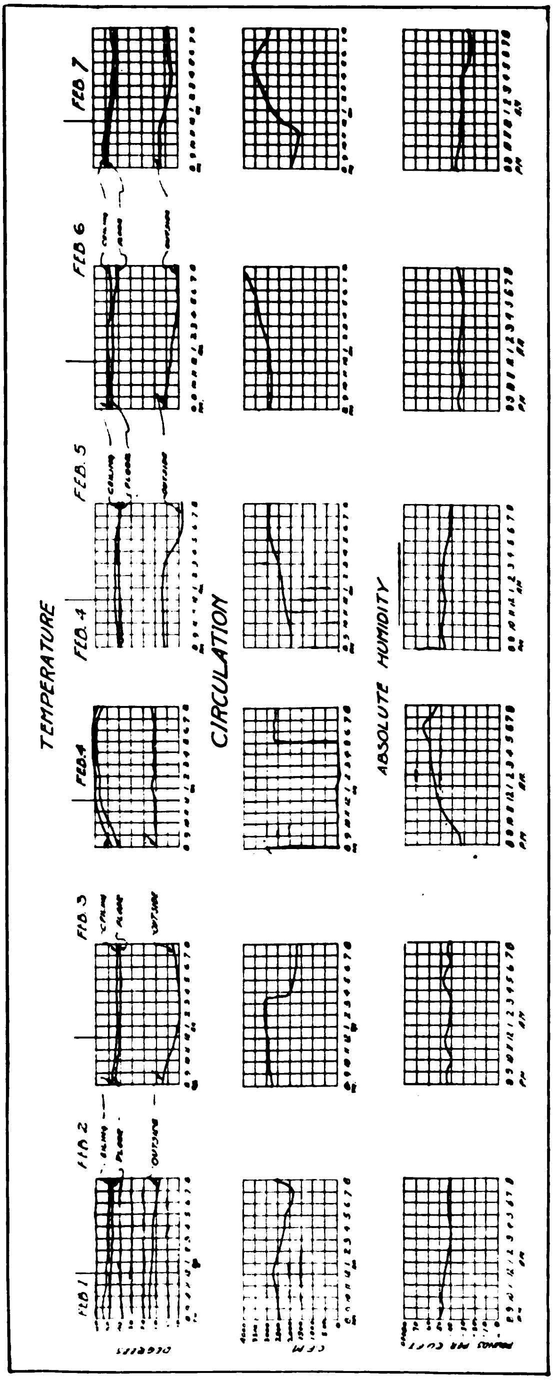


Fig. 3. Inside and outside temperatures, circulation, and absolute humidity in barn No. 1 for six nights

amount of heat is constant and the construction must be varied to suit the needs.

It is the use of this heat which must be varied, because the production of the heat of animals does not vary within wide ranges. While in the artificially heated building, the estimate of the heat loss is the basis for the installing of a heating plant, in the animal shelter the heat loss must be considered first in designing the barn so that there will be sufficient animal heat to keep the barn warm, and, second, in the actual construction of the walls so that they are within the limits required to retain the heat so that there will be a comfortable temperature.

It is thus evident that the sanitation of the barn which is primarily dependent on the ventilation is inseparable from the study of building construction and the production of animal heat.

I will give in detail the problem of working out heat balances in two barns, and in so doing will attempt to illustrate the influence of the various factors involved upon the ventilation of animal shelter.

Barn No. 1 (Fig. 1, exterior; Fig. 2 floor plan) is a very well arranged barn from the standpoint of animal heat. There are only 476 cubic feet of air for each animal to heat so that this barn is very well heated. This should be borne in mind throughout the study of this test. This barn contained twenty-six purebred Guernsey milk cows, averaging 800 pounds each; twenty-two heifers, averaging 650 pounds; one bull weighing 1600 pounds; seven small calves, and one yearling. The estimated heat production is:

$2200 \times 26 = 57{,}200$
$2000 \times 22 = 44{,}000$
$1 \times 3100 = 3{,}100$
$1000 \times 7 = 7{,}000$
$1 \times 1800 = 1{,}800$

Total ....113,100 B.t.u. per hour.

HEAT LOSS: Walls—860 (square feet exposed to outside air) $\times$ .48 = 461
Windows—111.5 (square feet) $\times$ 1.10 = 123
Doors—80 (square feet) $\times$ .55 = 44
Total heat loss = 628 B.t.u. per degree difference in temperature.

Then the estimated temperature difference, allowing for 59 cubic feet per minute per cow ventilation, is:

$$\frac{113{,}100}{628 + \dfrac{50 \times 60 \times 59}{55}} = 29.4 \text{ degrees}$$

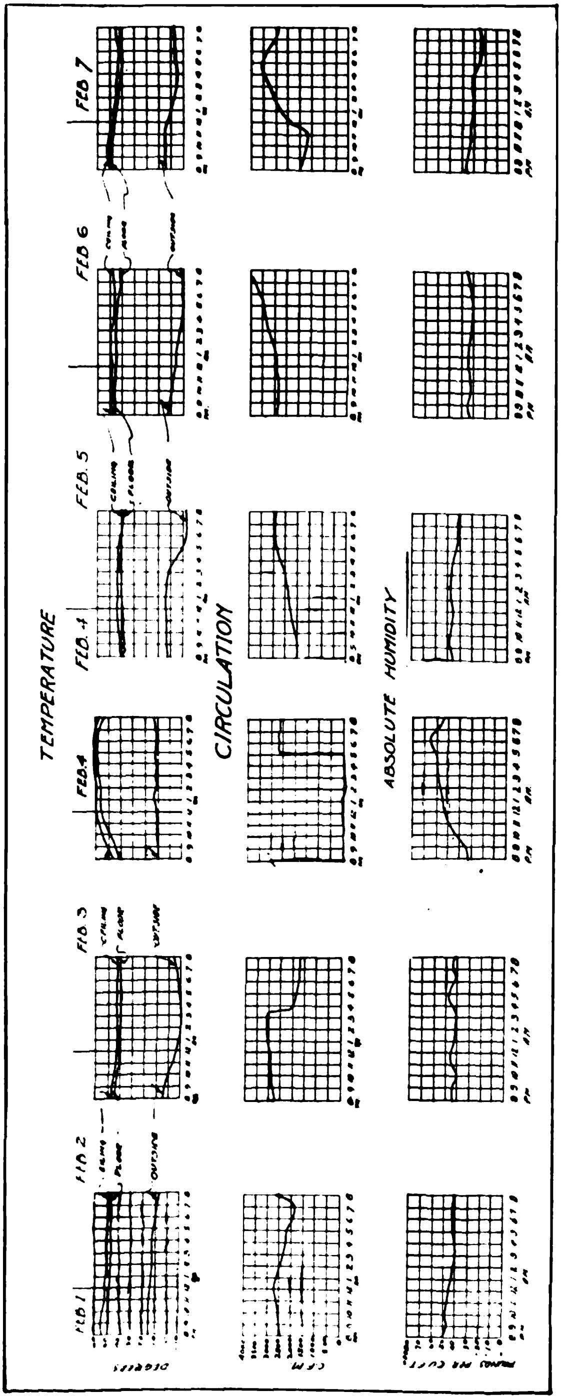


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Fig. 1. Exterior of barn No. 1 as mentioned in text

There is a wide range in the amount of temperature difference that can be expected in barns. The only way that the temperature difference could be made greater is either to insulate the walls more carefully or to house more animals or larger animals so that more animal heat is made within the barn room.

The heat loss through the ceiling and also the floor was disregarded because the ceiling was covered with a large amount of hay and the heat loss must have been very small and the floor, being concrete, directly on the earth and far below the surface of the ground could not have caused a great heat loss.

Fig. 3 shows the actual record of the temperature, circulation and absolute humidity in this barn. This is for the night period only, of six consecutive days. It will be noticed that the temperature difference varied from less than 30 degrees up to 50 degrees. This makes it evident that the temperature difference that will occur at any time is subject to many variations, but comparison of this test with the other tests shows that the analysis of the heat loss is a valuable index to what may be expected in actual conditions.

The test on the night of February 4 shows the actual condition which occurred when the ventilating system was closed off. It will be noticed that the temperature rose some 16 degrees and that the absolute humidity rose to double its value before the system was closed so that the room was excessively hot and very uncomfortable due to the presence of a great amount of moisture.

The purpose of this chart is to show that the actual temperature difference agreed with the estimated temperature difference substantially, and also to show that the conditions of the air in the barn was absolutely under the control of the ventilating system.

It is worthy of note that the circulation was continuous and of ample capacity to remove the excessive moisture when

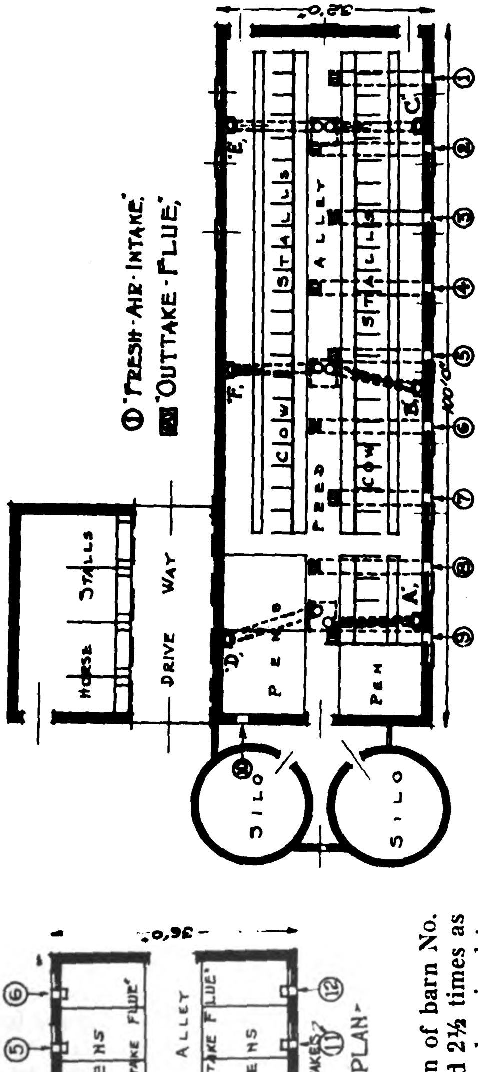


Fig. 2. Floor plan of barn No. 1, showing location of ducts

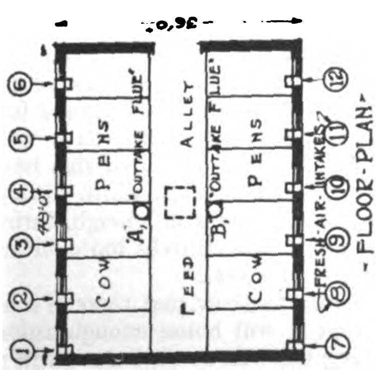


Fig. 4. Floor plan of barn No. 2 which contained 2½ times as much space for each animal to heat as barn No. 1

the system was left open and that the temperature was under the control of the ventilating system.

It is also interesting to know that on the night of February 4 when the outside temperature went to about 15 degrees below zero that the inside temperature remained practically constant, although the circulation increased with the falling temperature, and that the humidity was kept at approximately the same value as before.

The direct contrast to this barn is barn No. 2, shown in floor plan by Fig. 4. This barn was 36 by 48 feet and provided box pens for twelve test cows. It is in contrast to barn No. 1 in that the space for each cow to heat is 1230 cubic feet or two-and-one-half times as much as barn No. 1.

The difference in the condition of these two barns can be traced to this factor.

It was estimated that the twelve cows in this barn could produce 24,533 B.t.u. per hour. The heat loss through the walls was estimated at $1205 \times .26$, or 313 B.t.u. per hour per degree difference in temperature. For the windows the heat loss was estimated at 160×1.10, or 176 B.t.u. per degree difference in temperature and hour. Through the doors it was estimated to be $120 \times .42$, or 50 B.t.u. per hour. The total loss was 539 B.t.u. per hour per degree difference in temperature.

The estimated temperature difference was:

$$\frac{24{,}533}{539 + \dfrac{12 \times 59 \times 60}{55}} = 18.7 \text{ degrees.}$$

Comparing this estimated temperature difference of 18.7 degrees to the actual conditions, we find that it agrees very closely.

The difference in these two barns was not in the ventilating system because the system was approximately as well designed for one barn as for the other. The difference was in the ability to keep barn No. 1 warm and the lack of this ability in barn No. 2. Barn No. 2 was of more expensive construction because of the great amount of space for each animal, yet the sanitary conditions in this barn were not equal to those in barn No. 1. The owner of this barn was dissatisfied because it could not be kept warm during cold weather. Although this barn was warm enough during this test, during severe weather it was entirely too cold and the reason for this shows up in this test.

The tests of these two barns show that there is a need of designing the barn so that it will house enough animals to keep it warm and building the wall so that there will not be excessive heat loss through it.

In the arrangement of the floor plan of a barn it is well to remember that the lowest convenient height is about eight feet and that with this height a floor area of 75 square feet for each animal is allowable to come within the limit of 600 cubic feet per animal. When this is exceeded as in the illustration of barn No. 2, the building cannot be expected to be warm.

Condensation can be prevented by keeping the absolute humidity low and by good insulation. The continuous production of moisture by the animals requires a continuous circulation of air to remove the moisture. The greater the difference in the absolute humidity of the inside air and the outside air, the less circulation is required to prevent the accumulation of moisture. In other words, the greater the circulation, the more nearly the absolute humidity can be maintained at the dry condition of the outside air.

In barn No. 1 the 50 head of stock probably produced about 30 pounds of moisture per hour. The circulation of 177,100 cubic feet per hour, about the average of the test, would remove this amount of moisture at a difference of 30 ÷ 177,000, or 1.00017 pounds per cubic foot.

Actually, the absolute humidity inside of the barn was maintained at from 0.0003 to 0.0005 pounds per cubic foot. The maximum moisture content of air at zero degrees, about the temperature of the outside air at the time of the test, is 0.00008 pounds per cubic foot, so the actual difference between the humidity of the inside air and the outside air was not less than 0.00022 pounds per cubic foot during zero weather.

It is thus seen that the moisture content of the stable air can be reduced by increasing the amount of circulating air. The limit to which the amount of circulating air can be increased is limited by the loss of animal heat through the walls.

Because the absolute humidity of the air inside of the building must always be greater than that of the air outside, the walls must be well insulated so that the inside surface of the walls is not much colder than the air inside of the barn. If it is above the dewpoint of the inside air, no moisture will condense.

A NEW SYSTEM OF BARN VENTILATION*

By L. J. Smith

Member A.S.A.E. Professor in charge of Agricultural Engineering, State College of Washington

THIS is a preliminary report of a test made of W. J. Smith's barn north of Portage La Prairie, Manitoba, in the winter of 1920. I had hoped previous to coming to Washington to have gone into the matter of this type of ventilation more fully, especially because the fact that the barn itself was not properly equipped to carry out the test in a highly satisfactory manner. The material presented will be of special interest because it involves a new principle in ventilation which may or may not be of considerable importance, namely, that of introducing a comparatively small portion of cold dry outside air into the outtake flue which outside air in warming and expanding will take up a large proportion of the moisture in the warm, moist, outgoing air, thereby making it possible to get rid of that air without condensation in a fairly poor outtake flue. The accompanying sketch, Fig. 1, will give a good idea of the system employed.

The outtake flue consisted merely in boarding up the pair of two-by-five rafters and two-by-four studding, carrying the flue to the peak of the barn where it was connected to a rather crude galvanized iron cowl. This cowl was clogged up quite noticeably with frost at the time of the test, and I think had some influence on the tendency for the flue to back draft, which was done to a certain extent but not seriously.

Mr. Smith came into my office one day in the summer previous to the test to explain the system to me and tell what it would do. He has a great deal of faith in this system, of course, and it has attracted quite a considerable amount of favorable attention among the veterinarians in that part of the province. I was, of course, very skeptical in regard to the possibility of carrying moist, warm air from the stable up between a pair of studding and out through the roof of the barn without the crude flue becoming filled with frost. I was quite surprised, however, during the test to find that while there was some dripping found from the outtake flue, which was built very crudely indeed, yet it did not fill with frost during the severe temperatures indicated in the report. The weather conditions before and after the time of the test were equally severe being below zero all of the time. The results in the report of the test are rather meager, but they are indicative of the possibility of something worth while in this

*A portion of the report of the Subcommittee of Farm Building Ventilation presented at the fifteenth annual meeting.

type of outgoing flue, and Subcommittee on Ventilation of this Society might do well to look rather carefully into the matter of just what effect cold dry air has when mixed with warm, moist air in an outgoing flue. This is a matter to be handled from the physicists standpoint and I think our committee may find it rather interesting.

BARN DATA

Date of test: January 20 and 21, 1920.

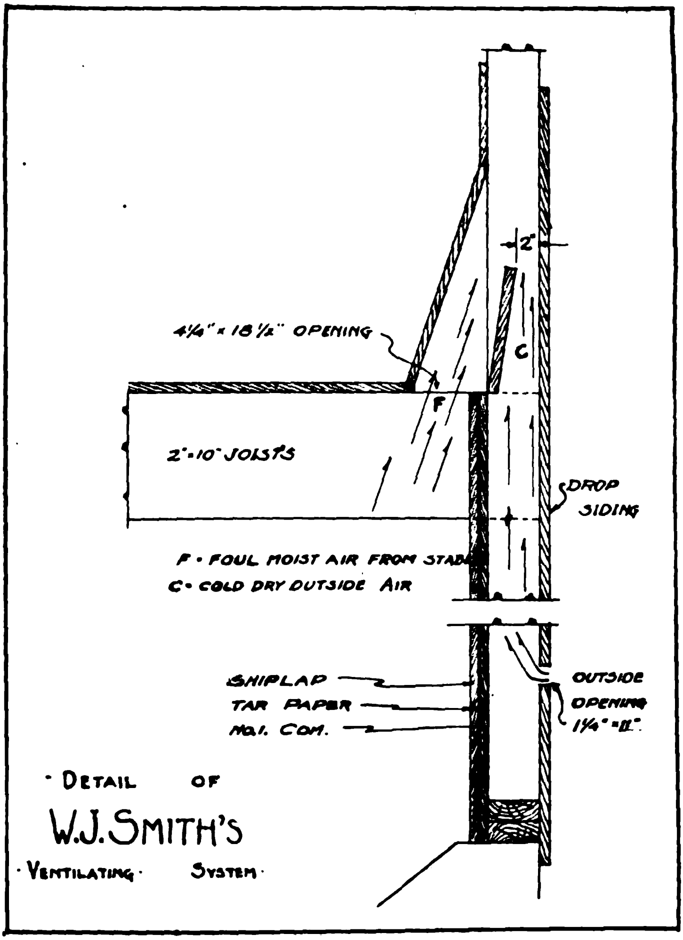
Type Barn: Saddle Roof with loft.

Capacity: 20 horses and 6 cows.

Volume: 14,040 cubic feet, 540 cubic feet per animal.

Height of stable: 9 feet to under side of loft floor.

Construction: 2x4 studs, 2x5 rafters, drop siding outside studs, common boards, tar paper and shiplap on inside studs. Studs and rafters, 24 inches on centers. Loft floor,



shiplap only, no ceiling under loft joist. Note: Loft floor thinly covered with average of one foot of sheaves and straw. The average temperature for 24 hours was 44 degrees Fahrenheit. Greatest variation, 5 degrees dropping to 40 degrees while cleaning out barn.

RESULTS OF TESTS

Afternoon of Tuesday, January 20,1920, (1:50 to 4:45)

Wind southwest, steady until about 5 P.M., then changed to west with velocity 10 to 11 miles per hour.

Outside temperature--1:15 P.M. zero; 4 P.M. 2 degrees below zero; 5:15 P.M. 5 degrees below zero.

Inside temperature—average about 44 degrees Fahrenheit.

Outtake flues open, 2; intake flues open, none.

Change of air per hour, 1.41 (average of 8 flue tests).

Cubic feet per hour per animal (25 in stable)—792.

Average volume through each outtake flue per minute—165 cubic feet.

Greatest variation from average—9.7 cubic feet.

Note: 25 animals in stable until 4:30 when one additional horse came in.

Evening of Tuesday, January 20, 1920, (8:30 to 9:55).

Wind—At 8:15 slightly south of west and same velocity; at 10 P.M. slightly north of west, velocity 7 to 8 miles an hour.

Outside temperature—8:20 P.M., 9 degrees below zero; 10 P.M., 10 degrees below.

Inside temperature—average 45 degrees.

Relative humidity at 8:30, 93; at 10 P. M., 89.

Outtake flues open, 2; intake flues open, none.

Changes of air per hour—1.24 (average of 15 flue tests).

Cubic Feet per hour per animal—670.

Average volume through each outtake flue per minute 145 cubic feet.

Greatest variation from average—14 cubic feet.

Morning of Wednesday, January 21, 1920, (8:55 to 10:00)

Wind—light, west.

Outside temperature—At 8 A.M., 22 degrees below zero; at 12 o'clock noon, 7 degrees below zero.

Minimum temperature—24 degrees below zero.

Inside temperature--average 44 degrees Fahrenheit.

Relative humidity—93 at noon.

Outtake flues open—2 (No intake flues).

Changes of air per hour, 1.03 (average of 19 flue tests).

Cubic feet per hour per animal (25 in stable)—580.

Greatest minimum variation from average—14.2 cubic feet. Tests on flue No. 1 (10:09 to 10:20).

Average volume per minute of six tests—101 cubic feet.

At times during the morning the foul air was backdrafting down from the stable and out the cold air intake slots of the outtake flues. A slight frost about these slots showed that this had occurred to a certain extent during the night. During all the tests, however, there was no evidence of the outtake flues backdrafting into the stable.

In the milder parts of the country we should more and more emphasize the necessity of ventilation from the standpoint of avoiding a stagnation of the air volumes in parts of the barn, and more important still to control the stable temperatures. The matter of proper control of stable temperature is of vital importance and cannot be over-emphasized. Tests of the carbon dioxide content in the air are merely an index as to ventilation and not an end in itself. It is extremely important that the temperature of the barn be kept under proper control which a ventilating system will do. A well-established ventilation system will prevent stagnation of air in parts of the barn which to my mind is of great importance, for one can have a good current of air ventilation through a barn and make very satisfactory tests and yet, on the other hand, may find that certain portions of the barn will be very stagnant as far as the air movement is concerned.

FACTORS INFLUENCING THE DESIGN AND OPERATION OF FARM BUILDING VENTILATION SYSTEMS*

By M. A. R. Kelley

Mem. A.S.A.E. Agricultural Engineer, U. S. Department of Agriculture

THE object of these investigations was to determine the factors which influence the operation and design of farm building ventilating systems. The tests were conducted in cooperation with various members of the A. S. A. E. Committee on Farm Building Ventilation and several state agricultural experiment stations.The ventilation of barns is an important consideration in the maintenance of the health of stock and in the preservation of hay and grain and barn timbers. It is of particular interest to agricultural engineers, since it is a large factor affecting the economic construction of farm buildings.

The tests were started during the early part of December, 1920, and continued through most of February, 1921. The first seven tests were made during December; eight during January, and the last four in February. Altogether nineteen tests were made; three in horse barns, one in a hog house, two in barns with mixed stock, and the remainder in dairy barns. Five tests were made in North Dakota, six in Minnesota, one in South Dakota, three in the upper and two in the lower peninsula of Michigan, and two in Massachusetts.

With one exception, that of the fan system tested in South Dakota reported in the October 1921 issue of AGRICULTURAL ENGINEERING, all tests were made on systems involving the principles of the King system of ventilation and its various modifications. Three tests were made in barns using windows for intake, that is, the Sheringham valve principle. Most of the barns were of frame construction with varying degrees of insulation. Two tests were made in barns with concrete block walls, one in a hollow-tile barn, and two in barns part frame and part masonry. The influence of the different methods of construction will be discussed in the complete report of the tests.

The stock involved in these tests were two colts averageing 750 pounds in weight, 46 horses averaging 1320 pounds, 439 cows averaging 1160 pounds each, 77 head of young stock averaging 670 pounds, and 63 calves averaging 156 pounds. The average weight of the horses is very nearly the average (1350 pounds) for horses found on farms in the United States in 1920.

A definite relation between the velocity of the wind and the effect which it has in the production of draft in a well-

*Summary of 1921 report of Committee on Farm Building Ventilation designed ventilating system has not as yet been established. The relation between the wind pressure due to impact and that to suctional effect may be computed theoretically from formulas found in textbooks on ventilation. The draft due to direct pressure is stronger than that due to suction under like wind velocities. This relation was noted especially in barns using window intakes. In barns using wall intakes, it was noted that the wind sometimes had greater effect upon the air going out than upon that coming in.

The velocity of the wind is quite variable and in designing a system of ventilation it should not be depended upon for assistance. However, in some sections of the country the wind velocities are so high that some provision for guarding against their effect is desirable. In one test the wind variation during 48 hours ranged from no movement to 40 miles per hour. Such variations are not common and during the tests of 16 barns in only three was the average velocity more than 8½ miles per hour, as will be seen by reference to the summary table. We have reasons to believe that the wind produces little, if any, suctional effect upon the ventilation when the velocity is below 3 miles per hour, and hence, during a great part of the time, the wind will be ineffective.

In some of the tests made the relation between the wind and the amount of ventilation secured is clearly shown while in others, because of complications due to other factors, principally temperatures, its effect could not be so easily traced. Although sufficient data is not available to establish a definite relation between wind and air circulation, we can anticipate a solution to this problem in the near future. When this relation is once established a long step toward the securing of a reasonable automatic system will have been made.

It is natural to expect that the velocity of the air through the intakes most exposed to the wind will be greatest. In some barns tested the velocity of the air through the intakes on the windward side was four times that on the leeward side. As the wind increases the velocity of the air coming in on the leeward side gradually decreases and if the wind is high enough, backdrafting may occur through these intakes. This condition is commonly experienced around corners and where milk houses, silos or other nearby buildings deflect the currents of air. When whirls are formed the air sometimes goes in and sometimes out, and this reversal of air currents may take place in less than half a minute. The design and position of the intakes have influence on backdrafting, and the velocity at which the backdrafting occurs. The lowest wind velocity which produced backdrafting in wall intakes, 5 feet or more in length, was 6 miles per hour. Backdrafting in window intakes at a wind velocity of 3 miles per hour was not uncommon and in one instance occurred at a velocity of less than 1 mile per hour. In one barn backdrafting occurred in a wall intake which was not close to the corner, and with a wind blowing from the opposite side at a velocity of 16 miles per hour.

The limits of ventilation secured by the use of window intakes are clearly shown by data secured in this series of ventilation tests. However, the fact that the limitations of windows as intakes are not widely known is made evident by their frequent occurrence in places not suitable to their use. Under unfavorable conditions windows cannot be kept open sufficiently to provide ample ventilation without harmful effect. It is obviously impossible to supply sufficient fresh air in remote sections of the barn without permitting a disagreeable draft chilling the animals near the windows. It is difficult to control the amount of ventilation when the wind direction varies and frequent adjustment of windows is necessary. In other words, no reliance can be placed upon window ventilation.

It is also difficult to control the temperature in the stable when window intakes are used. When wall intake ducts are provided the windows can be kept closed, the sashes fitted tightly in the frames and storm windows provided for barns in cold climates. When window intakes are used this means of controlling the stable temperature cannot be employed without restricting the amount of ventilation. When the cold incoming air passes over the sash it cools the panes of glass and the warm moist air coming in contact with the cold glass condenses and with low temperatures forms a frost. When the temperature is just enough to cause condensation, but not frost, water runs down the sash, rusts the hinges at the bottom, if they are used, and rots the sills and frames.

The velocity of the wind has a greater influence on the amount of ventilation in barns having window intakes than in those with wall intakes. Sometimes this is beneficial but, as a rule, it prevents the uniform regulation of the ventilation. Backdrafting in window intakes occurs at much lower wind velocities; in fact, instances have been noted where this occurred with no wind blowing. It was noted that at times the volume of air passing outward through the windows was more than twice that through the regular outlets. This was especially true during periods of high wind velocity. The air is apt to come in at a high velocity on the windward side and, practically unchecked, to pass out on the leeward side. Such action is not desirable especially during cold weather. The motive power furnished by the difference in temperatures of the inside and the outside air, in a well-designed system, is sufficient in cool weather to induce ample circulation without the aid of a strong wind.

It is not the intention to imply that ventilation through window openings is impossible, nor to advise against their use in mild weather, or in southern zones. They can be used when the outside temperature is above freezing and when the circulation of a large quantity of air does not cause harmful drafts on the animals. The use of windows should be restricted during cold weather.

A study of the temperature factors is of great importance in the design of a successful ventilation system. The draft introduced by the difference in temperatures of inside and outside air is the largest single motive power producing a circulation of air. Comfort to the animals must be considered as well as the purity of the air.

The heat of animals must not only warm the stable, but also be of such a quantity that part of it may be used in inducing the circulation of air without lowering the temperature of the barn to an uncomfortable degree. The production of heat is fairly definite, within certain limits, as will be discussed later. Hence, it will be necessary to study the means which will enable us to economically conserve the heat generated. Obviously the temperature which can be maintained in the barn is dependent upon two main factors—the heat produced and the heat conserved, and each of these in turn depends upon a number of conditions. Briefly, the maintenance of a desired temperature involves a study of the following questions: (1) insulation, which can be economically used consistently with the difference in temperature which we may expect in the various building zones or sections of the United States; (2) tightness of construction to prevent excessive leakage; (3) the amount of air space which the heat from the animal is expected to heat, and (4) the desired amount of ventilation and the methods used in securing it. Our tests show that a reasonable temperature can be maintained in a properly designed building and get ample ventilation. Two herdsmen complained that we were keeping the barn too warm when it had reached a temperature of 52 degrees. Too great stress has been put on high temperatures in the past, and it is reasonable to believe that a temperature much lower than this can be maintained without discomfort to the animals.

These tests were made under a range in temperatures of from 45 degrees above to 15 degrees below zero with an average difference of approximately 23 degrees between inside and outside temperatures. The greatest difference in temperature experienced was 55 degrees. It has been shown that even under these extreme variations a reasonable temperature may be maintained in the stable if the ventilation system is intelligently operated.

We would not expect a small stove to heat a large house, neither can we expect a barn to be warm when it is only partially filled with stock or when the volume of air to be heated by animals is unreasonably large. Some ventilation systems have been unjustly condemned for this reason.

Our study shows that under the average conditions there is a greater difference between the ceiling and floor temperatures in the horse stable than in the dairy section of the same barn. This may be explained perhaps by the fact that the breathing line of horses is higher than that of cows and that most of the body heat is given off at the higher plane. In one dairy barn a difference of 10 degrees was recorded between the ceiling and floor temperatures, but the greater part of the time the difference was less than one-half this figure. It will be evident to many that these conditions have an important bearing upon the factors related to building construction.

The area of intake openings has an important bearing upon the maintenance of stable temperature and it was possible in most of these tests to control the barn temperature by varying the amount of inlet area. The outtake area usually has a greater influence upon the amount of ventilation secured than does that of the intakes. Openings near the floor in the outtakes appeared more favorable to the maintenance of stable temperature than ceiling openings. Especially was this true during cold weather. Storm windows aid in maintaining the stable temperature. Where the leakage of air through cracks, doors, windows, etc., is excessive, it is impossible to maintain a uniform temperature in the barn, and variations in temperature inside follow closely that of the temperature variations outside.

Theoretically the value of temperature as a motive power for production of draft is known, but its practical application and correlation with the amount of ventilation which may be expected under a given set of conditions is yet to be learned. The prospects are bright for the early determination of the connecting link or constant factor, which will reconcile the theoretical and the practical.

The data from our tests show that the temperature and the percentage of moisture in the outside air have a great influence upon the percentage of moisture in the stable air, greater, perhaps, than that due to restriction of circulation of air in the average farm barn. However, in well-insulated barns this would not be true, since the moisture given off by animals adds to the moisture in the stable air and the point of saturation is reached unless there is sufficient circulation of air to remove the excessive moisture. In a stable housing 20 cows there is approximately 200 pounds of moisture given off per day. If this moisture is not removed fast enough, it collects on the stable walls and softens the paint or plaster which subsequently falls off; mold forms and hastens the rotting of the barn woodwork.

The most desirable percentage of humidity in the stable air has not as yet been determined as there are so many variable factors, which must be taken into consideration, and it is difficult to set a standard, but it is here suggested that at a stable temperature of 45 degrees a relative humidity of 81 per cent is satisfactory. The tests show that it is not difficult to obtain this degree of moisture when other conditions are favorable. In the majority of our tests the ceiling relative humidity was less than that near the floor.

In a few of the early tests the percentage of moisture in the stable air was determined by means of hygrographs. In later tests the sling psychrometer was used with more satisfactory results. A recording hygrometer is desirable for the determination of the rapidity of variation in the relative humidity, but the sling psychrometer gives readings which are more comparable, and which at the same time are more accurate.

In referring to the amount of ventilation the term "dilution of air per hour" is preferred to the "number of changes of air per hour." The air in the stable is not completely replaced by fresh air, but part of the foul air in the room is forced out and incoming air having a lower percentage of carbon dioxide is mixed with the stable air of a higher percentage of CO_2, thus decreasing the CO_2 content by dilution. Circulation of air is dependent upon the temperatures inside and outside and the difference between these two, wind velocity and direction, and various construction features, such as the height of the flues, effective cross sectional area of intakes and outtakes, design of intakes whether intakes are of wall or window type, etc. All these conditions, and a few others of lesser importance, have a bearing upon the amount of ventilation secured. It is difficult to study separately these factors so that the part which each plays in producing circulation of air may be learned.

There is in all cases some leakage and this varies according to the tightness of the construction and the difference between inside and outside temperatures. This leakage aids in the dilution of the stable air, but large leakage is not desirable as it is impossible to control the temperature of the barn. With old stables we sometimes have what is termed "crack system of ventilation." Some ventilation is secured in this manner, but it is impossible to effectively control it. In well-built modern barns leakage is greatly reduced and effective regulation in ventilation can be secured. There is a part of the leakage which cannot be measured, but the leakage which must take place in order to balance the incoming and outgoing air can be obtained by subtraction. With but few exceptions and these under unusual conditions, the amount of measured outgoing air was greater than that of the incoming air. Leakage of air is greater at times of high wind velocities and low temperatures. In one barn when the outside temperature was 11 below zero the intakes were closed and the dampers in the outtakes were closed, yet there was a measured leakage around the dampers sufficient to produce 1.4 per cent dilution of air in the stable per hour.

In these tests there was a range of from zero to 13 dilutions of air per hour and in many cases the full capacity of the system was not used. In one test the system was wide open, yet there was less than 0.1 dilution per hour, or in other words, it would take 10 hours to make one dilution of the stable air. This condition will be discussed in our final report.

A few of the barns tested used hot-air furnace registers on the intakes and in some cases for the heat door in the outtakes. Such registers are entirely unsuited for this purpose. The slats rust, become broken and collect dirt and cobwebs. During cold weather they collect frost and sometimes the entire area is ineffective. The grates and shutters retard the free passage of air. If no better means is available, a board, either hinged or sliding in a slot is superior to the furnace register. It is necessary to screen the outer opening in the inlet ducts to prevent entrance of thrash and vermin, but the passage of air through the inner opening should be unobstructed except as it becomes necessary to restrict the amount of ventilation by partial closing of the opening.

In some of the tests an interesting condition arose. When the intakes had been closed for sometime, the velocity of the air through the outtakes was greatly increased after the intakes had been opened. This may be termed a"ballistic" action, probably due to the immediately decreased resistance to the suction of the ventilators. The following reading showed decreased velocity and it is assumed that the ventilation had adjusted itself to the new condition.

The agricultural engineer knows within reasonable limits the amount of air necessary to produce a desirable purity of air in a stable. He has been told the amount thought suitable for a cow, horse, pig, etc., and these factors hold true regardless of the motive power. With mechanical motive power, it is easy for him to estimate the size of fan and the amount of power necessary to do the work.

The forces which produce the desirable amount of circulation of air in the natural draft system are wind, difference in temperature between the inside and the outside air and their related factors. The wind varies considerably and likewise the temperature. The velocity of the wind is given very little consideration as an aid in producing the desired circulation of air, but the temperatures must be given careful consideration. It is known that the construction details have important bearing upon the stable temperature, but we have given too little attention to the motive power which is largely responsible for producing a circulation of air in the barn.

However desirable and important it is to have plenty of fresh air in the stable, it is also important to maintain a stable temperature which will be comfortable to the animals. It has been demonstrated that an ample circulation of air and a comfortable temperature in the barn may be maintained if the building is properly designed. It would be just as sensible to try to heat a large room with a kerosene lamp as to expect an animal to heat a space which is much too large for it. When building a barn careful consideration should be given to the space provided for the animals since they are the source of the heat. Certain volumes of air space have been suggested for the different animals and we may use these as a basis for our designs, but we have yet much to learn in this respect. A careful study of the number of square feet of radiating surface and the capacity of a furnace is essential to the success of well-designed heating systems. Hence the heat produced by the animal must be given careful consideration as it is expected not only to warm the stable, but to furnish the motive power to produce circulation of air as well.

Dr. H. P. Armsby[1] has given us an excellent working basis with respect to the heat generated by a dairy cow, and we may accept his suggestions for hogs and sheep, but there is some doubt as to the advisability of using that unit which has been proposed for horses. This unit will be given further consideration.

The question of animal heat is very interesting but at the same time one of the most complex questions of physiology. The calorific energy produced by an animal usually is more than enough to maintain the temperature of the body and the surplus is given off or radiated into the air. Animals possess the faculty of regulating the production or loss of heat, an ability which is particularly prominent in warm-blooded animals and which they exercise under most diverse conditions. However, there is a limit to such regulation. Resting, working, lactation, environment, fattening, and the two factors which always enter into the calculations, weight and size, all have their influence upon the production of heat. Hence, it is obviously impossible to set a definite unit of heat production for the individual animal, but we may use as a working basis the average heat production of the animal under average conditions. It is not necessary to study the intricacies of animal nutrition, but it is desirable that the agricultural engineer know those factors which have an important bearing upon the proper ventilation of stables.

Dr. Armsby has shown that there is an important relation between the amount of ventilation needed and the heat given off by the animals. He has also pointed out that calorification varies inversely with the weight of the animal, but not in exact proportion. Rameaux in 1857 formulated the following law: "In animals of the same kind the calorification is proportional to the cutaneous surface and to the cube root of the square of the weight of the body."

The animal heat radiating from the skin is by far greater in amount than that given off through other channels. When the skin surface of animals of the same kind is compared with their weight, it is found to be greater, in proportion, in the smaller animal. If the quantity of heat produced by an animal in 24 hours is compared with the area of skin surface, the relation between them is remarkable.

The relative heat production of the hog, man, dog and mouse per square meter of skin surface per 24 hours has been given as: 1.078; 1.042; 1.030 and 1.188, respectively. This relation has been confirmed by the experiments of Rubner, Camerer and Stovtzoff. The relation between the first three is indeed remarkable and it would seem that it is not unreasonable to assume that a similar relation exists between the heat production of the horse and the cow which are more comparable with respect to weight, food and environment than are the animals mentioned above.

Dr. Moulton of the University of Missouri has determined that the surface area of steers of medium or thin condition is proportional to the 5/8ths power of their live weight, and that for fat steers it is proportional to the 5/9ths power. Voit held that the heat given off as computed per square meter of surface is substantially the same in small and large animals and that the extent of surface appears as the determining factor in the amount of metabolism. Then may we not assume that within the limits of their respective weights and surface areas the heat given off by horses is more nearly that given off by cows than is suggested by Dr. Armsby in his article "Some Fundamentals of Stable Ventilation," especially since Voit, and likewise Dr. Armsby, believed that

[1]"Some Fundamentals of Stable Ventilation," Journal of Agricultural Research, June, 1921; also July and August, 1921, issues of AGRICULTURAL ENGINEERING.

Test
21

m	Barometer
	29.80
	29.18
	29.34
	29.30
	29.06
	29.34
5	28.55
5	28.18
5	28.37
	28.55
	28.18
	28.37
5	28.44
7	28.01
4	28.19
5	29.20
5	28.67
3	28.83
6	29.12
0	28.68
0	28.96
	28.90
	28.24
	28.57
	28.94
	28.65
	28.79
.	28.94
.	28.65
.	28.78
	29.40
	28.78
	29.20
	28.33
	28.01
	28.25
	30.05
	29.70
	29.87
	29.85
	29.40
	29.62
.0	29.60
.0	29.30
.7	29.43
.0	29.70
.0	29.31
.4	29.49
.0	29.31
.0	29.15
.3	29.21
	30.40
	29.95
	30.20
	30.56
	30.50
	30.51

est, as these
of variation

r tests were

the data upon which the Armsby unit was based is of uncertain value and that his unit is too low.

Data secured in tests of two widely-separated barns of different construction made under different atmospheric conditions give further evidence that this unit is too low. Our deduction is made on a basis entirely different from that used by Voit and Armsby, and this adds further weight to the contention. It is not possible, at this time, to place a definite value on the heat production of horses, but from all these data there may be deduced certain general conclusions which may be accepted, at least tentatively, and which may be considered as connecting links between the known facts. We must conclude that until further research shall give us a more definite unit to use it would be advisable to base our designs for ventilation systems in horse barns upon the unit suggested by Professor King.

It is not possible to give the mass of tables involved in tests of this kind without making the discussion too long. These data as given in the accompanying table represent the minimum and average conditions found during each test. The reader who is unfamiliar with other conditions in these barns which affect the average results, is cautioned against the use of these data for interpretation and comparison with other tests unless a true comparison is evident. Measured leakage in Test "P" was the smallest of any test, and was indicated as 0.5 per cent. However, in this case the unmeasured leakage through cracks, doors, and around windows, etc., was undoubtedly large. These data are given more to show the scope of the work and to indicate the information which will be available when the work is completed. It is obviously impossible to give much detail in a report of this kind.

TEST OF A FAN SYSTEM OF VENTILATION FOR DAIRY BARNS*

By M. A. R. Kelley

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THE test reported in this article is one of a series of tests conducted by the writer during the winter of 1920-21 on a number of farm building ventilating systems in different states. The object of the investigations was to determine the factors which influence the operation of barn ventilating systems. The tests were made in cooperation with the subcommittee on Farm Building Ventilation of the American Society of Agricultural Engineers and with the assistance of several of the state agricultural experiment stations.[1]

The forced draft system has been used in the ventilating of public and commercial buildings for a number of years. It is only during the past few years that it has been tried in dairy barns. The circulation of air in this barn was obtained by the use of a fan connected with an electric motor. Since there are very few fan systems used in the ventilation of barns at the present time, a report of this test will, no doubt, be of considerable interest to agricultural engineers and others interested in the ventilation of farm buildings.

The installation of such systems is necessarily limited to buildings where suitable power can be obtained and at such rate that the operation and maintenance cost is not excessive. While ventilation systems as now installed in dairy barns primarily are used for ventilation during cold weather, the fan system is sometimes used to increase the circulation of air during the summer days of high temperature. Keeping the cows at a comfortable temperature and free from flies materially aids in maintaining the summer milk flow. However, the number of barns in which such an arrangement can be used economically is limited.

The system described in this article was newly installed in the South Dakota agricultural experiment station dairy barn, at Brookings, and was tested during the middle of

*From the October, 1921, number of AGRICULTURAL ENGINEERING. (Vol. 2, No. 10.)

[1]The writer was assisted by C. S. Whitnah, of the King Ventilating Company, Owatonna, Minnesota, a member of the Subcommittee on Farm Building Ventilation. R. L. Patty, also a member of this subcommittee and extension specialist in agricultural engineering at the South Dakota State College of Agriculture, made arrangements for the installation and assisted during part of the test.

January, 1921. The weather during this time was quite mild especially for this locality.

The barometer gradually fell during the first part of the test and during the last half rose again so that it was practically the same at the end of the test as at the start.

The wind velocity increased during the first half and decreased during the latter half. Unfortunately the records of wind velocities are not complete as the anemometer developed a short circuit in the electrical indicating apparatus during the third period reading. Although it was not possible to obtain an exact reading for this period, it was observed that the force of the wind was gradually increasing, approximately as shown by the dotted line on the chart.

The main part of the barn was protected on the northeast and northwest sides by sheds, and the horse and feed-storage barn was placed across the south end, thus forming a sheltered court on the east and west sides of the cow stable. (Figs. 1 and 2.)

The windows were 12-light (10 x 12) double hung, and were provided with storm sashes on the north and west sides. The window sashes fitted comparatively tightly into the frames while there was a considerable leakage through the Dutch doors on the east and west sides.

The walls were of frame construction with drop siding on 2-by-6-inch studs and ceiled with ⅞-inch dressed and matched lumber with building paper on both sides of the studs. About one half of the mow floor was well covered with straw while the balance was bare. (Fig. 3.)

The barn was well filled with stock, consisting of 29 mature cows and 21 head of young stock.

A number of years ago Romeaux established the law that

Fig. 1. Exterior of building group embracing the barn under test

heat produced by animals is proportional to the two-thirds power of their live weight. Armsby and Kriss have used this law in estimating the amount of heat given off by dairy cows of various weights under average conditions. Armsby has also shown that the amount of carbon dioxide given off by animals is in proportion to their heat production.[1] Hence, the heat production may be used as an approximate means of estimating the amount of circulation required for maintaining any desired standard of ventilation in stables. Using these data as a basis it was found that the total average heat produced in this barn (136,700 B. t. u. per hour) is equivalent to the average heat produced by 45.5 cows weighing 1000 pounds. The cows were generally heavy milkers. The 27 head, including three strippers, gave 459 pounds of milk per day during the test.

Fig. 3 shows the position of outtake flues built of shiplap and on the mow floor. The fan housing encloses a 24-inch electric fan. The motor was rated ¼ horsepower, 850 revolutions per minute, and 220 volts. The fan housing is shown where the two outtakes converge and opens to the air just below the roof plate. The motor is enclosed in a special casting and is cooled by drawing air through a by-pass which is open to the outside air. The outer opening of the fan casting is fitted with weighted shutter vanes so actuated that they close when the fan is not running. Two small sliding doors, 11 by 13 inches, one above each flue at the point of connection with the fan box, provides a means of decreasing

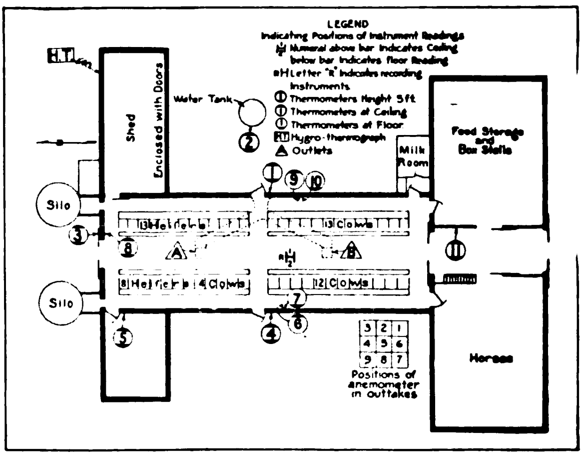


Fig. 2. Plan of building group shown on the preceding page

[1]A complete report of this is given in the *Journal of Agricultural Research*, of June, 1921, and reprinted in the August, 1921, number of AGRICULTURAL ENGINEERING.

the amount of air drawn through the flues. Opening these doors kills the draft at the lower end of the flues and reduces the volume of air drawn from the stable. It was found that by opening the doors fully the amount of air drawn from the stables could be decreased approximately 27 per cent.

Fig. 4 shows the lower end of the outtake flues as they appear in the dairy barn. They are hinged at the ceiling so that they may be drawn up out of the way in order to facilitate cleaning the barn. This picture also shows the hygrometers at the floor and ceiling in the center of the barn. The air about the hygrometers was circulated by means of a fan in order to obtain uniformity of air condition. The normal size of the outtake flues is 20 by 20 inches, inside dimensions, with an effective area of 2.77 square feet of each flue. The horizontal length of flue A (Fig. 2) on the mow floor is 26.5 feet, while flue B is two feet longer. The length of each flue

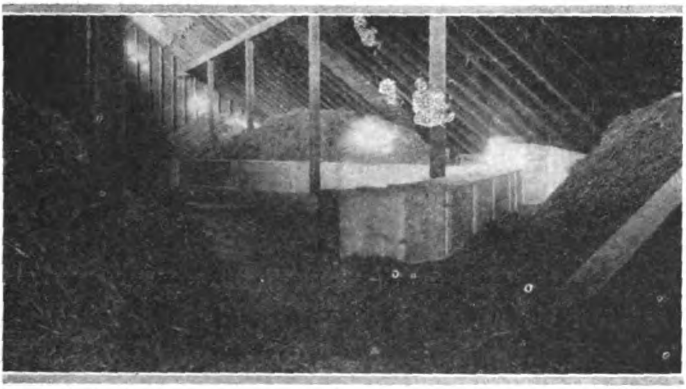


Fig. 3. Arrangement of outtakes and fan housing

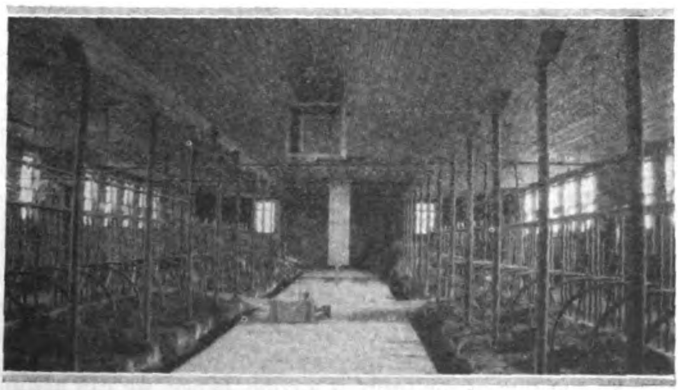


Fig. 4. Interior of stable showing hinged outtakes

TABLE I—VELOCITY OF AIR MOVEMENT IN FLUE IN FEET PER MINUTE

FLUE A

Position	1	2	3	4	5	6	7	8	9	10	Average
First day	458	436	477	430	389	421	502	418	431	511	448
Second day	603	624	580	582	536	611	580	572	604	601	590
Average	530	530	528	506	462	516	541	495	517	556	519

FLUE B

Position	1	2	3	4	5	6	7	8	9	10	Average
First day	444	450	451	481	398	454	517	...	...	...	459
Second day	598	586	620	587	539	591	599	574	572	647	591
Average	521	518	535	534	468	522	558	...	...	...	525

below the ceiling is the same.

It was impossible to secure data on continuous readings as the barn was used during the daytime for experimental and class work necessitating discontinuing the tests during the daytime. The readings were started after the barn was closed up in the evening and continued throughout the night, as shown in the chart and Table II. Readings of all instruments were taken every three hours.

A set of ten readings of the air movement in each flue was made at each period. The opening of each flue was divided as shown in Fig. 2, the anemometer readings being taken at the center of each square. The tenth reading was made about 30 inches up the flue at center. This was done in order to ascertain which position would give the best average reading for the flue and produced some interesting data. Table I shows the results of these various readings for the first and second day and their average.

It will be noted that the average sum of the readings (Table I) in flue A in positions 5 and 10 equals 450, while the average for all positions for the first day is 448. On the second day the average of the sum of the readings in positions 5 and 10 was 568, and the average for all readings for the same day was 590. It will be noted that in flue B the average sum of the readings for positions 5 and 10 on the second day equals 593, and the average for all positions on that day was 591. It was not possible to secure the average for positions 8, 9, and 10 on the first day as the power went off before the eight o'clock set of readings were completed. In calculating the amount of ventilation on this day average conditions were assumed for the missing readings. The average of readings for flue A at position 5 for both days was 83 per cent of the reading given in position 10 which was 30 inches above position 5, and the same difference occurs in flue B on the second day. In order to find some reason for this condition a smoke test was made and it was found that the air on all sides of the flue came down on the outside and entered the flue in the form of a cone, hence, we can assume that the reading at position 10 was higher because of the fact that it was nearer the apex of the cone formed by the incoming air.

There was some variation in the direction of the wind close to the barn, but the general direction was as recorded in Table II. It will be noted that the wind velocity reading is greater on the first day and that the direction was mostly in opposition to the draft of the fan while the second day the wind shifted so that it probably aided the effectiveness of the fan, as the ventilation was greater the second day with a lower average wind velocity. This is a natural assumption, but we do not have definite data as to whether the speed of the fan was constant throughout the tests although it is believed that the speed of the fan was fairly constant and would average up.

In referring to the amount of ventilation (Table II) the term "dilutions (of air) per hour" is preferred to "number of changes of air per hour." The air is not completely replaced by fresh air, but part of the foul air in the room is forced out and the incoming air having a lower percentage of carbon dioxide mixed with the stable air of a higher percentage of carbon dioxide thus decreases the carbon dioxide content by dilution. The inside dimensions of this barn were 39 feet 4 inches by 112 feet 4 inches. The total volume of the room was 43,495 cubic feet. In calculating the volume of the room, the variations in heights of the litter and feed alleys were measured with more care than is usual in roughly estimating the volume of a room. The height of the ceiling at the feed alleys was nine feet and at the center of the driveway ten feet two inches. The cows in this barn faced out (Fig. 4). With reference to Table II, it will be noted that the average number of dilutions per hour was three and four tenths (3.4) for the second day. Assuming that the average speed of the fan was the same for both days, the wind speed and direction made some difference in the amount of ventilation secured.

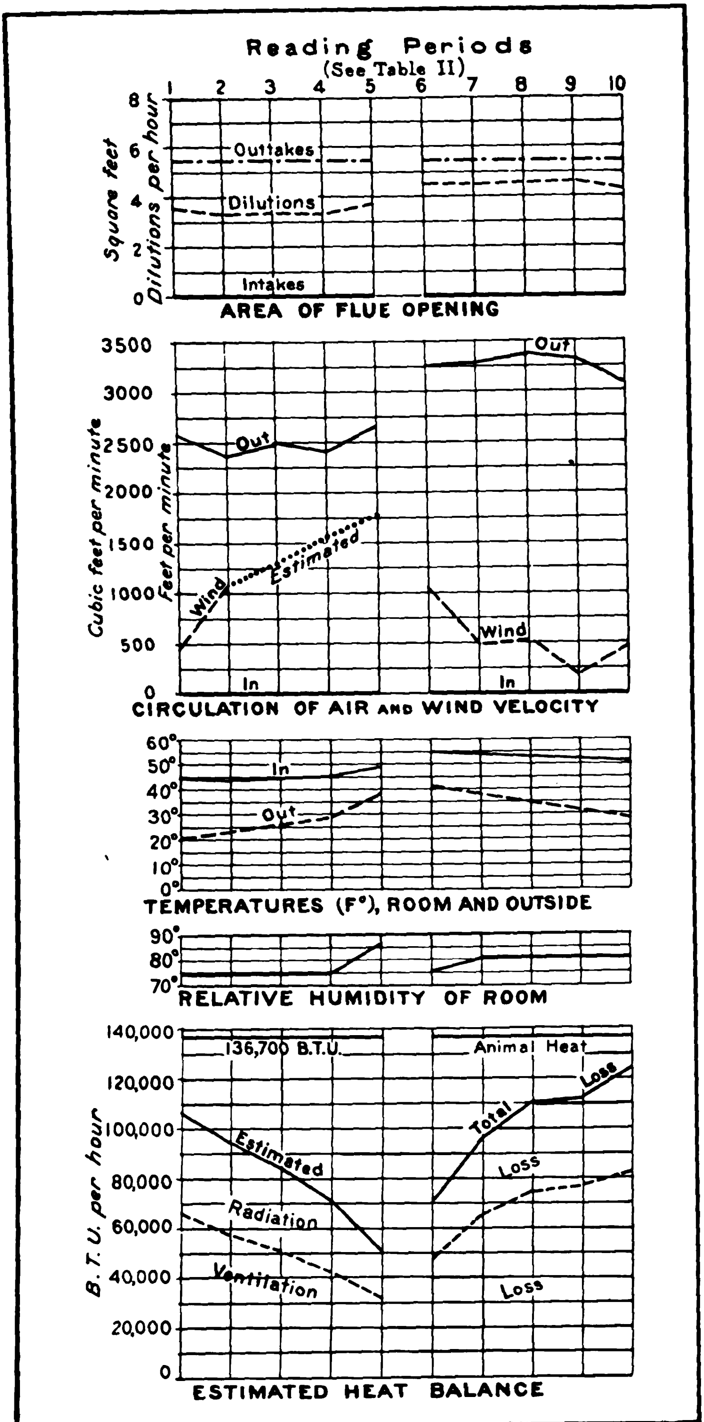
It will be noted that the temperatures during this test were very mild, especially so for winter weather in this locality. The lowest outside temperature, 21.5 degrees, was recorded at the beginning of the first day's test and the highest, 42.2 degrees, at the beginning of the second day's test. The average for the two days was slightly less than freezing. Reference to the accompanying charts shows that the variation of temperature throughout each day's test was quite gradual for each period.

The average ceiling temperature for the two days was 50.7 degrees, the floor temperature 47.7 degrees, and the average room temperature 49.4 degrees. The variation in the inside temperature during these periods was also gradual. It is regrettable that the weather conditions were not more

TABLE II—Readings Taken During the Test

Flue area: A, 2.77 sq. ft.; B, 2.77 sq. ft.; total, 5.54 sq. ft. Flue A was 2 feet longer than B.

Period Reading		Air Movement: Velocity Feet Per Min.—Average		Air Movement: Total Volume Cubic Feet Per Min.	Dilutions Per Hour	Wind Velocity —m.p.h.	Average Temperature			Humidity—%	Barometer	Wind Direction
No.	Time	A	B				In	Out	Diff.			
1	8:00 p. m.	480	448	2570	3.6	5.0	44.3	21.5	22.8	74.0	28.38	South
2	11:15 p. m.	402	464	2398	3.3	12.0	43.6	22.5	21.1	74.0	28.34	South
3	2:00 a. m.	439	457	2481	3.4	Out of	44.6	26.5	18.4	74.0	28.20	Southwest
4	5:10 a. m.	442	433	2423	3.3	Order	45.5	29.5	16.0	74.0	28.04	....
5	7:45 a. m.	476	496	2692	3.7	20.0	49.2	38.5	10.7	87.5		....
Average		448	459	2513	3.4	12.3	45.4	27.7	17.8	76.7	28.24	....
SECOND DAY												
6	7:00 p. m.	596	580	3257	4.5	12.0	55.1	42.2	12.9	75.5	28.12	Southwest
7	10:25 p. m.	592	589	3271	4.5	5.3	54.8	37.2	17.6	80.5	28.26	Southwest
8	1:20 a. m.	608	618	3395	4.6	6.0	53.6	33.2	20.4	80.0	28.29	Southwest
9	4:10 a. m.	595	612	3343	4.6	2.0	52.0	31.8	20.2	80.5	28.34	South
10	7:00 a. m.	560	560	3102	4.3	5.5	51.8	28.2	23.6	80.0	28.36	Southeast
Average		590	591	3274	4.5	6.1	53.4	34.5	18.9	79.3	28.27	....
Average readings of all		519	525.7	2893	3.9	9.2	49.4	31.1	18.3	78.0	28.25	....


Reading Periods
(See Table II)
1 2 3 4 5 6 7 8 9 10
Square feet
Dilutions per hour
8
6
4
2
0
Outtakes
Dilutions
Intakes
AREA OF FLUE OPENING
Cubic feet per minute
Feet per minute
3500
3000
2500
2000
1500
1000
500
0
Out
Estimated
Wind
In
CIRCULATION OF AIR AND WIND VELOCITY
60°
50°
40°
30°
20°
10°
0°
In
Out
TEMPERATURES (F°), ROOM AND OUTSIDE
90°
80°
70°
RELATIVE HUMIDITY OF ROOM
B.T.U. per hour
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
136,700 B.T.U.
Animal Heat
Total
Loss
Estimated
Radiation
Ventilation
ESTIMATED HEAT BALANCE

severe in order that we might have been able to test the system under conditions existing with the average winter weather experienced in this locality and the effect it would have had on ventilation in attempting to control the temperature in the barn.

Since Armsby has provided a means of estimating the approximate amount of heat given off by cows under average conditions of care and feed, it is interesting to note with reference to the chart how the temperature varied; as the total heat lost by ventilation and radiation decreased, the temperature inside increased. The outside temperature also increased and undoubtedly was the largest factor influencing the inside temperature. The radiation and ventilation losses were calculated in accordance with the best engineering practices. The total heat given off by animals was estimated using Armsby's data as a basis. The total amount of heat given off by animals is the sum of the heat generated by each and is based upon their individual weights and not upon the heat produced by an animal of the average weight of the cows in the herd multiplied by the number of cows. It is estimated that in this barn 43.7 per cent of the heat generated by the animals was lost by ventilation and 23.5 was lost by radiation. The balance less any leakage loss was available for warming the room. These percentages are true for this test and for the conditions in this barn at the time, and the reader is cautioned against applying these heat loss percentages to any other barn. It should be remembered that the ventilation in this instance was secured by mechanical means.

Other interesting facts in regard to the heat balance will be brought out in the summary of the winter's tests in a later report.

Since the ventilation was secured by mechanical means a report would not be complete without data in regard to the cost of operation. An electric meter of a type commonly used in measuring the amount of electric current consumed was used in this test. Since a meter was not available at the beginning of the test the exact amount of current used cannot be stated. However, it was possible to ascertain the amount of current used during the continuous run of 14¼ hours on the second day, and this may be used as representative of the entire test. The total consumption of electric current for this period was 2.3 kilowatt hours, or at the rate of 0.16 kilowatt per hour.

KEEPING THE WATER SUPPLY PURE*

By E. W. Lehmann

Mem. A.S.A.E. Professor of Agricultural Engineering, University of Illinois

IN MAKING a study of the water supply for the farm home a letter was addressed to the various state health departments, to the state agricultural experiment stations and extension departments, and to the engineering experiment stations of the state colleges requesting the latest information available on the subject. The response to this letter was very gratifying; a great many circulars, bulletins, and plans were received, which were helpful in preparing the material for this report. Every publication emphasized the crying need of a better protected farm water supply and the dangers of an insanitary supply.

It is commonly known by members of the state health departments, agricultural engineers, and others interested in farm sanitation that the purity of farm water supplies are generally questionable. The lack of definite data is evident in many of the state reports. There is a definite need for more investigations along this line, especially with reference to kind of supplies used in different sections. There is also need of a closer cooperation of the agencies interested in this problem. In some of the states the college representatives apparently do not know what the health departments are doing and some of the health departments do not know what the colleges are doing, and in some colleges the individual departments interested have not gotten together. The sanitary engineering, agricultural engineering, bacteriology and state water survey departments should cooperate in every way possible toward the solution of this problem.

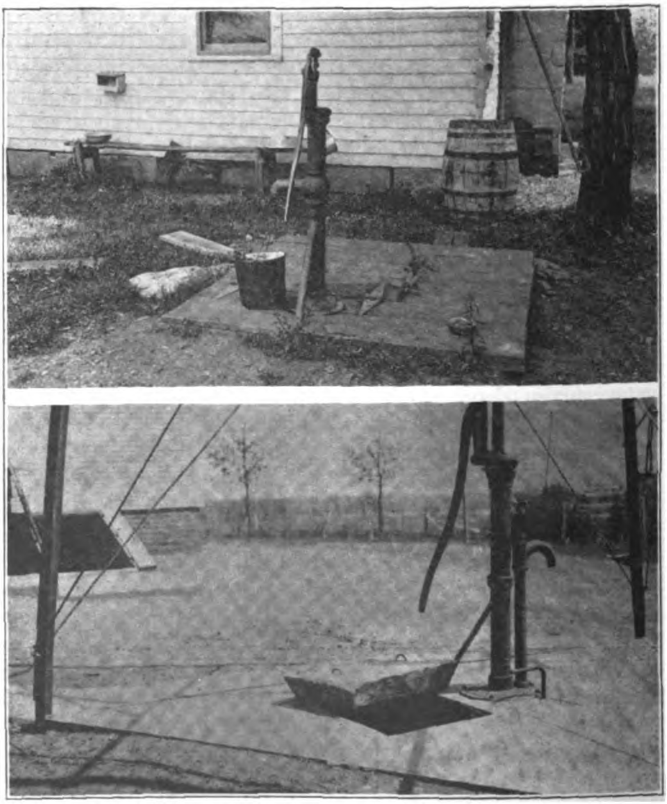
In every state where water surveys have been made the results have been practically the same. Surface supplies and shallow wells are nearly always contaminated. The same is true of cisterns. Deep drilled wells, that is, wells that pass through an impervious layer of material, are nearly always good. The greatest danger is from the surface or shallow underground supply, the shallow well, and the cistern.

The U. S. Department of Agriculture report on experiment station work in 1913, in Farmers' Bulletin No. 549, states that "of seventy-nine carefully selected typical farm water supplies in Minnesota, mainly wells, twenty were good and fifty-nine were polluted, mainly because of careless or ignorant management, and generally as a result of poor location or lack of protection against surface wash or infiltration. The rivers, surface reservoirs, and cisterns investigated were

*A part of the report of the Subcommittee on Farm Sanitation presented at the fifteenth annual meeting.

found to be polluted to an extent that it is considered doubtful whether satisfactory supplies can be secured for household use from such sources." F. T. Shutt of Canada Experimental Farms concludes from an examination of several thousand samples of water used on farm homesteads that "probably not more than one-third of them are pure and wholesome."

H. E. Barnard and J. H. Brewster of the Indiana Board of Health found in an examination of the rural water supplies in that state that "of private rural water supplies examined 177 were deep wells, 411 shallow wells, 5 ponds, 40 springs, and 27 cisterns. One hundred and sixteen of the deep wells were of good quality, 45 were bad and 16 doubtful. Only 159 of the 411 shallow well waters were potable, 309 unequivocally bad, and 43 were of doubtful quality."



Above: Typical wood cover with wide cracks allowing surface contamination to be washed into the well. Below: A deep well with good protection against polution either from the top or by seepage

The same bulletin reports that E. Bartow of the Illinois State Water Survey found that three-fourths of the shallow wells of the state were contaminated. Later surveys have shown about the same results.

In a survey made by the writer in 1913-14 in Iowa, sixty-three farm water supplies were investigated, thirteen of them were shallow open wells and fifty were drilled wells, more than 100 feet deep. The results of the analysis showed that all of the shallow wells were polluted and only one of the deep wells; the latter was a clear case of carelessness on the part of the owner. Impurities were allowed to gain entrance into the water supply through the vent hole in the pump standard.

In a survey carried on by the writer in Missouri fifty supplies were analyzed, forty-eight of these were from cisterns and two from shallow wells. The two shallow wells and forty of the cisterns showed contamination. In each case a standard sanitary chemical and bacterial analysis were made to determine the potability of the water.

Not only are many of the farm water supplies dangerously bad, but also many of the supplies for rural schools are not what they should be. The report of an investigation of the twenty-nine rural schools of Ramsey County, Minnesota, by the Minnesota State Health Department show that sanitary conditions are not satisfactory. "Surface drainage on 82 per cent were imperfect, water supplies on 92 per cent were unsafe, and the disposal of human excreta unsatisfactory in every case."

My own observations would lead me to make the statement that insanitary conditions and the poor water supplies at many rural schools are not only disgraceful but appalling. At many country schools in our southern states no privy is provided, and often the water for drinking is secured from a spring that is liable to contamination by human excreta.

While more data would be of value to emphasize the gravity of this problem, with the data at hand it should be recognized that shallow wells and cisterns are very often contaminated. A special bulletin of the California State Board of Health contains this statement: "Very often all that one may wish to know about the safeness of a supply may be learned by a common sense consideration, by any intelligent person, of the things that he may learn by looking about and perhaps by a few inquiries. The question that should be kept uppermost in mind is this: Does any opportunity exist for human intestinal or urinary discharge to gain access to the water?"

A prominent sanitary engineer states that it is his opinion that "90 per cent of all contamination of shallow wells and cisterns can be located within four feet of the top." It is evident that if the supply is carefully located and protected the possibility of contamination would be reduced to a minimum.

The first step in the solution of the problem of securing pure water supplies on the farm is to provide the right sort of conditions surrounding the supply. This is a matter of education. The neglect of private drinking water supplies, the lack of appreciation of the value of pure water, and the importance of keeping it pure is common throughout the country, in both small towns and on the farms.

The great majority of farmers pay little attention to the purity of the water supply. If it is of sufficient quantity and the water appears clean and it is reasonably free from odors it is considered all right.

It should be thoroughly understood by everyone that water to be really satisfactory for domestic use it must meet certain physical, chemical, and bacterial requirements. From a physical standpoint the water should not contain any substance that would produce an unusual color, bad odors, or disagreeable tastes. It should be free from suspended matter. From a chemical standpoint drinking water should not contain an excess of salts or of organic matter which might indicate the presence of contamination. From a bacterial standpoint a water is not safe for drinking unless it is free from germs that cause disease. These disease germs are carried in the human discharges, the most common of which are typhoid and dysentery. It can be readily appreciated that the proper disposal of human wastes play an important part in the matter of a pure water supply.

Too many wells are located with the idea of convenience to stock and a saving in first cost, without considering the matter of location in its relation to the safety of the supply. The writer has seen shallow wells located in draws through which the entire drainage from yards and barn lots passed. There is little question as to the quality of such supplies.

After a pure supply of water is provided the only way to keep it pure is by careful protection. This is true whether the supply is a deep well, shallow well, cistern, or spring. Illustrations of methods recommended for protecting water supplies against contamination were collected from various bulletins. Many of the suggested methods of protection can be improved on, which is a job for agricultural engineers.

The problem should be studied further so that definite plans can be worked out that members of the Society will be willing to recommend. At this time the following principles will apply in protecting cisterns, wells of different kinds, and, for the most part, springs. The deep drilled well must not be neglected:

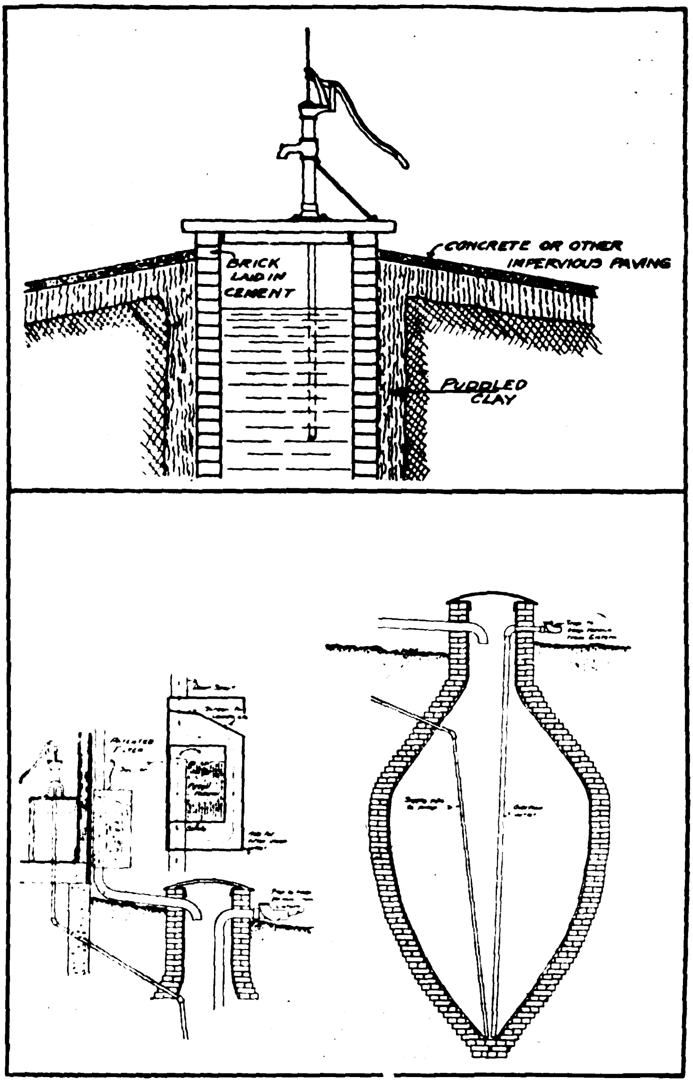
1. The curb should extend above the surface of the

ground at least one foot.

2. The walls of the curb should be constructed so that no water can pass into the well without percolating through at least eight to twelve feet of soil.

3. A layer of clay should be tamped around the curb, extending to the surface of the ground at the top.

4. The top should be made of impervious material.



Above: Use of concrete, cement mortar and puddled clay for exclusion of surface contamination
Below: Dr. C. F. Bennett's cistern and filter design

5. The top should be designed so there is no possible chance of the water going back into the supply once it is pumped out. Extend the top over opening rather than setting it in the opening like so many covers.

6. Use only tongued and grooved lumber and build of double thickness when the top is made of wood.

7. Provide a raised place for setting the pump.

8. Provide a distinct slope away from the supply at the top. This applies equally to cisterns, wells, and springs.

9. Do not have "ventilators." They are of no use if supply is clean, and may be a means of impurities gaining entrance.

10. Use a good pump.

It seems to be a common idea with many agricultural engineers that cistern water is seldom if ever used for drinking, but such is not the case. In many communities the cistern is the only source of water for drinking and often it is vile beyond words. I know of cases where folks have continued to drink water from cisterns until the odor would force them to clean it out, when they would find most everything from snails to dead cats.

As was stated earlier in the report, in one Missouri community forty-eight out of fifty supplies were from cisterns. In some localities in Illinois nearly all drinking water is from cisterns, the same is true in other states.

While the principles outlined above should be kept in mind in protecting cisterns, there are additional points to consider that should not be overlooked by either the city dweller or the farmer who has a cistern. The collection of the water is all important; in fact, most of the impurities that get into the cistern supply are washed in from the roof; this includes dust, dead insects, birds, bird droppings and nests, and spores of plants. The roof should be thoroughly washed off before any water goes into the cistern. This is so often neglected that the only safe way it seems would be to install an automatic valve to control the flow. Another matter that should be remembered is the cistern overflow outlet; it should always be provided with a type of trap valve to allow the cistern to overflow but prevent the entrance of mice, rats, snakes, snails, worms, frogs and even lizards. In practically every bulletin reviewed an overflow pipe was recommended for the cistern, but no means was provided for its protection.

Dr. C. F. Bennett, of Fenton, Iowa, has some rather advanced ideas in regard to cistern construction, arrangement of suction pipe, overflow pipe, and design of filter. He not only proposes the use of a trap in the overflow pipe, but proposes that this pipe extend to the bottom of the cistern, which is to be constructed in a cone shape so that all sediment would go to this point and be carried out through the overflow pipe. He also proposes that the suction pipe extend to the low point in the cistern so that any sediment that finds entrance would be immediately pumped out, if not carried out through overflow. These are points that might well be considered in cistern design.

Dr. Bennett states in substance to secure a safe, sanitary, and potable cistern supply the following must be accomplished:

1. Screening out of the course detritus such as leaves, birds nests, etc.
2. Flushing of roofs and gutters
3. Sedimentation during process of filtration
4. Constant and automatic removal of sediment
5. Proper and regular self-cleaning of filtering material

Another point suggested by Dr. Bennett is the screening of gutters.

The following principles on cistern construction are outlined in a recent Kansas bulletin by H. B. Walker:

1. The receptacle should be of proper size, suitably located, and absolutely water tight.
2. A proper filter must be installed to strain and clarify the water.
3. A well-arranged system of roof piping must be laid out for the collection of water.
4. An overflow or waste pipe should be provided to remove surplus inflow water.

A number of types of filters are suggested in the many bulletins and circulars studied. Among them are: The small commercial metal filter with screen and charcoal filtering material, the sewer pipe filter, the compartment filter, the concrete box filter, beehive filter, commercial pressure and gravity filters, etc.

Filters may be classified as pressure filters and gravity filters. The gravity filters may be further classified as downward flow and upward flow. Each of the different types have particular merit.

Pressure filters would no doubt be more generally used if the results obtained were more commonly known. Many water supplies in the towns as well as in the country could be greatly improved by using pressure filters. A common type of pressure filter which is quite effective in removing all impurities has as a filtering medium either unglazed porcelain or stone. These filters will not only clarify the water and remove sediment, but will remove bacteria.

While filtration is about the only practical method of making questionable or impure water fit to drink, water can be made safe by sterilization. Sterilization may be accomplished by either boiling, distillation, or by the use of chemicals. Water made sterile by boiling or distillation is flat and insipid to the taste. Distillation is impractical. Use of chemicals or making sterile by boiling, results in the water being still of poor quality because the impurities remain in it.

Purification of water by freezing is a method of which we rarely give consideration. Studies carried on by the Minnesota State Board of Health show that water is purified by this process. Samples of ice and water were taken simultaneously from the same sources in a number of different localities. The ice was clear and solid and was taken where the water was at least three feet in depth under the ice. The results of the analysis showed that the water contained 16,000 bacteria per cubic centimeter, while the same volume of ice showed only 5 bacteria. With reasonable care at harvest the ice supply should be safe.

While much is being said these days about the value of an adequate supply of water and the importance of having it piped to the point to be used, we must not overlook the fact that it is more important than all else that the water be pure and healthful.

FARM SEWAGE DISPOSAL DEVICES*

By H. W. Riley

Mem. A.S.A.E. Professor in Charge of Rural Engineering, Cornell University

IT IS not necessary to repeat that the usual sewage disposal system consists of two stages, the first an anaerobic septic tank for the liquefaction of solids, and the second an aerobic filter bed of some kind for the oxidation of the compounds in the septic tank effluent.

The purpose of this paper is to present very briefly the features of design which our experience leads us to consider essential, and the numerical constants to be used for ordinary rural conditions.

The septic tank must be so located and arranged that the sewage will enter it with a minimum of disturbance, pass through it always with uniformly low velocity, and pass out of it without transporting on into the filter any considerable amount of finely divided matter which is always found suspended in the liquid in an active septic tank.

To control the disturbance at entrance the grade of the sewer from the house to the tank should not exceed one-half-inch fall per foot, or, if more is unavoidable over part of the line, the velocity of flow must be reduced by arranging for a run with a fall of not over 1/16 inch per foot for a distance of from 25 to 50 feet located just preceding the tank. The fall from the invert of the inlet tile to the water level in the septic tank should not exceed 1½ inches. The end of the inlet tile should be submerged, the exact distance being unim-

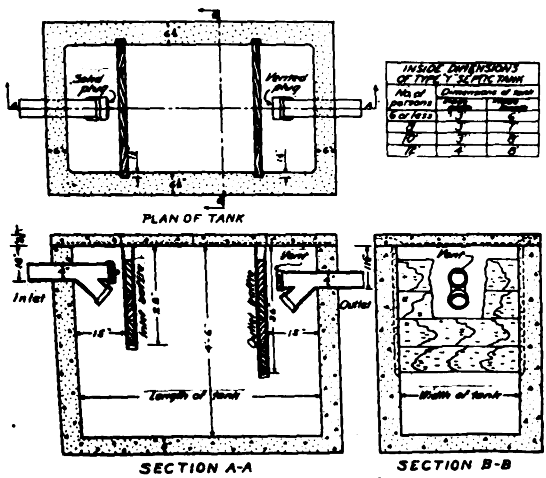


Fig. 1. Septic tank for farm sewage disposal

*Fifteenth annual meeting paper.

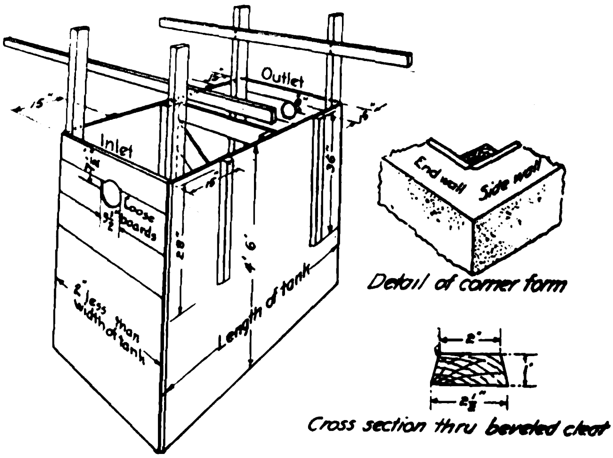


Fig. 2. Construction of form for septic tank

portant. A cross baffle closely adjacent to the inlet is highly desirable in small tanks to prevent localized currents.

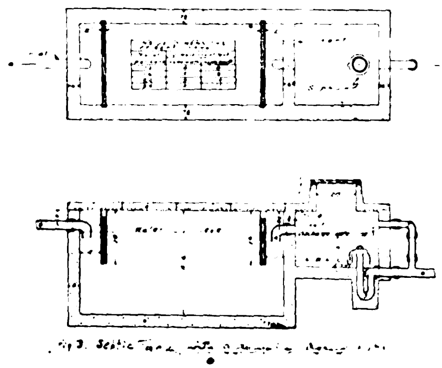
The rate of flow through the tank is sufficiently regulated in average rural domestic systems by providing a net volume of tank below the water line of approximately ten cubic feet per person served, and proportioning the tank so that the cross section of the liquid is approximately square, and the length about twice the width. Subdivision into numerous chambers is not necessary.

The end of the outlet tile should be submerged and a closely adjacent baffle holds back the bulk of the scum and prevents the easy escape of at least part of the finely divided suspended matter.

The type of tank which we have used as fulfilling approximately these requirements is illustrated in Fig. 1 and is constructed on a form shown in Fig. 2.

The filter bed for the usual rural system will consist usually of the upper eighteen inches or two feet of soil, but may be of sand or other material that is lasting and that will afford air spaces between its particles upon which the aerobic bacteria may develop. When soil is used and distribution is secured by subsurface irrigation from tile, we allow in gravelly and sandy soils from ten to twenty feet of tile per person; in light and heavy loams from thirty to fifty feet of tile per person, while in heavy clay an artificial sand bed with special drainage is usually necessary.

Application of the sewage to the filter bed must be sufficiently intermittent and as uniform throughout the bed as possible. For this purpose an accumulation chamber with automatic dosing syphon, as shown in Fig. 3, is unquestionably very desirable construction and, for households of over twelve persons, we usually recommend it. The dosing charge is made nine-tenths of the volume of the tile. A distinct advantage of this system is the positive and even distribution with such a velocity of flow that any fine material carried over from the tank and deposited in the tile will be flushed through to the ends of the runs and the tile kept clean. The cost and complexity of construction are distinct disadvantages and an added difficulty is the necessary loss of head



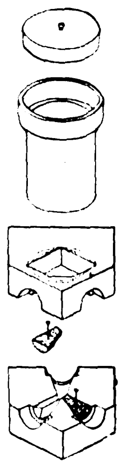
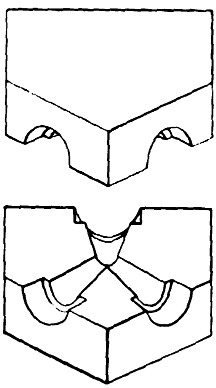


Fig. 3. Tank with automatic dosing siphon
Fig. 5. Cornell sewage switch with tile top



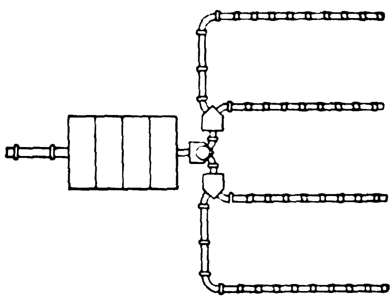


Fig. 4. Cornell sewage divider in perspective
Fig. 6. Sewage switch and dividers in use

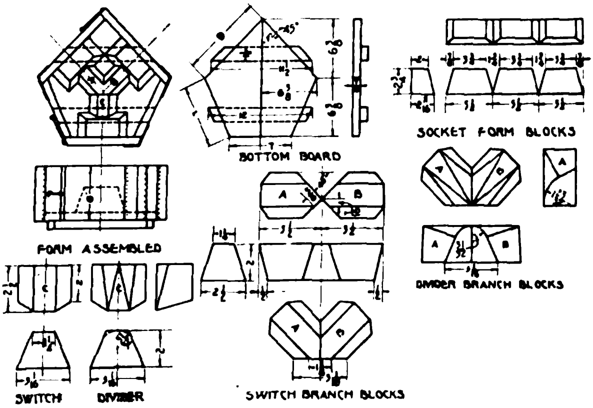


Fig. 7. Details of forms for switch and divider

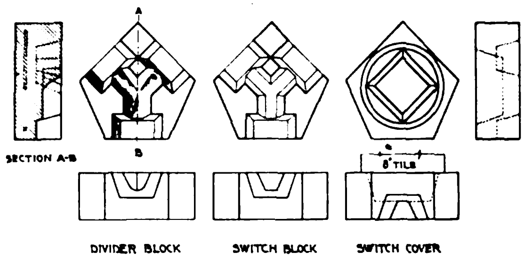


Fig. 8. Details of divider and switch blocks

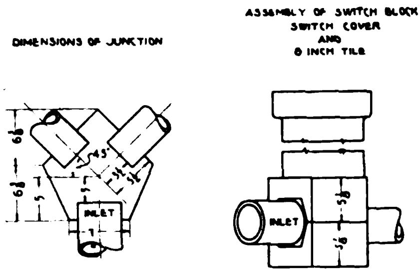


Fig. 9. Installation dimensions of Cornell sewage divider and switch blocks

which, in level sites, places the tile too far below the surface for best results. To avoid the cost, complexity and loss of head incident to the use of the syphon we have developed the Cornell sewage divider and sewage switch shown in their original forms in Figs. 4 and 5 and illustrated in use in Fig. 6. Each consists of a pair of five-sided concrete blocks, having through the center a Y-shaped channel arranged to connect the inlet pipe with two branches as in Figs. 4 and 5.

In the divider the channel is rounded at the bottom with the result that a stream from the inlet is divided into two almost exactly equal streams in the branches. In the switch the channel bottom is flat and either branch may be shut off at will by means of the plugs in Fig. 5 which are accessible through an eight-inch tile and the hole in the switch cover.

With these two fittings installed, as in Fig. 6, the entire flow may be alternated from one tile bed to another to give intermittency, and the stream may be divided into two, four or eight equal streams, as may be necessary in limited areas.

The details of the forms are shown in Fig 7, and the individual types of blocks in Fig. 8. When assembled in pairs as in Fig. 9, either three-inch or four-inch tile may be used in the hexagonal socket openings. With these fittings, since there is no positive flushing system, the purifying tile are given twice the fall in the first half of each run that there is in the last half. In light soils the grades are ⅛ inch and 1-16 inch per foot; in heavy soils 1-16 inch and 1-32 inch per foot.

The construction of the forms may seem at first glance somewhat complex, but a little study will show that they are really simple. They might well be made in high schools as woodworking exercises, the blocks run as concrete work, and finally put to work as home project work in sewage disposal. In New York state we will insure that the forms are made generally available by building numbers of them and sending one or more of each kind to each farm bureau office.

The divider and switch are recommended to your special attention as substitute devices for the dosing syphon which, by their use, render unnecessary the complexity and expense of the syphon and its chamber, and make possible alternate and uniform sewage distribution without loss of head.

BARN LOT DRAINAGE AND BARN SANITATION*

By Ralph L. Patty

Mem. A.S.A.E. Extension Specialist in Rural Engineering, South Dakota State College

I ASKED Dr. G. S. Weaver, state specialist in the control of animal diseases of South Dakota, to assist me in this work. He has given his attention to it throughout the season and to him is due most of the credit for investigation. Doctor Weaver has had some twelve years experience in meat inspection and animal disease control work and is a graduate veterinarian. He is an ardent advocate of barnlot drainage.

In visiting hundreds of farms each year, I am impressed more and more with the sanitary advantage of having it dry underfoot for stock raising, no matter whether it be in the barn or in the lot outside. Further, I have observed that the condition of the lot in most cases manifests itself in the barn, and I am certain that it is seldom possible to find a sanitary barn surrounded by wet, muddy lots. On the other hand, I have been on ranches in the drier western region where stables would score very low under the sanitary rules, but owing to their favorable location and dry lots, the health of the stock was excellent and the surroundings were generally sanitary.

Dr. Weaver has the following to say on the subject: wallow, as many hog owners have an idea that a hog wallow is necessary in hog raising. These hog wallows become infected with all sorts of germs and act as a source of infection for many different diseases. Many farmers have artesian wells and these afford an excellent water supply providing the overflow is properly controlled. If the overflow is left to run through the barnlot in an open ditch, the horses, cattle and sheep tramping through this water, and the manure pile draining into the same ditch, an ideal condition exists for spreading and harboring disease.

It is not definitely known as to how long hog cholera germs will live in such a place, but it is reasonable to expect that they will stay in such a mudhole for at least a year. A very common disease known as necrobacillosis, which affects cattle and sheep in the form of footrot, colts in the form of navelill, hogs in the form of sore mouths and "bullnose," is harbored in all sorts of mudholes and sloughs."—Following are some specific cases of actual disease reported from unsanitary lots by Dr. Weaver:

1. A rancher near Hot Springs, South Dakota, reported a cow that was lame and could not walk. Upon investigation, it was found that this cow was in the habit of standing in a

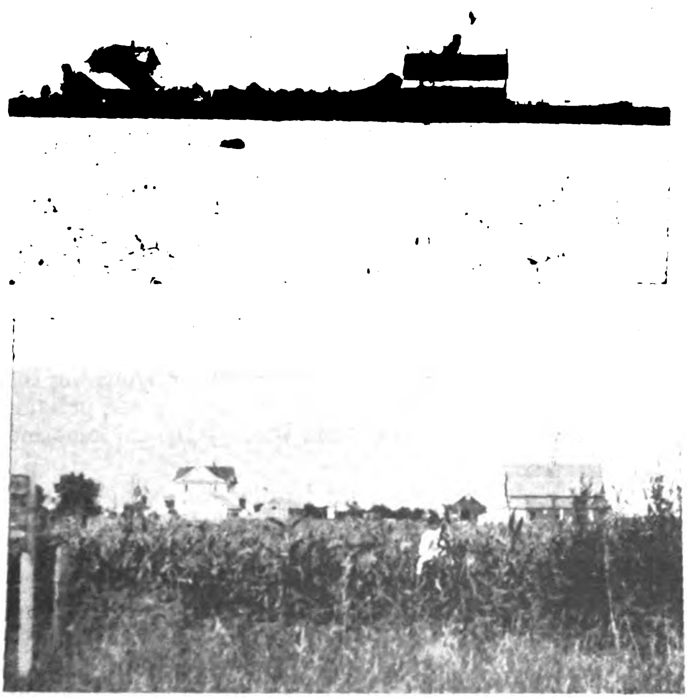
*Fifteenth annual meeting paper.

large pool or mudhole in the barnlot. In order to keep the flies off her legs she stood in this pool almost continually and finally became infected with footrot and was then unable to get about. As soon as she was shut off from this mudhole she began to recover with only slight treatment and the mudhole was later drained and no more footrot has developed.

2. A farm owned by John Andrews in Hand County was visited and a diagnosis of hog cholera and necrobacillosis made. This infection was harbored by the overflow from an artesian well.

3. Another farm owned by William Blatzford, Orient, South Dakota, was visited where severe infection after castration was found in the herd. Investigation showed unsanitary mud wallows were directly responsible.

4. It was reported by Phil Jacobson of Rowena, South Dakota, that he was having trouble with his hogs as a re-



Before and after draining hog lot shown at left in late spring. Beside eliminating disease in the herd there were reclaimed eight acres of \$200 land. The job cost \$1200. Parallel lines of tile were laid 75 feet apart in the flat sult of vaccination against hog cholera. The investigation showed that no hog cholera was present, but, on the other hand, a very bad case of necrobacillosis. This farm had one of the most unsanitary hog wallows seen in several years. In order for the hogs and cattle to get to the watering trough, it was necessary for them to wallow through about one hundred feet of mud. The cattle were all caked with mud up to their knees and practically every hog had a plaster coating all over his body. About twenty of these hogs had died as a result of the disease. As soon as this wallow hole was fenced off the disease conditions improved.

5. A herd of hogs on the farm owned by Earl Cass near Agar, South Dakota, was reported sick. At least two veterinarians visited this herd and diagnosed necrobacillosis, also a complication of swine plague. Dr. Weaver was finally called and found the worst infection of necrobacillosis seen in years. The lot contained an extremely unsanitary hog wallow. The herd was healthy when turned into this lot. When moved to a new dry lot, improvement was soon apparent.

In conclusion Doctor Weaver says: "It is useless to recite further instances, suffice it to say that a majority of all diseased conditions in hogs are due to unsanitary feed lots. At least one hundred and twenty-five cases have been investigated in the last year or so where it was definitely proven that the disease was harbored on the farm where very little work in the way of drainage would have prevented this condition."

For dry lots we must depend on drainage, either natural or artificial, plus the removal of litter. It is impossible to secure run-off of the surface water from the barn lot through natural drainage, even though the grade be fairly good, if the litter is allowed to accumulate over the surface, and it is more difficult to lead this water into a tile drain. Dumping the litter carrier onto the ground in the lot is a very bad practice as the litter is soon spread far and wide by the chickens and a muddy, filthy lot is the result.

The problem of draining the barnlot will be affected by the sources of water flooding it. Some of these sources are: Flood water from rains collecting in depressions in the lots; seepage or spring water breaking out on the side hills; overflow water from tanks or artesian wells, and the water falling directly on the lots as rain and running off the eaves of the buildings.

Two of these conditions must be met by cutting off the water at its source, namely, the seepage water and the overflow from tanks or artesian wells. The latter is quite a problem in South Dakota, owing to the large number of artesian wells over the state. Where a basin sheds into the lots the tile should, wherever possible, pick up the water before it settles into the depression. A surface inlet may be used if necessary to cut off or divert this water. We have found this method more effective especially in small lots where the ground is thoroughly tramped by the stock. The puddling effect of this tramping in some soils will make it almost impervious to water. This condition makes a surface inlet necessary, and the surface inlet in the barnlot is usually in the way and difficult to protect. The small hog lot is specially hard to underdrain, as the hogs do an extra good job of puddling and the lot is usually well covered with corn cobs and trash that especially endanger a surface inlet. Another source of water causing muddy lots, especially close to buildings, is the run-off from the eaves of the barn. I do not believe the average man realizes to what extent this contributes to his muddy yards. A concrete gutter for catching this water and carrying it to an outlet or into the tile is usually justified. If the water can be used to advantage it would of course be advisable to install evespouting and supply tank.

Following out the same line of argument, a dry floor in stock barns, including the hog house, is the first essential in sanitation. A smooth, well-drained, non-absorbent floor is desirable. A smooth, masonry floor sloping to gutters of standard design for carrying away the liquid manure gives excellent results. Such a floor is easy to clean and, therefore, encourages more frequent cleaning. It is, also, easy to disinfect. The same material when used in the side walls up to a distance of three feet or more above the floor is both sanitary and practical from the maintenance standpoint, and in the dairy barn this type of construction extending to the ceiling of the stable and offering a smooth surface, without ledges, is desirable.

NEED OF A COUNTRY PLUMBING CODE*

BY H. H. MUSSELMAN

Mem. A.S.A.E. Professor in charge of Farm Mechanics, Michigan Agricultural College

COUNTRY plumbing is closely related to the problem of water supply and sewage disposal and, as a part of that problem which has been given so much attention by the American Society of Agricultural Engineers, may properly come in for its share of attention.

The more closely people are crowded together the more apparent is the need for regulation of the systems of water and sewage disposal. A noted sanitary engineer said not long ago that "the modern city may be judged by its sewage system."

Because the need has been apparent and immediate, cities and some few states have worked out regulations and codes for the control of material devices and construction to be used in carrying such wastes and sewage. These codes have had the effect of standardization of equipment and work in plumbing in the cities.

Some states have deemed the problem of sufficient importance to enact regulations applicable to the whole state; the tendency seems to be to give more careful attention to safeguarding the individual against the dangers incidental to ignorance and neglect of good practice in this branch of sanitation.

In agricultural-college work dealing with education along the lines of water supply and sewage disposal new angles to the problem are presented. Undoubtedly the highest class of plumbing practiced in the cities is sufficient for the country. On the other hand, it may be asked whether all the refinements specified in the city ordinances are necessary for the country. For illustration, it is easy to see that an elaborate system of back venting may be of importance in a many-story building with its multiple city fixtures which are used by people who have no knowledge or interest in their successful operation. Perhaps in connecting a sewer from a dwelling to the street and where a volume of gas may form a pressure, it would be necessary to place a trap in the outlet sewer from the house. The heaviest quality of pipe may be specified to remove all danger from breakage when used under such a variety of conditions.

It would seem that some modifications ought to be made in the interest of economy and simplicity for country conditions. On the other hand, it might be maintained that standards of any kind are not necessary or applicable in the country. To show the need it is only necessary to point to the wide variation of both material and workmanship which

*Fifteenth annual meeting paper.

is used at the present time. It must be recalled that in many sections of the country plumbing is done by the local plumber who is none too skilled in the practice of his trade, the handy man in the local hardware concern, and sometimes by the farmer himself. Under these conditions a great deal of ingenuity and originality may be exhibited, but the party for whom the work is being done has little protection against bungling work even though he may be anxious to secure a first-class job.

Instances have been known where vent stocks were connected to chimneys to save pipe or cutting through the wall and ending near a window, or traps made of lead pipe with perhaps not ½ inch depth of seal and soil stock calked with putty. Both parties to the contract need specifications with the stamp of approval of the American Society of Agricultural Engineers for the work which will suit the needs of the case, which will insure safety and satisfactory operation, but which will not impose unnecessary financial burdens on the man whom the college extension specialist persuaded to take this important step forward.

At any rate it is believed that a country plumbing code sanctioned by the American Society of Agricultural Engineers would serve more as guide for country work than as an enforceable standard. It is believed that the situation calls for expansive inspection and enforcement.

The man on the farm has a more immediate and necessary interest in equipment of this kind than the man in the city, and it is to be hoped that a program of education may be so effective that it may never be found necessary to enforce good practice by law.

In a canvass of the need for a country plumbing code to members of the American Society of Agricultural Engineers interested in conveniences, a large majority felt that the present practice does not conform to good standard practice and a larger majority felt that a code adopted by the American Society of Agricultural Engineers would be of value in raising the standard. Few of the states have plumbing codes. In Ohio the state code seems to have benefited the country by bettering the grade of work done by plumbers in the cities and towns, who also do a good deal of work in the country. Many think that specifications need not be as rigid for workmanship in the country, as is also thought of joint connection traps, cleanouts and piping regulations, while others say that they should be the same. Screw joint would generally be permitted.

Opinion is also divided on the necessity of back venting, but opinion is quite general that inspection is not necessary or possible. The septic tank is favored as a final means of disposal.

FACTORS INFLUENCING TRACTOR DEVELOPMENT*

By L. J. Fletcher

Mem. A. S. A. E. Professor of Agricultural Engineering, University of California

IT IS the purpose of the author of this paper to present a few of the many factors which influence the development of the tractor, with special reference to its adaptation as an agricultural machine. While it may appear that at times certain institutions are unduly credited or discredited, this is most assuredly not the case.

At the 1914 annual meeting of the American Society of Agricultural Engineers, Mr. Patitz of the Allis-Chalmers Manufacturing Company presented a paper entitled "The Rotary Tiller" in which he quoted from a book written in 1850 by C. W. Hoskyns. In this book Mr. Hoskyns classifies the power employed by man as (1) manual, (2) animal and (3) mechanical. He analyzes the peculiar mode of action of each type of power. Manual power is most effective when working in a perpendicular manner or parallel to the backbone of the man. Manual force is most effective in lifting. The direction of animal power is horizontal, and horizontal draft is the only form in which it can be applied. Mr. Hoskyns then points out that mechanical power is totally different from either manual or animal, its favorite motion being frequently circular or rotary; as, for example, the steam paddle wheel, screw propeller, circular saw, threshing machine, cylinder, etc. He raises a question as to why this type of motion should be transposed into draft; in fact, in a number of machines the power is developed, transposed into a horizontal motion, and then again through a ground-propelled drivewheel of the machine transposed back into a rotary motion. Thus, over seventy years ago a man brought to our attention an inherent weakness in tools which were to be designed many years after his time; in fact, it is only of recent years that engine power has been applied to the operation of machines which were formerly ground driven.

Shall we examine briefly the development of these three kinds of power? History does not tell us when the horse or the ox were domesticated. The reason is that they were domesticated before the beginning of recorded history.

At one time in the development of the human race, the principal vocation of man was agriculture. Agriculture requires power. Before the lower animals were pressed into the service of man, there must have been a need for this labor.

*Fifteenth annual meeting paper.
[1]Pages 57-71 Vol. VIII, Transactions of the American Society of Agricultural Engineers.

In other words, the early farmer produced his own power and created his crude implements to best serve his own peculiar ways of applying force. There undoubtedly arose in him a desire for a better kind of power, which desire, by the way, is present in every user of power to this day. There must have been an interesting time when he was trying out the various animals. He had his problem of producing suitable tools, hitches and harness, of learning to control and care for his new power. Perhaps much of our present profanity originated during this period.

Nevertheless, our ancestors had thousands of years to master this problem, and tools, crops and methods of farming in general were adapted to the more efficient use of animal power.

We often hear that we are living in the "motor" age. Considering the length of the "animal" age we most certainly are not *in*, but only entering the "mechanical motor" age. This most especially applies to agriculture. We are in far enough to prove the latent desire of man for a better kind of power, but if the tractor manufacturer thinks that the farmer buys the tractor because he loves or longs for it as a tractor, or because a "high-powered" salesman sold it to him, he is mistaken. The farmer does not care what furnishes him power cheapest or produces the largest returns, just so it does. In fact the farmer benefits every time a new kind of power is developed for it gives him a greater choice when he goes shopping.

There has always been opposition to the introduction of new labor-saving machines. The mower, reaper and harvester were destroyed by field hands in England and in this country. The farm laborer fearful of losing his job destroyed the early reapers of Marsh and McCormick. Railroads were opposed and automobiles legislated against. However, in spite of comparative rhetoric, any movement economically sound will prevail.

Someone connected the crankshaft of a portable internal-combustion engine to the wheels of the rig and the tractor was born. It has had all the usual childish diseases as well as a few major operations, but nevertheless has thrived on its diet of kerosene and dust.

The mechanical motor long ago proved its superiority on belt work. It was this demonstration of the steam engine and later the stationary gas engine which, more than anything else, sold the tractor idea to the farmer. If the engine could beat the animal on the belt, why not in the field. How many of the early builders of tractors realized that the tractor must be four times more efficient to compete with the horse in the field than on the belt? The horse power absorbed about one-half the power of the horse so he was fifty per cent penalized

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However, there were places in the United States and Canada where the first heavy, slow tractors could be used economically. The early gas tractors differed but little from the steam except in the motive power. Constant and elaborate service was offered and accepted. The farmer cannot alone be blamed for "getting the habit." The automobile had not yet come to pave the way for the later invasion of the hordes. Breakages and delays were many, but the farmer was doing his part in the developing of a tool which later was to serve him. In other words, the tractor was being "domesticated."

The later development of the gas tractor is a different story. Before the manufacturer had a good start in the development in the small tractor, there arose a sudden demand. The war with its attendant high prices for agricultural products, the demand for large production, and the scarcity of farm labor, was the main cause for the waiting line at the delivery door of the tractor dealer. To meet this sudden market, many tractors were hastily designed and tested and then put into production. They were sold because there was a demand for tractors and they looked like tractors.

To reach even its present position the tractor has met many handicaps. There are too many orphan tractors and others whose parents are in very poor health. Early tractor buyers judged a machine by how it would pull and the price. So, in general, tractors were built to pull (when new) and to a price.

Manufacturers early realized the handicap the tractor had by the lack of sufficient knowledge on the part of the operator. They together with the state educational institutions conducted many tractor schools. The obtaining of honest and competent repair work has been and is now one of the biggest problems of the automotive industry. The first small tractors were sold with the understanding that the regular horse drawn tools could be satisfactorily used.

The present tractor situation is due in part to:

1. The great reduction in the price of farm products and the congealed credit.

2. The general tendency to stop buying when prices are lowering.

3. The belief that there are more tractors on the farms of the United States than normal times would have permitted.

4. The many practices which sprang up when tractor sales were easy, such as overselling, neglect of service, poor design or material, and general disregard of the value of the "satisfied customer."

5. The discontinuing of experimental and developing work by many companies during the war period.

6. Very large investments in patterns, special machinery, and stock of parts which must be changed if a radical alteration is made in design.

The above may be said to be the economic phases. The tractor at present may be divided mechanically into three parts: power unit, transmission system and traction devices.

One of the main problems in the power unit is a matter of the vaporization and distribution of our present fuels. Engine builders have repeatedly started the design of a new device for handling the fuels which they find they are called upon to burn. However, by the time the machine which they design is placed in production, the quality of the fuel is so lowered that they simply start over again on another similar job. For a number of years, at least, our fuels will come from petroleum or shale oils. This is almost necessary because of the need for proper lubricant. Engines are now being experimented with which will operate on a crude oil with the lubricating stock removed. This appears to be as far as the oil companies can go in the lowering of quality.

More attention has been given recently to the cooling of the tractor engine. This is evidenced by the many positive types of fan drives on the market, together with construction of cooling systems which provide for the maintaining of a uniformly high temperature without danger of overheating. Because of the increased price of fuel the various heat losses in the motor are being carefully analyzed and attempts made to exhaust at lower temperatures and pressures. Heavier cylinder walls may prevent some loss, but may introduce lubrication troubles.

In the matter of lubrication, considerable attention has been given to the matter of a positive supplying of oil to all of the principal wearing parts of the engine. The placing of an oil pump indicator of a suitable design in the sight of the operator is also a desirable feature.

There is no doubt but what the impulse starter used in connection with a high-tension magneto has wonderfully lessened the starting troubles on tractors. One company manufacturing a tractor in California realized that engines start best when cranked against full compression. To make this possible, they provided a 4-to-1 reduction gear on the end of the crankshaft so that the operator could crank the engine without undue exertion on his part.

Perhaps the biggest advance, however, has been the attention given to the keeping of dust out of the engine. This is indicated by the almost universal use of air cleaners and the present attention given to the determining of most efficient types. Air cleaners are now being placed on both crankcase breathers and carburetor air intake. Provision is also being made on some machines to prevent the dust from getting into the pump stuffing boxes and other places by providing a separate housing for these parts. Valve mechanisms are being enclosed and some engines are now developed in which the only moving part to be seen is the fan. Overhead valves, owing to the somewhat higher thermal efficiency of engines so equipped, are gaining in favor in tractor construction.

The main advance in transmission systems has been the use of better materials in the gears and better bearings. Attention has recently been given to the forcing of the transmission lubricant to the principal wearing parts rather than depending upon gravity and splash to distribute it. The location and design of stationary attachments should receive more attention on some machines. The absence of a clutch brake on some tractors is also a nuisance and often causes undue wear on the gear teeth. Dust is responsible for many changes in design, being perhaps the main reason for the enclosing of tractor transmission systems.

Of late tractor builders have begun to realize that a human being operates their machines and his comfort should be considered. This is evidenced by a few springs in the seat, and occasionally upholstering and a seat back.. Levers are more conveniently located and the steering of the machine made easier.

Undoubtedly one of the biggest single problems facing the tractor designer is the matter of efficient traction. Tests of tractors show that various machines will exert a pull on the drawbar from 30 to 93 per cent of their weight. Often the same machine will vary considerably on different soils. A careful study of the proper lug, or drivewheel and track, design will undoubtedly result in higher tractive efficiency. The swinging drawbar, and high steering bands on front wheels, have aided materially in the control of many of the smaller tractors.

A few general considerations would include the making of tractors requiring fewer special tools for their adjustment. Machines should also be made which will operate for a period of ten hours without replenishing fuel, oil or water to any of the parts of the machine. At the end of the ten hour period the various parts of the machine will receive attention and then be in condition to render another ten hours of service without the little delays caused in turning down grease cups, filling air cleaners or radiators, or making other minor adjustments. Parts of the machine absolutely needing lubrication oftener than every five hours and not automatically cared for should be so arranged that the operator can attend to them from the seat while operating.

The matter of the adjustments of the various parts of the machine should receive more careful attention. It is almost equally undesirable to have no adjustment or too many adjustments on such parts of the machine as the carburetor, clutch, fan drive of a belt, etc. The one adjustment tractor has the advantage of simple and sure adjustments. By that I mean the clutch with but one place to adjust; the carburetor with but one adjustment, and so on.

More consideration is being given each year to the matter of cost of replacing the wearing parts. A careful analysis of the machine will often show parts, which are required as a repair after a tractor has been used for some time, which could be divided into two parts—a small part, the wearing surface, which could be attached to the larger part or the nonwearing.

In the first sixty-five tractors entered in the Nebraska tractor tests, spark plugs were replaced in fourteen, valves were ground anywhere from once to three times in sixteen, forty-one required either minor adjustments such as a clutch and fan belt to taking up bearings, while on forty-six repairs or replacements were made which included everything from cylinder heads, valves and gears to the entire tractor. Those sixty-five tractors should represent at least the average of the factory production, but even in the hands of good operators with twelve hours to limber up and only twenty to thirty hours of work, the showing does not flatter the industry. Factory tests of tractors should be more often conducted by engineers who are entirely divorced from the designing or production staffs.

There are certain factors which will have more or less of an influence on the future tractor.

Much interest has been displayed in new types of power units. High pressure, condensing steam plants have been developed. However, the more natural trend is toward some form of internal-combustion engine, perhaps of the Diesel type. Electric power will be quickly adapted to agriculture if means for transmitting and directing it without wires are perfected.

Considering the very important part that the operator plays in the success of the tractor, even more attention should be given to real education. Tractor salesmen have too often used the tractor school to cloak sales effort or have informed buyers that no skill was required to operate their particular machine successfully. We occasionally find local dealers who oppose the tractor schools conducted by the universities on the grounds that we are teaching the owners to do certain repair work or make adjustments which they have been paid to do in the past. The farmer must become as intimately acquainted with the tractor as he is with the horse.

This Society could very well concern itself with a study of more efficient tractor courses. It is only fair to the tractor as an institution that it be given a just trial, which it certainly is not getting in the hands of the average operator.

Tractor courses should be arranged to provide the maximum of directed practice work in a short time. One week of five eight-hour days of properly organized work will furnish a surprising amount of real ability to do the various necessary jobs on a tractor. Some tractor schools enthuse the student, others show him how, but owing to the expense or trouble, many schools fail to provide enough actual repair work.

No one tractor manufacturer can succeed if all the others fail. Every opportunity for helping each other should be sought after. This applies to standardization of various parts of the machines and to a general, free exchange of information which will help the industry. *The* tractor must be sold and proven before *a* tractor can be permanently marketed.

The tractor has suffered because it has been considered a substitute for the horse. This has been carried to the point where tractors were driven with lines. We are gradually beginning to realize that we have here a different kind of power which can and must apply itself to the job in a different kind of way. We are realizing that there is more than one way to obtain the same results in tillage planting or harvesting. Undoubtedly mechanical power has been hindered in its progress by the impossibility of independent thinking in its development. It is common to see combinations of tools or unit tools combining the functions of several former types and occasionally an entirely new tool which is possible only when operated mechanically.

While we call ourselves agricultural engineers, we are mostly informed in the engineering sciences rather than the agricultural. Yet we are all directly connected with agriculture. Designers of farm machinery since its beginning have always taken the problems of the crop as they were and designed the machine to suit all the variations and difficulties presented by the crop. In other words, the engineer did not ask odds of the plant but took it "as is."

We all know that plant breeders have made wonderful changes in our crops by selection, hybridization and the careful development of new varieties. They have made chemical changes in plants such as increasing the sugar content of cane and sugar beets, anatomical changes such as the larger germ in the corn so as to increase the oil content and make certain varieties more valuable for the by-products so common today. Pasture grass has been developed which would resist the tramping of cattle, and corn so bred that it would throw out a better root system to resist the wind or produce the ears at a convenient height for harvesting.

It is entirely practical and possible to make mechanical changes in plants. If a plant presents difficulties in its present form to the use of mechanical power in cultivating or harvesting, it may be changed. An example of this is found in the development of a type of grain sorghum for California which could be harvested by machinery.

Grain sorghums, including Milo and Brown and White Egyptian corn, have not been popular crops in California because machinery has not been devised which would head them satisfactorily, and it has been necessary to pick the heads by hand at a high cost. Kafir corn, which is grown extensively east of the Rocky Mountains, and which because of its straight heads and uniformity of height, is easily headed with machinery, can not be grown in California because of its late maturity. Kafir ripens in from 160 to 170 days at Davis, while Milo and Egyptian corn ripens in from 120 to 130 days. Previous attempts to introduce Kafir heading machinery in California to head Milo and Egyptian corn have been unsuccessful because these crops are too irregular, too bulky and too goose necked to go through the machines. In 1917 the University Farm undertook to develop a variety which would ripen early enough to be grown in California, and yet would be uniform enough, straight enough and dwarf enough to be headed by machinery. Five years of continuous hybridization and selection have resulted in the development of "Yolo" which has met all requirements. It ripens at the same time as Milo and may be headed with the small one row Kafir headers or with an ordinary grain header.[2]

This Society should interest geneticists and plant breeders in the development of crops from the mechanical standpoint. If a certain crop is not satisfactorily handled by the present machinery, perhaps the plant could be changed in place of the machine. This might apply to the harvesting of such crops as cotton, beans and peas. If hay loaders knock the leaves from clover or alfalfa hay, why not change the hay so the leaves will stand more shaking while dry.

We are living in the early dawn of the mechanical age. New institutions do not grow overnight. We should judge every new step fairly and not let our enthusiasm accelerate our judgment.

[2]To illustrate how the California farmers welcomed this new crop which could be harvested by machinery, nearly 10,000 acres of Yolo have been planted in California from seed secured from the Agronomy Division at University Farm, Davis. This is the first year that this crop has ever been grown commercially. Indications are that it will become one of the leading cultivated grain crops in the dry farming section of the state.

COORDINATION OF THEORY AND PRACTICE IN PLOW DESIGN AND OPERATION*

By A. C. Lindgren

Mem. A.S.A.E. Experimental Engineer, International Harvester Co.

and O. B. Zimmerman

Mem. A.S.A.E. Experimental Engineer, International Harvester Co.

THE published literature on plow design, and the hitch, especially with relation to tractor plows, is meagre. A few figures will, however, attract attention to the desirability of concentration upon the above subject with a view to analyzing the basic features of successful operation, as well as design.

The Department of Agriculture indicates in its statistics the fact that there are about 360 million acres of land under cultivation in the United States at this time, seventy per cent of which figures can safely be used to designate the amount of land yearly turned over with a plow or equally effective implement using approximately the same power.

On the basis of an average pull of 550 pounds per 14-inch bottom and 4 inches deep, at a speed of 2½ miles per hour, the rough energy expenditure would amount to better than 2,668,050,000 horsepower hours per annum consumed in this one operation. In view of this fact are we doing all we can to reduce this energy expenditure to a sensible minimum? Have we analyzed the plow, the hitch, the tractor, the horse or other power to the extent possible and given the farmer the benefit of these deductions? Can we save him money on this amount? If one per cent can be saved it is calculated, on the basis of $2.75 per acre, that this saving would amount to nearly $6,930,000 a year. How much more than one per cent can be saved? Every needless energy loss is accompanied by a corresponding material loss, since energy loss reflects itself in the repair bill which will add considerably to the above named figures.

With an idea of showing what can be done, this paper is prepared placing special concentration on that elusive feature—the correct hitch. There are numerous factors to consider, each with its range of variables, but we shall assume a set of average data for emphasis.

Some argument might arise as to whether the modern method of turning over the soil with a standard moldboard plow is the ultimate or most logical. This cannot be definitely answered now, but for years to come this method will prevail because of the fact that in our present knowledge of the

*Fifteenth annual meeting paper.

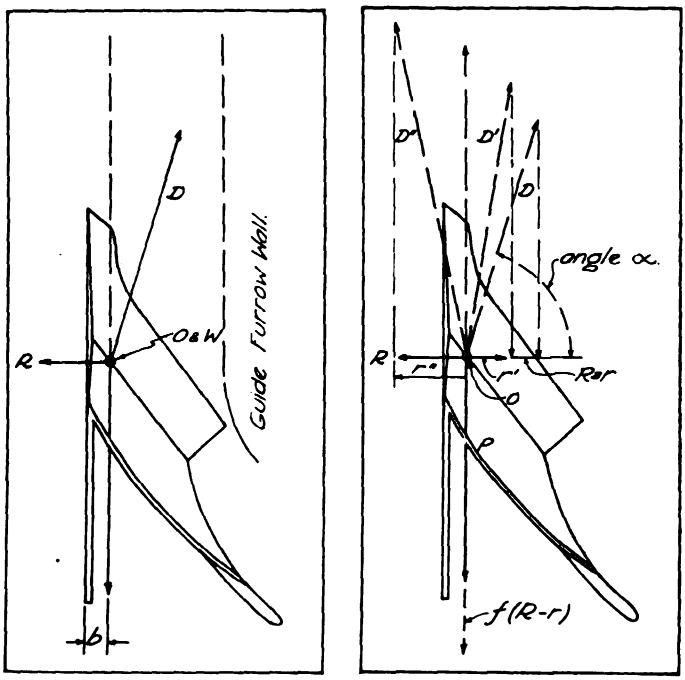
art it takes the minimum amount of energy to accomplish this given result, and such devices and methods which up to date have been substituted for the present plow, have unfortunately fallen to ground under this yearly task.

Perhaps this analysis will attract more careful study from new angles, and we may develop further ideas which will work out to success. While this analysis will carry us through an apparent maze of detail, it is hoped that the conclusions set up at the end of this paper, with their supporting technical argument, will be found practically useful.

With this foreword let us review the plow from the simple single unit to its combinations, operations and accessories.

Considering the single bottom (Fig. 1), and analyzing the complicated series of forces acting on this outfit, we readily see it is desirable to resolve all forces into three, whose center, (O) on the moldboard we shall have to assume as that point which is the result of judgment until it can be more definitely located by experiment.[1]

1. The Principal Vertical Forces. (a) That due to weight of the plow; (b) that due to the downward pressure



At left, Fig. 1, and at right, Fig. 2, illustrating forces acting on plow bottom around assumed point O

[1]This point is described by one authority as 2 inches up from the furrow sole, 3 inches from the furrow wall and 12 to 15 inches from the share point. By another the corresponding data is 2½ inches up, 2 inches over and 13 inches back.

exerted during the lifting of the soil; (c) the lifting component due to the hitch being above the point of resistance, and (d) that force developed when the plow is dull and worn and which has the upward component the result of the sloping under surface of the share.

2. The Principal Horizontal Cross Furrow Forces. (a) Due to the cross component caused by the friction of the soil on the moldboard, and (b) by the transferring of the soil sideways the width of the furrow; (c) the cross component due to the cutting and wedging edge of the sloping share edge in operation; (d) the component of the line of draft, and (e) such cross component as may result from rear or furrow wheel reactions in multiple outfits, where used.

3. The Principal Longitudinal Forces Acting Lengthwise of the Furrow. (a) The soil resistance to cutting; (b) the friction between the furrow wall and the landside; (c) the friction due to the weight and pressure on the bottom of the plow according to the setting or condition of the cutting wedge; (d) the component of friction of the earth sliding over the moldboard. For equilibrium then we have the sum resultant forces of W, R, and P, counteracted by D, the draft produced by the motive power.

It is then for us as engineers to see what can be done to reduce the necessary force D to a minimum by every sensible means and still retain good working conditions.

In the multiple plow outfit we carry the largest part of the weight on wheels in order to change the sliding friction of the simple plow into rolling friction; we choose our materials and model the shape to minimize the sliding friction as far as possible, and heat treat the parts to maintain the life of the plow against erosion to a satisfactory degree; we provide the shape and material such that necessary repairing and sharpening may be accomplished with facility; we provide means for arranging the hitch over a range of vertical and horizontal adjustments to care for the varying conditions of soil resistance, speed, nature of motive power, etc. It is clear that in the tractor plows the composite force (W) is generally carried on the three wheels, so for the moment we may delay considering this factor and concern ourselves with the forces in the horizontal plane.

The moldboard being a modified warped surface as analyzed in a paper by Dr. E. A. White [2], when it acts upon the soil creates the side pressure R against the landside, which, if not relieved by pulling or pushing the outfit, in a direction to counteract this force, will create a friction in excess of that necessary, in the magnitude of Rf, where f is the coefficient of friction between earth and steel; values of which are noted

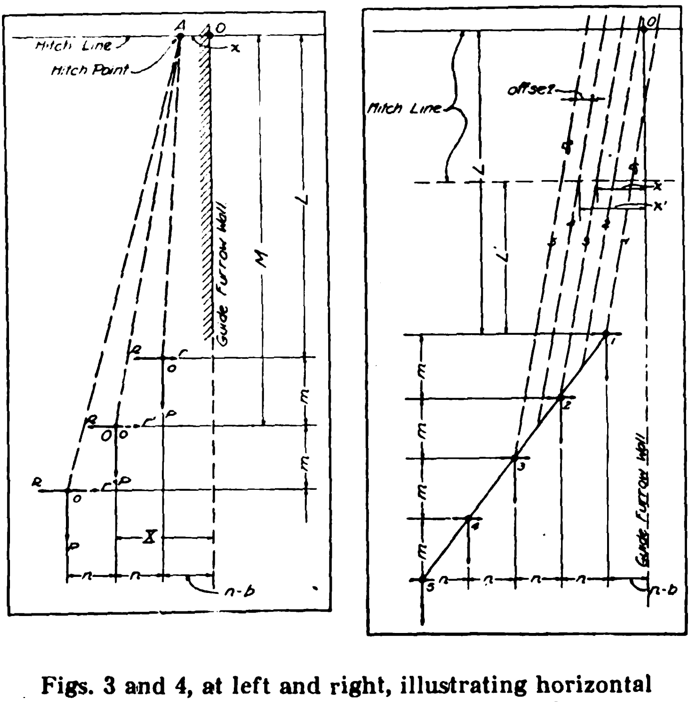
[2] A study of the Plow Bottom and Its Action Upon the Furrow Slice, Journal of Agricultural Research, Vol. XII, No. 4, Government Printing Office, Washington, D. C.

in Table I, which data this Society must revise and extend for future reference.

Judging from this and scouring conditions of moist and wet soils, we can assume that the coefficients of friction, earth to steel, run approximately over this same range. This data will have to serve our purpose until experimental data will give us definite facts.

TABLE 1—VALUES OF COEFFICIENT OF FRICTION

	Coef. of Friction	Angle of Repose in Degrees
Earth on earth	.25-1.00	14.0-45.0
Earth on earth, dry sand, clay and mixed earth	.38- .75	21.0-37.0
Earth on earth, damp clay	1.00	45.0
Earth on earth, wet clay	.31	17.0
Earth on earth, shingle and gravel	.81-1.11	39.0-48.0



Figs. 3 and 4, at left and right, illustrating horizontal angle and lateral adjustment of hitch

The general equations of horizontal forces then follows:

$D=\sqrt{[P+f\ (R\text{-}r)]^2+r^2}$
$D\ \ cos\ a=r$
D=drawbar pull
P=resistance lengthwise of furrow
R=cross furrow reaction to left
r=cross furrow reaction to right, or left
f=coefficient of friction, steel to earth

Or, we can say that when $D\ cos\ a = r=R$, and is acting in opposition, there will be no landside pressure and $(R\text{-}r)\ f=O$; hence, $D=\sqrt{P^2+R^2}$. This equation, then, would furnish the actual pull in the horizontal plane and through the center of reaction of all horizontal forces on O and in the direction of D. The strain in the line of D for any other angle from the horizontal would be $D \div cos\ B$ when B=angle of draft with the horizontal plane, the vertical component of which would counteract the load W in part.

It is certain that if we hitch to the right of O, (Fig. 2) or toward the guide furrow wall to a degree such that $D\ cos\ a$, or r, is equal to or greater than R, the plow will tend to run out onto the plowed land and likewise if we lead away from the guide furrow wall so that angle a is greater than 90 degrees, we automatically increase the pressure still further against the furrow wall, R, until a point is reached where the plows will run into the land due to a crushing down of the furrow wall receiving this pressure. These two extremes then give us the limits of possible practical operation on level ground. Obviously we desire to maintain, for steady operation, a component toward the unplowed land either as a reasonable pressure against the furrow wall, through the landslide, or by means of the rear or furrow carrier wheel, the sensible amount of which pressure we shall have to determine by experiment.

The tractor plow consisting of from two bottoms up to any desired number is, naturally, a multiple problem of the single bottom. Taking a three-bottom outfit for illustration, we reason as follows:

Assume the tractor hitch point at A (Fig. 3) a distance from the guide furrow wall equal to x. The distance (L) to the first bottom and P, R, and r, acting at the assumed point (o) of composite forces O, a distance b from the landside of any individual plow.

The three lines joining the plow bottoms to the hitch point are at different angles, hence the relief of landside pressure would be different for each plow bottom if these were not rigidly connected together. To find this combined effect we can analyze it by taking moments about any point as O

(Fig. 3), the intersection of the guide furrow wall and the hitch line, thus:

$P(n\text{-}b)+P(2n\text{-}b)+P(3n\text{-}b)= 3PX$
$6\ Pn-3bP=3PX$
$2n-b=X$

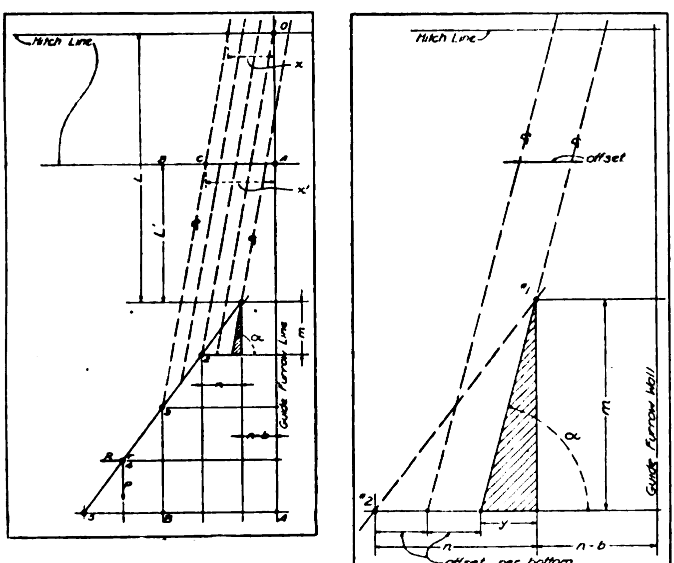
Also the center of action from the hitch line

$RL+R\ (L+m)\ +R(L+2m)=3RM$
$3RL+3Rm=3RM$, or $L+m=M$

Where M=the distance from hitch line to center O of plow outfit, which proves that the combined center of reaction of a three-bottom gang lies on plow No. 2 and at its center of reaction O. By deduction we can place the *center of reaction of any number of bottoms instantly as the mid-point on the line of center of reaction of the individual plows.*

What now interests us practically is the answer to the question of where to hitch on the motive power to meet the variety of conditions of the various soil resistances, moisture content, types of bottoms, length of hitch, condition of plows, etc. The basis, however, can be much aided by this analysis.

Whether it be one bottom or many, the theoretically correct line of draft in a given soil with conditions all alike, gives us a constant direction of the draft line D (Fig. 4), acting through the combined center of reaction, i. e., for one



Figs. 5 and 6, left and right respectively, analysis of hitch with exaggerated angle for clearance

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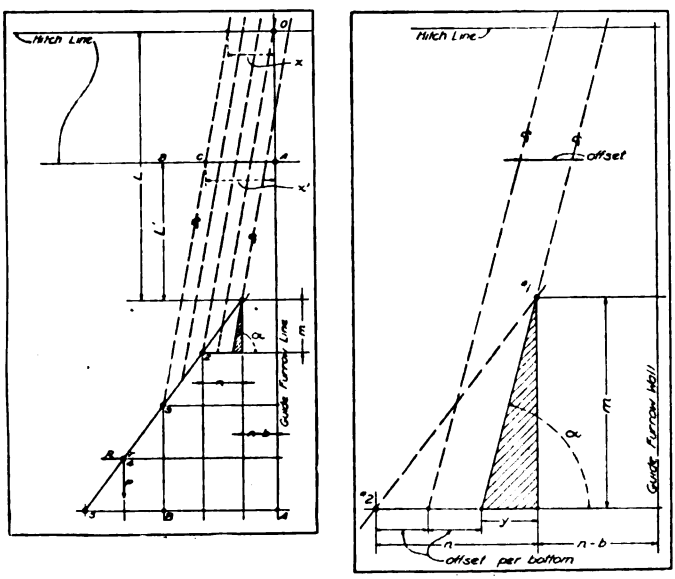

Figs. 5 and 6, left and right respectively, analysis of hitch with exaggerated angle for clearance bottom we have Line 1; for two bottoms, Line 2, etc., all of which lines cross any given line (as through O) at equal distances, and hence the distance we are interested in, x or x', is the theoretical hitch point distance from the guide furrow wall. This obviously is different for every variable length of L, or L', and every different number of bottoms, and varies also with every given size and type of bottom, nature and condition of soil. The shorter the length L, the farther we can hitch from the furrow wall, providing, of course, that this close hitch does not interfere with good operating and turning. Under these conditions we would have the same general reactions provided the same angle in the vertical plane is maintained with respect to the ground.

We are now in a position to develop the general formula, to cover any number of plows, any length of hitch, any width of cut or any spacing lengthwise of the furrow of the several bottoms, and determine the distance from the furrow wall to hitch to and have ***no pressure*** on the furrow wall. From this calculation we can arrange to secure what is desired in the way of furrow wall pressure, or an equivalent reaction taken by the rear or other carrier wheel.

Figs. 5 and 6 represent the conditions with an exaggerated angle a to facilitate the understanding. It is clear that as we add each plow we must offset from the furrow wall a definite amount according to the relation of the actual R against the furrow wall when pulling parallel with the furrow, and P, the draft lengthwise of the furrow without the added component of friction, such that $\cot a = R \div P$ which determines for no landside pressure the direction of D_1 to D_5. In Fig. 6, then, the offset between these lines may be found as $(n - y) \div 2$, or $y = m \cot a$, hence the offset $= (n - m \cot a) \div 2$
Refer to Fig. 5 and follow through the total offset from the furrow wall x or x' as being $x = AB - BC = (n - b) + (N - 1)\ (n - m \cot a) \div 2 - L' \cot a$
in which n = width of furrow cut

b = distance from furrow wall to composite O of action
N = number of plows in action
m = spacing of plows lengthwise of furrow
a = angle of D with respect to cross furrow line
L' = distance from first plow center of reaction to the pitch line

As the foregoing hitches are drawn with D as though consisting of a single line we have to substitute therefor the rigid or chain hitch of various forms.

In every case for proper operation the imaginary line DD is fixed, and modification of the single line hitch must balance about said line as indicated. The proof is simple by mechanics or graphics. This chain hitch is very useful when operating with plows having large numbers of bottoms.

Should the chain be continuous and pass over pulleys at the four corners as in the above third illustration, instead of a locked condition, it is obvious that no relief can be exerted for the cross-furrow force, hence the draft must be greater than in the first two. However, should this cross chain and pulley combination have been substituted for a hitch, which had acted on the tractor to the left of a line joining the center of reaction *O* and parallel to the furrow wall, relief would result, but not if the tractor hitch had been to the right of said line.

In these diagrams (Fig. 7) *CD* equals *DE* either side of the direction line *D*, and at the respective ends.

From practical results let us take the judgment of experienced plow operators as recommended to this Society for standardized hitch data and see how the *X* values stand.

TABLE 2—RECOMMENDED STANDARDIZED HITCHES

(A.S.A.E.) (S.A.E.)

14" bottoms: b = 2", L = 80', m = 19", n = 14"

	Distance from Furrow Wall OX			Calculated from Rear				
No. of Plows	OX Min.	OX Max.	Center	Off Center R		Off Center L		L' & M
2	15"	30"	20"	4.5"—3°	1'	10.5"—6°	42'	89.5"
3	20"	32"	26"	6" —3°	28'	6" —3°	28'	99"
4	24"	40"	32"	8" —4°	13'	8" —4°	13'	108.5"

The off center distances are shown right and left of a given line, like *P*, passing through the center of plow reactions and are read at the tractor hitch point. The distance from said reaction to the hitch line is equal to *L* and *M*.

As a practical example emphasizes readily the features desirable to drive home, we will take the case of the three-bottom outfit and calculate the ideal hitch in light and heavy land and show what modifications have to be made to co-

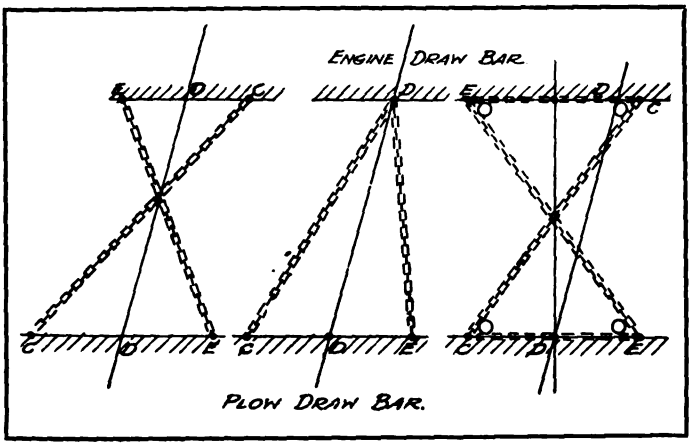

Fig. 7. Application of theoretical lines of draft to various types of chain plow hitch

ordinate with the theory advanced above, as well as these recommendations.

From Table 2 we find 6 inches advocated as the limits of center distances and 99 inches as the designed length $(L' + M)$ from the hitch point to the center of reaction. If force D pulls along a line 6 inches off center and 99 inches long, the cross furrow effect of D would be in relation to P, as $1: 16.5 = P: r$.

As the recommended minimum and maximum values of hitch from the furrow wall are 20 inches and 32 inches and are dependent on loose or light soil conditions, we wish to deduct the corresponding effects in heavy soil on the proper hitch point. The ratio of 1: 16.5 in various soils then give us the following:

TABLE 3—Soil Resistances P and Reactions per Bottom

P:R = 1:8. Angle of D — 6″ to right of center of reaction. Hitch 99″ from center of plow reactions.
r = D cos a = P cot (90° — x) 3° 28′. P:r = 1:16.5

P lbs.	R lbs.	r lbs.	(R-r) lbs.	Soil	f (R-r) f = .30 lbs.	f (R-r) f = 1.00
400	50	21.2	25.8	Very light	7.84	25.8
600	75	36.4	37.6		10.28	37.6
800	100	48.5	51.5	Medium	15.45	51.5
1000	125	60.6	61.4		19.32	64.4
1200	150	72.7	77.3	Heavy	23.19	77.3
1400	175	81.8	90.2		27.06	90.2
1600	200	97.0	103.0		30.90	103.0
1800	225	109.0	116.0	Very heavy	34.80	116.0

The first inspection of these figures emphasizes the feature that with a given type of plow bottom, operating in various soils the same theoretical hitch gives needlessly high pressures of $(R - r)$ in all but light soils. If 25.8 pounds will hold the plow against the furrow wall, 116 pounds is not necessary in heavier soils. We can then conclude that roughly 25 pounds per bottom should do for all, and we can relieve the balance of the reaction by decreasing the angle a or increasing the angle $(90 - a)$. What we want then is a net reaction $(R - r) = 25$ pounds all through. Here we have the calculation to determine the change in angle of pull to secure this:

$$\frac{R - r}{P + f\,(R - r)} = \tan\,(90 - a)$$

Case 1. Soil resistance 400 pounds, P: $(R - r) = 1{:}16.5$
Type of moldboard such that $P{:}R = 1{:}8$
50:400:: 1:8 and the soil friction $f = 0.3$
If now we pull to the right until $R - r = 25$ pounds and solve the equation above we have:

$$\frac{25}{400 \times 0.30\,(50 - 25)} = \frac{25}{407.5} = \tan\,(90 - a) = .0614.$$

Therefore $(90 - a) = 3° \ 31' = 6\frac{1}{8}$ inches offset to the right of center line which figure agrees very closely with that advocated.

Case 2. Soil resistance 1800 pounds, $P' : R' - r' = 1:16.5$ $P : r = 1 : 8$ with same moldboard as above, but the frictional resistance of this heavy soil we assume as $f' = 1$.

If again we pull to the right until $(R' - r') = 25$ and solve the equation, we have: $P' : R' :: 1800 : 225$

$$\frac{25}{1800 + 1.0\ (225 - 200)} = \frac{25}{1825} = \tan\ (90 - a) = .1101$$

and $(90 - a) = 6° = 17$ inches $= 11\frac{1}{8}$ inches to the right of center line. The center of reaction is $(n - b) + n$ from the furrow wall for three bottoms $= 14 - 2 + 14 = 26$ inches, from which we deduce

$26 - 6\frac{1}{8} = 19\frac{7}{8}$ inches $= X$ for *light soil* from the furrow wall

$26 - 11\frac{1}{8} = 14\frac{7}{8}$ inches $= X$ for *heavy soil* from the furrow wall

This gives us the same pressure against the furrow for light and heavy soil, and minimizes the draft D and landside friction to that which will give good operation.

It should be more clearly seen now that when we apply the first formula developed $D = \sqrt{[(P + f\ (R - r)]^2 + r^2}$ and make $r = R$, no landside pressure develops, solving results in a draft $D = \sqrt{P^2 + r^2} = 1814$ pounds

For the 25 pound landside pressure we have

$D' = \sqrt{[1800 + 1.00\ (225 - 200)]^2 + 200^2} = 1836$ pounds, or 1.2 per cent increase.

For pulling straight ahead we get no relief as $r = O$.

$D'' = \sqrt{(1800 + 1.00 \times 225)^2} = 2025$ pounds, or 11 + per cent increase.

Next by pulling 3 degrees 31 minutes, or 6 inches to the *left* of center we get

$D''' = \sqrt{[1800 + 1.00\ (225 + 109\ )]^2 + 109^2} = 2136$ pounds, or 17.7 per cent increase.

If we still further assume that the furrow wall will stand up against the force of net R up to the $6° \ 17'$ angle to the left of center which means a hitch $26 + 11\frac{1}{8} = 37\frac{1}{8}$ inches from the furrow wall

$D'''' = \sqrt{1800 + 1.0\ (225 + 202)^2} = 2235$ pounds, or 23.2 per cent.

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Next by pulling 3 degrees 31 minutes, or 6 inches to the *left* of center we get

$D''' = \sqrt{[1800 + 1.00\,(225 + 109\,)]^2 + 109^2} = 2136$ pounds, or 17.7 per cent increase.

If we still further assume that the furrow wall will stand up against the force of net R up to the $6° \ 17'$ angle to the left of center which means a hitch $26 + 11\frac{1}{8} = 37\frac{1}{8}$ inches from the furrow wall

$D'''' = \sqrt{1800 + 1.0\,(225 + 202)^2} = 2235$ pounds, or 23.2 per cent.

This discussion is on the assumption that the rear carrier wheel does not resist the cross furrow pressure. It can do so completely up to the point of pulling straight ahead of the center of plow reaction or up to a hitch 26 inches from the furrow wall for the three-plow outfit if it is so designed as to lock and resist side pressure, thus taking the thrust instead of its going to the landside, changing sliding friction to rolling friction, but it will not relieve landside pressure if the wheel is free to swing with plows in the ground acting only as a weight carrier. From the above it should not be wondered at that the same plows in the same land, at the same depth, in the same conditions, and operated at the same speed, show different drawbar pulls.

Varying hitch points relatively right and left would explain much of these differences. Other shapes of moldboards would either decrease or increase the percentages in accordance with the designed ratios of $P : R$, being different from 1 : 8, as assumed from this example.

Again if the speed is increased we readily see that the net R changes in a different ratio than the other several components, and a plow which at two miles per hour would be a 1 : 8 ratio, might be at three miles a 1: 6 ratio.

Attention to the recording of data covering hitch points from the furrow wall the distance from hitch point to center of reaction, the heights of hitch, the type of moldboard, and cross furrow forces should therefore appear as part of tractor trial field data just as much as speed of plowing, drawbar pull and fuel consumed per acre.

The vertical reactions next need attention from the standpoint of the hitch. Fig. 8 will serve to illustrate the rough relations which exist on a type of plow operating at 6 inches deep.

The weight, carried on three points as on wheels, *A, B, C,* will vary between the condition of simply hauling the outfit over ground to that produced by the plows being in action and lifting and turning the soil.

Table 4 illustrates the pure loads without the entry of the vertical component, resulting from the hitch to the drawbar being above the center of reaction O, and the inertia effects of very rapid plowing.

TABLE 4—LOADS ON THREE BOTTOM PLOWS
SOIL AT 90 LBS. PER CU. FT.

Wheel Loads	A Furrow Wheel lbs.	B Land Wheel lbs.	C Rear Wheel lbs.	Total lbs.	Distribution of Soil Weight Pounds			Total lbs.
					F.W.	L.W.	R.W.	
Light overland	360	336	367	1063				0.0
Pl. 3″ deep	412.2	397.6	469.6	1279	52.2	61.6	102.6	216.4
Pl. 6″ deep	464.3	459.2	572.2	1496	104.3	123.2	205.2	432.7
Pl. 9″ deep	516.5	525.8	674.8	1717	156.5	184.8	307.8	649.1

Review of specific data placed the gravity center of the three plow outfit at approximately just ahead of the nose of No. 2 bottom and about 1¾ inches to the right of the landside, viewed from the rear, also about 16 inches above the bottom of the furrow when set to plow 6 inches deep.

The simplest method of obtaining the center of gravity being to balance the outfit over angle bars, set first cross furrow then lengthwise of the furrow. The height of the center of gravity being determined by hanging up the plow and finding the gravity center by means of a plumb line projection onto two views.

The gravity center may also be calculated by taking equivalent moments of line A about the line BC, B about the line AC, and C about the line AB, each with respect to the total load W about the same lines.

Wheel B or A used to operate the power lift must have traction enough to withstand the drag of this operation, and also take care of the cross furrow reaction which may be transferred to it through the incorrect hitch, hence the necessary weight or other device to increase traction on this rim.

The rear carrier wheel running on newly cut ground must bear the necessary load so that its load multiplied by the coefficient of friction of steel to earth will still be safe against the side thrust of the three bottoms.

The reaction being W at $C \times f = 3$ times the net R per bottom. In Table 4 three bottoms 6 inches deep we see rear wheel load $= 572.2$ pounds, $f = 1.0$, and $(R - r)$ we shall take at its most, 116 pounds. Then 572.2 pounds is greater than 348 pounds. But if $f = 0.3$ we would have $572.2 \times 0.3 = 171.7$ pounds which is less than $3 \times 116 = 348$, hence the rear wheel would slip and be ineffective allowing the landside to carry the reaction net R. Under these conditions the rear wheel need not necessarily hug the corner of the furrow, in the first case; but would better do so in the second.

Again, our hitch between the rigid bar or chain and the plow drawbar may affect this materially, as shown in Fig. 8. The adjustment enables us to alter the hitch point, at both drawbars, above and below a straight line between motive power hitch and plow hitch. If the plow hitch be above the imaginary line we will lift part of the weight from the wheel C and transfer it to A and B, the whole outfit tending to rock about a line through the earth contact points of wheels A and B.

On the other hand, if the line runs low on the plow hitch bar the tendency is to lift the load from the wheels A and B and transfer it to C. Correction of this feature is however, more understandable than the side reactions, and less operation trouble is experienced in the field with it.

The chief cause of unsatisfactory draft which affects the vertical forces is that of dull shares.

With a properly set and adjusted plow outfit our downward forces are primarily the total load on the wheels plus the load of earth being carried. This is partly overcome by the upward pull or vertical component of *D*, but our net *W* is down and is carried entirely by rolling friction because the the bottom of the furrow.

As the shares become dull they, however, soon form a plow is so built that only the cutting edge is in contact with surface beneath sufficient to present an area and our draft increases because this dull wedge tends to lift and change part of the rolling friction load to sliding friction until at last the area and the furrow bottom present values which will carry the net weight of the whole outfit and our frictional resistance Wf has reached its maximum. Where $f = 1.0$ as before, and with a plow weight of 1495.7 pounds (Table 4), the draft has increased nearly 500 pounds per bottom, if we could keep it in the ground at all. The efforts will be within the values given below.

TABLE 5—DULL SHARES.

P—per Bottom lbs.	f—1.0 lbs.	Percent Increase	f—0.3 lbs.	Percent Increase
400	500	125	150	37.5
800	500	62.5	150	18.75
1200	500	41.7	150	12.50
1600	500	31.2	150	9.37
2000	500	25.0	150	7.50

The highest percentage shown for light soil and the lowest result for heavy soil are undoubtedly exceptional if not impossible, but the table serves the purpose of emphasizing this feature pending actual investigation.

Fig. 9 has reference to hitching draft animals to two-bottom plows. Two types of hitches are illustrated, the four-horse abreast and four-horse tandem.

In the Central West the two-bottom 14-inch plow with four-horse abreast hitch is without doubt the most popular, while in the West and the Northwest the tandem hitch is universally used. These tandem hitches may take four, five, six, or even seven horses. The four-horse abreast hitch on two-bottom plows, especially one that is smaller than 14 inches and also on the single 16-inch plow where very often four horses are necessary, has always had the attention of the plow designer.

The center of draft in any four-horse abreast equalizer will naturally be central, and when one horse walking in the furrow pulls upon this singletree over the center of the furrow, the center of draft on the whole device is governed by the length of the evener; the length of this evener is gov-

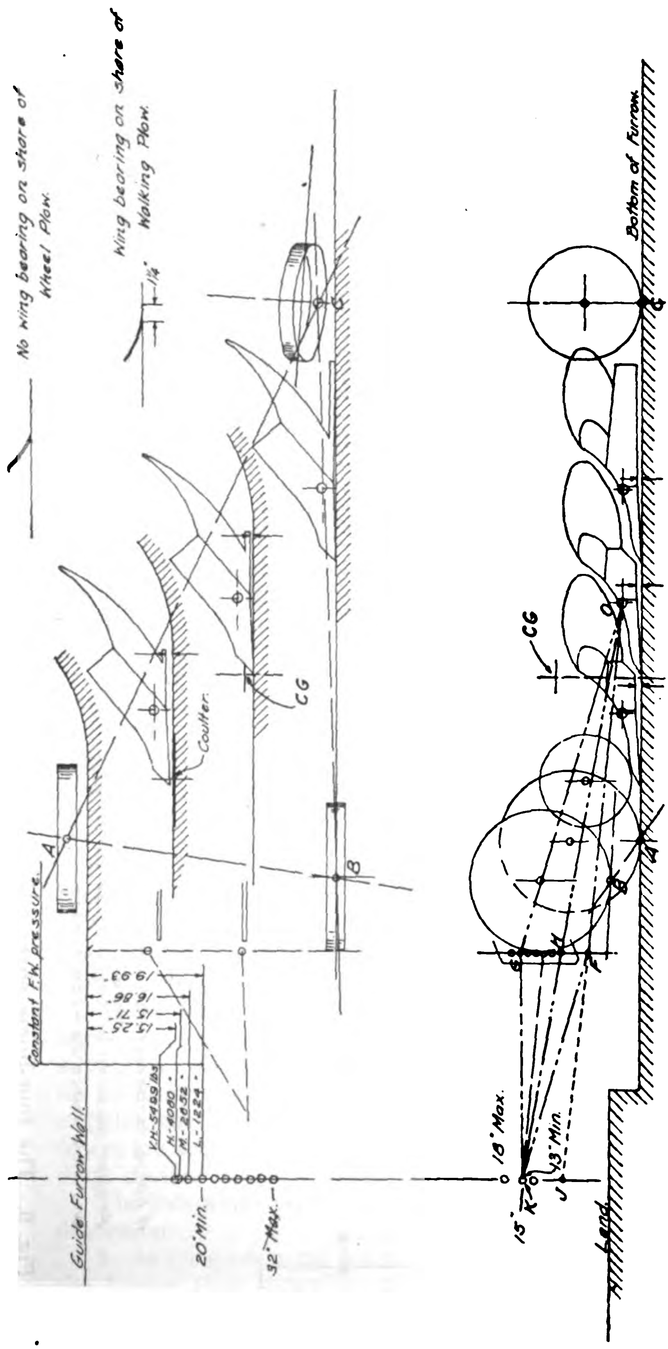

Fig. 8. Diagram showing rough relations, both horizontal and vertical, of a plow running six inches deep

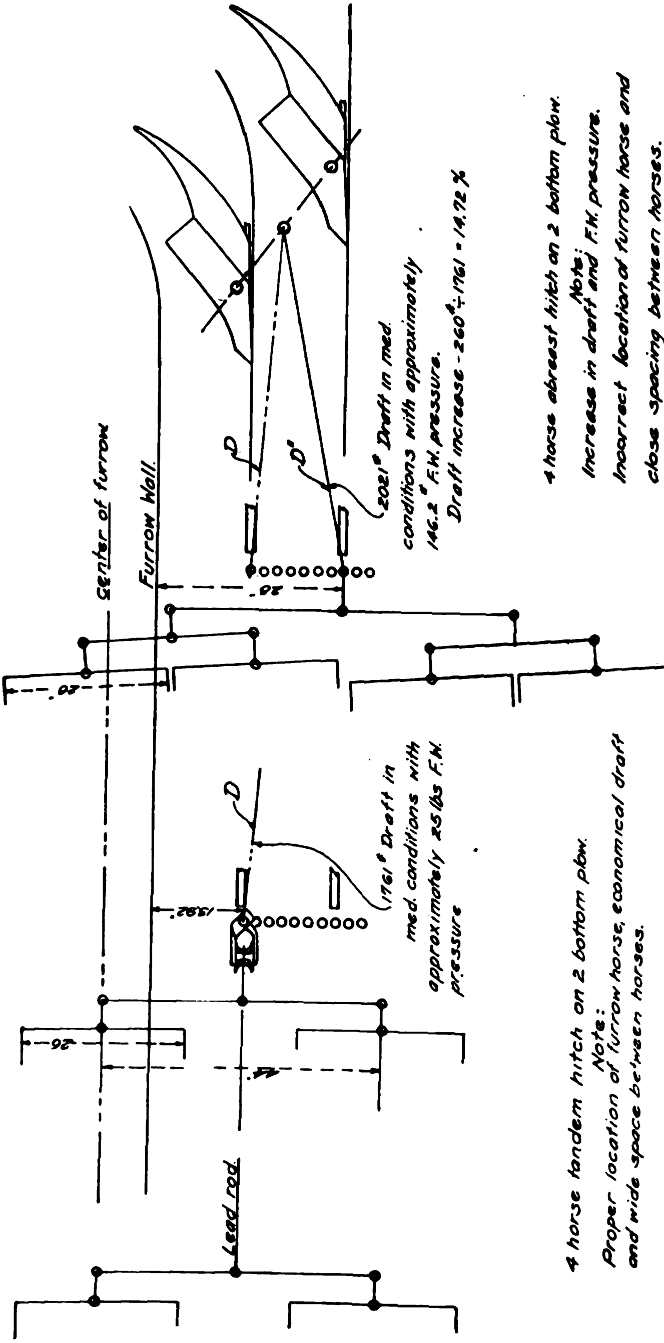

Fig. 9. The four-horse abreast hitch and the tandem hitch compared as to results with two-bottom plow

erned by the space in which it is possible to operate four horses abreast.

In order to keep the center of draft on the equalizer as near as possible to the furrow, the singletrees are usually very short—26 inches, or not over 30 inches. The singletree centers are as close together as possible, but unfortunately this equalizer center on the four-horse abreast hitch with one horse in the furrow is too far from the furrow wall to make it possible to hitch to the most economical hitching point on the plow. For this reason lateral hitch adjustments toward the land far in excess of what they should be are provided and to offset the evils of this incorrect hitch the plow designer has provided certain other adjustments.

Realizing that there is excessive furrow wall pressure when hitching to the extreme left, the rear wheel is therefore set close to the corner of the furrow, the edge of the tire usually being located about ½ to ¾ inches to the left of the landside of the plow, thus always taking advantage of the rolling friction on this wheel, even though the operator may not properly adjust the control rod controlling the direction of travel of this wheel.

The front furrow wheel is provided with adjustment on the tongue for adjusting the direction of travel of this wheel toward the land to properly hold the front end of the plow up into the land.

All friction against the bottom of the plow is eliminated, especially on wheel plows, by presenting only the cutting edge of the share to the bottom of the furrow, the rear portion of the landsides always being carried above the bottom of the furrow approximately ½ inch to insure carrying the weight on the wheels and avoid unnecessary friction on the bottom side of the plow.

The tandem hitch usually has this draft center near the furrow for the reason that more of the animals are operated in or closer to the furrow. It is also possible to have more space between each animal which is a big advantage particularly in the warmer climates.

There must be considerable energy lost by operating four horses abreast, as draft animals cannot work to the best advantage when crowded together. The principal reason for using four horses abreast is to facilitate plowing in smaller fields surrounded by a fence, while in the Northwest where fences are seldom used the tandem hitch is no doubt the better draft device.

The following conclusions are derived from the foregoing discussion:

1. As the economical hitching point on all plows is nearer the furrow than generally assumed, we should locate our draft animals or motive power in such position in front of

the plow that the center of draft will register as near as possible to the proper location of hitch on the plow.

2. Considering the tractor, we realize that the center of the tractor should be directly ahead of the center of load wherever practicable, although hitching to the right or left of the center of load to a certain extent can be done. However, the average width of small tractors pulling small plows does not permit us to use this center point on the tractor directly ahead of the proper hitching point on the plow, especially when the tractor is operated on the land. If not objectionable or necessary we can then overcome part of this difficulty by operating the tractor in the furrow, and then compromise still further by hitching on the tractor drawbar to the furrow side of tractor center.

A still further compromise may be necessary and can be made by adjusting the plow hitch to the left or away from the furrow wall, or its ideal point. It should further be remembered that inasmuch as the tractor is less sensitive to offside pulling than is the plow, the compromising should, as far as possible, be in favor of the desirable plow hitch point. Since most tractor plows have a rear wheel designed to take the side thrust there can be no serious objection to hitching within the limits recommended. Consequently, we find it desirable to support the recommendations of the several hitch points as given in Table 2.

It will be noticed that the recommendations for the extreme adjustment on the plow hitch away from the furrow

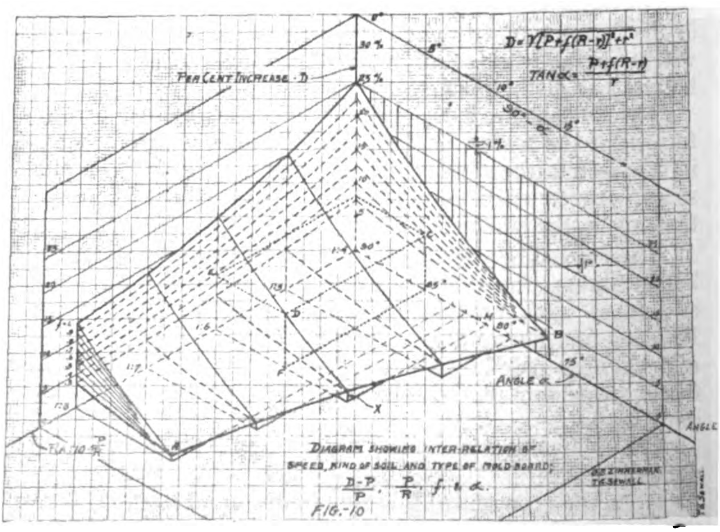

Fig. 10. Graphic representation of the entire hitch problem, taking into account varying friction

seem in excess of what they should be, especially in a two-bottom outfit. We have made this recommendation for the reason that in many conditions the tractor cannot be operated in the furrow, and we believe if the adjustment is used within these limits no serious operating difficulties will arise, but so far as practicable adhere to the minimum distance from the furrow wall.

In extremely light, fluffy soils, it is not advisable to make use of the extreme narrow adjustment from the furrow wall. Any plow must have a sufficient amount of furrow wall pressure to hold it in line of travel. At the same time it is desirable to keep this furrow wall pressure as low as possible.

3. When using draft animals it is useless to state any positive location of hitch on the plow without considering the center of draft on the equalizer used.

One essential requirement is proper width of cut and usually the operator will resort to the lateral hitch adjustment to accomplish this without regard for the economical hitching point. It should be the aim of every operator to arrange his draft animals by means of a suitable equalizer to bring about a center of draft on this equalizer that will register as nearly as possible with the proper hitch on the plow, and in the event that he is compelled to use four animals abreast where the hitch on the plow is considerably to the left of the ideal, he should not overlook all other possible means provided in this plow for offsetting this evil, such as proper location and direction of travel of the front wheel and proper relief on the under side of the plow from the bottom of the furrow.

When using the tandem hitch the difficulties are the reverse of those when using the abreast hitch for the reason that a tandem hitch can be just as far from proper in one direction as the abreast hitch is in the other direction. There are conditions of light, fluffy soils where a narrow tandem hitch will bring about a hitching point on the plow too far to the right, thus dragging the plow sideways. In this condition the operator should spread the draft animals and thereby automatically move the center of draft more to the left to bring about a reasonable amount of furrow wall pressure that is necessary for successful operation.

4. For most economical plowing the operator should keep in mind reducing friction wherever possible. First, the cutting edge of the plow should be kept sharp and present only the cutting edge to the bottom of the furrow on wheel plows, in this way reducing all possible chance of bottom friction. Second, use sharp coulters not only to cut the trash but to separate the furrow slice from the land before it is turned by the plow. Third, where wheel adjustments are provided these adjustments should be made use of to control

the direction of travel of these wheels. The rear wheel should lead slightly away from the furrow wall, and if hitching to the extreme left, such as when four animals are used abreast, the front wheel should lead slightly toward the land. If the wheel spindles are well lubricated this rolling friction may relieve considerable sliding friction. Fourth, the height of the hitch on the plow should be adjusted to distribute evenly the weight on the fore and aft carrying wheels, by adjusting downward at the clevis to relieve the load on the front wheel and increase the load on the rear wheel, or adjusting upward on the clevis to increase the load on the front wheels and decrease it on the rear wheel.

THE HITCH PROBLEM VISUALIZED

As we are interested in visualizing as much of the entire hitch problem covering as many variables and their interrelation as possible, Fig. 10 was constructed as a development of the formulae

$$D = \sqrt{[P + f\,(R - r)] + r^2}$$

$$Tan\ a = \frac{P + f\,(R - r)}{r}$$

We have here a space relation in which the three coordinates are:

1. The ratio $P : R$, or the relation of the down furrow force P to the cross furrow force R which exists at the moment under consideration when the plow is in operation and the various kinds of moldboards, those with long slope up to those very abrupt. While these ratios have been only roughly deduced from judgment and practical operation the diagram does not necessarily cover all but will serve a usefui purpose.

2. The angles of pull of D between the center of plow reaction and the hitch point, with respect to either a cross furrow line like R, values of a = 90 to 75 degrees; or, as shown above, as the angle to the right of a down furrow line like P, as $(90 - a)$.

The effect of angles of pull to the left of the down furrow line or over 90 degrees can be roughly interpreted by imagining an extension of the warped planes through the left coordinate planes.

3. The percentage of increase of pull D over and above that needed is shown in percentages from 0 to 25. As the draft D is affected markedly by the coefficient of friction f, this feature is also incorporated.

These relations form the surfaces shown as leaves of a book.

To interpret the diagram let us take one case, that of where we are hitching so as to have $a = 85$ degrees, or 5 degrees from the down furrow line and to the right. Run down line 85° to F, lying in the cross plane which represents $P : R$ as 6 : 1, then rise until the line pierces the plane as at D where $f = 1$. Then $F D$, read on the per cent scale, shows 8 per cent. $8 - X = 8 - 1$, or 7 per cent net, greater draft for D with a hitch at 85 degrees than would be shown if our hitch had been set at H, or 81½ degrees, run out from X. At 81½ degrees the cross furrow force would be O; hence the practical angle would be somewhere between 81½ and 85 degrees, according to the desired furrow wall pressure and such other practical accommodation as is necessary.

A review of the diagram will clear up the values of these relations, when thinking relatively of light and heavy soil operation.

We can say then that as a plow is operating in a field of varying soil the draft D will vary with a given angle of hitch, passing, say, from plane $f = 1.0$ to plane $f = 0.6$ back and forth. Also as the speed might vary causing the $P : R$ relation to go from 1 : 6 to 1 : 5.5 and if for any reason the angle of hitch should vary a few degrees due to hill slope plowing, say, between 4 to 7 degrees from the down furrow line, the draft would follow the corresponding relations according to the several coordinate values.

This emphasizes the desirability of our attempting to better establish the technical relations of $P : R$, which should be developed and the values of f which the Society should do, covering the typical soils tilled in the United States and the changes of f for the various moisture content. These are two real research problems in new plow design.

DISCUSSION

MR. CLYDE: One phase of this I have become interested in, because I attempted to do extension work on this matter of plow hitch, and I found, of course, that there were some difficulties, that is, in the matter of the vertical hitch. I have had occasion to measure and draw up several tractor plows to see whether it were possible to hitch in the straight line of draft vertically, and I find several plows on the market now where that is impossible. With the lowest hitch you can get you are below the straight line of draft, and naturally you are putting more weight on the front wheels and less on the rear wheels.

I wonder if there isn't some justification for that. The rear wheel is usually small, and therefore it is not as well fixed to carry the weight as the two front wheels which are the larger. I wonder if it wouldn't be possible to design the front wheels so as to carry practically all the load, making them large so as to reduce the friction and take practically all the weight off the rear furrow wheel.

MR. LINDGREN: Your troubles there depend largely upon the height of the hitch on the tractor. It may be that the hitch on the plow is not low enough to meet the height of hitch you had on the tractor, which was lower than usual.

MR. CLYDE: That is absolutely the case. I am thinking particularly of the Samson tractor and the plow where the tractor hitch is very low.

MR. LINDGREN: There are some tractors out where it is almost impossible to hitch a plow and distribute the weight evenly on all three wheels. In regard to your question of having all the weight on the front wheels, I don't think it is good. The aim is to hold the back end of the plow down, because it is the first end of the plow that comes up when it gets full, and anyone can tell you, after operating dull shares, that it is the back end that rears up first. In many conditions the shares don't keep sharp very long either. A plow when properly operated should have the weight evenly distributed on the three wheels.

One good way of telling is to run alongside of the plow and grab hold of the wheel and feel what it takes to stop it, and then grab one of the front ones and then govern your hitch accordingly.

MR. COLLINS: I would like to ask more specifically about the matter of the sharpness of the share. It has been my experience that unless we are working in alfalfa or something like that that has roots, that the sharpness of the edge has very little if any effect, but the form of the plow is what makes the difference; as he said, the way it fits on the bottom. If it is not up on the bottom you have the dragging effect. The experiments that I have run in that line I merely took a new share and dulled the edge so there was an eighth of an inch edge on it all the way along, but the plow was still, you might say, in ideal form. I found that in ordinary plowing it didn't show any difference.

MR. DICKERSON: I didn't quite understand Mr. Zimmerman's statement that the coefficient of friction was 1 in the case of the dull share.

MR. ZIMMERMAN: The coefficient of friction varies in different soils, whether you have a sandy or loose soil. It varies all the way, according to very meager experiments, from 0.3 up to 1, and with certain very unusual soils up to 1.2. In other words, the coefficient of friction was greater than 1, considerably.

RELATION OF LUG EQUIPMENT TO TRACTION*

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THE relation of lug equipment to traction is one of the most important factors in the tractor problem today. There is a lack of basic information relating to this important factor. This statement is borne out by the opinions expressed by both manufacturers of wheel tractors and agricultural engineers. Obviously, agricultural engineering departments of state agricultural colleges contemplating a program of tractor research should include this feature of the subject as one of prime importance.

As exceptions to the above, two striking pieces of work on the subject should be mentioned which have so far yielded the most of the data which is available.

In his report on "The Principles of the Wheeled Farm Tractor," E. R. Hewett found in a series of laboratory tests on full sized wheels that:

1. The maximum drawbar pull is a definite function of the weight per inch of width. Weights used varied from 10 to 200 pounds per inch; the ratio of maximum possible drawbar pull to total weight on the wheel was constant for that range. This was found to be true whether the ground was wet or dry.

2. On sandy ground the drawbar pull available with a smooth metal wheel is about 30 per cent of the weight on the wheel.

3. On damp, sandy ground, the maximum drawbar pull is greater, being about 43 per cent of the weight, and under some conditions even slightly higher.

4. Cleats increase the maximum drawbar pull only insofar as the soil resists shearing; that is, the cleat carries a section of the top soil and slides it against the soil below the edge of the cleat. Experiments indicated that this was practically independent of the depth of the cleat, depending solely on the shearing strength of the soil at the depth of the cleat edge. In some cases the shallower cleat pulled more than the deeper cleat because the roots in the sod were not cut off and advantage was taken of their shearing strength.

It was found that a cleat inclined forward at an angle would improve this condition somewhat. In going uphill the cleat enters the soil almost horizontally, acting like a step and tending to lift the weight off the wheel. On leaving, the cleat stands almost vertical and causes less fric-

*Fifteenth annual meeting paper.

tion and loss of power. An inclination of about 30 degrees was found to be the most satisfactory on a 6-foot wheel. This arrangement tends to self-cleaning to a certain extent. Setting the cleats at an angle of 30 degrees to the axis of the wheel also helps this cleaning effect by a slipping action. The shearing strength of the soils tested appeared to vary from 5 pounds per inch of width in dry molding sand to 75 pounds in loam or sod. No doubt tough sod or gumbo may prove even stronger than this.

From these facts it becomes evident that weight is the only means of obtaining a tractive effort of 40 per cent of the weight of the machine under bad conditions in dry ground or sand, as cleats will be of little use. Wheels 72 inches wide would give an added pull due to the use of cleats of only 360 pounds for loose ground. Weight is therefore practically the sole reliance for traction in sand or very dry loose ground. In sod or damp ground 72-inch wheels would ordinarily give 4000 to 5000 pounds pull from the cleats alone, and the light machine with only sufficient weight to hold the cleats down would show good results.

In a series of tests at Purdue agricultural experiment station the percentage of slippage of tractor wheels with different lug equipment was determined on a sandy loam soil which dries out hard but disintegrates under the tractor wheel and provides the poorest sort of footing.

As the tests progressed, it became evident that the manner in which the ground was cut by the wheel equipment and the spacing of the cuts markedly influenced the amount of slippage with projecting angle-iron cleats; the slippage amounted to 40 per cent under an average two-plow load, resulting in the conclusion that the extension angle is not the cleat for bare, dry soil of sandy texture. There was a decrease of 20 per cent in the slippage when extension rims were bolted inside the projecting angles, giving a 17-inch wheel face. This increased resistance to the backward push of the cleat was due to the firming effect of the rim on the soil.

When using narrow rims with lugs there was 16⅔ per cent slippage between no load and the average load. The slippage was 6.8 per cent when extension rims with lugs were used.

Fine results were obtained on wet ground in the spring. The "P-T" wheel equipped tractor pulled its plow up a seepy, clay hillside where the other wheel tractors would bog. The lip clear across the face of the pad gave a good holding power when pressed into the ground by the weight of the tractor, but in dry ground this same lip was a detriment as the cuts made a series of blocks which slipped back as the thrust came against the horns of the pads. The slippage on the dry, sandy ground was rather high amounting to 10 per cent. Since there is no direct disturbance of the ground by the rims of the wheel the pads afford a good opportunity to study the resistance of the soil as the tractor is forced ahead.

The tractor running all four wheels on the land was found to be at a disadvantage when pulling a two-bottom plow on bare, sandy, dry soil, as the constant crushing in of the furrow wall and the offset hitch made the tractor run on the skew and out of level. The thin spades entered and left the soil with but little disturbance, and when the plow was let down to give a stalling load, the motor stopped before the wheels would spin. This was the only case where the holding power of the wheels exceeded the motor power. To push in and withdraw the spades took power as was indicated by a slight increase in fuel consumption, but satisfaction from an owner's standpoint would come from its ability to go ahead taking the ground as it came.

The final wheel equipment tested on the in-furrow were the "Grid-Iron-Grips" attachment. These are designed for plain wheel rims, and have the same end in view as the "P-T" wheel, but accomplish the end in a somewhat different way. In effect, gear teeth about four inches narrower than the width of the rim are bolted to the rim. These force the tractor ahead by meshing in the backs of the shoes as they are laid on the ground. The tractor rolls on the part of the rim outside of the teeth, so the backs of the shoes furnish the grip for the teeth, and the track on which the wheels roll. The shoes are loosely attached so they remain flat on the ground until the wheel passes over. The "Grips" gave very good results, showing less than six per cent slippage. The slippage would have been still less if there had been fewer prongs on the shoes.

The "Miller Tractred," which has been designed as an attachment for the Fordson tractor, was tried under a variety of soil conditions during the last week of October, 1920.

The following results were obtained from the tests performed:

	Miller Tractreds	Round Wheel
On hard road, weighted sled as load		
Average drawbar pull in pounds	1800	1400
Oliver No. 7 plow in loam soil		
Average drawbar pull in pounds	1800	1400
Maximum drawbar pull in pounds	2300	1800
Oliver No. 7 plow in gravelly slope, approximately 12% grade		
Average drawbar pull in pounds	1800	1400
Maximum drawbar pull in pounds	2200	1800
Plowing speed with two 14-inch bottom plows, plowing approximately 8 inches deep. Tractor running in second speed		
Speed in miles per hour	2.09	2.70
Slippage in per cent at above speed	.05	15.9

Miller Tractreds increased the traction about 22 per cent over what was obtained from the round wheel.

Tests with the "Bentz" tractor lug were started at Pennsylvania State College with the idea of determining its efficiency as compared with various other lugs commonly furnished to the Pennsylvania farmer. The "Bentz" lug has a "quick detachable" feature which would be a distinct advantage in the state if the lug could be built cheaply enough and still have all the qualities of a good lug. Pennsylvania has a great mileage of improved state highways on which farm tractors often must travel in passing from one field to the other. In such a case the farmer must either remove his lugs or buy a license. This condition has caused a great deal of dissatisfaction among the farmers and much discussion in the legislature.

While the tests thus far conducted have indicated in most cases that the Bentz lug is somewhat superior to the angle iron, yet they have not been compared with the various other types of lugs which can be secured.

The tests were all run with the I.H.C. 8-16 tractor in competition with the regular extension angle iron cleat on the clay loam and sandy loam. The tests in sandy soil which were conducted in New Jersey with the Bentz lug were in competition with the California angle-iron cleat.

While the protection of the improved road from the effects of tractor lugs is important, there are such widely differing soil types and conditions in Pennsylvania that it is believed there is a distinct need for different types of lug equipment on individual farms if the best results are to be obtained.

The Bentz tractor lug system is so arranged that they can be attached or detached from the tractor wheel in a comparatively short time. In fact, the time required for putting the lugs on both wheels of an I.H.C. 8-16 tractor was fourteen minutes, and five minutes to remove them. This did not include the time required to jack up the tractor as this would vary with the kind of hoisting apparatus used. It should be said, however, that the man doing the work was Mr. Bentz himself who, of course, was familiar with the lug equipment and could distinguish the right and left lugs at a glance.

When the lugs have been applied to the wheel, they are held on by one bolt. These lugs hook over the edge of the wheel and each lug hooks over the one next to it. Friction between the wheel and the lugs is depended upon to resist the thrust of the wheel in moving forward.

The lugs which were used in the test were made of cast steel. Very little wear took place and no breakage. While cast steel is more expensive than malleable iron, yet there are places where steel might be preferable.

The bar lugs to lock with each other must be placed at alternate angles with the axis. One set of bar lugs was 3 inches high and the other set 4 inches. The base of the lugs next to the wheel is 2½ inches. To reduce the weight they were cast hollow, having a wall thickness of about ⅜ inch.

The tri-spade lugs were cast with three spades on each casting. These spades were 3 inches high, 2½ inches wide, and were staggered on the wheel when in place similar to the bolt on spade lugs.

An Italian spring dynamometer was used, the spring being calibrated in a testing machine in the engineering laboratory before the tests were run.

The time was taken with a stop watch in traveling 50 feet when the dynamometer tests were made. Two dynamometer cards were taken in both directions in each test on level and rolling ground and the pounds pull averaged. Also the travel in feet per minute for the two tests was averaged. On the grades the dynamometer was used only on the upgrade.

The slippage was determined by allowing the tractor to travel over a measured distance of 500 feet without load and the revolutions of both drivewheels noted. The count was taken in both directions in each test, and averaged, on rolling and level ground. On grades the drivewheel observations were made only on upgrade. Then the tractor pulled the plow or disk over the same distance and the revolutions on the drivewheels noted.

The drawbar horsepower of the tractor was calculated by multiplying the average pounds pull by the travel in feet per minute, and dividing by 33,000. The per cent slippage was determined by subtracting the slippage without load from the slippage with load, and dividing by the slippage without load.

The tests were conducted on three soil types: Clay loam, sandy loam, and sandy soil. The first two soils were located near Lebanon, Pennsylvania, while the other was located near Mt. Holley, New Jersey.

The accompanying tables give the results of the tests with Bentz lugs.

TABLE 1. PLOWING ON 4 PER CENT GRADE

CLAY LOAM SOD

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Draw-bar H.P.
I. H. C.	Angle iron	Plowing	4%	17.4	1627	189.6	9.3
I. H. C.	Tri-spade	Plowing	4%	9.4	1537.3	210	9.8
I. H. C.	3″ Bar lug	Plowing	4%	8.6	1478.2	213	9.5

TABLE 2. PLOWING LEVEL GROUND

CLAY LOAM SOD

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Draw-bar H.P.
I. H. C.	Angle Iron	Plowing	Level	17.3	1819.1	158.7	8.7
I. H. C.	Tri-spade	Plowing	Level	7.8	1734.9	174	9.2
I. H. C.	3″ Bar lug	Plowing	Level	10.1	1716.4	170.1	8.9
I. H. C.	4″ Bar lug	Plowing	Level	7.4	1833.1	159	8.8

TABLE 3. DISKING ROLLING GROUND
CLAY LOAM PLOWED

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Draw-bar H.P.
I. H. C.	Angle iron	Disking	Roll	20.3	11.58	174	6.1
I. H. C.	Tri-spade	Disking	Roll	16.7	1202.9	184.5	6.7
I. H. C.	3" Bar lug	Disking	Roll	15.2	1179.2	186	6.6
I. H. C.	4" Bar lug	Disking	Roll	13.8	1123.2	206.1	7.01

TABLE 4. DISKING ON 8.2 PER CENT GRADE
SANDY LOAM PLOWED

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Draw-bar H.P.
I. H. C.	Angle iron	Disking	8.2%	23.1	942.6	115.2	3.3
I. H. C.	Tri-spade	Disking	8.2%	13.2	821.4	181.8	4.5
I. H. C.	3" bar lug	Disking	8.2%	20	795.3	187.2	4.5
I. H. C.	Tri-spade & extension rims	Disking	8.2%	10.4	823.9	181.8	4.5

TABLE 5. DISKING ON ROLLING GROUND
CLAY LOAM PLOWED

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Draw-bar H.P.
I. H. C.	Angle iron	Disking	Roll	26.8	1094.1	154.9	5.09
I. H. C.	Tri-spade & extension rims	Disking	Roll	16.4	1497.3	188.2	6.2

The following shows the comparison of fuel consumption and time required in disking with angle-iron cleats and Bentz tri-spade lugs with extension rims. This run was made the same day and in the same field in which test No. 3 was conducted.

Angle iron: Fuel-gallons	Angle iron: Time-hours	Bentz tri-spade and extension rims: Fuel-gallons	Bentz tri-spade and extension rims: Time-hours
20.5	10	16.5	7.2

TABLE 6. DISKING ON SANDY SOIL ON ROLLING GROUND
ORCHARD

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Draw-bar H.P.
I. H. C.	Angle Cul. lugs	Disking	Roll	12.0	903.4	183.1	4.98
I. H. C.	Bentz tri-spade with extension rims	Disking	Roll	11.0	896	190.5	5.11
I. H. C.	Bentz 4" bar lug	Disking	Roll	11.0	1005.9	175.4	5.3

TABLE 7. DISKING ON ROLLING LAND
SANDY LOAM PLOWED

Type Tractor	Type Lugs	Operation	Grade	Per cent Slip	Average lbs. Pull	Speed in Ft. Per Minute	Draw-bar H.P.
I. H. C.	Angle iron	Disking	Roll	6.	679.3	200	4.11
I. H. C.	Bentz tri-spade	Disking	Roll	9.	650.9	214.2	4.2
I. H. C.	Bentz tri-spade with extension rims	Disking	Roll	4.2	665.2	214.2	4.3
I. H. C.	Bentz 3" bar lug	Disking	Roll	6.8	694.4	200	4.2

In the light of the limited data which is available on this subject, it is impossible to draw any definite conclusions or set down any definite recommendations as to the best lug for any particular condition. Therefore, I wish to suggest: First, that the Standards Committee of the American Society of Agricultural Engineers standardize traction devices, and, second, that the Research Committee outline some definite plan or method for conducting tests with various traction devices.

REMOVING DOCKAGE FROM WHEAT AT THE THRESHER*

By Robert H. Black

Mem. A.S.A.E. In charge of the Minneapolis office of Grain Cleaning Investigations, U. S. Department of Agriculture

ONE of the principal agricultural industries of the world is the growing of wheat. The United States produces about 800,000,000 bushels of wheat each year and about one-third of this, or over 250,000,000 bushels, is spring sown. Most of the spring sown wheat, or about 200,000,000 bushels, comes from the states of Minnesota and North and South Dakota.

This part of the spring wheat district has for many years produced grain containing an abnormal amount of weed seeds. The official grain standards of the United States for wheat designate such weed seeds as can be removed readily from the wheat by the use of appropriate sieves, cleaning devices, or other practical means, as "dockage." When wheat is sold on the market, the weight represented by the dockage is deducted from the total gross weight before payment is made for the wheat.

The Minnesota grain inspection records for the past 18 years show that the percentage of dockage in wheat arriving at terminal markets has been increasing. The average dockage for 1903 was 2.2 per cent; the average dockage for the six-year period ending 1914 was 2.9 per cent; and for the six-year period ending 1920 was 4 per cent, while for the 1920 crop of wheat alone marketed up to January 1, 1921, the average dockage was 5.1 per cent. This means that on this basis the 1921 crop of spring wheat contains over 10,000,000 bushels of 60 pounds each of dockage.

Some of the material removed as dockage has a certain feed value, while other constituent parts of the dockage not only have no feeding value but are actually harmful as a feed. The expense of removing the dockage at the elevators and flour mills at the present time practically offsets this commercial value, with the result that the farmers seldom receive anything for the dockage when they sell grain at their local elevators.

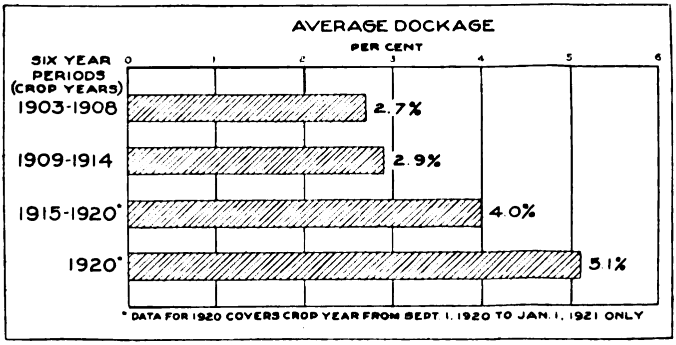
Dockage gets into the wheat from various sources. One of the principal sources is the sowing of foul wheat just as it comes from the threshing machine without any further cleaning. In order to determine just how much foul matter was being sown with the wheat, samples of seed wheat were taken from many of the drills which were seeding in the fields of Minnesota and the Dakotas last spring. On analyzing these samples it was found that a few were almost entirely free

*Fifteenth annual meeting paper.

from weed seeds, but that the average amount of weed seeds sown with the wheat was over 2 per cent of the weight of the seed wheat. Many of the samples contained over 10 per cent of weed seeds and one sample of wheat being seeded contained as much as 18 per cent of weed seeds. In terms of numbers of weed seeds sown the range was from 2,000 to 489,000 weed seeds per acre, each of which was probably capable of developing a strong weed plant. Wild oats, wild buckwheat, vetch, and kinghead, in the order named, were the four weeds most common in the seed wheat. If the farmers insist upon sowing the seed as it comes from the threshers without further cleaning, then the threshers should clean the wheat much better than is now being done.

The weed seeds that are in the threshed wheat must be removed before the wheat is ground into flour. Removing these seeds at the flour mills is not only expensive but is also economically wasteful for many reasons, one of which is that the repeated handling of wheat through the elevators and during shipments breaks up many of the wheat kernels. These small pieces of cracked wheat, which would make good flour if they could be saved, are removed with the weed seeds when the wheat is cleaned in the flour mill, because the small pieces of cracked wheat are approximately the same size as the weed seeds and are removed in the cleaning operation.

A greater economic waste is due to the expense of handling the dockage itself. At the present time the farmers in the central northwest haul this dockage in the wheat to the elevators and sell the wheat without receiving anything for the dockage. Much valuable space is occupied in every wagon load of wheat, in every country elevator, in every carload of wheat, and in every terminal elevator and flour mill by the dockage in the wheat. If this dockage could have been removed at the time of threshing, the farmer would



The dockage problem not only is a serious one but one which steadily becomes worse have been able to feed that part of the dockage having feed value, and he would also have saved the expense of hauling the dockage to the elevator. The farmer would in all probability have received a better price per bushel for his wheat if it had been clean, because among other things it is necessary in basing the prices which the country elevator pays for wheat to take into consideration either the cost of removing the dockage or the freight charges which must be paid on the dockage contained in the uncleaned wheat which is shipped to the terminal markets.

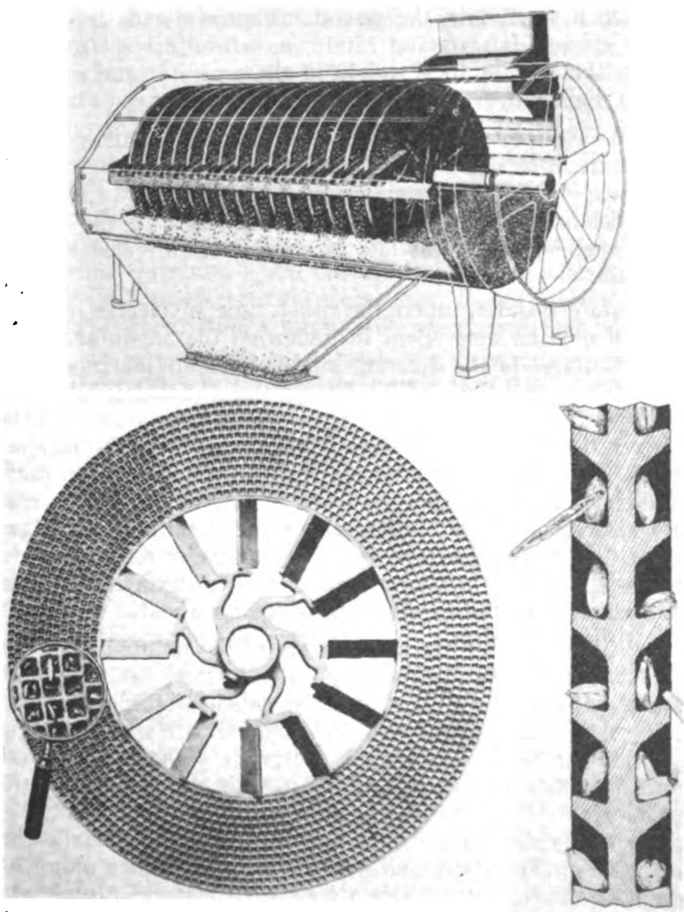
Dockage is always a troublesome factor in every stage of the marketing of wheat. It causes suspicion on the part of the farmer when he is selling his wheat because he has to depend upon the integrity and accuracy of the buyer when the percentage of dockage is being determined. Every time the grain is sold, one of the vital questions is, "How much dockage is to be assessed?" The only prevention of many of the disputes that arise during the marketing of wheat at the country elevator is either to raise wheat without dockage, or to take the dockage out of the wheat before the wheat is sold by the producer.

The federal grain investigations office of the United States Department of Agriculture on the Pacific coast had two experimental recleaners in operation on threshing machines during the 1920 season. One of these was an aspirator, and the other was a recleaner which is built for the export trade. The results secured during these trials indicated that it would be possible to develop apparatus which would make cleaning at the threshing machine entirely feasible, and it was decided to conduct similar tests in the spring wheat territory tributary to Minneapolis.

In the central northwest many weed seeds are common which are not found on the Pacific coast to any great extent. The seventeen seeds most commonly found in wheat grown in the central northwest are wild oats, wild buckwheat, tame oats, mustard, lambsquarters, barley, green foxtail, hares' ear, flax, rye, cow cockle, pigweed, yellow foxtail, sunflower, corn cockle, wild rose, and wild peas.

In past years before wild oats became so numerous, it was possible to remove such weed seeds as mustard and cockle from the wheat at the time of threshing by the simple means of placing a sieve in the bottom of the threshing separator, under the chaffer. This method is no longer effective because the wild oats which are present on nearly every farm in the central northwest quickly clog the sieves, sometimes to the extent of even stopping the flow of wheat to the grain auger. It is impossible during threshing to remove many of the weed seeds by blowing them into the straw stack, because if sufficient wind is used to blow out the weed seeds, a large amount of wheat will also be blown into the stack. Any apparatus therefore for use in connection with the threshing machine which can successfully clean wheat containing wild oats must be able to remove not only the wild oats, but should also have sufficient capacity to clean the wheat as rapidly as it is threshed.

In planning our grain cleaning experiments to be conducted in the central northwest, it was decided to concentrate our efforts on the installation of two types of cleaners, namely an "aspirator" and a "disk machine."



Assembly and details of the disk type cleaner or seed separator which gives most promise in spring-wheat areas

An experimental aspirator similar to the aspirators which the federal grain investigations office was using on the Pacific coast was built and installed on a 20x34 Port Huron separator. The top of the aspirator was fastened to the hopper which is directly below the weigher on the elevator. A valve was built into the hopper under the weigher so that the grain could be made to flow steadily out of the hopper and onto a metal disk 13 inches in diameter. The grain piles up on this disk and then falls steadily over the edge of the disk in a thin stream. As the grain falls over the edge of this disk, it is treated with a current of air which sucks out many of the smaller and lighter weight particles which are deposited into a settling chamber, and the cleaned grain passes out through a spout into the wagon. The suction is produced by an exhaust fan running 2500 r. p. m. and driven from the beater shaft. The total weight of the aspirator and exhaust fan is slightly over 160 pounds.

The aspirator was operated while threshing oats, rye and a mixture of oats and wheat usually known as succotash. In these experiments between one-third and one-half of the foul material or dockage was removed from each of the grains mentioned with a slight loss of small and shriveled kernels of grain.

Before deciding upon the other type of cleaner to use, several months were spent in reviewing the advantages and disadvantages of the different kinds of cleaning machines used in elevators and flour mills. It was thought that it might be possible to make changes in some type of cleaning machine already in use so as to adapt it for use on a threshing machine, but it was found that all of the machines used in mills and elevators were either too large, too heavy, or of too small capacity for use on a thresher. To assist us in these investigations, the officials of several of the threshing machine companies showed us thresher recleaners which they had built, but which would not successfully clean spring wheat.

Wild oats seemed to be the cause of the failure of most of the recleaners already built, and as wild oats are numerous and hard to remove, it was finally decided to build a machine using the basic principle of disks provided with small pockets, and moving vertically through the grain. The elevator and mill machines of this type which were in use were found to weigh from 1½ to 4 tons and the biggest problem was to reduce the weight of the machine to 1000 pounds or less. The machine of this type which we finally built weighed only 670 pounds. The disks in the machine were made of aluminum. Both sides of these disks contain small undercut pockets and when set up the disks are mounted 2¾ inches apart on a shaft which rotates at about 60 r. p. m. The center of each disk contains fan blades for removing the grain toward the discharge end of the cleaner. The pockets on the disks being slightly undercut, pick up material of certain length and discard material of greater length, and as the disks rotate vertically the material picked up by the pockets is carried up and over the top of the rotating shaft and there discharged into small troughs. Three sizes of pockets were used for making the different separations, one size of pocket only being used in any one disk. The grain to be cleaned is fed into the machine near one end and the small weed seeds and dirt are picked out of the mixture by the first disk containing the smaller sized pockets, and as the grain progresses through the machine the disks containing the larger size pockets pick out the wheat kernels and leave the oats, wild oats, barley, and other material longer than wheat, which material is discharged through the opposite end of the machine. In operation the fine seeds are discharged into sacks at one side of the separator, the cleaned wheat is discharged directly into the wagons or tanks, and the wild oats and other coarse material which is discharged at the opposite side of the thresher may be either sacked or discharged directly into a second wagon.

The disk machine was installed on a 22-inch Twin City separator which was operated in North Dakota, and was used while threshing 8,000 bushels of Marquis wheat, 3,000 bushels of Kubanka durum wheat, and for separating 2,000 bushels of wheat from a mixture of wheat, oats and barley.

In our experiments the cleaner was driven from the fan shaft and only a little over one horsepower was required to operate it.

One of the objections made to the recleaners previously built for use on threshing machines was their lack of capacity, compelling the thresher operators to slow down the feeding when working in grain easily threshed. While operating our disk machine several attempts were made to clog or flood the machine, but it was impossible to feed the grain into the threshing cylinder fast enough either to clog the cleaner or to lower the quality of work which it performed.

The grain as threshed contained varying percentages of dockage, ranging all the way from 1 to 38 per cent. The efficiency of the recleaner was such that wheat which contained up to 20 per cent of dockage, after cleaning contained no assessable dockage. That is, the dockage remaining in the clean wheat was less than 1 per cent. When cleaning wheat containing over 20 per cent of dockage, it was necessary to make slight adjustments on the cleaner, but with these adjustments the dockage was reduced to less than 1 per cent in the cleaned wheat. The screenings removed in the cleaning operations contained very little wheat, in fact, much less wheat was found in the screenings from the disk cleaner than is found in the average elevator screenings.

It is our plan to make certain improvements on the disk recleaner and to continue these investigations through the next threshing season because the results secured the past season in threshing and cleaning over 15,000 bushels of grain demonstrated that grain can be cleaned successfully at the time of threshing to a point where no dockage will be assessed when the wheat is sold on the market. If wheat is cleaned at the threshing machine, farmers would not be paid lower prices or charged discounts because of the dockage which would otherwise be in it, nor would there be opportunity for disputes as to the percentage of dockage which should be assessed. The valuable parts of the screenings can be used for feed, and clean seed wheat will be available for sowing, which will mean increased yield per acre.

The Department of Agriculture is keenly interested from an economic standpoint in developing practical methods which will bring about both the sowing of clean seed wheat and the marketing of wheat free from dockage. These experiments have demonstrated that wheat can be successfully cleaned at the time of threshing and in the development of this method, the agricultural engineers, the threshing machine manufacturers, and the thresher operators can assist very materially in ridding the spring wheat states of the dockage problem.

DISCUSSION

MR. BARTHOLOMEW: I would like to know why it is necessary, or even the practice, in this wild oats country to raise wild oats at all. Why not just get rid of them before you ever raise crops? What is the use of raising them and then going to all this expense and trouble of getting them out of the grain after you have raised them? My theory is at least, backed up by some encouragement from practical farmers, that wild oats can be eliminated from the land by summer fallowing, that is, by plowing at the right time, in June, and it will take a long while for them to come back.

I would like to know whether there is anything in that. The same way with weeds. The best way to get rid of weeds is to kill them before they get into the crop.

MR. BLACK: Wild oats cannot be killed by one year's summer fallowing; that has been demonstrated time and again. The region of North Dakota and some parts of the Red River Valley of Minnesota are somewhat dry and the oats will not sprout unless they are near the surface of the ground where they receive the slight rainfall which occurs. Wild oats have been known to lie in the ground as long as 16 to 20 years, without their germination being entirely killed.

MR. WIGGINS: I would like to ask Mr. Black if it was his idea to equip all the present threshing machines with the device for removing dockage which he described?

MR. BLACK: The dockage question is increasing in seriousness, not only in the states that we are talking about, but all through the United States. The average dockage in the wheat marketed from the entire country this last year was slightly under two per cent. That may not seem like a large amount of dockage until you think of the large wheat crop which a country like ours produces. It runs into a large amount of economic waste in handling this dockage. Our idea hasn't been to manufacture or produce machinery that will be put on all the threshing machines, but rather to show that it can be done, and to create among threshing machine manufacturers an interest in the removing of the dockage. That is, the dockage question is a much larger question than is commonly supposed, and one which is increasing very rapidly, that is, the amount of dockage and the per cent of dockage is increasing very rapidly from year to year. I say very rapidly because an increase of even one per cent in three or four years means the amount of dockage produced is, you might say, a calamity.

MR. KRANICH: I would like to ask if anything can be done to urge farmers to clean their grain with so-called Bandey graders, or grain cleaners? If the farmer receives clean grain, and much should be done to urge him to do that, which would be a cheaper way, perhaps, than putting this device on the threshing machine?

MR. BLACK: I cannot answer that question from an impartial standpoint. I think that probably some of the men from the state agricultural experiment stations here really ought to answer that, because in their extension work they are really responsible for getting that information before the farmers. I don't think that anywhere near the amount of education has been brought to the farmers regarding the use of fanning mills or the advantages of using them in cleaning their seed wheat. I think there is a field for education there that shouldn't be overlooked by the agricultural experiment stations.

MR. WELTY: I would like to ask Mr. Black the question why the dockage seems to be increasing. On his chart for 1900 or 1905 there was only about two per cent or less of dockage, while in 1920 there was five per cent. Is that because there are more weeds allowed to grow, or is it because the wheat receives a different inspection? Certainly the methods of cleaning today are as good as they were in those days, in fact, they are better.

MR. BLACK: The figures as to the percentage of dockage are not influenced at all by the buyer. The figures were established, and the dockages were assessed by inspection departments entirely separate from any buyers or actual handlers of wheat. That is at the present time and for the last four years, the dockage has been assessed under the supervision of the federal government, and the figures therefore are truly representative of the actual increase in the amount of dockage that is in the wheat when it is marketed.

MR. DICKERSON: In regard to this matter of the farmer cleaning the seed wheat, I had an interesting experience when I was teaching at the University of Illinois. We tried to put on a seed cleaning demonstration there once or twice and to get the farmers interested, and we also taught the work to the students in the regular agricultural courses, and it is really appalling the ignorance that the average farmer has of the proper use of seed cleaning machinery and the indifference they apparently have toward that part of farm work, and I am losing all hope of ever doing anything serious along that line. We have tried through the farm papers to encourage the farmers to clean their seed wheat, but I believe there are fewer fanning mills sold now in comparison with the number of farmers than there ever has been. Every grade of grain is a problem in itself. Every difference in size of kernel and every difference in the mixture of weed seed makes a different problem, and it is almost impossible to do anything very satisfactory in educating the farmer to use the fanning mill properly.

MR. DINSMORE: As a matter of fact, will fanning mills take the wild oats out satisfactorily?

MR. BLACK: The ordinary fanning mill, if properly operated, will take most of the wild oats out, and supposing that you had about 14 per cent of wild oats to start with, with the ordinary wheat that is raised in the Red River Valley of the North, you would probably be able to get out all of the wild oats except about one per cent.

The ordinary fanning mills will not remove all the wild oats because the wild oats are of such a shape and size that many of them will go through the sieves. That is one reason we didn't attempt to use the sieves in our threshing machine experiments.

MR. DINSMORE: That in itself justifies the necessity of developing this cleaner on threshers.

DISCUSSION BY PROF. WM. BOSS

Mr. Black has presented a very interesting paper and I can see no reason why the machine would not be practical. I believe that by the use of such a device it would be possible to remove practically all of the dockage from wheat and to remove weeds and other small seeds from other grains.

I believe it would also be of considerable value in separating the various grains in such a crop as succotash, a crop which is being raised quite extensively in many communities, and which would be more extensively grown were it easily possible to separate the various kinds of grain of which it is composed.

I have discussed the question of weed seeds with Prof. C. P. Bull, Minnesota state weed inspector, who says that the weed problem is a serious one and a device such as this, that will remove the weed seeds, would be very desirable and would do much to eradicate the weed nuisance.

The important question, however, is the economic one. Whether the additional cost of equipping threshing machines with the device, the additional cost of power for driving it, the extra time required by the operator in looking after it, caring for the three separate deliveries of grain, etc. and the higher price per bushel which the farmer must pay for threshing, will be justified by the farmer receiving clean grain At first thought, it perhaps seems doubtful. The average thresher would prefer not to bother with it and if the trend is to continue toward the small threshing machine operated by the farmer owner, it would probably not come into very extensive use. If, however, the trend is to be back to the commercial or professional thresher, and the thresher is competent and takes the proper pride in doing good work, I believe it would be a commercial success and would help to reduce the quantity of weed seed and wild oats sown, thus reducing the amount of dockage grown.

The weed seeds would have some feeding value to the farmer if ground or cooked. It would not be advisable to feed them unless so treated.

While the machine is especially designed for removing the dockage from the spring wheat grown in the north central states of the United States, it is possible that it would be desirable in other localities and perhaps be supplied on nearly all machines for threshing grain.

On the whole I believe Mr. Black's work is well worth while and I should like to see his experiments continued another year at least, working to perfect the machine and reduce its cost if possible, also continuing his cooperation with the various threshing machine manufacturers and see if it is not possible to incorporate the device as an integral part of the separator instead of an attachment to it. This it seems to me might reduce the manufacturing and sales cost and make its general adoption possible.

REPORT ON DISK HARROW INVESTIGATION*

THE problem of this investigation is to determine whether the cutaway disk has any real merit or enough real merit to justify the manufacturers in continuing its manufacture. They felt it would be a step backwards. During the war the War Industries Board eliminated the cutaway disk as a manufactured product from all except one manufacturer who had that as its main line. Our investigation took two general forms: first, questionnaires to obtain information, and, second, field tests to determine if possible definite results. In the first place we had to find out where the cutaway disks had been used. It was no use to send out a general questionnaire, because the man that had never used a cutaway disk—and he is in the large majority—certainly could not give any definite opinion. In order to do this we first sent questionnaires to prominent manufacturers who were listed in the directories as manufacturers of cutaway disks. We received very excellent reports from them. Thirteen manufacturers replied; only one of them is making cutaway disks or has made cutaway disks since the elimination by the War Industries Board.

Together with this we asked them for their own opinion regarding cutaway disks. The advantages given are: (1) The cutaway penetrates the ground easier, (2) is more effective in stony soil, (3) does more effective work in hard baked land, (4) lighter draft (which is one that hasn't been borne out by field tests), and (5) cuts sods to better advantage. Of course, manufacturers don't all agree in these.

The disadvantages of the cutaway type are: (1) it does very uneven and ragged work, (2) it doesn't pulverize the ground as thoroughly as do round blades, (3) it is not as satisfactory for general work as the round blade, (4) it is much more difficult to sharpen, (5) short lived, (6) has a larger percentage of breakages, and (7) more expensive to manufacture. Of course with a manufacturer there is a big problem in the distribution and duplication of these implements.

Taking the localities which were given as still demanding the cutaway, a series of questionnaries were sent out to dealers, county agents and farmers.

From the central states we didn't get very many replies, which indicates that it is not a very vital question. A few of them are thoroughly sold on the cutaway, and some of the replies we get indicate that the cutaway penetrates deeper in hard ground, cuts stalks better, is harder to sharpen than the full blade, but doesn't need sharpening

*Fifteenth annual meeting report.

as often. That is one thing that is brought out very forcibly by the men that use the cutaway; they state it is considerably more troublesome to sharpen it, but some farmers use them three or four years and never have sharpened them. They can still go out and scratch the ground with a dull cutaway where with a round blade equally dull they couldn't make tracks. One dealer thoroughly sold on the cutaway said that in the last year he had had the blades on his disks made cutaway to meet the demands of the trade. The reports coming in favoring the round blade are much in the majority. First, they find the cutaway disks are easily broken, and short-lived. Only one-half of the disk penetrates, and they find a lot of trouble with repairs. Eastern Oregon is the place where most of this opposition has come from. I have the following statement from Mr. Brandt: "If the cutaway disks should be discontinued the average Eastern Oregon farmer would feel that he had to go out of business. The average farmer in Western Oregon cares very little one way or the other."

Their problem in that country, where they use a header, is that a large amount of straw is left on the ground which must be worked into the soil, and taking implements as they come; I have an idea the cutaway disk under the average conditions would show some advantage the first time over.

The field tests were made at both the California and Iowa agricultural experiment stations. At California one disk was used for a comparative test, with both sets of blades. The blades were changed for each test. At the Iowa station two identical disks were used, with the exception of the blades. Draft tests were made in both places. In all the tests the full blade gave a lighter draft than the cutaway blade. There was no case that came under my observation where the reverse was true. The cutaway pulled heavier. From the results of the Iowa station tests it averaged about 15 per cent heavier, the weight on the disk being the same, in some cases running up as high as 20 per cent. I had always heard the statement before that the cutaway disk pulled lighter: that is what I was expecting to find, but we found the reverse to be true. As would be expected, the cutawav blades penetrated more deeply than the full blade. This deep penetration of course is intermittent. However, this is of no particular advantage in hard ground, as under these conditions the cutaway blade will be broken.

I ran some tests on very hard ground, and in traveling about 20 rods we broke five leaves off the cutaway blade, so that advantage of penetration doesn't mean anything on hard ground.

The observations made would indicate that the ability to penetrate is of most advantage in cutting through coarse materials on the surface of the ground, such as corn stalks, heavy stubble, or heavy application of manure that is not well rotted. I think the first application over, the cutaway will make a better showing in some of those conditions, but with regard to cornstalks, I find that while the cutaway cuts through and gets at the ground, there is quite a tendency for the corn stalks to be pushed along until it gets to a notch and then the disk rolls over it.

It would seem that the ability to penetrate might better be obtained by loading the disk than by using the cutaway blade.

Regarding durability, at both stations considerable breakage of cutaway blades was encountered when used on hard ground, and no breakage with the full blade. Mr. Hoffman of California made some tests on the testing machine with the two types of blades, putting them in the testing machine and breaking them down. I don't have a report of that test, but it is very favorable of course to the round disk. The design of a cutaway blade is essentially weak. The round blade owes its strength to being dished like a wagon wheel, so it is very strong.

In all the tests we had no trouble with breakage of the round blade. The cutaway blade seems to scour a little more readily, but to offset this it is difficult to apply a scraper satisfactorily on account of the notches, and the scrapers are likely to jam where the points of the blade are broken off. That is, you get into hard ground and break a blade off and the scraper is apt to go through there and lock the disk. We have had that happen quite often. At the Iowa station on the hard ground we attempted to make a comparison of the ground that was loosened by each type. We had a place where we had done some grading. The ground was very hard. It never had been plowed and was quite smooth. We drove through with one disk and then with the other and marked off equal areas in each one and gathered up the loose dirt to see which one loosened the most dirt. We couldn't find any consistent advantage for either one, either on single disking or double disking.

That is all that we have to report, and, briefly, I would say that the disadvantages of the cutaway disk far outweigh its advantages.

COMMITTEE ON DISK HARROW INVESTIGATION

E. V. Collins, Chairman	A. E. Brandt
C. I. Gunness	E. J. Stirniman

DISCUSSION

MR. CUNNINGHAM: To what do you attribute the increase of draft on the cutaway disk?

MR. COLLINS: You see it when you clear off the ground. With a cutaway you dig down in a little pocket, and you have to loosen that all the way around. With a round blade it is a continuous process. That is, it is easier to dig a ditch than it is to remove the same amount of dirt by digging a series of post holes.

PRES. WHITE: I sometimes wonder if the members of this society realize the importance of this investigation. Now this is a matter over which the manufacturers are very seriously concerned, and it is no small compliment to this society that they turned it over to us with the injunction "Find the Facts." We selected the best committee that we thought we could find, and we believe we got them, but in this matter there is a responsibility that rests upon every member of this society, and especially the college men, to see that we get the facts in this case. I am sure we will be glad to receive suggestions or criticisms of the work that has been done to date, and suggestions for other lines of investigations that may be profitably taken up.

There is one phase of this investigation that Mr. Collins hasn't reported on at all yet. The committee hasn't gotten into what it costs the manufacturers to carry two types of disks in their lines, duplicate equipment and all that. It not only adds to the cost of the cutaway harrow, but adds to the cost of the full blade harrow. There are many ramifications to this problem. It is not only an engineering problem, or to state it in a better way, it is an engineering problem in the biggest sense, which not only takes into account technical investigation, but also the attitude of the man who is manufacturing the disk, who is selling it, who is using it, and the entire economics of the situation. An investigation like that is one big job, isn't that right, Prof. Collins? Prof. Collins is doing the work, he knows better than the rest of us.

MR. JOHNSON: I think the committee have overlooked one essential point in the investigation of this question of cutaway disks, and that is that it is largely a sectional one, and from the report of Mr. Collins and from the standpoint of the manufacturer, the investigations have been made in territories where there is not a real, live demand for cutaway disks. The cutaway disk was developed in the East by a concern that made a four gang harrow, and when the manufacturers began developing tandem attachments for the original two gang harrow they equipped them pretty generally with cutaway disks, and in the distribution and introduction of tandem attachments for disk harrows I think any manufacturer will bear out this statement that the West, the country west of the Mississippi, gradually but almost universally began to ask for tandem attachments with regular straight blades and that the demand today continues in the East, on account of the difference of soil conditions, and also in the South.

Now what the manufacturers would like to know, it seems to me, is whether in those sections, East and South, the demand for a cutaway disk has some basis of efficiency under those conditions, or whether it is just a notion of the farmers. I would suggest that the committee in continuing this investigation in the territories where the cutaway disks are quite commonly called for, secure this information.

MR. DICKERSON: There is one point which has come to me in connection with this investigation which might well be followed up. That is, in some of the brushed over land of Wisconsin there seems to be a demand for the cutaway disk for the first cultivation of this brushed over land, before it is plowed. I wonder if the committee has run into that.

MR. COLLINS: I haven't gone into that at all.

PROF. WIRT: There are hundreds of farmers and dealers in the East, that swear by the cutaway disk harrow, and I feel that the committee should do a lot of investigational work there and have several institutions conduct these tests, that is, in Pennsylvania, Maryland, Virginia and the Southeast.

I appreciate the fact that it takes considerable time to make a real test on the farm machines, but on a subject of this importance I believe that a great many institutions should cooperate and test out these harrows fully before we say that one or the other is the one to use.

PROF. GUNNESS: In Massachusetts I was rather surprised at the results. Of course, the cutaway is made close to us, and I think the older harrows are largely cutaway, but of late the tendency has been toward the full disk. The county agents invariably reported they can see no necessity for obtaining the two types, even in our state, where we have the stony land. They recognized some of these points that are universally known, that the cutaway has the advantage in certain sections, but in spite of that they felt that the advantage of standardization would be enough to warrant the discontinuing of it, although that wasn't just what we were supposed to investigate.

MR. CRAMPTON: There is one point that Mr. Collins makes I would like to go a little further into. That is the question of corn stalks. Now is it a fact that the section where the corn stalks are prevalent, that is, where they have been used on corn stalks, is where they are discontinuing the use of the cutaway? His report, generally speaking, in this section anyhow showed they were discarding the cutaway harrow. In that case it seems they must have been convinced that the round disk was better for corn stalks than the cutaway. And the further fact, that it seems as though the insistent demand was still from sections where corn stalks were not used very much, such as he mentioned in a certain small district in Washington and another gentleman mentioned a few limited districts in the Southeast.

MR. COLLINS: I think that is very true. I am glad you brought that out. While the cutaway will go through the corn stalks and get at the dirt, it doesn't cut the corn stalks and that is what we want to do. The corn stalk is big enough so it will slide along the edge of the blade until it gets to the notch and then it rides through on the notch.

REPORT ON LEFT HAND PLOW INVESTIGATION*

THE first step we attempted in this investigation was the locating of the left-hand plow territory; and the first step was a questionnaire to the plow manufacturers. The second step was the conducting of an investigation among manufacturers, dealers, county agents, farmers, etc., as to why the left-hand plow was preferred, and to determine if the general situation would be benefited by the complete elimination of the left-hand plow.

We have gotten as far as the county agent this year. We have a compilation of something like five hundred different counties in seven different states, and we feel that according to the general law of averages the preliminary conclusions drawn from these results will be fairly accurate.

The first questionnaire was sent out to thirty-three manufacturers building left-hand plows and we received thirty-one replies.

We divided it into three major questions. In the first question it was asked if they manufactured left-hand plows. If so, whether they manufactured walking plows; also riding plows, which included sulky and gang.

To the first question, as to whether or not they manufactured left-hand plows, 70.9 per cent replied that they did, and 29.1 per cent replied that they did not. So there is a large number of the companies still manufacturing the left-hand plow, even though it was eliminated during the war and later reinstated.

The walking plow seems to be the thorn in the flesh; in connection with that situation, 95.4 per cent manufactured walking plows while only 4.6 per cent of that number manufactured riding plows, which included gangs and sulkies.

Only 59.09 per cent manufactured riding plows, while the balance did not manufacture riding plows in left-hand molds. It can be readily seen then that the big problem is with the walking plow, and that is practically confined to Indiana, Ohio, and Pennslyvania. There is where the problem I believe will have to be attacked the hardest.

We also have some very interesting figures that were obtained from a federal government report on the statistics of the number of plow molds laid down in 1920. The total number laid down in that year by all plow manufacturers in the United States were 820,259. Of this number of molds 801-993 were right hand and only 18,266 were left hand.

On a percentage basis, only 2.2 per cent of the total number of molds laid down are left hand. Therefore, the left-hand plow is indeed in the minority as to the number being

*Fifteenth annual meeting report.

manufactured. It was rather interesting in going through those letters and questionnaires to find some of the statements made by the manufacturers. There was no general opposition to the elimination of the left-hand plow with the exception of three companies, and they were rather outspoken.

One company, of which I happened to know some of the officials and which is an Ohio firm, said they would continue to manufacture left-hand plows no matter what the manufacturers' association recommended.

One of the Michigan companies said they were entirely opposed to the elimination of the left-hand plow. Upon investigation I find they are manufacturing left-hand molds only.

And another company said they had participated in several of these discussions and had never gotten anywhere, and, therefore, they did not want to go on record as entering another discussion on the left-hand plow situation.

As to the distribution of the left-hand plow territory, I am giving this on a percentage basis, which I think is more comprehensive. Taking the manufacturers as a whole, 80.9 per cent reported Indiana as a big left-hand plow territory; Ohio, 71 per cent; Pennslyvania, 33 per cent; Kentucky, 47 per cent; Tennessee, 42 per cent; Illinois, 42 per cent; and so on down the line, including North Carolina, New York, Michigan, West Virginia, Delaware, and New Jersey, some of Kansas, and some of Missouri.

The county agents gave us some valuable information. We have about four hundred and fifty questionnaires answered by them and I place a lot of faith in their answers for the reason that the majority of the county agents in Ohio waited to answer the questionnaire until after they had had a meeting with their farm bureau, so you can see that their answers are not alone their opinions but also the opinions of the executive boards of the farm bureaus.

Indiana's report was based on manufacturers' figures which showed that 38 per cent of the total number of bottoms are left hand.

QUESTION: You said that 80.9 per cent of the manufacturers reported Indiana as the big territory.

That is, 80.9 per cent of the thirty-three manufacturers reported that Indiana was their best left-hand plow territory. I knew these figures would be more or less confusing if I did not make that point clear because the sum total would be more than one hundred per cent. Indiana's report I have said is based upon manufacturers' figures.

Ohio's report was based on reports of 59 out of 89 county agents; 30.6 per cent of the counties do not use the left-hand plow extensively, and 38.9 per cent do use them extensively.

Comparing the figures (percentage using left-hand plows) for the two states, Indiana's is based on the manufacturers' figures and is 38 per cent; Ohio's data is based on county agent figures, substantiated by the Farm Bureau, and is 38.9 per cent. There is 0.9 per cent difference between the two states, based on two different methods of inquiry.

In Pennsylvania 27.4 per cent do not use the left-hand plow at all. Pennslyvania is one of the largest states which we have to deal with. Also 8.4 per cent do not use left-hand plows extensively, while 40 per cent do use them extensively.

Here we have three states bordering, in which 38, 38.9 and 40 per cent of the states respectively use left-hand plows. That is based on the data we have at hand.

New York reported 45 counties, all in the negative, that is, left-hand plows are not used extensively. There are certain localities in which left-hand plows are used, but not to any extent.

Kentucky reported 38 out of 62 counties, or 61.2 per cent reporting; 42 per cent reported left-hand plows used extensively, and 57 per cent not extensively.

In Michigan, out of 52 counties reporting, only one reported that left-hand plows are used extensively.

So the left-hand plow territory is practically confined to Kentucky, Ohio, Indiana, and Pennslyvania, in which the percentage of counties using them ranges from 38 to 42 per cent.

The next phase of this investigation we propose to take up, inasmuch as we have the left-hand plow territory well located, is to get some definite information as to the viewpoint of the dealers. We asked the county agents to give us a list of three or four prominent dealers in each county. We wanted well-established dealers, men who had been in business a considerable length of time because they understand the situation better than anyone else; also we wanted these dealers widely distributed in the county so there would not be three in the same town. We have a list of between 1400 and 1600 dealers, to which we will send questionnaires.

Following the dealers, we are going to the farmers through the agricultural college extension workers in a house-to-house canvass. Whenever an extension worker is on a project of some sort we will make it a point to get all the information we can on the plow situation in that particular locality.

The important phase of the work will be the education of farmers to the use of a standard moldboard, a right-hand moldboard.

The whole problem is largely a question of psychology. They say that after horses are once broken to the left-hand plow it would be a hard matter to change them to right-hand plowing. I do not believe it. At Indianapolis a demonstration of that sort was made. One of the leading plow manufacturers told us how he took a plow out to a farmer near that city and said: "We would like to have you try this plow out for us." He looked at it and said: "That is one of those damned right-hand plows; I cannot make my horses work on it." However, inside of half an hour, after he had made a few changes in his reins and hitching and in the adjustments, the horses went off as if nothing had been changed. So it seems to be purely a psychological question with the majority of the farmers.

COMMITTEE ON LEFT-HAND PLOW INVESTIGATION

G. W. McCuen, Chairman	C. I. Gunness
Wm. Aitkenhead	R. U. Blasingame

DISCUSSION

PRES. WHITE: Understand, gentlemen, that these are purely preliminary reports, given primarily for the purpose of getting these problems before the members of the Society. We would like to have some discussion on this question.

PROF. GROSS: I want to ask Prof. McCuen whether the investigation took into consideration and provided for any data on two-way plows made with two bottoms, one right-hand and one left-hand, used in the irrigated sections chiefly.

PROF. MCCUEN: We found that to be particularly true in New York and in some of the terraced regions in southern Ohio. Manufacturers would have to continue building the two-way plow, because the user could not turn the plow down or up, as the case might be, satisfactorily and do a good job of plowing. That will have to be an exception I believe; in fact, I know its manufacture will have to be continued because there are certain sections that will necessitate that type of plow. As a matter of fact, they are not interested in those sections in right and left-hand plows because they use both of them. They have to have that particular type of plow there to meet their particular conditions.

PROF. GUNNESS: The eastern farmers, a good many of them at least, demand the two-way plow. I have been told that is one of the objections that every tractor salesman meets in the small farm regions; he cannot sell a tractor plow that works both ways. That is a much more serious proposition for the salesman of the small tractor than you might suppose.

PROF. DUFFEE: I was born and raised with a left-hand plow and went through the transition from a left-hand to a right-hand plow. When this question of the elimination of the left-hand plow came up some time ago, I happened to be visiting one of my uncles. I made it a point to ask him about it—he is a very progressive farmer, and has a tractor. I said, "What do you think about the right-hand plow?"

"Well," he said, "it is just as good, there is no question about that. It is just a matter of getting used to it, and if it is economy for the manufacturers to manufacture it, let them go to it." I wanted to add that to the discussion from a practical farmer.

STANDARD CODE FOR TESTING TRACTORS*

THE object of this report is to recommend a standard method or code for rating tractors, by which either new or old models may be more accurately rated. The rating is to consist of

(a) Brake horsepower rating as delivered to the pulley on the machine driven

(b) Drawbar rating as delivered to the drawbar at plowing speeds

Brake Horsepower Rating

The following tests shall be conducted on each tractor selected by the board of engineers in charge of the tests:

A. "Limbering-up" Run

The object of this run is to take out the stiffness likely to be found in a new machine. Tractors in this run will be used to pull harrows, packers, or anything that will furnish a suitable drawbar load.

The loads to be pulled will be (1) approximately one-third load for four hours, (2) approximately two-thirds load for four hours, and (3) approximately full load for four hours.

If the tractor manufacturer believes that twelve hours is not sufficient length of run to get the tractor limbered up, reasonable additional time will be allowed.

B. Brake Horsepower Test at Maximum Load

The object of this test is to determine the greatest load the tractor engine will carry on the belt, with the governor set for rated speed and the carburetor set for maximum power. The brake load will be increased until the horsepower developed is the greatest.

The rated speed is to be considered the speed of the motor under load.

This test should begin after the temperature of the cooling fluid has become constant.

The duration of the test will be one hour continuous run, with no change in load or tractor adjustment.

If the speed should change during the test, enough to indicate that conditions had not become constant when the test was started, the test will be repeated with necessary change in load.

C. Brake Horsepower Test at 80 Per Cent of the Maximum Load Recorded in Test B

The object of this test is to show whether or not the engine will carry continuously its rated load on the belt and to

*Report of the Subcommittee on Tractor Ratings presented at the fifteenth annual meeting.

show the fuel consumption at the rated load. The governor is to be set to run the engine at rated speed.

The test will also commence after the temperature of the cooling fluid has become constant.

The duration of the test will be two hours continuous run, with no change in load or engine adjustments.

After tests B and C are conducted to the satisfaction of the board of engineers conducting the tests, the nearest whole number to the load carried in test C is to be considered the brake horsepower rating of the tractor.

D. Brake Horsepower Test at Varying Load

The object of this test is to show fuel consumption and governor control when the load varies.

All adjustments are as in test C.

The time and the load are as follows:

10 minutes at rated load (or load carried in test C)
10 minutes at maximum load
10 minutes at no load
10 minutes at one-fourth rated load
10 minutes at one-half rated load
10 minutes at three-fourths rated load

The total running time is one hour and the test is to be conducted without stopping the engine or changing engine adjustments.

If the load changes make readjustments necessary, the final report of the test will state that such was the case.

The variation in speed from the rated speed shall not be more than 10 per cent.

E. Nebraska Results May Be Accepted

In lieu of tests A, B, C, and D, the board of engineers may accept the results of similar tests on the same model of tractor conducted by and under the rules of the Nebraska tractor tests. The brake horsepower rating, however, is to be only 80 per cent of the maximum horsepower determined by the Nebraska tractor tests.

METHOD OF TESTING

It is recommended by the American Society of Agricultural Engineers that the brake test outlined above be conducted by one or more disinterested engineers. These engineers to be selected from full membership in the following societies:

American Society of Agricultural Engineers
Society of Automotive Engineers
American Society of Mechanical Engineers

The engineer or engineers conducting the tests must first be approved by the Council of the American Society of Agricultural Engineers.

Reports of the tests must be signed by all of the engineers conducting the test and the signed reports sent to the secretary of the National Association of Farm Equipment Manufacturers to be placed on file, subject to inspection by anyone interested in them. Duplicates are to be furnished the secretary of the American Society of Agricultural Engineers and the manufacturers of the tractors tested.

Members of the engineering faculties of the state agricultural colleges and universities are also eligible to serve as members of the board of engineers.

These tests are to be conducted on one or more tractors picked at random by the disinterested engineers conducting the test from the stock run of tractors from the factory. If more than one tractor is tested the averages of all tests are to be used in determining the brake horsepower rating.

All tests will be made on the *lowest grade* of fuel which the tractor manufacturer recommends for this particular tractor, these fuels to be purchased in the open market and to consist of the low grades of either kerosene or gasoline sold in the locality. All fuels to be tested by the board of engineers.

Manufacturers must specify the kinds and grades of lubricants to be used in the different parts of the tractors tested.

The manufacturer will be required to furnish operators during the entire series of tests, the board of engineers to act in a supervisory capacity and to take all readings and compile results.

All belt tests must be made with an electric dynamometer, an accurately tested Prony brake, or other power-measuring device approved by the board of engineers. If a Prony brake is used, allowance must be made in the results for the power needed to drive the brake.

The quantity of fuel used in each part of the test will be determined by weight and the quantity reduced to gallons at 60 degrees Fahrenheit. For brake tests a tank will be placed on a scale and set at the same height as the tank on the tractor. Fuel will be drawn from this tank on the scale during the tests. The fuel tank shall contain at least two gallons of fuel during any part of the tests.

The quantity of oil used is to be determined by the standard gallon, quart, or pint measure, or by weight if more convenient.

The quantity of water used in the radiator and cooling system is to be determined by measuring the height of the water at the beginning of the test and filling to the same level at the end of the test, weighing or measuring the water added. If necessary in order to secure accurate results, the water added will be heated to the same temperature as the water in the radiator or tank.

The quantity of water used in the carburetor, where such water is used for fuel purposes, is to be determined by weight. A tank is to be placed on a scale and set at the same height as the tank on the tractor. Water will be drawn from this tank on the scale during the test. The water tank shall contain at least two gallons of water during any part of that test.

These tests may be conducted at any place which meets the approval of both the manufacturer and the board of engineers conducting the tests.

DRAWBAR RATING

In the drawbar rating the manufacturer is to be given the choice of either of the following two methods:

(a) The drawbar rating to be 60 per cent of the brake horsepower rating determined by test C.

(b) A maximum drawbar test conducted by and under the rules of the Nebraska tractor tests. The drawbar rating is to be 80 per cent of the maximum drawbar horsepower developed in this test.

Respectfully submitted,

SUBCOMMITTEE ON TRACTOR RATINGS

Geo. W. Iverson, Chairman
K. J. T. Ekblaw
D. L. Arnold
D. P. Davies
F. N. G. Kranich
O. W. Sjogren
L. R. Van Valkenburg
F. M. White
H. H. Bates

DISCUSSION

MR. JOHNSON: It is desirable that we have a method of rating tractors that will be accepted by the purchaser, the manufacturer and state legislators, but after working on it several years it seems to me it is going to be a pretty hard thing to obtain. I wondered why the fuel consumption entered into the proposed method. Is it proposed to make that a part of the rating, or just the test?

MR. IVERSON: That is to be a part of the finished report; it does not enter into the rating at all.

MR. JOHNSON: After testing engines for a number of years, and you talk to me about taking a tractor out of stock at random and running an official test, I could not possibly say that would be satisfactory. For instance, well-built engines that will develop 35 horsepower, taken out of stock, may show a mechanical loss several times that which it will show after it is properly run in. I don't think any method of testing tractors that provides for picking them out of stock means anything to anyone, either the purchaser or the manufacturer, or anyone else. If it is possible to find a means of testing tractors that will be satisfactory it will be a fine thing, but it is a big problem on account of so many variables entering into the test.

MR. IVERSON: I want to explain how the proposed drawbar rating was devised. The main reason why a drawbar rating is needed is to determine in a relative way how many plows the tractor will pull. The farmer does not care whether the tractor has forty horsepower or sixty if it will pull the correct number of plows under his own conditions. The main drawback to many of the ratings given has been that they have misled the farmer. He has been told that he could pull three plows when he could actually pull only two, so the disadvantage of the drawbar ratings in the past has been overrating, and underrating. We wanted to be sure, so far as we possibly could, that any rating that we gave would be conservative. That is the reason we took 60 per cent.

Now if a manufacturer feels that his tractor has more efficiency the only means of finding it out is to test it in some way, and that test ought to be conducted so it would be comparable with another test, and the only way it would be at all comparable would be to confine it to one place. We already have that place at the University of Nebraska. The manufac turer who feels that his tractor has more efficiency than allowed by the 60 per cent can take advantage of this.

TESTS SHOW INCREASED EFFICIENCY IN WINDMILL PERFORMANCE*

By A. F. Mohr

Mem. A.S.A.E. Engineer, Hyatt Roller Bearing Company

OF ALL existing forces that nature has so far permitted mankind to use as a source of power, wind and water are the cheapest. The abundance with which nature bestows these elements fluctuates from day to day but simple storage methods readily overcome this handicap. While water power is limited to certain localities, wind power is available everywhere, and this is one of the reasons why the farmer is the greatest user of wind power in the world. Another reason is due to the fact that a windmill of reasonable size and cost will pump sufficient water to supply him with all his needs.

The object of a windmill when used for pumping water is to convert the force of the wind into a vertical mechanical motion for operating a pump rod, and it is the aim of every good designer that the mechanism necessary to accomplish this be as efficient and require as little attention as possible. The early windmills while very crude in this respect, nevertheless served the purpose for which they were intended, but the trend of design in modern agricultural equipment is to make all improvements that will increase its life and make it deliver more, with less effort on the part of man, beast or the machine itself.

One of the handicaps in the operation of a windmill is the oiling problem and when driving through farming sections evidence is everywhere available that most mills suffer from lack of lubrication. The farmer can hardly be blamed for not wishing to climb a 50 or 60-foot tower. It is a hazardous business at best, and in the late fall or during the winter the risk of life and limb is just so much greater.

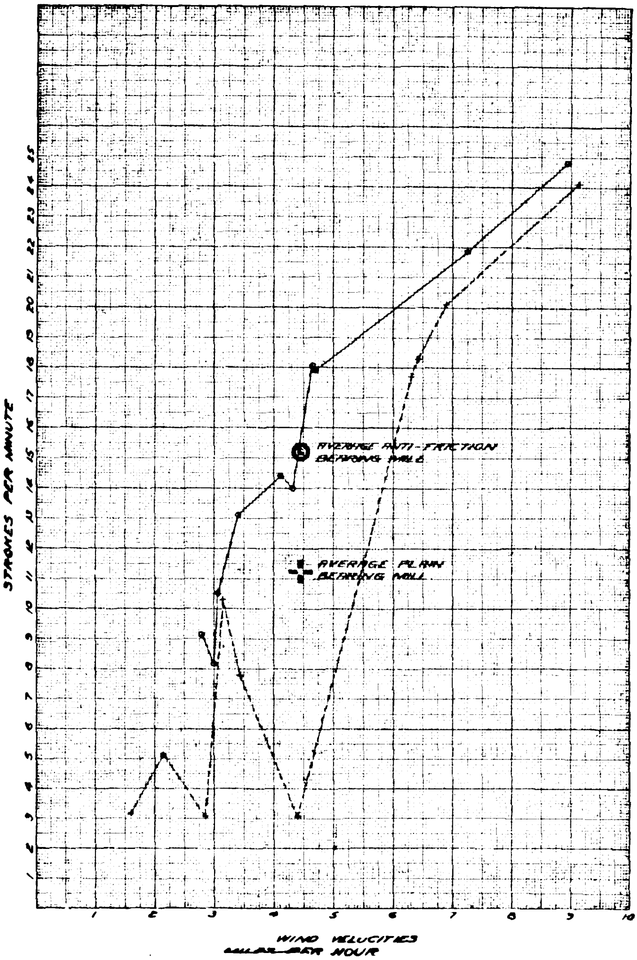
To lessen these dangers and to increase the efficiency as well as the life of the modern windmill, some mills are provided with anti-friction bearings that need attention far less frequently. Oiling these bearings once in three or four years, and at a time when conditions are most favorable for this work, is all the attention they require. Thus a dangerous work has been reduced to a minimum and time is saved which, of course, means a saving of money. But this is not all. These anti-friction bearings also save power, or, in other words, they increase the amount of power available for useful work.

In order to establish the actual gain obtained by this im-

*Article which appeared in the May, 1921, number of Agricultural Engineering.

provement, two 8-foot mills were mounted on separate 50-foot towers. At various times tests of from four to seven hours duration were run on each mill during which the wind velocity, the strokes of the pump rods, and the amount of water pumped were carefully recorded. The wind velocity was determined by anemometer readings recorded every fifteen minutes. The strokes were counted with a regular mechanical counting device and the amount of water pumped was weighed every fifteen minutes.

To balance the possible difference between the efficiency of the pumps, the heads of the windmills, which included the anti-friction bearings, were interchanged often so that the results are entirely comparable. The accompanying table



shows the average result of the runs on the two types of windmills.

To illustrate graphically the difference in performance of the two mills, the average number of strokes for the various average wind velocities have been plotted in the accompanying chart. The average strokes for the ten tests on both mills is also shown on this chart.

It will be noted that although the average wind velocity during the tests on the plain bearing mill is a trifle higher than during the tests on the anti-friction bearing mill, the latter shows nearly four strokes more per minute. Expressed in percentage, it shows that the mill with the anti-friction bearings delivered 34.9 per cent more water than the one with plain bearings.

Another test was run on two 10-foot mills of the direct-

WINDMILL TESTS WITH 8-FOOT STOVER STEEL MILL

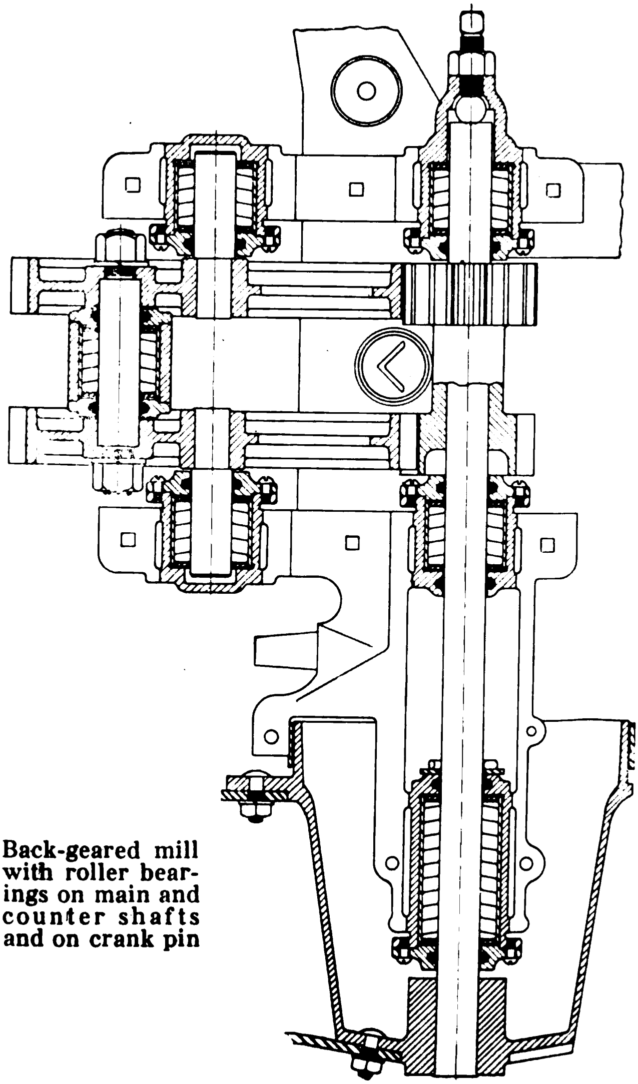
Anti-friction Bearing Mill

Test No.	Duration of Test	Average Wind Velocity M.P.H.	Average Strokes Per Min	Average Water Per Stroke
1	7 hours	3.00	8.18	1 lb.
2	7 hours	7.26	21.85	1 lb.
3	7 hours	3.38	13.08	1 lb.
4	7 hours	3.07	10.54	1 lb.
5	7 hours	2.77	9.11	1 lb.
6	7 hours	4.31	14.00	1 lb.
7	7 hours	4.65	18.04	1 lb.
8	7 hours	4.70	17.91	1 lb.
9	7 hours	4.11	14.40	1 lb.
10	7 hours	8.95	24.81	1 lb.
Average		4.619	15.19	

Plain Bearing Mill

Test No.	Duration of Test	Average Wind Velocity M.P.H..	Average Strokes Per Min	Average Water Per Stroke
1	7 hours	2.13	5.14	1 lb.
2	7 hours	3.17	10.31	1 lb.
3	7 hours	2.86	3.04	1 lb.
4	7 hours	9.13	24.10	1 lb.
5	7 hours	3.44	7.75	1 lb.
6	7 hours	6.42	18.32	1 lb.
7	7 hours	6.30	17.70	1 lb.
8	7 hours	1.60	3.17	1 lb.
9	7 hours	4.40	3.06	1 lb.
10	7 hours	6.90	20.09	1 lb.
Average		4.673	11.26	

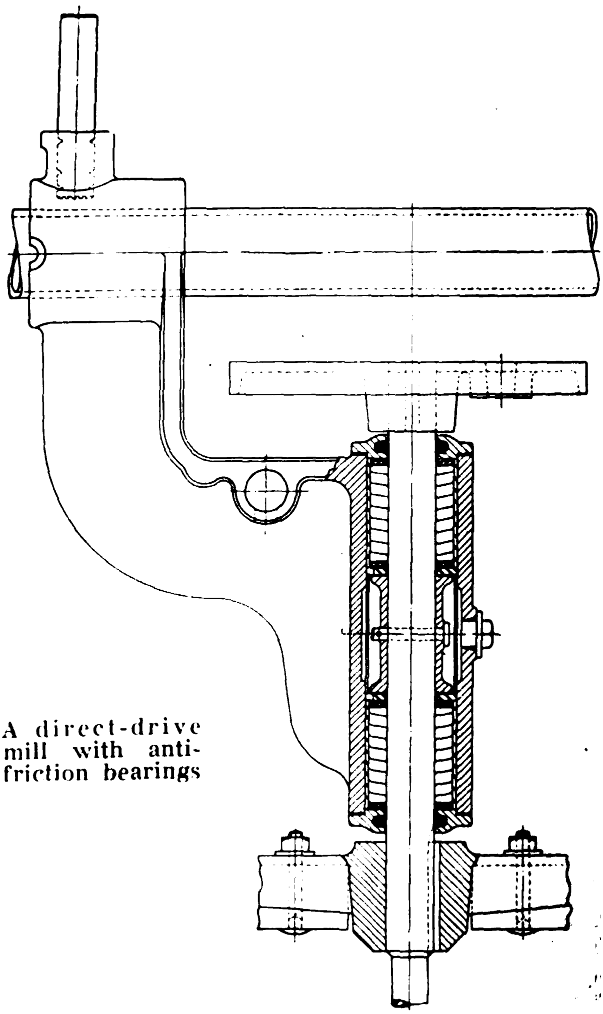
drive type of windmill, mounted on 70-foot towers. The duration of this test was 370 hours and very careful measurements were made with devices properly calibrated. In this case the pumps were interchanged during the test so that the results are also strictly comparable. The only constructional difference between the mills consisted of two anti-friction bearings in place of two plain bearings on the main shaft. Although these bearings represent perhaps only one-half of the places where friction occurs, the mill with the two anti-



Back-geared mill with roller bearings on main and counter shafts and on crank pin

friction bearings pumped 14 per cent more water. When it is considered that the back-geared mill of the former tests was equipped with anti-friction bearings at all five rotating positions, the result of this latter test is not at all out of proportion.

An interesting and very significant fact was established during these tests. It was noted that the anti-friction bearing mill would start to pump at a considerable period before the plain bearing mill and when the mill velocity was low the



A direct-drive mill with anti-friction bearings amount of the water pumped was as much as 50 per cent greater.

As the velocity of the wind increased the increase in water pumped gradually became less. This is due to the fact that windmills are fitted with governing devices which limit the speed of rotation of the wind wheel, and it therefore follows that as the mills approach the point where they both run at the same speed the frictional loads necessarily become alike.

Since the prevailing winds in this country are light, and furthermore, since most of the light winds occur during the summer when the demand for water is greatest, it becomes apparent at once that the application of anti-friction bearings to windmills is a genuine improvement of great economic value.

The anti-friction bearings are installed into these mills in such a manner as to retain the oil and prevent dust and other foreign matter from entering the bearing surfaces thus insuring long life and freedom from frequent oiling, and since they are non-adjustable they also require no attention in this respect. Severe weather conditions of either summer or winter have no effect on these bearings so that they are ready at all times to do the work for which they were intended. A grade of lubricant is used which remains fluid in the coldest weather and yet performs satisfactorily in the hottest climates. Accurate workmanship coupled with the use of a high-grade anti-friction bearing which reduces the element of wear to a minimum without question increases the life of this machine. This, of course, is another important consideration.

Summing it all up, it appears that real progress has been made in this equipment in that the amount of water delivered has been greatly increased, water is delivered under conditions when conventional types will not operate, the time required for oiling and other attention has been reduced to a minimum, and the life of the outfit has been lengthened.

Windmills embodying these improvements have been on the market for several years and thousands of them are proving to farmers the advantages of anti-friction bearings.

It is almost needless to say that the farmer is not only interested but is also vitally concerned in these things that really tend to make farming more of a pleasure and less of a task.

A STANDARD BELT PULLEY*

By Chris Nyberg

Mem. A.S.A.E. Chief draftsman, thresher works, Advance-Rumely Co.

IN LOOKING over various makes of agricultural machinery, the writer has noticed that the pulleys used are made with arms or spokes of innumerable designs. Some are straight and others are curved, some are tapered with the large end toward the hub, while others have no taper at all, and the number of spokes varies all the way from two up to eight or nine. This same variation also holds true in the design of the rims and hubs of the pulleys. The only reason we can account for this condition to exist is that when patterns for most of the pulleys now in use on agricultural machinery were made, the manufacturers did not employ draftsmen and the designing was left up to the pattern makers, who simply made up a pattern of some kind which would serve the purpose.

While there is a good deal of technical data on the subject, most of it is not in a very convenient form, and nearly all the tables given in the engineering handbooks are taken from the practices of makers of pulleys for transmission machinery. These pulleys are usually made with the same sizes of arms for a great number of different widths of face; this is done in order to have as few patterns as possible. But in order to do that, the spokes will have to be made strong enough for the widest face, which will of course make them a good deal heavier than necessary for the narrower.

The following formulae (refer also to drawing) were arranged by the writer to be used in the drafting room where he is employed, in order that the design of pulleys there would be uniform although made by different draftsmen:

For single leather belts and rubber or canvas belts up to and including 4 ply

$$A = \sqrt[3]{\frac{DW}{4N}} + \frac{1}{8}''$$

For double leather belts and rubber or canvas belts 5 ply and up

$$A = \sqrt[3]{\frac{3DW}{8N}} + \frac{1}{8}''$$

D = Diameter of pulley

W = Width of belt

F = Width of face of pulley = W + ½″

*Article which appeared in the January, 1921, number of Agricultural Engineering.

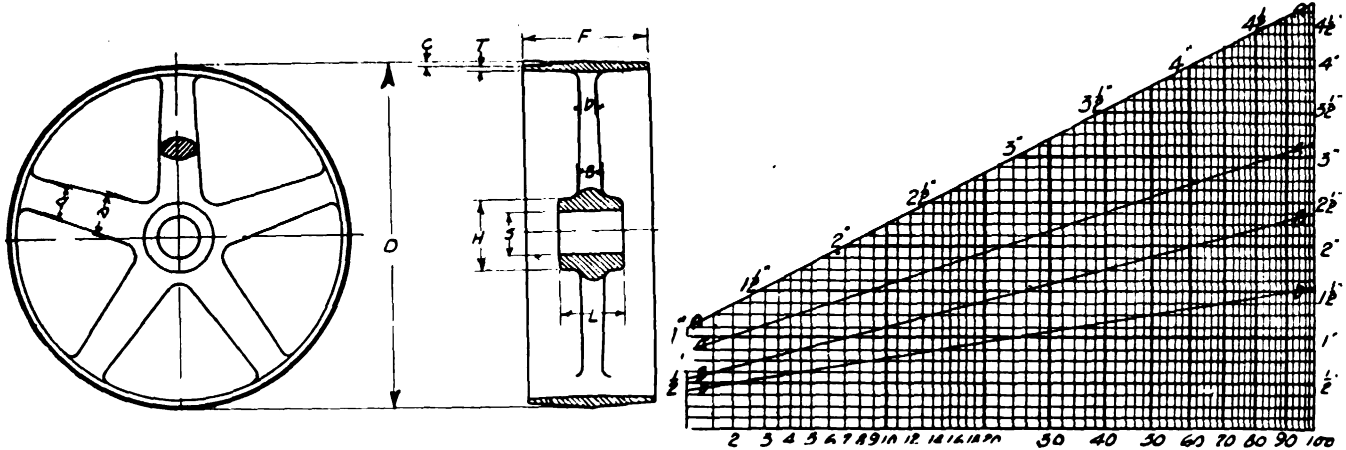


CHART FOR SOLUTION OF PULLEY SPOKE DIMENSIONS

To find the dimensions of the arms of a 12-inch single belt pulley having five arms and for a 5-inch belt substituting these factors in the quantity under the cube root sign for a single belt pulley gives $\frac{12x5}{4x5} = 3$

Locate 3 on the base line, trace upward and read A = 1½ inches, B = ¾ inches, a = 1⅛ inches, and b = 9/16 inches.

A = Width of arm at hub
B = Thickness of arm at hub = 0.5A
a = Width of arm at rim = 0.67A
b = Thickness of arm at rim = 0.5a
T = Thickness of rim at edge = 5/32″ for single belt
= 3/16″ for double belt
S = Diameter of shaft
N = Number of arms = 5 for pulleys up to 30″ dia.
6 for pulleys over 30″ dia.
L = Length of hub = 5×1.25 to 2.5
H = Diameter of Hub = $S + 1''$ to $1\frac{1}{2}''$

$$C = \text{Crown} = \frac{F+2}{64}$$

It is not claimed that these formulae contain anything new, as it has been taken from different reliable sources, but was arranged more for the sake of convenience.

The chart is an alternate method of determining the sizes of the arms in pulleys. Both the chart and formula were taken from Halsey's handbook, given as the practice of the Todd and Stanley Mill Furnishing Company. They have been modified slightly so the results obtained correspond more nearly to the practice of two of the largest manufacturers of agricultural machinery.

It is based on a belt pull of 50 pounds per inch width of belt for single belts, and 75 pounds for double belts. The working strength of the material from which the pulleys are made is considered to be 2,000 pounds per square inch. The thickness of rim, length of hub and number of arms are also taken from the practices of these two concerns. The crown of the face and diameter of hub is what one of them has used successfully for years; the other one recommends a slightly higher crown and heavier hub.

THE EFFICIENT USE OF ANIMAL POWER*

By Wayne Dinsmore

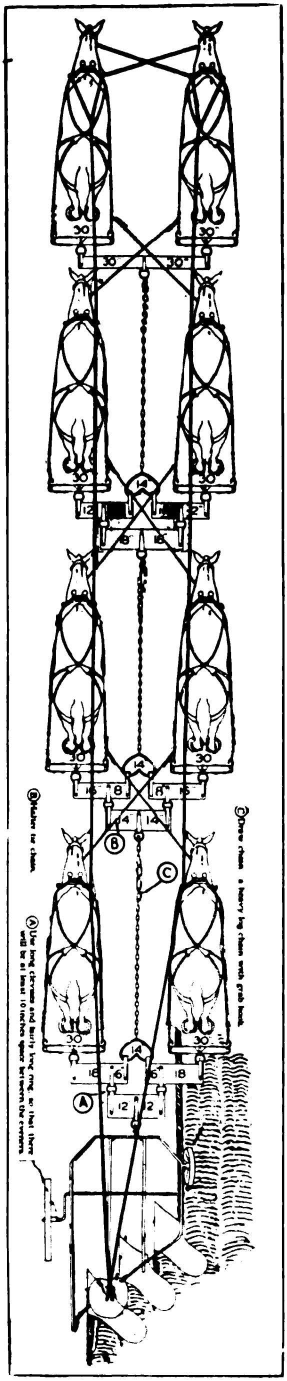
Mem. A.S.A.E. Secretary, Horse Association of America

EFFICIENT use of animal power is the very basis of our system of agriculture. It has made possible the production of more farm products, per capita employed in agriculture, than in any other nation. The importance of the subject is shown by the fact that the studies of the Horse Association of America indicate that there were more than seventeen million horses and mules actually employed in work on farms in 1921. The only available figures on mechanical motive power use on farms is that disclosed by the census of January 1, 1920, which reported 246,139 tractors and 139,-169 trucks used on farms. Mechanical motive power used on farms has decreased rather than increased since that time. It is therefore evident that animal motive power furnishes more than ninety-five per cent of the power used in field work on American farms.

You are agricultural engineers. Most of you are employed by the various states. The farmers of these states pay the bulk of the taxes which support your work. You owe them the direct duty of increasing, in every possible way, the efficiency of the motive power used on their farms, and this duty should take precedence over work designed to bring out and popularize new motive power. Motive power is power, whether it be animal motive power or mechanical motive power. From the broad scientific standpoint it is just as much your duty to study efficient ways of using animal motive power and methods of increasing the efficiency of such animal motive power units as it is to study efficient ways of using mechanical motive power or ways of increasing the efficiency of such mechanical motive power units.

Despite this obvious fact, I regret to say that practically no work of any kind has been done by the agricultural engineering departments of the various states relating to the more efficient use of animal motive power or relating to the development of more efficient types thereof, and I make this statement with full knowledge for on June 10, 1921, I sent letters to every agricultural engineering department in this country asking for complete, detailed information in regard to what had been done on this subject. Some scattered observations had been made here and there, but nothing of consequence had been done nor were there any projects at that time actually under way. I regret that I am obliged to make this statement, but it is the truth, and I hope that the publication of my statement in this particular, may arouse some of the

*Fifteenth annual meeting paper.



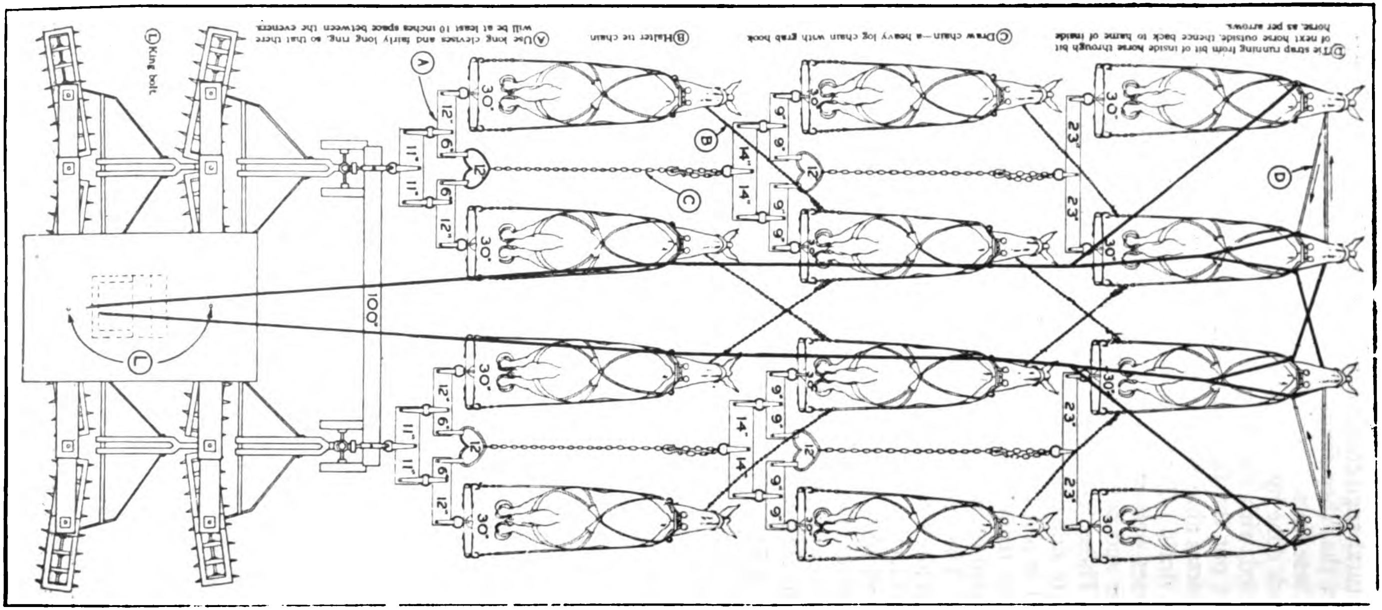
Dimension drawing of tandem hitch for eight horses on three-bottom plow to maintain true line of draft agricultural engineering departments of the various states to the fact that they should do some definite constructive work along these lines.

Work done by your retiring president, E. A. White, while connected with the Illinois agricultural college at Urbana brought out the fact that it is impossible to hitch three or more horses abreast on plows without some loss of power due to side draft. Close observation also disclosed the fact that the horses were working at a disadvantage because crowded together and not situated so as to obtain a straight, forward pull. These tests also demonstrated that it is possible to eliminate side draft by using plow hitches where teams were hitched in pairs tandem, also the fact that a correct angle of trace for teams removed some distance from the plow can be secured by weighting the clevis immediately back of such teams. The development of the pulley hitch, resulting from Prof. White's work, marked a step in advance; but these were altogether too complicated for the average farmer to build and while a company has put them on the market sales have been comparatively limited. Farmers do not want to use hitches that they have to buy. They want simple home-made hitches which will enable them to use their teams efficiently and which they can make up on their own farms during time which would otherwise be unoccupied.

From 1910 till 1920 my work as secretary of the Percheron Society of America took me to all parts of the United States and Canada, and during the last two years my work in behalf of the Horse Association of America has required still more extended traveling. I have studied very closely, and with regard to detail, the hitches used with all types of farm implements and with teams of varying size, and I have been able to conduct such observations in practically all of our states and in the northwestern provinces of Canada. What I have to say to you regarding efficient use of animal motive power is therefore drawn from unusually extended observation, and I shall present to you information regarding those hitches which have been tested out for years by practical farmers in actual field work and found to work satisfactorily with ordinary hired labor.

Three factors determine farm profits. These are the cost of production, the yield per acre, and the selling price. The selling price of most farm products is determined by world wide conditions which are beyond the control of any individual. The cost of production and the yield per acre, however, are partially within the control of each individual farmer. The type of farm power used and efficiency shown in its application have more to do with reducing costs of production than any other factors.

As an illustration, take conditions observed in different



Hitch for twelve horses on two tandem disk harrows cutting all hoof prints except on turns parts of the United States and Canada. The amount of plowing done in a day by one man may serve for comparison. This ranges from one to one and a half acres in New England, from two to three acres on many farms in Pennsylvania and Ohio, from four to six acres in Illinois, Iowa and other midwest states, and from eight to twelve acres in our own western and northwestern states and in Canada. The amount of work done in other operations, such as disking, harrowing and seeding, varies in substantially the same proportions. It is obvious that the man labor expended per acre is much higher in New England, Pennsylvania and Ohio than in the Mississippi Valley, and that there it is higher than in the northwestern states and Canada. The cost of production is consequently greater. The size of fields, character of land and presence of stones or stumps make it impossible in many instances to apply the same labor-saving methods used in the West and Northwest to farms in other sections, but whenever and wherever these larger units can be used, production costs can be measurably reduced. It is now, and always has been true, that horse labor costs less than man labor in the United States; and if, by increasing the number of horses used, we can reduce the amount of man labor required, the advantage to farm profits immediately appears.

Surveys made by the Horse Association of America within the last two years show that the number of horses needed varies from one for each 20 acres to one for each 32 acres of tilled land. In general it may be said that well-managed farms, where good rotation of crops exists, can be operated with one horse for each 25 acres of tilled land. West of the Missouri River, where small grains are grown more generally, many farmers are efficiently operating large farms by using one horse or mule for each 30 acres of tilled ground. The exact number required will depend upon the size of the fields, rotation of crops and climatic conditions plus the degree of intelligence manifested by the individual farmer in handling his farm work.

The rule should be to have a little too much, rather than not enough power, even if it be necessary to buy an extra team in the spring and sell it off in the fall. The man labor saved and the more timely despatch of the various farm operations will more than offset any slight loss between buying and selling prices. If the individual be a competent judge of horses or mules, actual profit will result, for good type four year old horses or mules can be bought in the spring and sold at a profit in the fall.

The experience of farmers in the West, Northwest, and Canada furnishes ample evidence of successful use of large teams and the establishment of a standard day's work. It has been found possible to drive teams 20 miles per day in a ten hour day on various farm implements and to maintain this rate week after week. This allows two hours for driving to and from fields, hitching and unhitching, turning at ends and occasional examination of collars, etc. It requires that teams shall actually be in motion on productive work eight hours per day at an average speed of 2½ miles per hour. When fresh, horses will exceed this; when weary, they will not equal it, but it is a practical standard, attained where sufficient horses or mules are used to permit of steady driving, without stops to rest animals. Whenever teams require stops for rest, not enough power is being used. Put on another horse or a pair, or more if necessary, but add enough so that you can turn dirt 20 miles per day and not overdo the teams. The number of horses needed will depend on the hardness of the ground, the depth to which implements are cutting, the weather and the age, size and condition of the work animals used, so that each man must use horse sense and gauge his teams according to power needed.

Twenty miles productive work daily means 5.6 acres plowed with two bottom gangs, 14-inch plows; 24 acres double disked with 10 feet disks and trailer attachment; 70 acres harrowed with 6 section harrows (5 feet sections); and as these soil preparation tasks are the ones requiring the most time, they also offer the greatest opportunity for cutting costs by increasing work done per day.

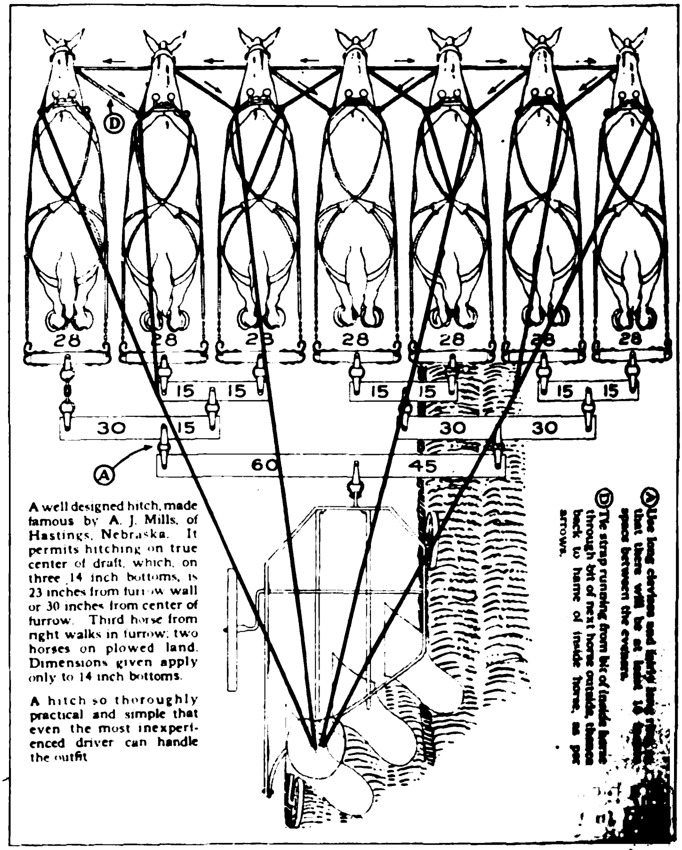
Disking is the greatest labor-saving soil tillage operation. On good farms it precedes and follows plowing. It pulverizes trash, kills weeds, conserves moisture and makes easier and better plowing. The 20-blade, 10 feet disks now available are usually drawn by six horses, but often need eight for steady progress, especially early in the spring when the horses are soft. One rule governs: Use horse sense, and if you see the load is too heavy for the number of horses you are using, put on more, until there is enough power attached to allow the horses to walk at a good pace all day. You hire men to accomplish work, not to sit out in the field waiting for horses to rest and recuperate, and it is sound economy to furnish plenty of power, especially as one more horse, or a pair, will turn the balance between overload and ample power.

Plowing is heavy work, made worse by the general practice of crowding the horses too closely together and by failure to hitch on the true center of draft. On every plow, whether one bottom or more, there is a point of hitch termed the "center of draft" and when the hitch is made at this point, the plow pulls with less exertion than when the hitch is made at a point more distant from the furrow. On a gang plow, two 14-inch bottoms, this center of draft is approximately 16 inches from furrow wall or 23 inches from the center of furrow when plows are cutting full even furrows as they should. This means, therefore, that the eveners must be of such length, and the horses so hitched, as to give a straight forward pull over the true center of draft. This cannot be attained with four or more horses except by putting a horse or horses on plowed land, or by stringing the pairs out tandem fashion. If the hitch, for three or more horses, is made more to the left, so as to put the right-hand horse in the furrow and the others on solid ground, they pull the plows at great disadvantage, and the extra load thus created is called "side draft."

The average Illinois or Iowa farm is a six horse farm, i. e., there are usually 150 acres, more or less in crops aside from pasture, woodland, orchard, yard, etc., and six horses of working age are kept. Every farmer should recognize that it is just as easy to drive four, five or six horses as it is to drive two, providing they are properly hitched; and the ease with which eight, ten and even sixteen horses are handled in the west by hired men who never before drove more than two or four, is evidence, if proof be needed, that there is no real obstacle to multiplying the amount of work done per man per day. The size of the units, however, must depend largely upon the size of the farm. On a one hundred acre farm, there are seldom more than 80 acres in tilled land, and four good horses are ample to operate such acreage. The implements purchased and the hitches used should therefore be based on a four horse unit. This calls for six-foot disks with trailers, (12-disk units), two bottom gang plows of 14-inch bottoms and 4-section harrows, together with seeders not over ten feet in length. Other implements should be proportionate. All these can be handled by four good horses, although if the ground is full of stones or ledges of rock, gang plows cannot be operated satisfactorily. Under such conditions, it is wise to use 14 or 16-inch walking plows with three horses, which are the oldest but most satisfactory plow units for use on such land.

On farms that have around 150 acres in tilled land, six good horses or mules will be needed. Here, with fields of 30 acres or over, six horse units can be used on disks, plows and harrows, which are the implements chiefly used in the preparation of the seedbed. It is in soil preparation that the greatest saving in man labor can be effected. One man, by using six horse units wherever possible, can handle all the work on a farm containing 150 acres of tilled land, until time for corn plowing, thus cutting down the need for an extra farm hand to the months of June, July and August, three months instead of six.

On some farms throughout the corn belt and on a good many farms west of the Missouri River, the acreage under cultivation may run up to from 400 to 1000 acres per farm, and there are some places where the improved acreage runs up to 25,000 or 30,000 acres actually under the plow. On these larger farms the use of 7, 8, 9, 10, 12, and even 16 horse units on various farm implements is both practical and desirable, and I take pleasure in showing herewith efficient hitches long used by farmers with such larger teams. The seven-horse hitch shown in the accompanying illustration and the nine-horse hitch, based on exactly the same principle, have been brought into prominence by A. J. Mills, of Hastings, Nebraska, although I found similar units in use on various farms in Canada, the owners of which had no knowledge of the work which Mills had done in developing these larger team units. The great advantage about this seven-abreast or nine-abreast hitch is that it gives an absolutely straight



Seven-horse-abreast hitch for three-bottom plow pull over the true center of draft and the horses are back next the plow and are so hitched and driven as to make it possible for anyone to handle the team very easily. The only disadvantage that can be charged against the hitches in question is the fact that they require three or four of the horses to walk on the plowed land, but the objection to working some horses on the plowed land, although generally made by the average farmer, is inconsistent, for the very men who object to working two, three or four horses on fresh plowed land will work five or six of them abreast on the same freshly plowed land the same day or the next while harrowing or disking, and the actual experience of men who have worked these seven, eight or nine horses abreast on plows shows conclusively that this objection has no serious weight. The strongest, toughest horses, best able to withstand the work, should be put on the plowed land and they will keep pace with the others so that no slackening in mileage per day will result. The details of these hitches are so fully shown in the illustrations that I do not need to enter into detailed description at this point.

Three bottom gang plows (14-inch bottoms) will turn 8.4 acres per day; four bottom gang plows (14-inch bottoms) will turn 11.3 acres per day; two 8-feet disks hitched abreast with trailer attachments (double disking a strip 16 feet wide) will double disk 38 acres per day; an eight section harrow (5-feet sections) lapping one foot each round, will harrow 94 acres per day, and the three seeders (one 12 foot and two 11 foot) will seed 80 acres per day.

While the majority of men prefer an abreast hitch, because of greater ease in handling horses and keeping each animal up to his share of work, others who have more skillful teamsters available prefer the tandem hitch, where pairs are strung out as shown. This unit, found in successful use on many farms in the northwest and in Canada, is easily made up on any farm, but it is important that the units should be made up exactly as shown, and the heart-shaped ring, made from ⅝-inch round iron rod, should follow the diagram both as to shape and dimension shown in the center. The distance between the eveners, adjusted by the length of the log chain should be no more than just enough to permit the horses to walk without stepping over the evener in front of them. It will be found that they can touch noses to the tails of the horses ahead and still not interfere with the evener. At the turns, the eveners drag on the ground, but the horses soon learn to avoid them, as well as the draw chain and singletrees. The records of farms where these hitches have had long usage, show that this is not a source of accident or injury for the animals. Halter tie chains extend from halter to traces of horse diagonally ahead. Adjust length as needed to let horse work with free head.

It is very important that the traces on the swing and lead teams pull at right angles from their shoulders to the singletrees, the same as on the wheel pair. If, instead, they tend to run parallel with the horses' backs, the teams work at great disadvantage and in many instances sore shoulders result. The condition when encountered can be remedied by attaching a weight to the evener or to the chain just in back of the evener, sufficient to bring the traces of the lead and swing pairs to a right angle with the shoulders, as observed on the wheel pair. Also, if any horse seems persistently inclined to forge ahead tie a strap from the check rein back to the heart-shaped ring, making the length such that he will be pulled back whenever he tries to advance too much. This is called "bucking back," but will seldom be needed if the draw chains are adjusted so as to bring the eveners back close to the horses' front feet.

All eveners shown that have to withstand the full pull of eight or more horses, should be of 2x10 or 2x12 material. The larger size should be used if evener is long, as in the 8 or 9 abreast plow hitches. The short eveners in tandem hitches that withstand pull of four or six horses should be 2x8, and the smaller eveners can safely be made from 2x6 material. The eveners should all be made of the best hickory. Where this cannot be obtained, other materials, such as oak or ash, are sometimes used but are liable to give way under heavy pull. Hickory alone can be depended upon to stand the strain.

Where the ground is unusually dry or horses small, it is oftentimes desirable to put on one more team on a three-bottom plow and turn an eight-horse tandem hitch into a ten-horse tandem. In such cases, it is customary to use the slowest team next the plow and to hitch them directly to the plow while a chain runs from the plow clevis forward to the first team ahead of the wheelers. These and the teams ahead of them are then hitched on the regular eight-horse tandem, as shown in accompanying illustration, and in actual practise farmers report that it is better to do this than to undertake to make up the same type of tandem hitch involving ten horses.

Disking land pulverizes trash, kills weeds, conserves moisture, makes plowing easier and is one of the most effective of all tillage operations. Anyone can drive four or six horses on an ordinary disk with trailer attachment. It is just as easy to drive 12 horses on two disks with trailers. The accompanying illustration shows how to unite two double disks for use with the 12 horse team. The hitches are simplicity itself, as they only consist of two six horse tandem hitches.

It may be argued that it is impossible for one man to take these large teams to and from the field and to hitch and unhitch them alone. That this is erroneous is shown by the fact men who have never driven more than four quickly learn how to take 12 horses to the field, hitch, drive and unhitch without assistance. On the Noble farms, where these 12 horse teams have been in use for several years, teamsters are paid a bonus of 50 cents a day for each pair used in excess of four pairs. One man receiving a bonus of one dollar per day accomplishes as much as two men under the old system. The saving is obvious.

In taking such teams to the field, the off horse in each pair is tied to the hame of the near horse, and the near horse has his tie chain fastened to the left side of the horse immediately ahead, at the point where the back band crosses the traces. The three pairs on the right are thus attached tandem fashion, just as they work in the field. The three pairs on the left are hitched together in the same way and the driver can either lead his teams to the field four abreast, or, if the road is narrow, the lead pair in the left six can be dropped back of the wheel pair in the right six. On arriving at the field, the left six is untied and led up beside the right six. The horses are then led directly into their respective positions. The four lead horses are then hitched. The first step is to snap the lines into the bits, then run them back through the hame rings on the swing and wheel horses, tying lines to the seat. Traces of the lead four are now hitched and tie straps of the swing four attached thereto. Traces of the swing four are then hitched and tie straps of the wheel four attached thereto. Traces of the wheel four are next hitched and driver swings to his seat and drives off. In unhitching, reverse steps just described.

Eight horses from this outfit can be used wherever needed by dropping out the wheel four with their eveners and draw chains. The sixteen-mule team used on three seeders is handled in same fashion as the 12 horse hitch. An eight abreast plow hitch can be made by taking the eight horse hitch off harrow, and putting in another evener (instead of the 20-foot harrow evener) of correct length to strike the "true center of draft," next to the plow.

In conclusion I wish to say that what I have presented here is but a beginning in the study of more efficient use of animal motive power. One large farm that is making extensive use of 12 and 16 horse units will carry out some further experiments this coming season by doing away with unhitching at the noon hour. It is planned to water and feed the horses in the field from feed bags without unhitching, and the plan which is to be put into operation is based on the experience of the British army during the late war. If actual field work proves the plan to be successful it will be another distinct contribution to the efficient use of animal motive power for it will save time and increase the amount of work done per day.

DISCUSSION

MR. CLYDE: On those smaller hitches in which we are more interested I am wondering just what the advantage of putting some of the horses on the plowed ground is, to get rid of side draft of course, but you are working the horses on plowed ground much harder, and I wondered if there is much advantage in doing that; one would offset the other.

MR. DINSMORE: You are getting rid of side draft and making it possible for the horses to pull straight forward. You do away with sore shoulders, and while you are working the horses on the plowed ground somewhat harder, you can obviate or overcome that by putting your strongest horses out there so you actually get more work done per day. Put on enough power to drive your 20 miles per day, and while weather conditions, soil conditions, depth of plowing, conditions of your horses and all must govern, the one test is this; do you actually turn dirt 20 miles a day, are you driving your horses constantly, or must you stop to rest them? If you have to stop to rest them, it is proof positive that you are not using enough power and our great trouble with ninety-nine farmers out of one hundred is that they are not using enough power on the heavy work, such as disking and plowing, and if you men will simply go to them and impress on them that the one test is to put on enough power so they can drive straight through, you will do more than any other one thing. Of course I know absolutely that a great many farmers object very strenuously to putting any horses on the plowed ground. You cannot do anything with those fellows.

QUESTION: Have you made any observations as to the real speed you get in going down the furrow?

MR. DINSMORE: Yes, I have actually timed teams over measured distances with stop watches. A good big team, fresh, will walk close to three miles an hour. When they begin to get tired they will drop down to even 2 miles. If you overload them they will go less than that. On the average I would say they will walk a little better than 2½ miles when fresh and gradually taper down to about 2 when they begin to get tired.

REPORT OF THE COMMITTEE ON ANIMAL MOTORS

I. The most important, because most costly, single factor in farm crop production is motive power.

II. Animal motive power constitutes more than 90 per cent of all power used in field work at the present time.

III. No accurate scientific work has ever been done in

America to determine the efficiency of animal motive power units.

IV. Definite, accurate data regarding the efficiency of animal power will contribute immeasurably to the production of more efficient animal motive power units.

The Committee on Animal Motors of the American Society of Agricultural Engineers accordingly recommends that work be begun at the earliest possible moment by the federal department of agriculture and state agricultural experiment stations to determine the absolute pulling power of horses and mules (which relates to their efficiency as animal motors) to be determined in the following specific projects recommended by this committee:

1. Determine maximum pulling power of horses and mules for short periods, alternated with periods of rest.

2. Determine maximum pulling power for 10 days, also for period of 20 days.

3. Determine maximum pulling power of horses and mules for a day's work of 10 hours.

4. Determine maximum pulling power of horses and mules for a ten day period, wherein animals are worked for 5 hours per day, 2½ hours in forenoon and 2½ hours in afternoon.

An accurate record shall be kept on the following controlling factors to be observed:

1. Feed consumed. Time fed, kinds and amounts given, physical condition of feed and exact analysis of feed used, different rations to be used to test efficiency of rations on efficiency of horses.

2. Determine from foregoing and work accomplished the thermal efficiency of animal motive power units.

3. Temperature, humidity, wind, cloudy or clear, and any other meteorological factors.

4. Kind of harness and manner of hitching.

5. Length of pulling period and period of pause and rest.

6. Weight, height, length, grip on road surface, muscular development, angle of shoulders, age and sex, special attention to be given to testing various types of horses, good, as well as defective or unsound types to be studied. All of these factors are of far reaching importance as a guide to breeding operations.

7. Temperature, respiration and pulse of horse in tests.

It is further recommended that a thoroughly experienced competent teamster be employed and that he shall train and condition all horses for at least 60 days before they are put into any tests to insure horses being in normal condition.

These tests shall, at the outset, be conducted under controlled conditions which shall be set forth in the report, and subsequently under normal field conditions.

These tests shall be conducted under the immediate personal supervision of a committee consisting of an agricultural engineer, a trained horseman, a nutrition specialist, a veterinarian, and an experienced farmer.

This is but the first step in a program of animal power studies intended to ultimately determine the efficiency and economy of animal power.

ADVANTAGES OF A PLANNED RURAL DEVELOPMENT*

By Elwood Mead

Hon. A.S.A.E. Professor of Rural Institutions, University of California, and Special Lecturer for Harvard University

THE most inviting field for rural planning is in the creation of new communities. Here no obstacles arising out of the past have to be removed. No established institutions or human prejudices have to be put aside. The advantages of aid and direction in the creation of new communities will therefore be my theme, but before entering on its discussion I wish to consider briefly some of the conditions which confront rural life in both old and new communities.

American agriculture is influenced from forces long in operation but which have operated with greater vigor during the past half century. One of the results is an exodus of land born people to the cities. The farmer's son once he sets his foot in the city rarely wants to return. What is the cause of this migration? Why this dislike of life on the farm? The problem has been too suddenly presented for complete agreement as to the answer. These facts, however, seem well established.

With the disappearance of free land this nation entered on a new social and economic era. Free land had been the open road to opportunity. When it closed nothing had been provided to take its place. Organizing thought and ability had been centered so largely on cities that conditions in the country were overlooked. In the cities single shops had been grouped together into mass industries. Great combinations to control a single product girdled the earth with their warehouses and factories. Trade unions fought for better wages and better conditions of life for their workers. A new social and economic civilization was being created.

These forces left the American farmer untouched. The pioneer was solitary in habit and thought. He did not seek to create communities but to acquire land. He shifted for himself and left others to do likewise. The result has been that a well-organized rural society which offers to men and women a life as attractive as the city is rarely found. The great social and economic advantages of the organized life being created in cities passed over the heads of farmers, until he found himself confronted by forces he did not understand and oppressed by power against which he rebelled but against which he was helpless.

The loss to American agriculture from this individualistic attitude has been greater than is realized. But so long as there were farms to be given away and public resources to be seized it could not be overcome. Rising prices for land made

*Fifteenth annual meeting paper.

owners ignore conditions created as city factories took from the farm more of its arts and industries.

Now there is an awakening. The farmer has come to realize the importance of business in agriculture and that his business is organized and controlled by others. Keen witted business men sell his grain and stock, make his bacon and butter, and bake his bread for him. He has to accommodate his life and business to outside forces. In politics and trade he finds the business minority controlling the farming majority. With the profits of rising land prices gone, with the need for increased returns to meet increased costs, with tenantry increasing at a disquieting rate, the farmer is awakening to the need of better business and an organized community life. The farm bureau movement owes much of its vitality to the fact that it is bringing to rural life the aid of men trained in business affairs.

The creation of new communities according to carefully thought out plans is a new idea in American life. In this we are behind the rest of the world. In Denmark, Germany, and Australia, for instance, the ablest minds have studied how to create organized rural communities as Americans have developed manufacturing industries. Ownership of land by its cultivator has been a basic idea. The money or the credit necessary to do this is provided before settlement begins. The settler is required to have a definite capital and a credit system, under which he is loaned the remainder, is a part of every scheme.

Realizing that conditions must be created that will enable the farm buyer to earn the money to pay his debt out of the soil, these governments give all the aid which science can extend in relation to soil, climate, and crops and in the design and erection of farm buildings. The result has been one of the greatest agrarian advances in all history.

The Land Settlement Act of California passed in 1917 was an innovation. Nothing resembling this had ever before been attempted in the United States. This nation had sold and given away public lands but there had been no selection of settlers. Nothing had ever been done to render it certain that the public domain would go to those who needed it or would permanently live on it. There had been no classification of soils or adjustment of prices to agree with the differences in soil and locality. The subdivision of land has been mechanical. Nothing has been done to hold people in one place or create an affection for a particular locality or piece of land.

The Land Settlement Act of California sought to change all these methods. A nonpolitical board made up of able business men was given authority to buy areas large enough to create organized communities. It was to subdivide any area bought into small farms, fix the conditions on which these farms were to be sold, and determine the capital which the settler must have. It could select the settlers and was given unrestricted authority to reject any settler not regarded as qualified to succeed.

The basic ideas of this settlement plan were as follows:

1. That there should be no attempt at settling people on single isolated farms. Only tracts of land large enough to create an organized community and this meant that it must be large enough to have at least 100 farms. Less would not afford the economic advantages of cooperation and social life and the overhead expenses of administration would be too burdensome.

2. That the settlers should own their farms. An effort should be made to postpone if not prevent tenantry. Ownership of the land by its cultivator is required for not less than 10 years.

3. That a credit scheme should be provided under which the settler having the capital required could be loaned money to complete his development.

4. That expert guidance both in development and in the subsequent farming operations should be provided.

5. That cooperation should be encouraged.

6. That the kind of agriculture or horticulture of any community should be based not only on soil and climate, but on the opportunities for a market and on securing a return for the settler's industry at the earliest possible date.

7. That the community spirit should be encouraged so that loyalty and civic pride in the locality would be strengthened and opportunities for wholesome recreation and fun be provided.

Two settlements have been created. One at Durham in the Sacramento Valley, the other at Delhi in the San Joaquin Valley. In both cases the settler pays 5 per cent cash and is given 36½ years' time to complete the payments. The payments are amortized. The annual interest rate is 5 per cent and the principal 1 per cent, so that by paying 6 per cent a year the settler becomes the owner of the property in 36½ years. The board can loan the settler up to $3,000 as an aid in development. If this money is used to make permanent improvements like houses, 20 years' time is given in which to repay the loan. If it is used to buy livestock, then the money must be paid within five years' time. Loans may reach 60 per cent of the cost of improvements

The first question in a new community is health. The experts from the University said Durham was menaced with malaria, but that this could be prevented by the creation of a mosquito abatement district. A health district which took in not only the settlement but a large surrounding area was created.

In order that the price of each farm would agree with its value a soil map was made and was the basis of the subdivision of the land and the price of farms varied from $48 to $250 an acre. This seems like an extreme range but when these farms were applied for, every one was the first choice of some applicant. One hundred and twenty-five families bought farms in the Durham Settlement. If this had been an unplanned development, every settler would have had to do everything needed to change raw land into productive farms. Those 125 families came from half a dozen states. If they had been left alone, they would have competed with each other for the services of the local blacksmith, carpenter, and mason to build their houses and make their improvements. They would have paid more for material than it was worth because they were compelled to purchase at a disadvantage to buy quickly. Some settlers would have built shacks, and others houses too costly for their means. This situation had been foreseen. Long before the land was thrown open to settlement the board had employed a farmstead engineer who had planned the layouts of farms, secured prices of building material, made arrangements to buy at wholesale and secured discounts that no individual settler could have obtained. When the farmers and their wives came on the ground, they found suggestions for homes. They had their designs of houses suited to the climate and to be built of material that could be used most effectively. As a result the settlers' homes while not expensive, show taste, comfort, and beauty, and are the admiration of all who behold them. Yet this result has been brought about at an expense of anywhere from 10 to 25 per cent below what would have been possible in an unplanned development.

Those who planned the community believed that dairying should be the most important single industry. Before any settler arrived on the ground, letters had been written to fifteen of the leading agricultural colleges of the country asking if the adoption of a single dairy breed of cows would be an advantage, and if so, what breed was recommended. All answers agreed there were marked advantages in having a single breed.

Under an unplanned development, each of the 125 families would have had to buy cows in the local market and each would have competed against the other. Instead, a committee of three who knew good stock bought cows for the settlers all over the State of California.

The money value of combination and cooperation was most strikingly shown when these settlers had to find a market for milk. Selling as individuals they would have been at the mercy of dealers, but selling as a community with the central skimming plant, a chilling apparatus and testing not only for butterfat content, but for bacteria. They were then in a position to offer an article of superior quality and in an amount large enough to attract distant buyers. The result is that Durham milk is sold to a single purchaser at a price fixed by the seller and not by the buyer. The sign "WE USE DURHAM MILK" is to be found in restaurants one hundred miles up and down the Sacramento Valley.

Intelligent dependable farm laborers are as necessary as farm owners. The American farm laborer has almost disappeared because he is at a disadvantage both as to the hours of labor, the wages received, the opportunity for the education of his children and their social or lack of social status in the community when compared with the city laborer.

So far as is known, the California state settlements are the first to create farm laborers homes. Twenty-eight of these homes were included in the plans of the Durham Settlement. With each there were two acres of land. Those who acquired these properties bought them on the same conditions as the farmers bought theirs. The state loaned money to help build the houses. The buyers paid only 5 per cent of the cost of the land and were given 36½ years in which to complete their payments.

There was considerable misgiving regarding the results of what was regarded as a socialistic experiment, though why the helping a farm laborer to secure a home should be regarded as more socialistic than helping a farmer become the owner of the land he cultivates is difficult to understand.

Today no one questions the success of this innovation. Each farm laborer has met his payments to the state. These homes are the most attractive feature of both the Durham and Delhi settlements. The children of these laborers live in homes that are as convenient, comfortable and satisfactory as the homes of the children of farmers. There has been no trouble about employment. The income from the two acres of land has constantly increased until in some cases, it now affords a comfortable living. The families of these laborers are leading lives of independence, comfort and self-respect. The children of these farm laborers will be the farm owners of the future.

Under unplanned development, it takes about 25 per cent of the cost of the farm to find the settler. In other words, one-fourth of his money goes to pay for his capture. Under the planned development of California, not one dollar has been spent in commissions to selling agents or in advertising these farms. The broader opportunity has been sufficient attraction. About 8,000 letters asking about farms were received by the Land Settlement Board between January and

October this year. Land owners are coming to realize that it is far better to have their land sold under the conditions of this Act than under the haphazard methods of land salesmen. The board is offered large areas of good land without the payment of a dollar. Owners are willing for them to handle it and to accept payments as made by settlers.

That a land settlement policy of this character should be a feature of every reclamation scheme is now generally recognized. It is destined to have wider field of usefulness. There are sections in the Middle West where 70 per cent of the land is now cultivated by tenants. This condition of affairs cannot continue. If it does, a land problem as serious as that formerly in Ireland or Denmark will soon confront this country. Nothing but planned development with a credit system, with expert advice will serve to reconstruct and rehabilitate some of these tenant farmed areas. The conditions are similar to those which made planned development the policy of Denmark and Germany. The work of the rural colonizer should go hand in hand with the work of the reclamation engineer. One creates the conditions which makes settlement possible and the other pays the cost.

FLOOD CONTROL IN MIAMI VALLEY*

By O. N. Floyd

Division Engineer, Miami Conservancy District

We had a flood in the Miami Valley which you have heard more or less about, the flood of March, 1913, in southern Ohio. Something like five hundred lives were lost at that time. No one ever tabulated exactly the property damage but it was variously estimated at from one hundred and fifty to two hundred and fifty million dollars. The cities of Piqua, Troy, Dayton, Miamisburg, Franklin, Middletown, and Hamilton were all flooded and more or less torn up. In Dayton alone there were seven square miles flooded in the business and manufacturing districts. This flood ran anywhere from a foot up to twenty-five feet deep. In Hamilton where the velocities were much higher on account of the greater volume and a little more slope to the valley it almost ruined the town.

Immediately after the flood naturally the people of the valley began to discuss what they could do, what they should do. The Morgan Engineering Company was asked to handle the situation, and I was sent to the Miami Valley to make surveys and to collect such other data as might be helpful in formulating some sort of plan for flood protection.

It took us about ten months to make surveys and collect sufficient data to begin to have much of an idea ourselves as to what could be done. We had no more idea of the final plan for the first few months than anyone else had; it was forced on us by the process of elimination. We investigated many plans which were too expensive or otherwise impracticable.

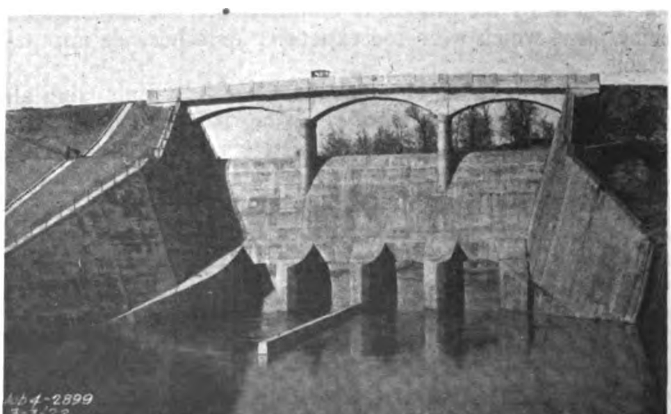
We found it much cheaper, after carefully analyzing all our data, to plan a system of retarding basins to benefit all the cities and protect the whole valley rather than protect Dayton alone by channel improvement. We then set out to find some way whereby a strip of territory over 120 miles long, involving about seven counties and a number of towns and villages, could cooperate. We found there was no law on the statute books under which we might work. The governor of Ohio at that time lived in Dayton and knew what the flood had done, and he was very anxious to help out. He called a special session of the Legislature and what we called the Ohio Conservancy Law was passed.

The work up to this time had been carried on by a flood prevention committee, the same committee that was organized and employed Mr. Morgan in the beginning. They had no legal status, except they were incorporated, but they

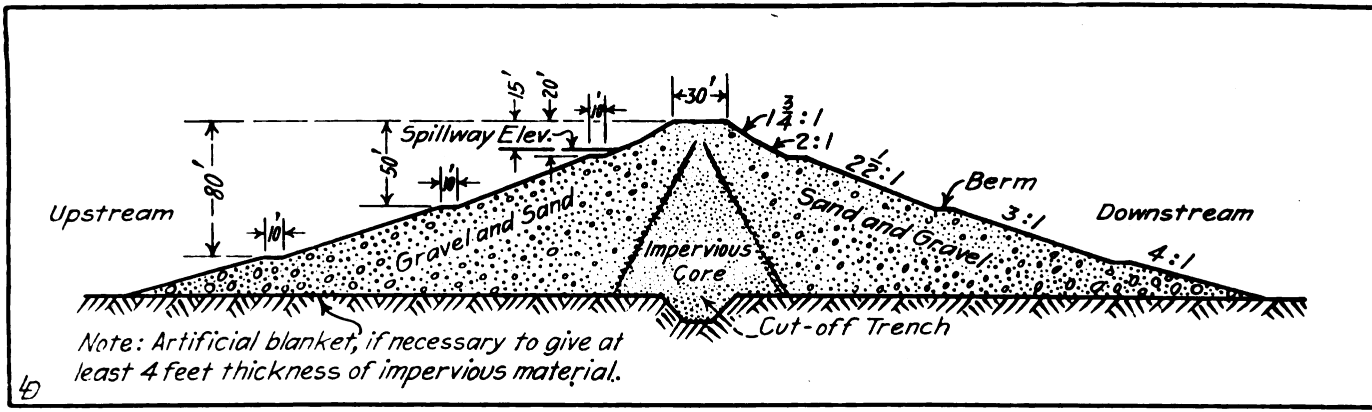
*From an address before the fifteenth annual meeting of the Society, Chicago, December, 1921.

raised by private subscription in Dayton a fund for carrying this work forward, to which 23,000 people subscribed. The entire amount was a little more than two million dollars—that was by private subscription, understand—no law, assessment, or anything of the kind. Of course, that gave the flood prevention committee a good standing. They had no legal standing, but they had the money back of them to pay for surveys, lawyers' fees, and such other expenses incidental to the carrying forward of this work.

We worked under this committee until the law was enacted and the Miami Conservancy District organized. The organization of the District had to be approved by the court; the law provides that the district shall be under the supervision of the conservancy court. The conservancy court consists of one common pleas judge from each county affected by the District, in this case seven common pleas judges meet together in Dayton as a conservancy court. They have jurisdiction over all the work. The law provides that they shall appoint a board of directors of three men for a term of six years. This board of directors then operates the district in very much the same manner as the board of directors of a corporation operates. Col. E. A. Deeds was appointed on the board from Dayton, H. M. Allen, of Troy, from the northern part of the territory, and Gordon S. Rentschler, a prominent business man in Hamilton, from the southern part of the territory. Col. Deeds was elected chairman of the board and is still its chairman. The court



Outlet, spillway and spillway bridge at Taylorsville, dam. Each of the conduits is 15 feet wide and 19 feet high. Crest of spillway is 58 feet above conduit floor and 19 feet below top of dam. A flood like that of 1913 would rise to within 3½ feet of spillway crest and drain out through conduits in seven days



Typical cross section of Miami conservancy dams. Material was moved, assorted and placed hydraulically also appoints a board of three appraisers which is independent of the directors.

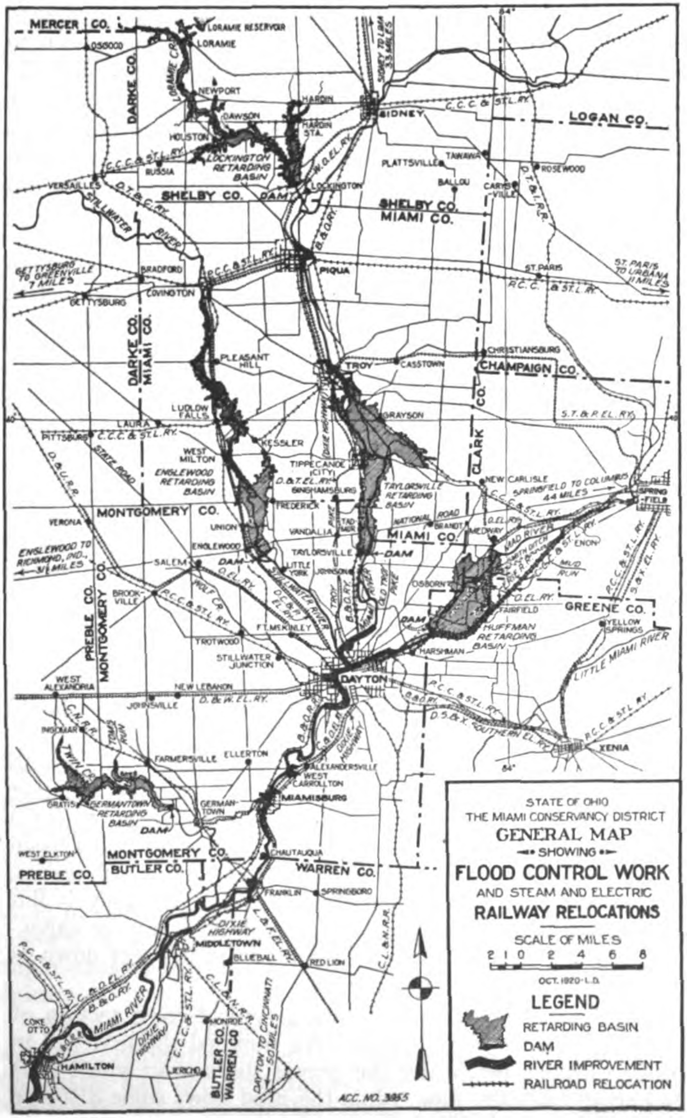
The board of directors instructs the engineers to prepare an official plan, and they have to work out this plan, setting forth in more or less detail just what it is expected to do. When this plan has been approved by the board it is filed with the court for their approval. The court may approve the plan or they may return it for correction or amendment, but any property owner may object to the plan and be heard in court before the court's verdict is given. When the plan is finally approved the court instructs the appraisers to go out and appraise the damage and the benefit according to this plan. The appraisers report directly to the court and they have to appraise all property, whether benefited or damaged by the project, and their appraisal roll is submitted to the court, and, if approved, it is then open to public inspection. and every person has a right to come in during a period of thirty days and make complaint. There is something over sixty thousand different pieces of property affected, so you can imagine the complaints we got, but not nearly as many as you might suppose, only a small percentage; however, it ran up to a few thousand.

This work took about two years, even after we got our district organized. The appraisers, of course, went to work as soon as the plan was approved and they employed many assistants, but they themselves had to pass final judgment on every piece of property in the District. The engineers furnished much of the data for them to work on, such as flood heights in the valley from the 1913 flood for property benefited and property damaged, made up a contour map showing the depth of flooding of all the different property. and where we could we gave some idea of the velocities and destructive effects of the currents. In the basis we had to show the depth and duration of flooding that would likely occur after the dams were in. This was largely the basis of the damage to property in the basin. Largely the appraisal of benefits is a matter of judgment, just as the assessor's work for taxing is a matter of judgment. But what they tried to find out was what this property was worth in its present condition and what it would be worth if it were fully protected. Before they could arrive at that, it was necessary to know how it was affected by the flood, and also how it would be affected by the official plan. If it were not affected at all they set it aside, and if it were only partially affected it came in for a slight benefit. Then the question they would ask themselves was, "How will it be affected after the official plan is put into operation? Will it be completely protected? Or will it be only partially protected?" Not all property was completely protected. That applies especially to farm lands.

Practically all city property is completely protected, but the farm lands we could not protect fully at any reasonable cost.

In this district I think there are something like one hundred thousand acres of farm land, but it only pays about one per cent of the total cost.

The total cost of the project was thirty-five million dol-



Map of the Miami Conservancy district

lars. The assessed benefits against the property is about two and a half times that amount. The farm lands are not completely protected from overflow, because the river channel itself carries such a small proportion of the flood flow, and that part of the valley subject to flooding is so narrow, the average width being about a mile, that the expense of further restricting the flood flow by retention basins so as to confine it to the river channel through the rural district would have been more than the value of such lands. The only way to have protected these lands completely would have been to supplement the retention basins by building levees. But the farm lands could not stand the cost.

On the other hand, the overflow on most farm lands does little harm. Most of the farmers do not object to their land being overflowed; they rather like it if the velocities are not destructive.

Now the ordinary floods and the floods such as will go through the dams will not rip the farm property up, make gulleys down through it, or deposit great beds of gravel in other places, as the 1913 flood did, because the volume is not great enough and the velocity is not high enough. So we have given the farm lands a degree of protection that is practically as much as they need, because it is expected that the lands down in the valley will overflow, and most of the farmers prefer that they overflow still.

Because the plan for the Miami Valley has proven a happy solution of the flood problem there and the only solution that was financially possible, many people in other localities have jumped to the conclusion that it would be the solution of their flood problem. We have had to say in the case of a number of the projects we have examined in a preliminary way that such a system was not applicable. Many people want to know why we cannot control the Ohio River in the same way, and some think the Mississippi River should be so controlled.

It happens that the drainage area above Dayton is spread out somewhat like a fan, the three rivers coming together there, and the topography makes it very convenient to get a basin on each river. On the larger watershed we put a basin on the main river and one on one of the main tributaries, making two in this same drainage area. The valley is flat enough and wide enough so that we got good storage capacity. The fall in the valleys there runs from five feet down as flat as three feet to the mile.

One of the illustrations shows a typical cross section of the Miami Conservancy dams. We pumped the material in through dredge pipes and the gravel stays near where it is discharged from the pipe, while the mud flows some distance with the water. We keep the outside of the fill higher than the middle, and the water flows in and the mud, fine silt and sand retained in the water goes to the core pool and settles out. The water was then drawn off at the top, leaving a mud core in the middle and the gravel on the two slopes. An effort was made to keep the thickness through the mud core equal to the distance from the top down. If the dam were 100 feet high we would want the core to be about 100 feet wide at the bottom. When within twenty-five feet of the top the core should be about twenty-five feet wide. It is not necessary to have a core that wide, in our material at least, because a thin layer is quite impervious, but for practical and mechanical reasons you cannot work too close. The line between the gravel and the core cannot be controlled absolutely. If allowance is not made for the irregular extension of the gravel into the core it may be the gravel from one side will meet the gravel from the other.

Practically all of the core material will pass a 200-mesh sieve. The Department of Agriculture analyzed it for us from time to time. They classified it as coarse sand, silt, and clay. Samples of it taken after it is dried out may be polished more or less like soapstone. Right on top it is rather polished but after it has been built up a few feet and some of the water squeezed out of it, it weighed about 125 pounds to the cubic foot, which is about the same weight as saturated gravel. If the core is too fine or light the gravel is likely to sluff in and press the core out.

DISCUSSION

Mr. Cromley: I understand you are making use of the land in the reservoirs for agricultural purposes. Can you tell us how you are handling that?

Mr. Floyd: Back of the dams we have no gates, it is automatic, somewhat like a funnel. You know when you pour into a funnel real fast it will fill up, and if you quit pouring it will run empty. All the records for Dayton show (we have a government record there daily for about twenty-nine years) four floods in that time that would have caused any flooding at all from about April 15 to January 1. There is small chance for a flood that would flood the basins during the crop growing season. It will be safe to plant most any thing in these basins after about the middle of April, except possibly down near the dam, where an ordinary little flood might cause a rise of five feet and a little head on the conduits.

We planned to utilize the basins still as farm land. There was much opposition to this project, however. The farms in the basins had not been subject to serious flooding and we had to get land there for the benefit of the towns, which is a little bigger scheme in social cooperation than the average fellow is used to. Some of the people objected very strenuously, and a few politicians took advantage of their fears. We tried hard to get the farmers to understand that the best thing for them to do was to sell the District a flood easement on the land, the value of which the appraisers appraised at anywhere from five dollars up to fifty dollars an acre. We tried to get them to let us pay them the easement value and they keep their farms, with certain restrictions as to buildings. Many of the farmers did; some did not; and in that case we had to take their land outright. But most of that land now is being sold with flood easement retained, sometimes to the very farmers we bought it from. They have more confidence now in our scheme and there is considerable demand for this land.

As soon as the Conservancy District came into possession of this land one of the best farm managers in the country was put in charge of it. As a revenue producer, the farm department has made a good showing, although it is not the policy of the district to hold farm land, only until it can be sold advantageously. I see no reasons why there should be any restrictions on any kind of a crop in the basins, except upon winter wheat and alfalfa or something of that kind that has to go over through the winter and spring and this would apply only on very low ground.

In figuring the probability of these floods, we do not have records enough to predict with much accuracy how often the big floods will come, but they probably would not come oftener than once in a hundred years, and the floods that will fill the basin to about half full it seems may come about every forty to fifty years. A flood that will cover more than a third the area will likely come about once in twenty years. This latter size seems to come along quite regularly, judging from the history of the valley. We have no definite records back of 1892; the other is all history, but the history appears to be fairly reliable from about 1800 on.

Mr. Bishop: The consistency of the core wall I presume was more or less a viscous mass. I was wondering if the drainage took place through the coarser materials or whether holes were placed in the side walls and slopes of the dam to take care of the water in that center core wall. Was the water drawn off from the surface?

Mr. Floyd: Yes, drawn off from the surface. We had a regular spillway for that. We had a concrete well built in a recess in the wall and put concrete blocks up over that as we came up, and drew it off from the surface. But there was a lot of seepage through the coarser material. We had to watch out for that. We found we could not lay our pipe line as close to the edge of the slope as we got higher, as we did further down, because it was liable to get it saturated near the discharge and somebody would come along and step on it causing a small slip. A tremendous amount of water seeps out through the gravel, most of it from the pool, but that is largely the way, I think, that the outward part of the mud gets rid of its water and solidifies, although a large part of the water comes upward out of the mud strata through pressure. Sometimes we would be shut down for a few days and the water in the pool would become clear, and one could see the little streams of muddy water rising all through the thin mud on top, which indicated that the pressure from the top was causing the water to come up. We had some pressure cells gotten up by the Department of Agriculture which we used in the core. They seemed to work very well, although they are new and we do not know just exactly what they do indicate, but they seem to indicate that the core solidified rather fast as the dam came up, probably more from pressure than from anything else. At a certain depth it does not seem to matter much how fast the dam comes up, the core seems to get about so solid. The pressure cells were set some for horizontal pressure and some for vertical pressure.

Mr. Bishop: You figured on the lateral pressure against the gravel. The thickness of the section would be sufficient to take care of the lateral pressure from the viscous core, wouldn't it?

Mr. Floyd: Yes. That is one of the things that you cannot overlook. We had a very large factor of safety there. We figured that first and we found it gave a core too wide, more than was needed. The core is always a source of danger while the dam is under construction. If anything happens to the outside, for instance, if the pool water on top happens to break over the levee, it washes the gravel out, and if it is not closed at once it may wash out a place in a few minutes large enough to hide a residence. After it gets started it will make a messy job. Those are some of the ugly sides of the hydraulic fill, but they are likely to occur on any job.

Note: The principal part of Mr. Floyd's talk was given with lantern slides and therefore had to be condensed considerably before publication. This accounts for the lack of order in places.

NEW ENGINEERING DEVELOPMENTS IN LAND CLEARING*

By John Swenehart

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CONDITIONS have changed recently in the development of land clearing in the Great Lakes states. In 1915 Wisconsin started with one man devoting his entire time to land clearing problems. This was the first directed effort by state or federal government. In the three lakes states, Minnesota, Wisconsin, and Michigan, we now have sixteen men putting in their entire time to land clearing. Positions are now open in Wisconsin alone for three more land clearing men. Why the increase?

First, undoubtedly there has been directed towards the land clearing problem the attention of trained men who honestly recognize the possibilities in cut-over regions. In the past few years land values have changed, not the result of a boom as in the great agricultural states, but rather the steady and conservative rise in the value of land due to its increase in productiveness after cleared. In other words, today the value of raw cut-over land in the Great Lakes states plus the ordinary cost of clearing is less than the actual value of the land when cleared. Nearness to markets, adequate railway transportation, and close proximity of ocean waterway in the very near future are considerations which should lead engineers to study the necessity for a rapid reclamation of these lands. Since 1910 between thirty and thirty-five thousand farmers have come to northern Minnesota, Wisconsin, and Michigan, where they are rapidly converting labor into improved farms. A total of over 100,000 farms now exist on cut-over land in these three states.

Land clearing is the limiting factor in the agricultural prosperity of this region. Dairy production which at the present time has not been carried on to a point of diminishing returns, is the type of farming to which the region is adapted. The number of livestock today in the various counties of upper Michigan, Minnesota, and Wisconsin is such that the natural increase must be cared for by either buying expensive feed or clearing land. The ordinary rate of clearing is not sufficient to meet the demands.

It is doubtful whether government aid will ever be given to help the man who starts with little or no capital and practically no equity in the land. Financial aid in a business way depends on the productive possibilities of the land. A big phase of the engineering problem of reclamation in these sections is to develop the land immediately to a point where

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it can be made collateral for a loan. Raw cut-over land anywhere is not sound collateral unless it is a part of a farm having considerable improved land. The Federal Land Bank system says that cut-over land has a loan value only when there are at least ten acres of land fully cleared on the farm. Banks generally are of a similar opinion. Therefore, the problem today in Wisconsin, Minnesota, and Michigan, and in other cut-over sections, is to get the land to a point where it can produce and where it can be collateral for a loan without outside help. Perhaps greater and quicker financial arrangements can be made through a colonization company. However, colonization companies with independent capital really interested in development are few and far between. Most of the thirty thousand new farms in the lake states must bear their own or individual financial burdens. The solution is clearing, rapidly pushed to a point where the new farm will pay interest on investment. a living to the farmer and prospect for paying principal debt. The ordinary rate of one acre cleared per farm annually will not do this. Financial bankruptcy will almost surely follow agricultural conditions today unless clearing is speeded up.

Three aspects of the land clearing reclamation project seem of particular interest to the agricultural engineer: First, promotion work; second, mechanical engineering work; and third, the training of men capable of carrying on one or more of these phases of the work.

The first task of the land clearing engineer is to sell his idea to the people who have land to clear and who are to be benefited by land clearing work. This involves sale of the project not only to farmers and prospective farmers but to bankers and financial interests who must be convinced in order to furnish the money to back the enterprise, and to the public generally so as to create enthusiasm and interest in the project.

The land clearing engineer today can place before a banker or financial interest, before the farmer, or before any business man or organization, an array of facts which proves that land clearing is of importance to every member of such a community. The farmer has definite money returns figured in increased land values and in crops raised. The banker has increased collateral, therefore increased business. More production should mean more money and more business for everybody, and better living.

Realizing that the rate of clearing in the past has been too slow for sound development, a plan has been worked out which stimulates and promotes land clearing, and gives a definite opportunity for engineering assistance. The plan is to organize a cooperative land clearing association composed of farmers, bankers, business men, press, college and other state agencies, manufacturers of explosives and machinery, and all business interests which can be enlisted in the cause of more cleared land. It is necessarily not a farmers organization because it must have the support of other members of the association who are largely if not equally interested with the farmer. A representative organization is worked out with a membership in all parts of the district or county and with a central committee representing the various units of this district. This central committee or board of directors employs a business manager or land clearing engineer particularly qualified to carry out such a project. A definite quota is decided on in terms of acres to be cleared and based on the needs and possibilities of the district. This man is a full time land clearer having charge of the association, planning distribution of materials, creating enthusiasm for land clearing, and supervising demonstrations and instruction so as to make the materials cover the largest possible area. His is the clearing house for land clearing work of all kinds, sale or rent of machinery, contractors, publicity, etc. He is the driving engineer to get a definite quota of land cleared in the county within the assigned period. Details of his particular job and the whole scheme can be worked out. In connection with distribution of materials the associations saved from $15,000 to $20,000 each last year in addition to other work. This plan was first successfully carried out under the direction of L. F. Livingston, in Marinette County, Wisconsin.

The county agricultural agent is a factor which should by no means be disregarded in this land-clearing program. He has often confined his efforts to projects which seem more directly related to his agricultural work. He can be made to realize, however, that land clearing is one of the problems which vitally affect the agricultural prosperity in his county. He is then the natural leader particularly in the promotion and demonstrational phases of land clearing work. The strictly technical engineering phase is of course the job for the specialist.

The big feature is that there is definite need today for a land clearing engineer in charge of land clearing reclamation in counties or equivalent districts in the cut-over area. He has labor, he has finance, he has good land. It is for him to harness and drive the team.

The mechanical engineering phase of land clearing has to date been only touched. The present margin between the value of raw and cleared land is such that wholesale clearing seems much nearer than it used to be. In addition, interests and taxes are forcing the big nonresident land owner to get busy. It seems that some method will be developed to clear or provide for clearing a part of the land on every farm and thus hasten settlement.

It should be here pointed out that it will be several years before these cut-over farms can be a factor in production. By that time agricultural price conditions should become adjusted and apparent overproduction avoided.

Many social and economic questions are involved in such a program, but the financial conditions seem to be pushing toward larger land clearing operations for the first few years at least on the new farm.

Stump removing machinery in the past has been developed very largely by guess work. Nobody seemed to know just what strength or speed would be needed. As a result, we have machines being made strong enough to give five or ten times as heavy a pull as is needed. These machines either must be very heavy or they must be very slow. Tests were made in Wisconsin the past year to work out the relation between the speed of pull and the pounds of pull as well as the probable strength of ordinary materials. We have long known that it is easy to use a horse power puller of the capstan type and pull a stump so large that it can not be handled after it is pulled. A team is the most common unit of power for skidding, dragging, and other work on farms in the cut-over district. Therefore, it was deemed desirable to base our work on a unit equivalent to the work which could be performed with a farm team. While these investigations are not complete, some interesting facts have been brought out.

Trials were made largely on white pine stumps in different kinds of soil, varying from sandy soil to superior red clay. The pull required, of course, varied with the size of the stump, its age, kind of soil, and many other conditions. It seemed absolutely essential at the outset to use sufficient dynamite to split the stump so that the pieces could be handled when finally pulled. For making the pulls a 5,000-pound dynamometer was equipped with a set of levers to permit measuring the high pulls. Three-quarter-inch cable was used in all tests. Larger sized cables are heavy and unwieldy to handle and much less flexible for use on drums in pulling. The pulls on stumps (two feet in diameter and over) ranged from a little over 10,000 pounds to 24,000 or 25,000 pounds.

Pulls of 25,000 pounds broke ordinary three-quarter-inch cable which had been used but a short time on the machine. Stumps which required a pull of 20,000 to 25,000 pounds, were so large that it was very difficult and impractical to handle them afterwards. Pulls up to 18,000 to 20,-

000 pounds can be safely made with the three-quarter-inch cable. It should be noted that the manufacturers list the breaking strength of standard plow steel cable as 23 tons. This figure is, of course, based on the strength of the cable when new. They also indicate a working load of approximately 20 per cent. From the trials, it is observed that 30 to 40 per cent of the breaking strength can be considered a fair load in stump puller work where the speed is slow. Statements by stump puller makers claiming enormous pulling power seem entirely untrue.

There is no doubt that larger sized cable and larger equipment throughout could be provided to pull any stump, but in view of the fact that the majority of conditions require pulls ranging from 10,000 to 18,000 pounds, it would hardly be desirable to have larger machines and equipment when it could not be used at full capacity very much of the time. In the design of machinery a maximum pull of perhaps 15,000 to 18,000 pounds seems desirable under Wisconsin and lake states conditions. In the skidding and piling operations trials showed that a maximum pull of approximately 2500 pounds would be desirable which also means that the skidding line could have eight to ten times the speed of a pulling line, using the same power equipment. Speed and flexibility in skidding and piling operations are the essential of all around land clearing equipment. For an occasional heavy pull, either with the skidding line or with the pulling line, a pulley could be used and very nearly double the pull. This is a much cheaper method than to devise the machine at the outset with a sufficient strength to make the big pulls direct.

Several power machines have recently been developed, each perhaps having some particular advantages. The Southworth machine, designed by P. D. Southworth, Chippewa Falls, Wisconsin, is probably the most promising development along this line. It is designed more for skidding and piling but handles light pulls to advantage. This gives a pull of approximately 12,000 pounds maximum pull by dynamometer test on low gear. A high gear on the same drum gives a speed of 166 feet per minute and a pull of about 2,000 pounds. Field tests show that the high gear should have a little greater pull as well as a little greater speed. For the low gear a pull of 12,000 pounds seems to be sufficient and a speed of 30 to 35 feet per minute can be easily maintained. This machine was designed with a view to skidding and piling rather than for pulling, it being realized that to get a machine large enough for pulling required greater weight, larger power units, greater expense, all of which would not be used much of the time.

It was felt that explosives would better be used in advance of pulling and reduce the size of the equipment all around. This machine is also equipped with a drum to be used for piling. The piling boom or derrick remains stationary in height but can be swung from side to side. The piling drum operates a cable passing through a pulley at the upper end of the boom. On its outer end this cable is fitted with power pulley through which the main pull line passes. This power pulley is permitted to hang free from the end of the boom nearly to the ground. When the stump is pulled and drawn up to the machine, then the piling drum is set in motion, raising the stump to the top of the boom and on to the pile. A third drum is used as an out-haul.

The Rabey stump puller and piler built by W. W. Rabey, of Hill City, Minnesota, is a two drum machine, using a 12-25 Avery tractor engine. The particular feature of this machine is the friction drive with a 24-inch friction disk keyed to the crankshaft of the engine and a 24-inch friction wheel set on the shaft at right angles and driving the gears which in turn drive the drums. Actual tests of the pulls are not available on this machine. It is steel built and mounted on a wheel base which is geared to the engine to provide traction. A ground speed of one and one-half miles per hour may be maintained. The hoisting line is listed as having a speed of 440 feet per minute. The pulling drum has a speed of 20 to 600 feet per minute.

Public demonstrations of large numbers of stumps pulled in an hour and in a day have been made with these machines but such demonstrations under favorable conditions mean nothing to the land clearing engineer. Both of these outfits, however, do recognize the fact that piling is the most important part of the land clearing job. Both are designed lighter with a view to moving from place to place.

The Bissell stump puller is designed to use a large steam engine on a caterpillar tractor base with two drums, one pulling from each side. No anchor is used, the stumps on one side being pulled serve to anchor for the pulling on the opposite side. Stumps are dragged into a windrow occupying about 20 to 30 per cent of the land. The machine weighs approximately 55,000 pounds according to advertised specifications. One and one-eighth-inch main line cable is used. No haul-back is specified, a horse being used for this purpose. The caterpillar tractor base permits the pulling direct from the rear of the machine. The ground speed is approximately one mile per hour. While there is, of course, no question but what this machine will pull stumps rapidly, the large cost of the machine and its construction eliminates it from consideration by the man of small means. Even the small contractor cannot hope to have the equipment which such an outfit would entail. Several other machines have been constructed but do not seem to have the promise of the machines first mentioned. As far as pulling alone goes, a horse power machine is generally superior. Skidding and piling are the big items in stumping cost.

Each year brings many other new machines and methods into the land clearing game. Among these might be mentioned the Crockston brush mower which is a large tractor-operated device for the cutting of brush where stumps are not in the way.

The usual number of burning stunts have developed with various drums and ovens suggested for char-burning the stump. Chemicals have again been suggested to hasten the decay of stumps. None of these latter schemes seem to have much practical value to commend them for the lake states. It is hoped that with definite information as to the requirements, that engineering skill can be combined with land clearing field knowledge and progress made to a point where power can be economically applied to clear land.

In some portions of the cut-over districts, particularly in Minnesota, Michigan, and Wisconsin, there are areas of considerable extent having very few stumps to the acre and where the brush has not grown very large on account of fire or other conditions. In these districts plowing outfits are being devised to turn under brush, even as large as 3 inches in diameter. Investigations are being made as to the practicability of such a plan. The effect of the method on the soil and the effect on the settler who has his work done for him are questions to be investigated as well as those of strictly mechanical nature. Obviously to plow down large brush requires a large sized tractor and a plow having very large clearance. Frank Conrath, of Conrath, Wisconsin, living in a district adaptable to this method, used a 15-27 tractor with an Oliver brush breaker but found that the throat room between the beam and the land was not sufficient to permit the plow to keep clean. The brush would accumulate and throw the plow out of the ground. To obviate this difficulty, he selected a peculiarly shaped tree and hewed out a special beam which increased the clearance from about 16 inches to 25 inches. This was found to increase materially the effectiveness of the outfit. Large plow manufacturing concerns have designed plows having very much more clearance and designed more particularly for marsh and cut-over work. These plows are being made with 20 to 24-inch bottoms.

Undoubtedly, the development of brush plowing has only begun in those districts where the plan is adaptable. Work of this kind has been done also in Minnesota where a very large area bordering the prairie section is particularly adapted to the method, having few stumps and comparatively light brush. The question of using large power units, consisting of several teams of horses, is being considered and a later report will be made of the results of this investigation. One of the big needs in connection with land clearing work is to speed up the clearing, at least on the first ten acres. This means that plowing of the land, whether the brush is still standing or whether the brush has just been cut, is done under difficulties on account of the many fine green roots. Plowing on a large scale, however, requires big equipment entirely out of the reach of the ordinary farmer. Therefore, it is only a contractors equipment or perhaps the equipment of a colonization company which is particularly interested in the sale of their mortgaged indebtedness on the land. Where a colonization company or a contractor is available and where the natural land conditions are such that few stumps exist, brush plowing can be very economically carried on. In this connection, it is important to note that the large plows are very much more effective on stony land than the ordinary small plows with a small two horse team. On the other hand, consideration must be given to the fact that the settler desires to market as much labor as possible in the clearing of his own farm.

The most advanced demonstrational idea is the traveling land clearing schools of Marinette County conducted by the Marinette County Land Clearing Association in 1921. In this work trucks were used to transport stump pullers, pilers, and complete blasting outfits. The trucks carried a crew of experienced men who acted as instructors. They visited thirty-three communities in Marinette County during May and June. In each place, not less than ten farmers signed up and agreed to spend the day with the land clearing school, actually working under the direction of the demonstrator instructors, using the tools and equipment carried by the land clearing association with the cooperation of manufacturers of land clearing equipment, business men, and the Wisconsin college of agriculture. The idea of taking the work to the immediate community is its claim for effectiveness.

The land clearing school idea is now the most important form of demonstration in Wisconsin. The fundamental idea in this method is to get the farmer actually working with the demonstrator instructors rather than having him stand to one side and watch the other fellow do it. It is not quite so spectacular but much more productive of good in the community.

The Minnesota Land Clearing Fleet, a new demonstration idea, was operated in the fall of 1921. Taking the show to the people was the big idea. This consisted of complete land clearing equipment, pilers, pullers, explosives, and cut-over land tillage implements. These were carried from place to place on trucks by means of motor trucks giving daily demonstrations to crowds of farmers, bankers, and business men interested in the development of Minnesota's cut-over land.

War salvaged explosives perhaps should not occupy a very large portion of our time in this discussion, but inasmuch as there are many million pounds of picric acid yet available to farmers of the various states, it is fitting that a few words be said about it. Investigations were conducted by the Wisconsin college of agriculture in cooperation with the U. S. Bureau of Mines and the U. S. Department of Agriculture to devise methods of packing and use of war-salvaged picric acid. This involved the preparation of the picric acid, drying and cartridging it, and it was found that 2 per cent moisture permitted this operation to be carried on economically. Wet picric acid as it is stored, being unexplodable and dry picric acid being so dusty that it could not be satisfactorily cartridged. Two per cent water allays the dust but does not kill the explosive. Picric acid, while shattering in its effect, was found to be entirely usable, its strength being about one-third to one-half greater than ordinary dynamite. It is worth, in terms of dynamite, approximately 20 to 23 cents per pound, dynamite selling at approximately 15 to 18 cents per pound.

Picric acid is entirely unaffected by temperature changes which are ordinarily encountered. It is not a liquid and, therefore, does not freeze. In handling, in land clearing operations, no poisonous effect could be noticed; in fact, its use as a medicinal agent in connection with burns indicates that the material is not poisonous to the human body. The gases given off on explosions, while containing considerable quantities of carbon monoxide, are easily avoided in land clearing operations. Altogether the picric acid is a desirable explosive when it can be secured from salvaged surplus. It cannot be manufactured at the present time to compete with commercial explosives. It is not a material which should be used as a basis for a campaign because the effect will not be permanent and while we may be able to get "a flash in the pan" by using a limited quantity of war explosives, we will not get permanent results if this is the basis of a campaign. Therefore, in Wisconsin we are basing our campaigns on the use of a commercial explosive, unlimited in quantity and desirable from the standpoint of the particular needs of land clearing which desirable qualities are, first, a slow heaving dynamite; second, a dynamite cheap to manufacture; and third, a dynamite effective to use and as near foolproof as possible.

Obviously to carry out the program suggested requires experienced land clearing engineers. Their experience must be gained in the field. Developments of new farms from cut-over lands is coming in other states as well as the lake states. Many areas have land which permits purchase and improvement at a profit based on sale and loan values. This does not mean an increased production to swell an apparent present surplus, but it will mean homemaking first and production later when it will be needed at fair prices.

FINANCING OF DRAINAGE DISTRICTS*

By S. H. McCrory

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IN CONSTRUCTING drainage improvements one of the most difficult questions that those entrusted with the execution of these works have had to deal with in the past few years has been the problem of borrowing money with which to finance them. Changed economic conditions due to the war caused a large increase in interest rates. Many new and attractive securities yielding a very high rate of interest were sold, the result being that drainage bonds with their relatively low rate of interest could not be sold at par, despite the fact that they were exempt from all federal income taxes, and in some states from state taxes. The market for bonds is now improving and interest rates are falling. Present indications are that within the next few months a much improved market for drainage bonds will prevail and that large issues of well-secured bonds can be sold without difficulty.

In every drainage district before construction of the necessary works can be started three things must be accomplished. Legal organization under the laws of the state in which the district is located must be effected, the plan of drainage must be developed and adopted, and arrangements must be made to secure the funds required to pay for the construction of the necessary drains, levees, and other appurtenances.

For the purpose of this discussion, I shall assume that a legal organization has been perfected and that a plan of drainage has been adopted by the commissioners of the district. It now remains to secure the funds necessary to pay for the construction of the proposed improvements. In most drainage districts it is not possible to meet the cost of the improvements by taxes which can be paid in one or two years. Therefore, it becomes necessary to borrow the money which will later be repaid as the drainage taxes are collected from the landowners. To meet the needs of drainage districts a system of financing has been developed that provides for issuing drainage bonds which are repaid from the taxes. Usually bonds are sold by the district to investment bankers who in turn dispose of them to persons or institutions who desire them for investments.

A drainage bond to be saleable must be issued by a legally organized district whose affairs are in good condition, and the land in the district must be of such a character and of such value as to insure the payment of the bond. Purchasers of drainage bonds inquire closely into the organization of the

*Fifteenth annual meeting paper.

district and make certain that all requirements of the law have been met before agreeing to purchase the bonds. Generally the purchasers of bonds require the district to furnish a certified copy or transcript of the district record for their examination. This record is examined carefully by an attorney for the purchasers, and if there are any errors or omissions, the purchaser will delay buying until these can be corrected or adjudicated by the courts. To successfully pass this scrutiny the records of the district must be carefully and accurately kept, and every provision of the law under which the drainage district is organized must have been complied with and due record made of each step. Before they will purchase the bonds, many investment bankers also require that an engineer of their own selection shall examine the land in the district and pass upon the plan of reclamation, in order to make certain that the security back of the bonds is of good character and that the plan of drainage is adequate.

The investment banker purchasing the bond usually has an inspection and report upon conditions in the district made by one of his own employees. Their inquiries are apt to cover a broad field. The general reputation of the officers of the district as to business ability and character is ascertained. For this reason, if for no other, it is desirable that the officials of the district be men of good business judgment and high standing in their own community. The past reputation of the community with regard to prompt payment of obligations of a similar character is also given consideration. If after all examinations are completed the reports upon the prospect are favorable and the banker is satisfied with the conditions in the district, he is in position to bargain for the bonds of the district.

In selling bonds to the investment bankers various methods are followed. Some states require that the bonds be sold only after advertisement of the time and place of sale, in much the same manner as in letting other contracts. At such sales the bonds are sold to the bidder who offers terms which the officials consider most advantageous to the district. In other states the bonds may be sold by private agreement or by public sale as the officials deem most satisfactory. It would seem that under the ordinary conditions the method of selling bonds by public sale after due advertisement, is to be preferred. Before advertising the bonds for sale consideration should be given to the type of bond which will most satisfactorily meet the requirements of the purchaser, and be most economical for the landowners.

Three types of bonds are in common use: Sinking-fund bonds, annuity bonds and serial bonds. Sinking-fund bonds are issued to run for a certain definite period and at maturity are to be retired from the proceeds of a sinking fund which has been accumulating during the life of the bond. The fund to retire the bonds is accumulated from the annual instalments of taxes collected from the benefited landowners and the interest on these instalments. These instalments and the interest thereon are so proportioned that the desired amount will be available to retire the bonds at the date of maturity. The interest which the sinking fund draws is usually less than that drawn by the bond. The objections to the sinking fund type of bond are numerous. It is difficult to insure that in case of an emergency the officers of the district will not draw upon the sinking fund to meet this emergency and fail to make arrangements to replace the amount withdrawn, thus resulting in a deficit in the funds necessary to retire the bonds at maturity. In other cases it may not be possible to secure the rate of interest on the sinking fund that was assumed when the bonds were issued. There is also always the possibility of loss due to the failure of the institution in which deposited or embezzlement of some of the funds. The costs of a bond issue of a fixed amount and interest rate when sold at par will in every case be greater when provision is made to retire it by a sinking fund than where the annuity bond or the serial bond is used. The sinking-fund type of bond is not to be recommended for drainage districts.

In the case of the annuity bond, the principal and interest are discharged by constant annual or semi-annual payments depending upon the taxing system of the State in which the district is located. The amount of each payment is determined by the rate of interest and the terms of the bonds. The amount of principal retired is small at first, but constantly increases while the interest payments decrease. The total amount of principal and interest paid on the bond issue each year remains constant. This is an advantage in that the authorities charged with the collection of the taxes know how much money must be collected for this purpose each year, and the yearly taxes are the same on each parcel of land during the life of the bond.

Serial bonds differ in form somewhat from the annuity bonds. Instead of keeping the payment of principal and interest a constant amount each year, the amount of the principal retired each year is kept constant and the interest charge gradually decreases. The moneys collected are disbursed soon after they are collected, there is little loss of interest by the district, and the possibilities of loss by embezzlement are reduced to a minimum. The cost to the district of a given amount is less with the serial type of bond than with either the annuity or sinking-fund types. This type of bond has become very common during recent years for all types of public improvements and is probably more widely used at the present time than any other.

A comparison, as between the three types, of the total cost of bond issues for the same amount, bearing the same rate of interest, and sold at par, may be of interest. Let us assume a bond issue of $100,000 for 20 years at 6 per cent, and that in the case of the sinking-fund bond the money in the sinking fund will draw interest at the rate of 4 per cent. The cost of this money to the landowners in the district then will be in the case of the sinking-fund bond, $187,163; in the case of the annuity bond, $174,360; and for the serial bond, $163,000. In other words, the serial bond is about 7 per cent cheaper than the annuity bond and about 15 per cent cheaper than the sinking-fund bond.

The life of a bond is a matter that should have careful consideration. If the term is made too short the annual cost will be high and the landowner will have difficulty in meeting the tax. If too long, the amount of interest that will have to be paid will be greatly increased. Experience has shown that in districts where all the land can be utilized soon after the ditches are constructed, a serial type of bond running for a period of from one to ten years is very satisfactory. For lands not so well developed a life of fifteen or twenty years will possibly be more satisfactory. It is questionable if drainage bonds should ever run for a greater period than 20 years.

In many states it is customary to allow a period of from 3 to 5 years before payments of principal are begun in any district. This is done on the assumption that by that time the work will have been constructed and the benefits of the improved drainage will accrue to the land in the district, thus enabling the landowners more easily to repay the cost of this work. The arrangement is a desirable one and makes the burden of the landowner lighter. It would be well if every drainage law gave the commissioners the option of making such an arrangement when issuing bonds.

After the type of bond has been decided upon, there arises the question of where the money shall be kept after it has been secured. This is a matter that deserves very careful consideration upon the part of the district officials and their financial advisors. Bonding houses usually would like, if possible, to retain the fund and to make payments to the district only as the needs of the work develop. This is possibly as good an arrangement as any provided that the bonding house does not require delivery of all of the bonds at one time, and that it will allow accrued interest on the bonds which are delivered at a date subsequent to the date of their issue.

In some cases districts which have sold bonds have arrangements with the bonding house to allow them interest on the balance at an agreed rate. This arrangement is satisfactory provided ample security for the money left on deposit with the bonding house is given. In other instances drainage districts have loaned the money to local banks for given periods at agreed rates of interest and have required the bank securing the money to assure the repayment by security bonds or other acceptable security. At first thought it would seem that the matter of interest on balances was one of relatively minor importance, but a few computations will indicate that it is a matter of considerable importance to the landowners in the district. I recall one instance where a district issued some $300,000 worth of bonds with an agreement to allow the money to remain with the bonding house without interest until it was needed. A few thousand dollars were spent on organization expenses; but before a contract could be let and construction work started, legal difficulties occurred and the work in the district was discontinued for some three years. The bonding company had the use of more than $250,000 for this period, without expense. The district meanwhile was paying interest on the bonds. Had the money been put out at four per cent interest it would have reduced the cost of the project to the district more than $30,000. Such situations are of course to be avoided.

In cases where the state law does not permit bonds to be sold below a given figure, it is sometimes possible to arrange with the bonding companies to accept bonds at an agreed valuation with the understanding that the funds of the district, properly secured and drawing an agreed rate of interest, are to be left with the bonding house until the district has need to disburse the money. While such arrangements are not to be commended, they sometimes afford the only solution available, and are much to be preferred to making payments to the contractor in bonds for work done, which bonds he later sells at a large discount.

In issuing bonds careful consideration should be given to the dates on which payment of taxes will be made, and the dates upon which the payment of principal and interest on the bonds will fall due. The date of payment of principal should, in the case of annuity and of serial bonds, be after the date on which drainage taxes become delinquent. One would think that the purchaser of bonds would be sure to make certain that funds would be available to pay interest and principal when due, but I recall one instance in which neither the seller of the bonds nor the purchaser gave it consideration, and when the first instalment of principal and interest came due it was found that there were no funds available to take up the maturing obligation as the drainage tax was not yet due. In this case the investment banker and the local banks came to the rescue of the district and arrangements were made to issue funding bonds to provide the funds necessary to take up the payments due.

After the bonds have been issued, the officials charged with the duty of collecting the taxes and making the payments of interest and principal when due should make out a schedule showing the payments of principal and interest due each year, the total amount of the taxes that must be collected, and the amount of tax that must be collected from each parcel of land, each year, until the bonds are retired. Every precaution should be taken to make sure that after such a schedule has been prepared the taxes are certified to the proper authority for collection each year. Instances are known where this has not been done, and consequently there was no money on hand when payments came due.

After bonds have been issued and arrangements made to the collecting of money with which to pay them, there remains one important duty—that of paying promptly the several instalments of principal and interest as they become due. It would seem that it should not be necessary to mention this, but frequently we hear of instances where payments of principal or interest have been delayed for very trivial reasons. The person who invests his money in such securities frequently depends upon the income therefrom for his living and it is apt to cause him considerable embarrassment if payments are not made promptly when due.

Some months ago I met a gentleman on a train and in some way the conversation turned upon the relative merits of different types of investments. During the conversation I mentioned drainage bonds as one of the most desirable types of investments, due to the relatively high yield, to their exemption from all federal income taxes, and to the large valuation back of well-selected bonds of this type. Somewhat to my surprise he disagreed with me very vigorously in regard to the merits of drainage bonds and related an experience of his with a block of drainage bonds which he had bought upon the representations of an investment banker. The checks for the interest and principal were never sent by the county officer when due and it was only after repeated requests were made that the money was forthcoming. Upon inquiry he learned that the taxes had been paid promptly and that the only reason that the bondholders were not taken care of promptly, was due to the disinclination of the officer in charge to take care of such payments promptly, he having a feeling that the delay of a few days or a few weeks did not make serious difference. Yet the delay in this case was serious enough to prejudice this investor against drainage bonds to such an extent that he stated he had never bought another lot of them. Almost every investment banker can tell of similar instances. They bring out clearly the necessity of securing for the officers of the district the best business men in the locality. Men who are accustomed to handling considerable amounts of money and to carrying out involved business transactions. Only men who have demonstrated their ability in the business world should be selected for such positions. It is ability to properly protect the district's interest when dealing with contractor, bond brokers, and landowners that is desired—not pleasing personality or political standing—although these are desirable qualifications provided the official has had proper business experience. Bond buyers give careful consideration to the ability and standing of district officials, and the bonds of a district that has strong officers from the standpoint of the buyers are much more desirable than those of a district where the officers are men of little experience or capacity.

The financing of a drainage district, if it is to be done at the lowest possible cost to the landowner (and that should always be the aim of the district official), requires that the provision of the law under which the district is organized be carefully followed; that a detailed record of all action be kept; and that the plan of drainage for the district be carefully worked out by a competent and experienced drainage engineer. In selecting the type of bond to be sold preference should usually be given to the serial type. The life of the bond, the date on which payments of principal will begin, and the interest rate on the bond, should be fixed only after careful consideration of business and agricultural conditions. In selecting the officers of the district the best business talent of the locality should be obtained, as in addition to the problems involved in the sale of the bonds in a manner most advantageous to the district, there will be many other questions come up in connection with the district requiring the exercise of sound business judgment.

TILE SIZE STANDARDIZATION*

By James A. King
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and Ralph L. Patty
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IN THE discussion of tile size standards, the practical features of factory economy must be considered as well as the practice and theory of design. The statements, therefore, of men engaged in the production of tile have been made a part of this report.

One tile manufacturer having a widely distributed product writes as follows:

"We very much question whether or not it is advisable to make or use a 4-inch drain tile for the reason that it costs the same to lay a 4-inch that it does a 5-inch, and as you no doubt know, the carrying capacity of the 5-inch is nearly twice as great as the 4-inch. Under flood conditions we are sure that the extra capacity of the 5-inch is well worth while. It is a fact that a great many of our best farmers and engineers in Iowa are going to nothing smaller than a 6-inch for branches. We believe, however, that in some cases they are wrong and that for laterals of short length in many cases the 5-inch tile is large enough. * * * *

"We feel very sure that there is no occasion at all for 9-inch but we do believe it would be difficult at times to get along without a 15-inch. It would be better to drop the 14-inch than the 15-inch, and it would not be difficult to get along without the 16-inch."

Another has contributed the following:

"We think that the sizes of drain tile are pretty well standardized among the clay-tile manufacturers. We, after serious thought, cannot really make any further recommendations regarding sizes. We think they are about as practical as possible. Of course, 4-inch tile are too small for any farm drainage work, and it is quite universally thought so, but we will practically have to continue manufacturing this particular size because they come in very handy for such work as cellar drains, etc., in connection with general building contracting work. There surely is no real necessity for one-half-inch sizes; we think they are made more for a talking point by manufacturing concerns that make them than because of real necessity of them. The 9-inch size is absolutely necessary; they are made quite a bit cheaper than a 10 or 12-inch because they are made by a different process, as a rule, and can be manufactured cheaper. There are numerous cases where an 8-inch is too small and a 9-inch would suffice very nicely. There would be no advantage in doing

*Fifteenth annual meeting paper.

away with this size as far as manufacturing cost is concerned, either as to handling or distributing."

In the accompanying tabulation of relative costs and capacities of drain tile, the retail carlot price f. o. b. factory have been used as a basis of costs. Sizes from 4-inch to 12-inch, inclusive, represent the product of a representative clay tile factory, while sizes from 14 to 72 inches inclusive represent the product of a representative concrete tile factory. The bulk of the drain tile of the country is now made by clay and cement companies who follow quite uniformly the size variations shown in this table.

It will be noted that their sizes increase in units of two inches up to forty-eight, and beyond this point increase in units of six inches. For years the sewer pipe people have been accustomed to increase sizes of sewer pipe in units of three inches; and yet most of them increase the sizes of their drain tile products in units of two inches above the sixteen-inch size.

The percentage figures represent the per cent which the amount of increase (either theoretical capacity or price) is of the smaller sized unit, not of the larger. Opposite the 15-inch is found capacity increase of 14.795 per cent and price increase of 25 per cent. This means that the amount of difference in theoretical capacity between the 14-inch and the 15-inch is 14.795 per cent of the capacity of the 14-inch, etc., while the percentage figures opposite the 12 to 15 shows the relation between the 12 and the 15.

The capacity increase for all sizes from 12 inches and up is computed for increases of one, two, and three inches; and above 48 also for increases of six inches.

The percentage increases in capacity and cost are reasonably correlative. When there is a sudden increase in cost percentage as compared to capacity percentage, it is because of a variation at that point in web thickness or length, or some such factor which enlarges the cost increase for that size.

In the making of clay tile, the 11, 13, and 17 do not nest well with other sizes, and so would have a higher relative cost. Engineers throughout the Mississippi Valley already tend to increase in two-inch units above the six-inch size. Already sales of 7-inch is materially less than of either the 6 or 8-inch, while the sale of 9-inch is very materially less than that of either 8 or 10-inch. The relative sale of 15-inch also seems to be on the decrease.

In general the great basic error made in the design of drainage systems is to make the mains too small. The desire for economy in the cost of construction seems to overrule the question of ample margin of safety. Engineers are growing away from this error. But boards of supervisors and private owners will persist often in sacrificing capacity and safety for economy. There even seems to be an increased

RELATIVE COSTS AND CAPACITIES OF DRAIN TILE

Diameter —inches	Price per thousand feet f.o.b. factory[1]	% increased capacity over previous size	% increased cost over previous size
4	28.00		
5	37.00	56.250	32.143
6	46.00	44.000	24.324
7	58.00	36.111	26.087
8	71.75	30.612	23.708
9	104.00	26.562	31.010
10	131.00	23.456	25.962
11		21.000	
12	170.00	19.008	
10 to 12		44.000	29.771
13		17.408	
14	224.00	15.976	
12 to 14		36.111	31.765
15	280.00	14.795	25.000
12 to 15		56.250	64.706
16	320.00	13.777	14.285
14 to 16		30.612	42.917
17		12.891	
18	400.00	12.111	
16 to 18		26.562	25.000
15 to 18		44.000	42.857
19		11.420	
20	480.00	10.803	
18 to 20		23.456	20.000
21		10.250	
18 to 21		36.111	
22	560.00	9.751	
20 to 22		21.000	16.666
23		9.298	
24	640.00	8.885	
22 to 24		19.008	14.286
21 to 24		30.612	
25		8.507	
26	920.00	8.160	
24 to 26		17.402	43.744
27		7.840	
24 to 27		26.562	
28	1080.00	7.545	
26 to 28		15.967	17.391
29		7.270	
30	1200.00	7.015	
28 to 30		14.795	11.111
27 to 30		23.456	
31		6.777	
32	1320.00	6.556	
30 to 32		13.777	10.000
33		6.348	
30 to 33		21.000	
34	1560.00	6.152	
32 to 34		12.891	18.181
35		5.977	
36	1760.00	5.796	
34 to 36		12.111	12.821
33 to 36		19.008	
37		5.710	
38	2000.00	5.478	
36 to 38		11.420	13.625
39		5.332	
36 to 39		17.402	
40	2160.00	5.194	
38 to 40		10.803	8.000
41		5.063	
42	2480.00	4.938	
40 to 42		10.250	14.815
39 to 42		15.976	
43		4.819	
44	2680.00	4.705	
42 to 44		9.751	8.065
45		4.597	
42 to 45		14.795	
46	3000.00	4.494	

44 to 46		9.298	11.940
47		4.318	
48	3200.00	4.301	
46 to 48		8.885	6.666
45 to 48		13.077	
49		4.211	
50		4.123	
48 to 50		8.507	
51		4.010	
48 to 51		12.886	
52		3.960	
50 to 52		8.160	
53		3.882	
54	4000.00	3.809	
52 to 54		7.840	
51 to 54		12.109	
48 to 54		26.562	25.000
55		3.738	
56		3.338	
54 to 56		7.544	
57		3.603	
54 to 57		11.419	
58		3.539	
56 to 58		7.270	
59		3.478	
60	4800.00	3.418	
58 to 60		7.015	
57 to 60		10.803	
54 to 60		23.456	20.000
61		3.361	
62		3.306	
60 to 62		6.777	
63		3.252	
60 to 63		10.250	
64		3.199	
62 to 64		6.555	
65		3.149	
66	5840.00	3.101	
64 to 66		6.350	
63 to 66		9.751	
60 to 66		21.000	21.666
67		3.053	
68		3.008	
66 to 68		6.152	
69		2.963	
66 to 69		9.297	
70		2.919	
68 to 70		5.969	
71		2.877	
72	7040.00	2.836	
70 to 72		5.796	
69 to 72		8.884	
66 to 72		19.008	20.548

[1]Prices for diameters from 4 inches to 12 inches inclusive are Mason City Brick and Tile Company, f.o.b. factory prices for clay tile. Prices for diameters above 12 inches are Minnesota Pipe and Tile Company, f.o.b. factory prices for concrete tile.

tendency this year to use 4-inch instead of 5-inch because of saving in cost. If these intermediate sizes were available they would be an additional temptation to economize in first cost at the expense of safety or capacity under emergency. Any justified savings thus made would be far more than offset by unjustified and unwarranted restrictions of capacity on other jobs.

Spread the saving in first cost over the total acreage served by a ditch and it will sink into insignificance as compared to the acre damage done when the reduction proves to be poor engineering. The saving is made only once, while the loss is repeated each time there is a wet spell in which the ditch proves inadequate to the demands made on it.

When one of these intermediate sizes could be used without sacrificing capacity of ditch this object may be accomplished by using a smaller supplementary main for that tract nearest the outlet. Thus a 6-inch would make more than a half break in capacity between a 16-inch and an 18-inch. The difference in cost per 1000 feet between the 16 and the 18-inch is $80; and this will be considerably more by the time they are delivered on the ditch because of greater freight and haulage costs. The cost of the 6-inch is $46—only slightly over half the f. o. b. factory cost difference between 16 and 18-inch. Thus provision is made for this intermediate increase in main capacity at an intermediate cost. And yet it is not available in such form as to be so tempting to the penurious-minded individual.

Dependable figures for costs for maintaining dies and carrying stocks in the yards are not available. The labor and expense of keeping costs on these items is out of proportion to the benefit the management would receive from keeping them.

The only possible place where the use of 4-inch tile can be justified is in hilly lands where steep grades are available. Even there the wisdom of their use might be questioned.

From 16-inch up the percentage increase in theoretical capacity for each inch increase is from 12.9 per cent down. In these sizes it is easily conceivable that variations in actual net carrying capacity of the finished ditch, due to accidents of manufacture or of construction would largely nullify this theoretical difference. Thus the wisdom of increasing diameters by less than 2-inch units seems questionable. When the 24-inch and larger sizes are reached it is indefensible. While no definite recommendation can yet be made it seems that the 4, 9, and 15-inch sizes could be dispensed with, although the 15-inch size seems to be more thoroughly intrenched in usage. On the other hand, the trend seems to be away from it to at least a noticeable degree and the danger of damage from false economy in its use is greater than with the smaller sizes.

Somewhere in the region of 30-inch it would seem logical to change to a unit increase of 3 inches instead of 4 inches. Then again in the vicinity of 40-inch change to a unit increase of 4 inches. Thorough consideration, however, has not been given to just what the intervals should be for the different sizes, therefore, no recommendation can be given at this time.

DISCUSSION OF TILE SIZE STANDARDS

By David Weeks

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DRAIN tile diameters should be adjusted so the likelihood of flooding or excessive pressure at any point due to lessened capacity will be reduced to a minimum. Two factors must be considered, therefore, in selecting diameter intervals from a standpoint of design. First, the relation should be uniform between the drainage coefficient which might prevail, due to the use of the next commercial size larger than that required, and that coefficient which is used in design. The other factor to be considered is to have this interval as small as is in keeping with economic practice and still keep the relation between drainage coefficients uniform. In order that the relation between the possible maximum coefficient and the designing coefficient may remain constant the following relation would exist between ΔQ, the increment in discharge between successive tile diameters and the discharge.

(1) $\Delta Q = K_1 Q$

To find what ratio should exist between the increment in diameter, ΔD, and diameter, D, it is possible to find the rate of change in the discharge with respect to diameter and to express Q in terms of the diameter. From the Woodward-Yarnell formula for flow in drain tile the following relation will be found to exist between discharge, Q, and diameter in inches, D, and slope, S.

(2) $Q = K_2 D^{8/3} S^{1/2}$

(3) $$\frac{\Delta Q}{\Delta D} = K_3 S^{1/2} D^{5/3}$$

(4) $$\Delta Q = \frac{\Delta Q}{\Delta D} \Delta D$$

(5) $\Delta D \, . \, K_3 S^{1/2} D^{5/3} = K_2 D^{8/3} S^{1/2}$

or (6) $\Delta D = KD$

In other words, the interval in inches, ΔD, between tile diameters should vary in inches in a direct proportion with the diameter.

If one inch is the proper interval in diameter for a 5-inch tile then proper intervals would be two inches for a 10-inch tile, three inches for a 15-inch tile, four inches for a 20-inch tile, six inches for a 30-inch tile, eight inches for a 40-inch tile, and twelve inches for a 60-inch tile.

Other considerations, however, may make it wise to maintain a smaller interval between the larger sizes. It must be remembered that the larger tile is serving a much larger area, and therefore the greater cost of any excess in size is spread over a much larger area. If an analysis is made upon the basis of cost of the possible excess due to selecting the next larger commercial size, it will be found that a still larger interval would be consistent with economic practice. Cost per acre for the excess in size over that required by design is not the controlling factor.

The effect upon the possible range in drainage coefficient, if the above intervals were adopted, can be seen by making a few computations. A 10-inch tile with 0.5 as a minimum coefficient will drain 40 acres, if the Woodward-Yarnell formula is used. If the area is slightly over this, the 12-inch would be used with a resulting coefficient of 0.81 or an increase of 62 per cent. Likewise the interval between the 20 and 24-inch gives an increase of 62 per cent in the coefficient, and the interval between the 30 and 36-inch gives an increase of 62 per cent in the coefficient. It seems that 62 per cent is altogether too much and might lead to undesirable results. A much more reasonable range of intervals would result from assuming that the one-inch interval is proper for the 8-inch size. If such is the case, the interval would be less than 2 inches until the 16-inch size is reached and less than 3 inches until the 24-inch size is reached, etc. Such a scale of intervals would result in a maximum possible difference in drainage coefficient, at a point of change in tile size or grade of 37 per cent; even this seems somewhat high. Such a scale, however, would make it possible to adopt the same standards as have been established for sewer pipe without any serious changes.

Sewer pipe was standardized by the War Industries Board during the war to include the following sizes: 4, 6, 8, 10, 12, 15, 18, 20, 21, 24, 27, 30, 33, and 36-inch. The 20-inch was left in because of its popularity. These standards could be adopted for drain tile without seriously upsetting the above theory. It is believed, however, that one-inch intervals should be retained at least up to a 10-inch tile. It seems that above 36-inch the intervals could be 4 inches without any undesirable results, and above 48 inches a 6-inch interval should not be inconsistent with the above analysis.

Many engineers lose sight of the fact that usually grades and tile sizes can be so adjusted that the minimum economical coefficient can be used almost uniformly throughout a project where the grades are not too flat.

STANDARDS OF TERRACING*

By J. T. Copeland

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THE agricultural terrace is designed for the economical prevention of erosion and for reclaiming lands which have become unprofitable through exposure to the natural and free course of water.

Coefficient of vertical distance for terracing a given slope is ascertained by measuring the vertical distance between the top of the slope and the upper extreme of the topmost natural wash or erosion of the slope. The measure thus obtained becomes the factor or coefficient of vertical distance between terraces, and should be maintained in its use until the grade of the slope warrants the use of the multiple of the coefficient.

Spread, or lateral distance, between terraces should not exceed 300 feet. Usually the slope and the coefficient of vertical distance act as the limiting factors of the spread.

Fall, or grade, is considered in inches fall per hundred feet as:

(1) 1 to 2 inches giving soil deposit;
(2) 2 to 4 inches little or no soil deposit; and
(3) 4 to 8 inches scouring terrace.

Length of terrace should not exceed 2000 feet.

Construction of broad terrace. The most economical and universal equipment for terrace building, under ordinary circumstances, consists of 10-inch or 12-inch turning plows, slip scrapers, and V-drags. (The directions and suggestions here set forth shall be as a guide or standard by which terraces made by other means may be gauged.)
With the line of terrace indicated by stakes set regularly at 50-foot distances and of the desired fall, the line is "walked out." To walk out a terrace the "walker" starts at one extreme of the terrace and in walking averages the irregularity, or deviation from a smooth curving course of the two immediate stakes forward. The walker's course is followed with a furrow which becomes the ridge furrow of a land or course twelve or fourteen furrows wide. With the landside of the V-drag following the last upper furrow it is necessary to drag a sufficient number of times to raise a 4 to 6 inch ridge 4½ feet from the path of the landside. The course is replowed, the ridge-furrow of this plowing falling upon the ridge made by the drag. The first plowing gives the terrace width, while the second increases the depth of trough and height of bank. The second process of dragging should complete a terrace 18 to 24 inches deep, varying in width from 18 to 24 feet. Any

*Part of the report of the Committee on Drainage presented at the fifteenth annual meeting.

depressions in the terrace bank should be graded up with slip scrapers, raising the bank fully one-fourth higher at the point of fill, to allow for settling.

By following the foregoing as fundamental rules or standards of terracing, heeding the natural coefficient of vertical distances, by dividing the grade at the shoulder or point of the slope to avoid excessive lengths, and by diverting the water in the reverse direction of the natural outlet, much embarrassment and loss of time through mistakes may be avoided.

BUILDING FARM DRAINAGE DITCHES WITH WATER*

By W. W. Johnson

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THE use of water in moving dirt is not a new factor in Malheur County, Oregon, for as early as in 1881 a larger part of the excavation for the old Nevada irrigation ditch was accomplished by this method. This work was done by C. W. Mallett, of Ontario, Oregon. Other irrigation ditches and one or two large drainage ditches are reported to have been sluiced out in Snake River Valley. This article, therefore, simply reports a new adaptation of an old method and deals with the construction of small but deep drainage ditches calculated to serve individual farmers or small groups of farmers.

The first ditch on which the sluicing method was tried was constructed by the Oregon agricultural experiment station, in cooperation with Glenn E. Burrelle, the owner of the land on which the drain was built. This ditch was built for the purpose of draining a plot of land on which the station is conducting experiments calculated to determine the best method of reclaiming naturally alkaline land in this section. This field, besides being located within a quarter of a mile of the Malheur River, adjoins a deep slough; and since the surface of the soil is fully 15 feet above the water level of the river a need for drainage would usually not be expected. In this instance, however, the natural drainage has been hindered by a number of hardpan dikes, running parallel to the river, the first one extending to a depth of about 12 feet where it connects with a layer of almost impervious, putty-like clay, a condition which has prevented the proper drainage of the land. The remainder of the field was found to be underlaid with streaks of hardpan running parallel to the first occurring some 2½ to 5 feet from the surface and varying in thickness from 2 inches to 2 feet. The surface soil was not water-logged and the water table was from 4½ to 6 feet from the surface. The drainage ditch was so located that it would cut through these hardpan layers and consequently part of the excavation included the removal of hardpan. The surface soil was found to be a clay loam and the subsoil was only slightly lighter in texture. Some streaks of sand and gravel were also encountered.

Since it was considered desirable to have some earth for refilling in case tile should be put in later and in order to have a good base for sluicing operations a ditch 2½ feet deep, 9 feet wide at the top, and 8 feet wide at the bottom was built with a fresno, a groove 6 inches deep and the width

*Article which appeared in the December, 1921, number of AGRICULTURAL ENGINEERING.

of a slip scraper being made in the bottom in order to confine the water to a narrow channel.

It was first planned to sluice by keeping the water falling with a straight drop of 5 feet or more and to loosen the earth by working on the perpendicular surface beneath the falls with a long bar, the idea being that the dirt would be broken off in large pieces which would be further broken up and put into suspension by the force of the falling water. With this end in view 70 feet of the outlet, where the ditch crosses a shallow slough, was taken down to grade with scrapers leaving the end of the ditch with a perpendicular drop of about 10 feet. This system was found to be fairly successful, as were a number of others that were tried, but the hand method which was finally adopted in building this ditch was to loosen the earth with a shovel while the water was running, instead of using the straight drop, the ditch was sluiced back in a series of layers each about 16 inches deep and about 40 feet long, so that the ditch was taken to grade as the work progressed.

When hardpan was encountered it was found necessary to break it up with a pick. Small quantities were found to sluice out without difficulty, but when a considerable amount was encountered the larger particles settled to the bottom and it was necessary to loosen this material again and throw some of the larger pieces out by hand. Some of the worst hardpan layers were removed with a pick and shovel without the aid of the water. Whenever it was possible to break up the hardpan into small pieces it sluiced out without difficulty.

The 676 feet of the ditch which is now completed and which averages 11 feet in depth required 353½ hours of man labor and 209½ hours of horse labor, or the equivalent of one man working 353½ hours and one horse working 209½ hours. This included also the labor required for the fresno work for 200 feet in addition to the amount which is now completed and all the work on the outlet, etc., the cost of which will ultimately be distributed over several hundred more feet of drain. Figuring man labor at 35 cents an hour and horse labor at 12½ cents an hour the cost of digging the drain would be $149.90. Charging all the labor to date to the 676 feet now completed the cost per foot of drain would be a fraction over 22 cents and the cost per yard of earth removed would be approximately 14 cents. These figures of course include the fresno work and pick and shovel work as well as the actual sluicing. The cost of sluicing where no hardpan was encountered and the earth sluiced easily was approximately 6 cents a yard.

A plow was used with some success in loosening the earth for sluicing, but for the short ditch that was being made it was found impracticable to go to the expense of rigging up to give this method a thorough trial. It showed considerable promise, however, and would probably work best on a large ditch and for the first few feet of excavation.

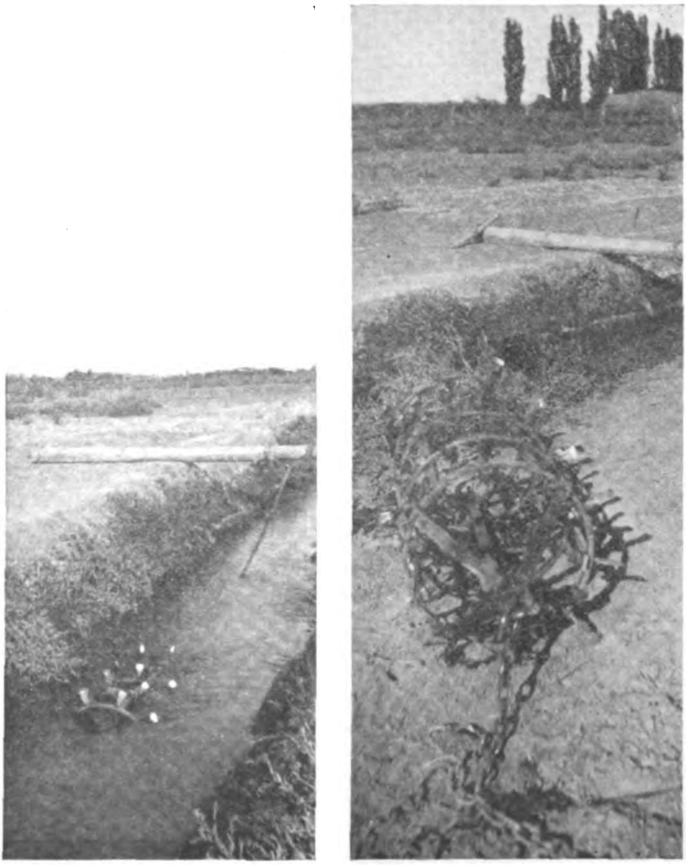
A cultivator was used with marked success. This tool was used for taking out the last dirt after the ditch was practically completed; in the half day that it was used the loose earth was sluiced from the entire length of the drain and a cut of about 6 inches was made in addition. The handles were set close together so that it could be handled in the bottom of the ditch without difficulty, and it was fastened by means of a 20-foot cable to the center of two-by-fours 18 feet long which extended across the ditch. A horse was hitched to each end of the improvised doubletree to haul the cultivator. It was only possible to use this tool one way for it could not be held in place against the force of water when it was attempted to pull it up the stream.

This work with the plow and cultivator showed that there was a need for some kind of tool that would work in the bottom of the ditch without requiring a man to guide it. Percy Purvis, who lives near Vale, has developed a tool patterned after a threshing machine cylinder, but with specially prepared teeth, designed to meet this requirement. This machine is shown in the accompanying illustrations. The machine is made of five iron hoops placed parallel to each other and about 10 inches apart, being held in place by five pieces of strap iron running perpendicular to the hoops and at regular intervals. Each hoop contains ten sharpened cylinder teeth, the first two rows of which have cutting edges and are so placed that the teeth on the preceding hoop will not come directly behind those of the first but will bisect the space between them. Those on the third hoop are placed so that they will bisect the interval between the first and second and the teeth on the other hoops are placed correspondingly so that no two teeth will run in the same groove. The teeth on the last three hoops have flat or scraping surfaces.

The device is 5 feet in length, 19 inches in diameter, and weighs about 150 pounds. It is drawn through the trench by horse power. A long pole is placed across the ditch, and a long chain from the center of it to the sluicing machine is connected from the center to the sluicing machine, where it fastens on a swivel, making it possible for the machine to rotate as it goes through the trench. A horse is hitched to each end of the pole and the tool is dragged up and down the trench while a head of about 5 second feet of water is running through the ditch.

The only crew required to operate the machine is a boy to lead each horse; for best results two men should be employed at the same time to keep the banks dressed down and to insure that the sides have the proper slope, which will result in the building of a permanent ditch and will also prevent caving in while the work is still in progress.

While Mr. Purvis has not kept an accurate record of the time spent in his ditching operations so as to make a definite statement of the cost of sluicing possible, it is certain that the cost has not exceeded 5 or 6 cents a cubic yard. The actual saving in cost of excavation per cubic yard does not represent the entire benefit derived from the system of building drainage ditches; for where conditions are such that the sluicing method will work, it is possible for small groups of farmers to put in the deep drains required (8 to 12 feet), for the proper drainage of irrigated soil without purchasing expensive trenching machines, the cost of which is usually prohibitive excepting for large districts. Excavation to a depth greater than 5 feet cannot be economically



Sluicing tool developed by Percy Purvis of Oregon

accomplished with fresnos, due to the fact that an excessively large ditch must be made in order to make room for the horses to work; and since hand digging of deep drains cannot well be done under present labor conditions the two methods first mentioned are about the only ones that can be used.

At a field day held under the auspices of the Malheur County Farm Bureau in early September, 1921, an opportunity was given to the local people to observe the results of the experiment station's work and also to see Mr. Purvis' machine in operation. At this meeting Mr. Purvis made his invention public property.

TEACHING OF DRAINAGE AND IRRIGATION IN LAND GRANT COLLEGES*

BY QUINCY C. AYRES

Mem. A.S.A.E. Associate Professor of Agricultural Engineering, Iowa State College

FEW activities of life may truthfully be called free from the influence of personal touch. Hence it is but natural that a paper of this kind will reflect almost wholly the experience of the writer. If he lives in the arid West, and it is here that a majority of his students will practice, he will undoubtedly devote the bulk of his efforts to problems of irrigation and the drainage of irrigated lands. On the other hand, should he reside in the humid regions of the United States, he is likely to emphasize, with propriety, the importance of drainage. In the case of the writer, being a native of the southern states with eight years of practical drainage experience in the Middle West, East and South, he confesses he finds it difficult to restrain himself from unwarranted emphasis on land drainage and the development of drainage enterprises. Again, such a paper will be colored to a very large extent by the methods and policies in vogue at the institution which the writer serves. Indeed this feature is perhaps important enough to justify a definite outline of the work to be given here with the hope that such treatment will produce diverse opinions from other members of the Society and thus direct the discussion into profitable channels.

Courses in drainage and irrigation offered in the agricultural engineering department of Iowa State College may be classified under two headings: (1) required work and (2) electives.

The work required of all candidates for the professional degree of agricultural engineer consists of a course in farm drainage given in the fall quarter, irrigation in the winter quarter, and drainage engineering in the spring quarter of their senior year. The drainage classes meet one hour per week for lecture and recitation and one three-hour period per week for laboratory and field work. In irrigation the class meets for lecture and recitation three one-hour periods per week, no laboratory work being required. When planning the courses just mentioned it is assumed that the student has received prior training in soils, surveying and hydraulics. In addition to these studies, there is a special course in surveying and drainage required of all students who major in farm management.

Under the head of electives, three new courses have been

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prepared to meet a growing demand of students wishing to specialize in drainage and irrigation. These courses are being taught for the first time during the current year under catalog captions as follows: A. E. 86, Dredges and Dredging Machinery; A. E. 88, Drainage Administration, and A. E. 89, Drainage Pumps and Pumping Plants. These three courses, carrying eight credit hours, are offered in conjunction with courses in other departments of the college to form an attractive drainage group. Students who specialize in some branch of agriculture frequently swell the drainage enrollment by electing the course in farm surveying and drainage designed especially for them.

The great field of drainage research, which is almost untouched at present, offers unusual opportunities to those with the time and inclination to explore it. Suggestions along this line for the convenience of graduate students will be incorporated in the forthcoming catalog as follows: 108a, 108b, Land Reclamation Problems, Study of Soil Water, Drainage Practice, Engineering and Institutions, Irrigation Practice, Construction and Organization, Cut-over Land Problems.

In my opinion, no text is published at the present time which deals with the subject of drainage engineering to the extent which its importance, the magnitude of the works necessary and the financial consideration involved justify. Practically all existing books treat the matter from the standpoint of the agriculturist alone; none possess the technical polish and advanced treatment of important allied subjects so frequently found in texts of older branches of the engineering profession. Consequently, the teacher of this subject is reduced to the necessity of choosing the text most nearly meeting his requirements and then supplementing it very liberally with other material gathered from a variety of sources.

With irrigation the situation in this respect is better. Here is presented a class of data which lends itself readily to exact mathematical analysis. Computations may be made with scientific precision of the amount of water applied to the land, the amount lost in transit by seepage, and therefore of the acreage a given quantity of water will serve. The great uncertainty which exists in the relationship of rainfall and run-off seldom becomes a serious factor in irrigation studies. Furthermore, a large number of highly trained engineers have been engaged for years in this field so that it is not surprising to find irrigation texts more comprehensive than those dealing with drainage.

Much valuable information may also be found in publications of federal and state organizations, as well as in the journals of numerous technical and scientific societies. One should not fail to scan closely the pages of current periodicals nor should he neglect the opportunities afforded by his collegiate library. Habits cultivated by collateral reading assignments are worth much to the student in later life.

In the consideration of instructions for laboratory assignments much energy may profitably be expended on the form in which they are presented. An admirable precedent regarding this matter has been established at Iowa State College by the writer's predecessor who printed his directions on loose-leaf sheets of a size to fit the student's field book.

Accurate cost data is a fetish often pursued but seldom captured. Yet expediency requires the instructor in land grant colleges to render expert advice of this kind on short notice. In the attempt to meet this demand and supply reliable information the writer keeps a close watch on construction news columns of the technical press and consults practising engineers whenever opportunity offers. He also deems it of great advantage to engage in practical work himself during the summer months for reasons not altogether pecuniary.

The modern trend of teaching thought is undoubtedly toward the use of more and better equipment covering a wider field of application than formerly. Certainly there has sprung up a well-grounded conviction that old methods are susceptible of improvement to a considerable degree, though just what form this improvement shall take is still a matter for debate. The value of models, illustratory maps and charts, lantern slides and exhibits of manufacturer's products has not always been appreciated to a warranted extent. As important teaching adjuncts, they are of great assistance in moulding clear images in the mind of the student in such a way as to insure permanent retention.

Frequent use of surveying instruments and accessories together with current meters, weirs and water stage registers is of course indispensable in successful teaching of drainage or irrigation. Such equipment at Iowa State College consists principally of twenty-seven steel lockers, each of which contains the following supplies: Instrument (transit or level), tripod, level rod, range poles, 100-foot steel tape, rodman's hand axe, and plum bobs with cord.

A cardinal principle of later day pedagogy lays stress on the necessity of keeping the student's interest aroused. As this is chiefly accomplished by the use of numerous illustrations, it follows that the engineering teacher should possess, in addition to usual qualities of teaching personality and aptitude, a broad fund of practical knowledge which can only be acquired through extensive personal experience.

For the sake of brevity, perhaps the best manner of treating teaching methods would be to epitomize the ideas of the writer in abbreviated form. Accordingly, the following compendium has been compiled to represent the writer's ideal "Code of Teaching Commandments":

1. Master every phase of your subject in a thorough going manner. This is the prerequisite on which all other points depend.

2. Present data in concise, systematic form. Do not confuse an orderly arrangement of essential facts by the inclusion of too much detail.

3. Tie in new information to facts with which the student is already familiar.

4. Develop your teaching personality. Make it clear that you are a rational, red-blooded human being—not a scholastic crank.

5. At the same time uphold the dignity of your position; this can be done without bigotry.

6. Win the confidence of your students. Don't bluff. If a question is asked which exposes your ignorance, acknowledge it.

7. Remember that college students are alert, merciless critics. Do not shatter their faith by any over tact.

8. Promote personal contact by keeping your class sections as small as possible.

9. Keep your material up to date by a close persual of current literature.

10. Sell your subject at the very beginning. Prove beyond peradventure of doubt that a real, present and practicable need exists for just such information as you seek to impart.

11. Use inductive methods as much as possible in presenting facts. By adroit questioning lead the student to reason out a truth for himself.

12. Make constant use of practical illustrations from your own experience.

13. Insist on a high standard of excellence in all branches of the work, especially that of draftsmanship.

14. Treat your students as men of honor and discretion. They will reciprocate in kind.

15. Don't allow yourself to grow stale. Be quick to appropriate all new ideas of merit.

16. Lend a sympathetic ear to the trials of your staff associates. In cooperation as well as union there is strength.

17. In general, strive to fit the student for a broad career of public service with due regard for the ideals of professional ethics.

THE COLLEGE SECTION AND ITS POSSIBILITIES*

By J. B. Davidson

Mem. (Charter) A.S.A.E. Professor of Agricultural Engineering, Iowa State College.

IT HAS been pointed out that the stability, the success, and the future of any organization depends upon having in its individual membership a common interest and a clearly defined purpose. Stated inversely it is impossible to build a strong, efficient organization out of a membership with diverse interests and the wise never attempt to do so. Organization and association effort is carried forward and developed by a magnification of the common interests and a depreciation of the conflicting interests.

If this principle of organization be true, then the newly organized College Section of the American Society of Agricultural Engineers is based on a solid foundation, for as far as I am able to see the interests of the membership of the College Section are absolutely common. If there are any conflicting interests I do not know them. The agricultural engineering departments of the agricultural colleges and experiment stations are all trying to render the same kind of service and differences exist only as they relate to the needs of local communities.

The College Section is one of the most promising developments in the history of the American Society of Agricultural Engineers. It is comprehensive—it plans to include all of the public institutions, federal and state, committed with education and research in agricultural engineering. It has been pointed out that much effort has been lost and the general efficiency of educational work in many lines has been lowered through lack of cooperation.

The new College Section is planned to be an outstanding example of cooperative effort. It bids fair to attain such recognition because it is being organized at a strategic time with the full support of all parties concerned.

No doubt most of those present are familiar with the steps which led up to the organization of the College Section. In October 1920 an invitation to a number of college representatives from the different geographical sections of the country was extended by the Division of Agricultural Engineering, Bureau of Public Roads, U. S. Department of Agriculture to come to Washington to discuss the general problem of cooperation. Those in attendance at this conference became much enthused over the possibilities of cooperation and the provisions written into our revised constitution for a College Section came from plans made at this conference

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and which were reported to the Society at its last annual meeting by S. H. McCrory of the United States Department of Agriculture.

The significant features of the organization of the College Section are as follows:

1. The necessity of an entirely new organization is obviated.

2. Membership is not limited to members of the Society thus making membership in the Society more inclusive.

3. Each state is entitled to one vote and only one vote in business matters thus providing wide representation.

4. The officers consist of (a) a chairman appointed by the President of the Society; (b) secretary who shall be the Secretary of the Society; and (c) an advisory committee of five members of which the chairman is one.

The first conference undertook to make a general survey of the agricultural engineering field and outline a plan of action. A statement was made of the relation of agricultural engineering to agricultural development. To this conference the functions of agricultural engineering—which would constitute a grouping of the many phases of civil, mechanical, electrical engineering and architecture applied to agriculture, are as follows:

1. To bring about an improvement of living conditions on the farm by the general betterment of dwellings and the introduction of modern time and labor-saving devices.

2. The increasing of the efficiency of the individual farmer to the end that his earning capacity may be increased, and funds be provided for maintaining the desired standard of home life.

3. The enlargement of the productive area of the country by the clearing of stump lands, the drainage of wet areas and the irrigation of arid regions.

At this conference cognizance was made of the commercial and professional organization, state and federal departments, and various other agencies now existing and interested in the furthering of the development of agricultural engineering practice and science. The relation of these were carefully considered. It was clearly pointed out that those agencies receiving public support had much in common and that for safeguarding the use of public funds should be grouped together.

Careful consideration of the situation developed enthusiasm to the idea that substantial progress in solving the agricultural engineering problems of the present and the future and efficiency in the dissemination of useful information now available, or to be obtained from future research and surveys, will depend to a large degree upon the cooperation of the various agencies in correlating their work.

It was recognized that the greater burden of the work must come upon the state agencies on account of greater resources. Although local problems should be studied by local organizations much could be accomplished by assigning parts of large general problems to certain institutions.

It was further pointed out in the report of this conference that the U. S. Department of Agriculture should take the lead in coordinating and stimulating the work of the state colleges and experiment stations, and other agencies on local or specific problems, in which special care should be taken to maintain individuality of organizations and workers. Furthermore, the United States Department of Agriculture should supplement the work of the states by its own surveys and investigations and conduct work which for any reason cannot adequately be performed by the state agricultural colleges or experiment stations.

At a conference held at Washington last May careful consideration was given to the development of research in agricultural engineering. It was evident from a study of the situation that (1) little research was being conducted regardless of the fact that such work is fundamental to good teaching and extension service, and (2) such research as was under way was not fundamental in character.

An accurate statement of the situation was given in an editorial in the August (1921) number of the Experiment Station Record and should be read by all.

At the May conference an outline of the research problems which in the minds of those in attendance needed attention was made and is available for all those interested. Some forty-five problems were listed.

It should be the function of the College Section to see that work is begun on these problems at the earliest possible date. Every college man should select some problem and have his selection recorded with the proper committee.

The efficiency of experimental work and research at the present time is lowered materially because it is the common practice not to report any results until the work is completed. The outcome of this practice is that the results of much work is never reported and therefore lost. Furthermore, it would be a material aid to have progress reports circulated among research workers before conclusions are drawn. Such data would include isolated observations from tests which would not be suitable for publication by itself. A committee has been appointed to arrange for the circulation of such data. It is obvious that certain restrictions must be introduced and the personal responsibility of those receiving the service fixed.

I would like to commend the most excellent work performed by our Research and Data Committee during the past year. It is a splendid service that this committee is rendering in criticizing the project outlines submitted. I would strongly urge that all new projects be submitted to the committee.

It appears to the speaker that sufficient care has not been taken to cultivate public opinion. We live in a democracy. We are permitted if not compelled to do that which the public wishes done. Engineering methods have had a far reaching influence upon agricultural development. The capacity of the individual farm worker, the standard of farm life depends almost directly upon the application of agricultural engineering methods to production and rural life. Likewise, future progress depends upon the development of agricultural engineering. Let us so educate the public.