CH 1950

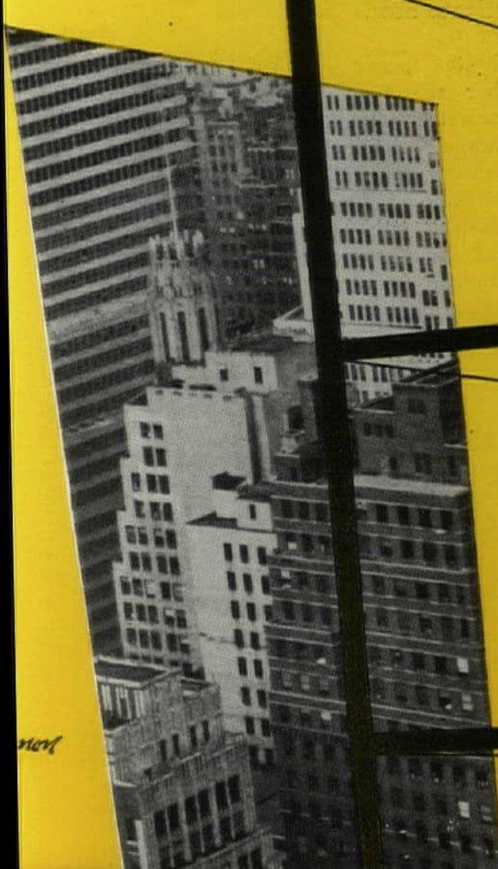
ARCHITECTURAL forum

THE MAGAZINE OF BUILDING

THE CURTAIN WALL

THE CURTAIN WALL

The editorial pages of this issue of the FORUM have reviewed and brought together the materials, developing techniques, new theories and widening opportunities which make the principle of the curtain wall more important to more people in the building industry than ever before. To supplement that information, and to serve as a convenient reference, FORUM also presents this special advertising section devoted exclusively to products which apply to curtain wall construction. Reprints of the combined editorial and advertising sections on the Curtain Wall are available at fifty cents each.



ARCHITECTURAL forum

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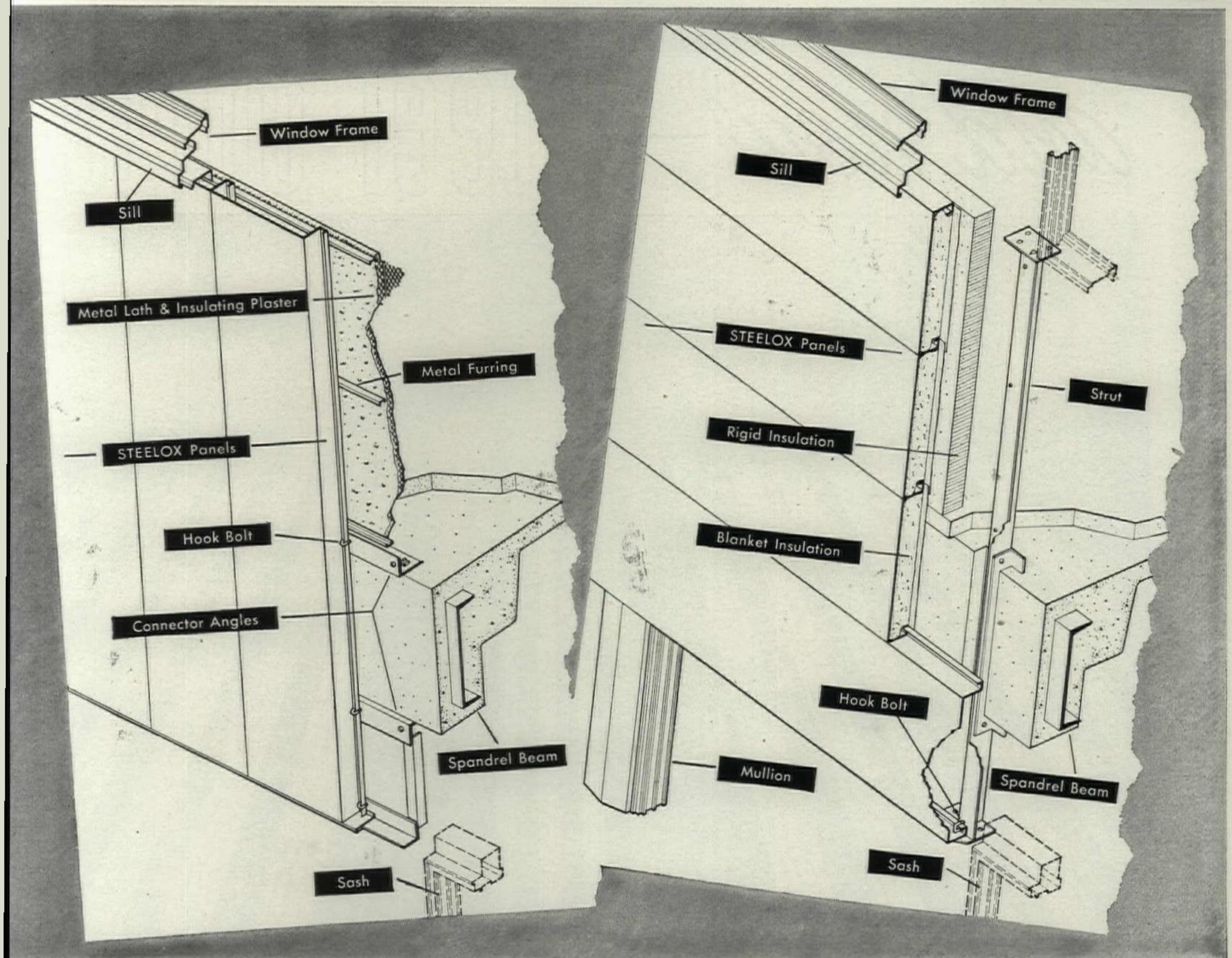
MARCH 1950



Here's a handsome, permanent panel for wall construction

Armco STEELOX, long used as a basic building material, now is available in Armco Stainless Steel for wall construction.

The strong, light, easily erected wall panels can be obtained in module widths and offer great flexibility in designing walls for all types of buildings—large and small. Full architectural freedom is assured by self-framing STEELOX panels, which respond to horizontal or vertical treatment, as shown. Insulation and interior wall combinations are easily made with standard materials. Batts, rigid board, light-weight concrete slabs or insulating plasters can be used conventionally to meet individual requirements.

The exterior surface of the panels is a soft, smooth, satin-finish stainless steel—pleasing to the eye and as enduring as it is beautiful. Stainless steel is well known for its great strength and corrosion resistance. It has the further advantage of being easy to clean and keep clean.

With Patented Armco Stainless STEELOX, architects and builders are assured of long life, proved construction and sound engineering. Write and outline your problem or interest today.

ARMCO STEEL CORPORATION

981 CURTIS STREET, MIDDLETOWN, OHIO • PLANTS AND SALES OFFICES FROM COAST TO COAST • THE ARMCO INTERNATIONAL CORPORATION, WORLD-WIDE

and now—steel curtai

valls for multi-stored buildings
—let us give you the facts

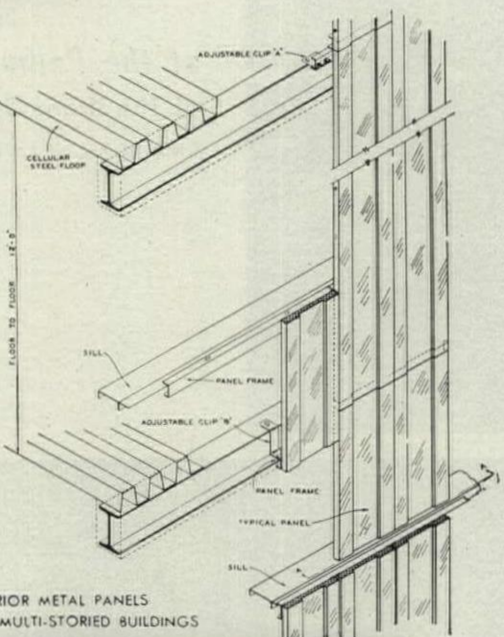
URING the past few years we have accumulated a vast store of infor-ion on this advanced type of exterior construction that promises mate- improvements over present conven-al multi-story building practice.

ere are facts and data carefully hered from many sources that will you clarify your thinking on the parative merits and future possibili- of thin, lightweight curtain walls in ch handsome, non-weathering, fire-stant and durable U·S·S Stainless l panels provide a unique combina- of permanence and low maintenance greater ease and greater economy of struction.

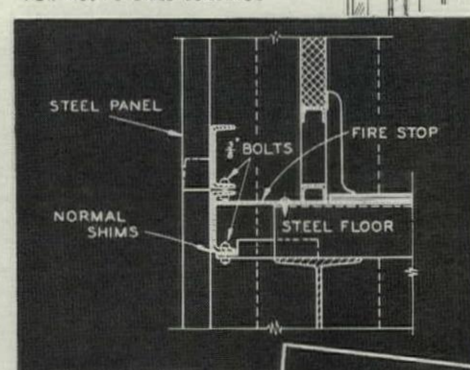
et us show you how these large-size, ly-handled, easily-fitted curtain wall els of U·S·S Stainless Steel can reduce site labor costs and simplify and d up erection . . . how readily these els can be adapted to both vertical horizontal designs . . . how ideally nless Steel pilaster sections can be combined with colorful spandrels of porcelain-enameled steel to produce an infinite variety of attractive wall treatments.

Let us calculate for you the potential economies of such construction— how its lighter weight can reduce costs by reducing the tremendous loads of present exterior walls on steel skeleton and foundations . . . how its thinner section will save space to provide additional rentable area . . . how it will save money by minimizing upkeep and cleaning costs. Learn, too, how recent and contemplated changes in building codes are paving the way for an ever-widening use of such construction.

These pertinent facts and many more which are essential for a better understanding of this important development are yours for the asking. Write us and tell us what you want to know, or better still, have one of our development engineers call in person to discuss this matter with you.

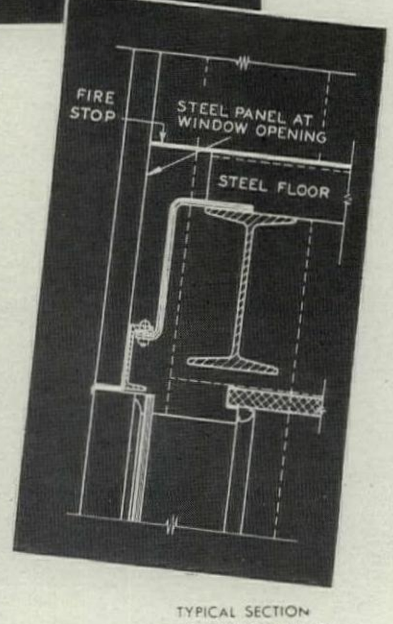


EXTERIOR METAL PANELS FOR MULTI-STORIED BUILDINGS



TYPICAL SECTION AT FLOOR LEVEL

U·S·S STAINLESS AND PORCELAIN-ENAMELED STEEL combined in lightweight, permanently good-looking panels like this, provide a curtain wall that saves weight and space, that speeds up erection, that can be kept clean and weather-tight at minimum cost. The Stainless Steel sections can be produced in a variety of attractive contours, fluted, formed or corrugated, and in all architectural finishes. Porcelain-enameled steel sections can be obtained in any color and in any finish and texture desired. These all-steel panels, produced to *exact* dimensions, can be fabricated in units, one, two or even three stories long, and up to 96 inches wide. All attachments to the building frame are simple and differ only slightly from conventional methods.



TYPICAL SECTION AT WINDOW HEAD

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO · CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH · TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL

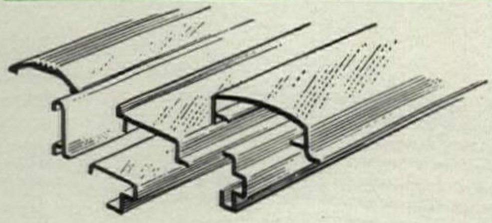
REYNOLDS

A COMPLETE ALUMINUM SERVICE TO ARCHITECTS AND FABRICATORS

THIS complete aluminum service, from mine to you, is as near as your phone. And remember, bright, enduring Reynolds Architectural Aluminum costs less than any of the modern architectural metals. So, whatever your needs, large or small, just call the nearby Reynolds Sales Office listed under "Aluminum" in your classified telephone directory. They can tell you where many of the items may be obtained from local warehouse stock. If it's a fabricated aluminum product they will be glad to recommend the names of dependable suppliers. In any case, when it's aluminum for architectural use, ask Reynolds.

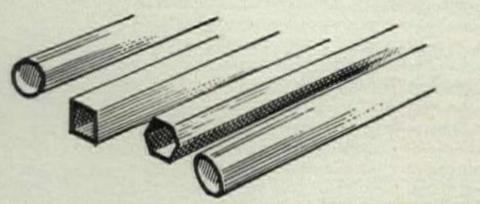
Write for the Reynolds Architectural Aluminum folio. Contains technical data on the complete range of materials and engineering drawings for direct tracing.

REYNOLDS METALS COMPANY
Aluminum Division
2528 SOUTH THIRD STREET • LOUISVILLE 1, KY.



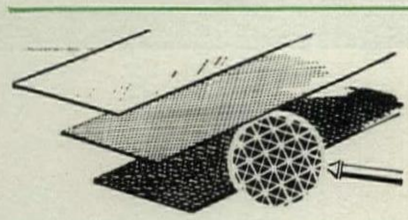
EXTRUDED SHAPES*

Reynolds standard extrusions include thresholds, jambs, sills, copings, etc., many of which are locally warehoused. Special designs can be produced to meet building schedules.



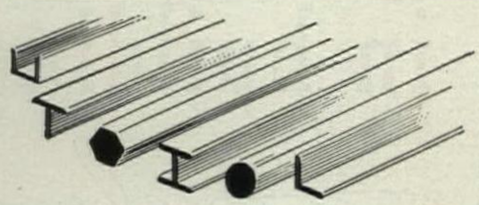
TUBULAR PRODUCTS

A full line of aluminum tubing in local warehouse stock. Special shapes fabricated to order.



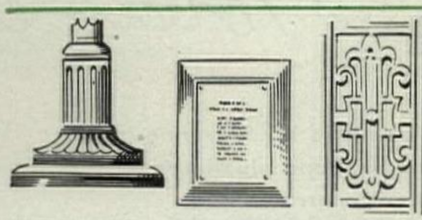
SHEET*

A complete selection of aluminum sheet in plain, corrugated, embossed and perforated designs.



STRUCTURALS

Rolled aluminum structurals such as angles, H beams, I beams and many forms of rod and bar stock.



ORNAMENTAL CASTINGS

Any type of ornamental casting produced to specification by independent foundries from Reynolds Aluminum pig and ingot.

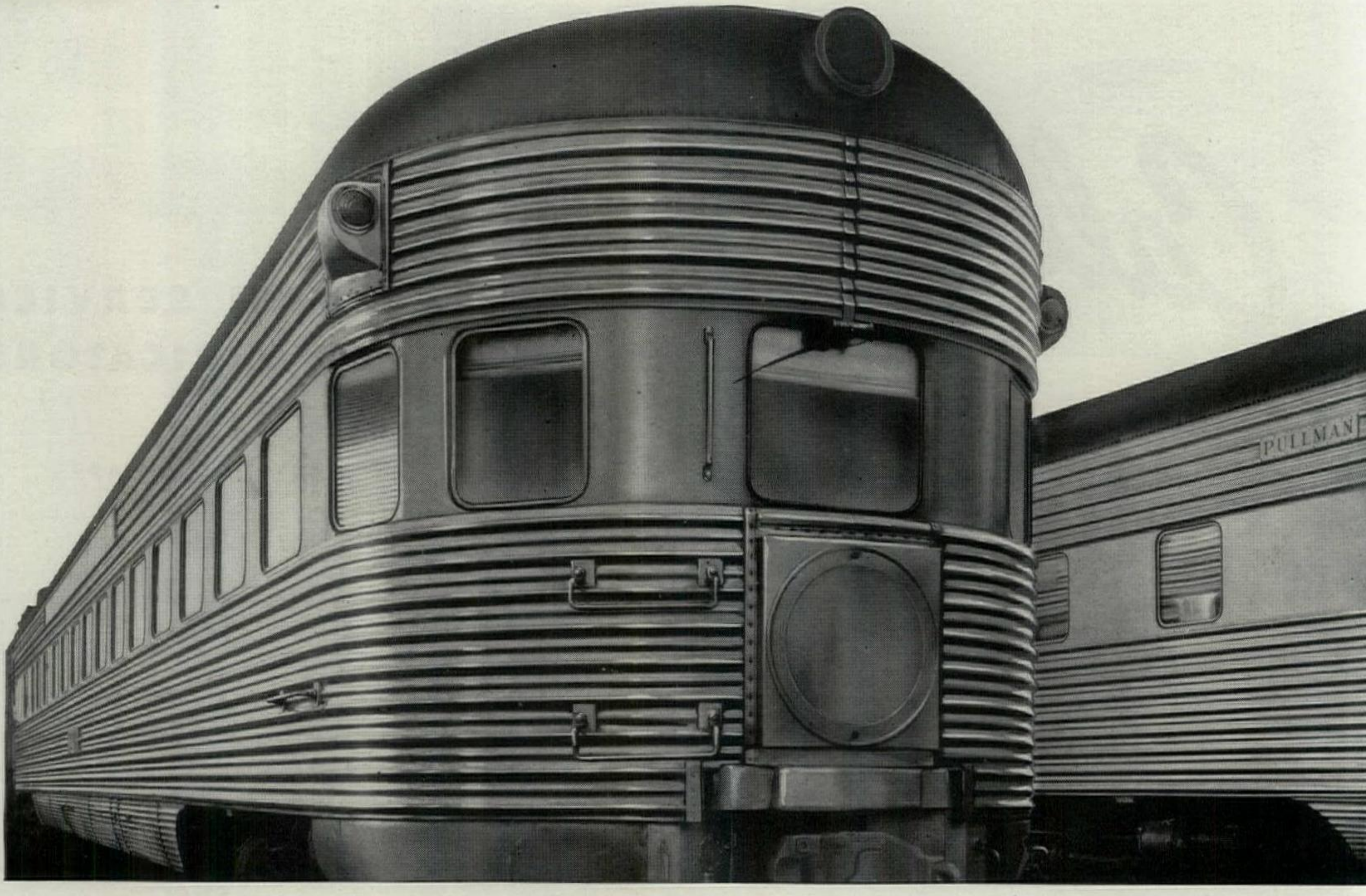
OTHER ALUMINUM BUILDING MATERIALS — Alumi-Drome (prefabricated utility building), Gutters, Downspouts, Reflective Insulation, Roofing and Siding, Built-up Roofing, Windows. Address requests for information to Reynolds Metals Company, Building Products Division, 2019 South Ninth Street, Louisville 1, Kentucky.

***IDEALLY SUITED TO MODERN CURTAIN WALL CONSTRUCTION**

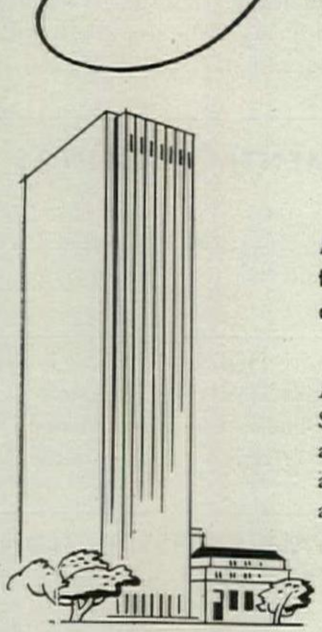
REYNOLDS METALS

REYNOLDS *Architectural* ALUMINUM

A COMPLETE ALUMINUM SERVICE TO ARCHITECTS AND FABRICATORS



First in building Curtain-Wall *"Hotels on Wheels"*



Mellon-U. S. Steel Building, Pittsburgh.
Harrison & Abramovitz, Architects;
Turner Construction Co., General Contractor.

Stainless steel spandrels and trim by Pullman-Standard.

Again first—Pullman-Standard is pioneering in the fabrication of stainless steel and aluminum for the curtain-wall buildings of tomorrow.

America's most famous streamliners, built by Pullman-Standard, are traveling demonstrations of experience and facilities which now can be directly applied in a new and spectacular field—the use of die-formed metal panels and spandrels in curtain-wall building construction.

Pullman-Standard has already entered into discussions of designs and specifications with a number of architects, builders, owners, and metal producers—aimed at the development of the best and most economical methods of fabrication, assembly, and erection. One large-scale project, involving metal panels for a building exterior, has already been undertaken.

These developments at Pullman-Standard are backed by eighty-three years of service to the American economy. Architects, builders, and owners are invited to use the services of Pullman-Standard's engineers . . . at *any stage* of their planning.

Pullman-Standard

CAR MANUFACTURING COMPANY

79 E. ADAMS ST., CHICAGO 3 • 52 VANDERBILT AVE., NEW YORK 17

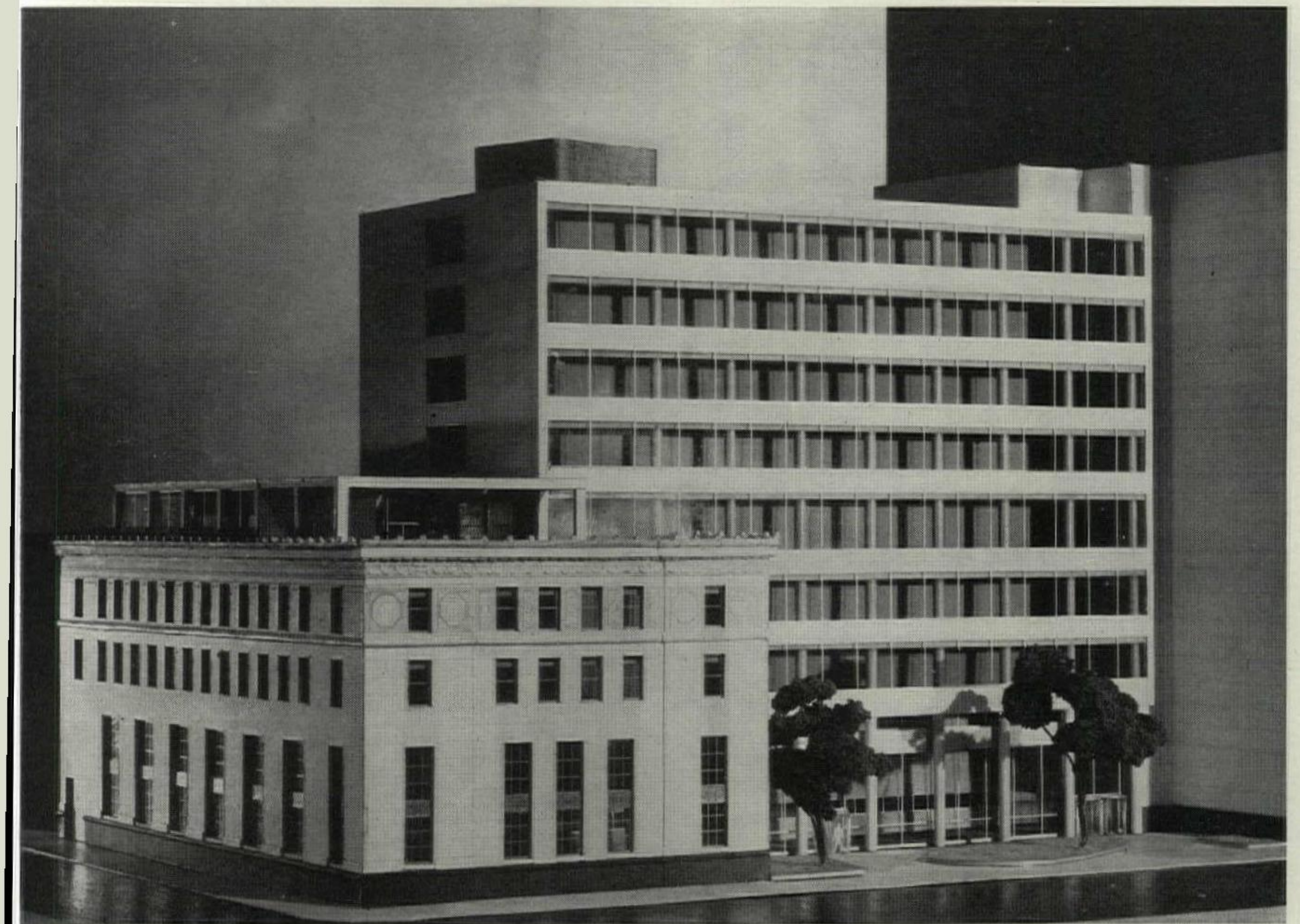


Photo of Model

DETROIT BRANCH FEDERAL RESERVE BANK OF CHICAGO

1927

Original smaller building of traditional design employing Georgia Marble. Architects: Graham, Anderson, Probst and White — Chicago. Contractor: Walbridge-Aldinger Company—Detroit.

1950

Addition now being built featuring Georgia Marble in Curtain Wall Construction. Architects: Smith, Hinchman and Grylls—Detroit. Contractor: O. W. Burke Company—Detroit.

Demonstrating versatile GEORGIA MARBLE

REG. U. S. PAT. OFF.

in the exciting New Technique of

CURTAIN WALL CONSTRUCTION

That Georgia Marble is thoroughly adaptable to contemporary design is evidenced by its application in Curtain Wall Construction in the Detroit Branch of the Federal Reserve Bank of Chicago. A preview of this construction is editorially featured in detail in this issue of Architectural FORUM. As a modern material, versatile Georgia Marble lends the same dignity, beauty and permanence as when used in buildings of traditional design.

In the project illustrated above Georgia Marble was specified in both the original building erected in 1927 and in the addition now under construction.

Thus in the span of 23 years, Georgia Marble has been twice employed and demonstrates its flexibility for use in both contemporary and traditional type of design.

We invite inquiries to any of our Sales and Service Offices listed here, concerning the use of Georgia Marble in any type construction.

The GEORGIA MARBLE COMPANY of Tate Ga.

SALES AND SERVICE OFFICES:

New York, N. Y. Brighton, Mass. Cleveland, O. Philadelphia, Pa.
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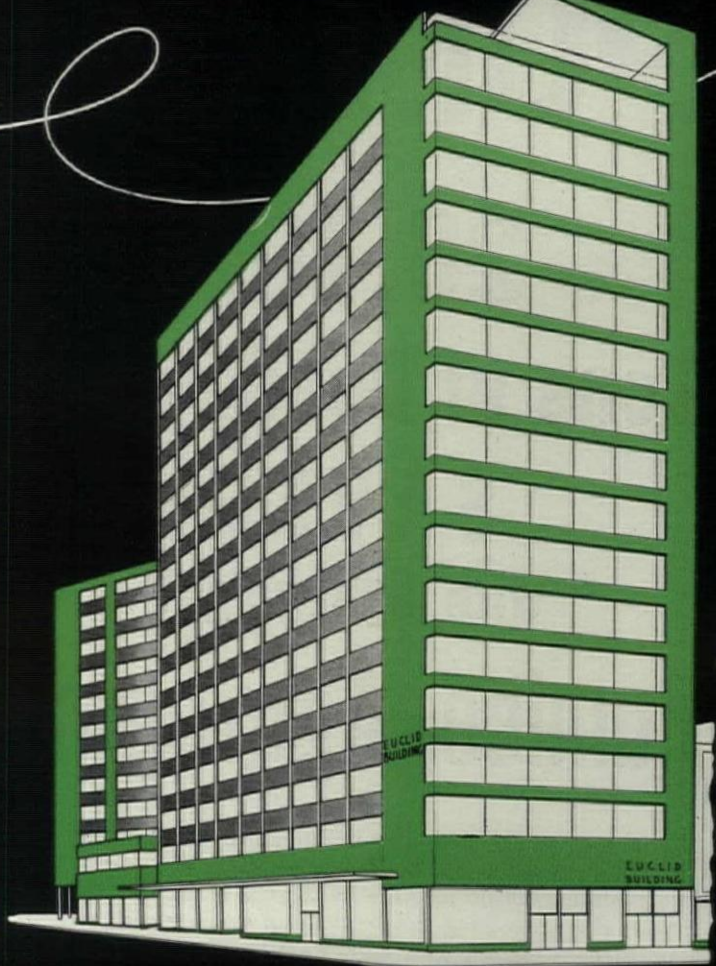
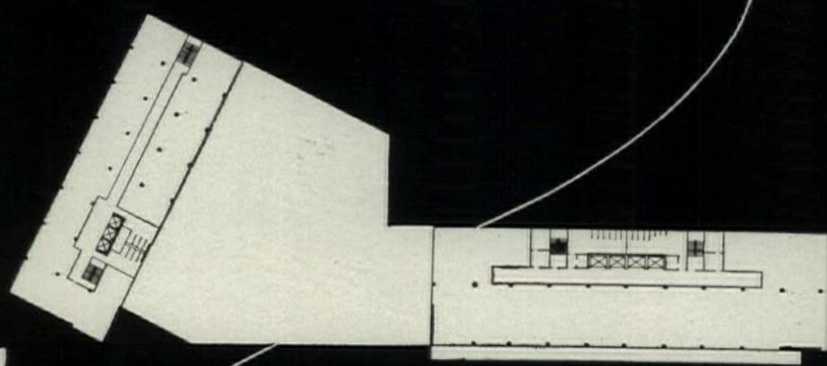


PERSPECTIVE TAKEN FROM MAIN BUSINESS STREET

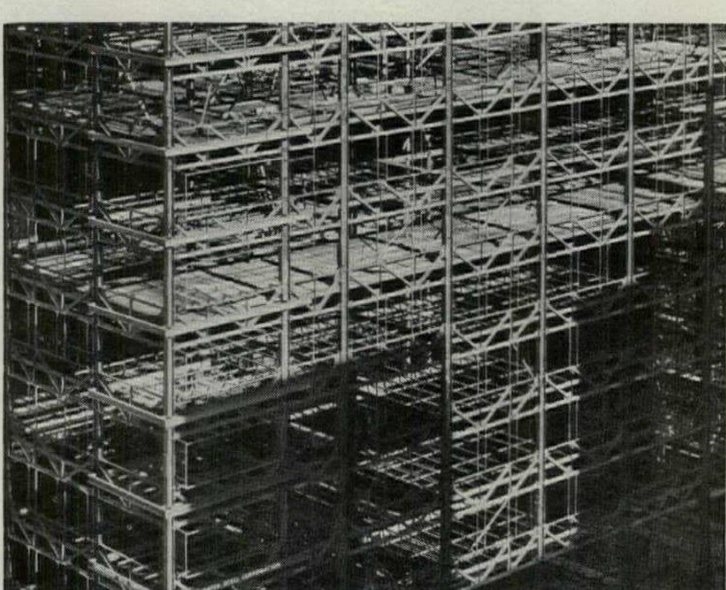


TYPICAL OFFICE FLOOR LAYOUT (MOVABLE OFFICE PARTITIONS NOT INDICATED)

ELEVATION ON SECONDARY BUSINESS STREET

FRONT ELEVATION

PROFITS PLUS with G.P.C. PUMICE!



GENERAL PETROLEUM BUILDING*, LOS ANGELES, CALIFORNIA. WURDEMAN & BECKET, ARCHITECTS. 13,100 TONS OF DEADWEIGHT ELIMINATED BY USE OF LIGHTWEIGHT AGGREGATES.

PRUDENTIAL BUILDING*, LOS ANGELES, CALIFORNIA. WURDEMAN & BECKET, ARCHITECTS. 15,600 TONS OF DEADWEIGHT WERE ELIMINATED BY USE OF LIGHTWEIGHT AGGREGATES.

* Pumice aggregates for these buildings supplied by Desert Materials Co., Inc., Los Angeles, California.

28,700 Tons of Deadweight SAVED with lightweight Pumice Aggregate

28,700 tons of steel and other building materials translated into dollars represent a very handsome profit to the owners of these two buildings, made possible by the use of lightweight aggregates. The same thing can be done in every other city in this type of construction with GPC Pumice. Architects and engineers who design around the multiple characteristics of GPC Pumice are sure to achieve weight-saving, space-saving, and a reduction in the operating cost of a building.

GPC PUMICE CONCRETE Features

- low weight-to-strength-ratio
- passes 4-hour fire test
- low-cost fireproofing for steel
- unusual shock resistance
- an excellent insulator — eliminates furring out
- high acoustical values — sound transmission reduced 50%

Here is a summary of tests on GPC Pumice made by a U. S. Government unit:

Cement Sacks Cu. yd.	Actual Compressive Strength PSI	Weight per cubic foot Wet	Dry	Thermal "k" Factor	Insulation 8" wall "U" Factor
3.00	690	77	54	1.42	.156
3.50	1,000	78	55		
4.11	1,700	78	57	1.64	.177
5.00	2,230	82	60	1.67	.180
6.97	2,780	89	65	1.67	.180

Write for booklet "DESIGN WITH GPC PUMICE"

General Pumice Corp.

P. O. Box 1445
Sante Fe, New Mexico

70 East 45th Street
New York 17, N. Y.

PERMALITE (Perlite): an ideal lightweight building material effects important economies under ne curtain wall building codes. Many uses of Permalite* . . . including its application as an outstanding curtai wall material . . . are presented here by one of the major producers of perlite aggregates.

FINANCIAL AND REAL ESTATE INTERESTS are thoroughly studying the use of Permalite in new construction planning as it becomes evident that a dead load-live load ratio as low as 1:1 for an *ideal* low cost, lightweight building is now considered possible through extensive application of this versatile lightweight material.

POSSIBLE SAVINGS OF 80% in dead load for ideal lightweight building.

The many combined uses of Permalite in lightweight building construction result in important savings in structural steel and foundations and make possible a permanent fireproof, lightweight, insulated building with a dead load to live load ratio as low as 1:1.

An ideal lightweight building is possible through the *combined* 5-step use of Permalite as follows:

FIREPROOFING

Step 1) Lightweight Permalite plaster—speedily applied—for fireproofing of all structural steel. This replaces the slow, costly imbedding of structural steel in heavy concrete, at present in use.

CURTAIN WALLS

Step 2) Thin, light Permalite concrete curtain walls (blocks, slabs or monolithic)—easily formed and erected to replace heavy, thick masonry, much more costly erected, in general use today.

FLOORS AND ROOFS

Step 3) Lightweight Permalite concrete used in roofs and floors over lightweight steel decking to replace heavy reinforced concrete in conventional construction.

PLASTER

Step 4) Lightweight Permalite plaster—more crack resistant than sanded plaster—replaces sand plaster at less than half its weight.

ELEVATOR SHAFTS AND STAIR WELLS

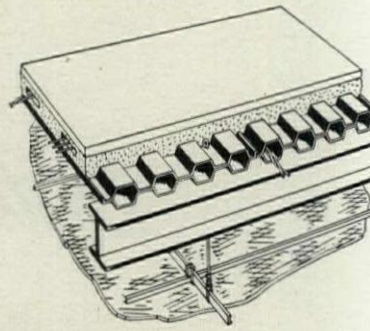
Step 5) Thin, light Permalite plaster partitions—used for vertical fireproofing such as elevator shafts, stair wells and corridors to replace thick heavy masonry.

These many individual weight savings in construction added together plus appreciable savings in erection time, result in amazingly lower construction costs; i.e. *lower initial building investment*. And the thinner wall sections under steps 1, 2, 4 and 5 will result in increased rental areas; i.e. *more revenue space*.

It can be said that the use of Permalite is as important a development in building history as the original use of structural steel to replace load-bearing walls.

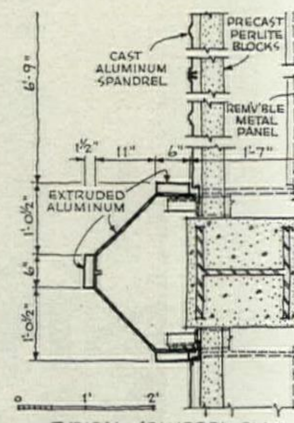
PERMALITE OFFERS FIREPROOFING AT LOWER COST. Full scale fire tests in accordance with A.S.T.M. E-119 have been made at Underwriters' Laboratories, Bureau of Standards and many Universities. From these various fire tests, recommendations can be made for the use of Permalite in various applications, such as: Steel columns, 2, 3, 4 hours; Steel floors and suspended ceilings, 3, 4 hours; Solid interior partitions, 1, 1½, 2 hours; Exterior walls (curtain walls), 1, 2, 3, 4 hours; Hollow interior partitions, 1, 2, 3 hours.

Series of photographs taken at Underwriters' Laboratories before and after actual tests, given (1) technique of Permalite plaster fireproofing, (2) fireproofed column before test, (3) fireproofed column after test.



Fire tests conducted by Underwriters' Labs. Inc. as described in U.L. Rep No. 2993, cover a steel floor assembly made up of 2 in. Permalite concrete fill cellular steel decking, supported on steel beams with a suspended ceiling of 1 Permalite plaster on metal lath. This construction received a 4-hour rating.

18,000 precast Permalite concrete blocks were used as a thin, lightweight curtain wall (4-hour fire rating) in the Employers Casualty Building of Dallas, Texas. Architect: George Dahl; General Contractor: James Stewart & Company, Inc.

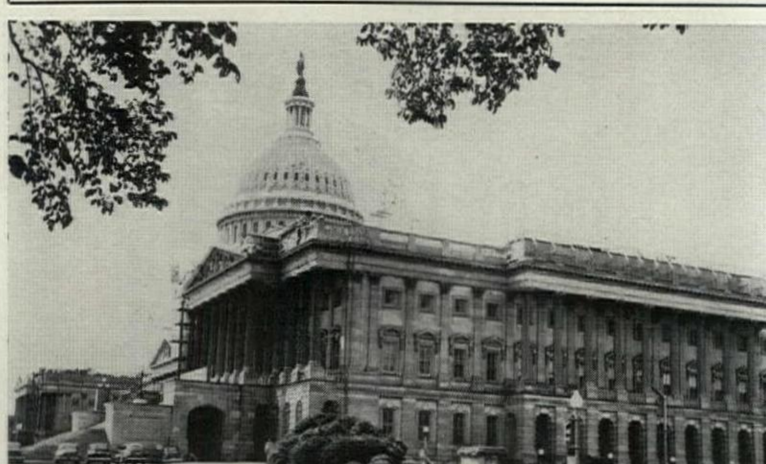


TYPICAL SPANDREL PLAN

Permalite is included in the Underwriters' Labs. Inc. List of Inspected Fire Protection Equipment and Materials under classification Plaster Aggregates.

* Reg. U.S. Pat. Off.

As a service to the readers of Architectural Forum, Great Lakes Carbon Corporation *will make available complete information on Permalite plaster and concrete aggregates, their multiple applications and all test results to date. The Product Engineering Department, Architectural Sales Department and extensive research facilities are available to assist your staff in the actual design of a low cost, lightweight building or other applications of Permalite. Requests should be made to Dept. FM, Building Products Division, Great Lakes Carbon Corporation, 18 East 48th Street, New York 17, N. Y.*



Permalite plaster aggregate was used to fireproof the structural steel roof suppor in both the Senate and House Chambers of the Capitol Building, Washington, D. Architect of the Capitol Building—David Lynn. General Contractor—Consolidat Engineering Co. Plastering Contractor—McNulty Brothers.

INSULATED METAL WALLS

for INDUSTRIAL and COMMERCIAL BUILDINGS

ALUMINUM, STAINLESS or GALVANIZED STEEL

Mahon Insulated Metal Walls are available with aluminum, stainless steel, or galvanized steel exterior plates. Interior plates are galvanized steel. Insulation is two inches of Fiberglas. Thermal properties are excellent — a uniform overall "U" factor of 0.15, which is equivalent to that of a 28 inch solid masonry wall, or a 16 inch masonry wall of face brick, concrete block, furred insulating board lath and plaster. Pilasters, coping and other effects, for individual architectural treatment, may be produced by simply reversing the standard wall plates, which can be rolled in any length up to 55 ft. to produce high expanses of unbroken wall surface without horizontal joints. The power house below is a typical application. Mahon Insulated Metal Walls in combination with a Mahon Steel Deck Roof cost less, provide a firesafe, permanent building which can be quickly and economically erected in any season of the year. See Sweet's Files for complete information and construction details, or write for Catalogs B-49-A and B.

THE R. C. MAHON COMPANY

Detroit 11, Michigan • Western Sales Division, Chicago 4, Illinois

Representatives in all Principal Cities

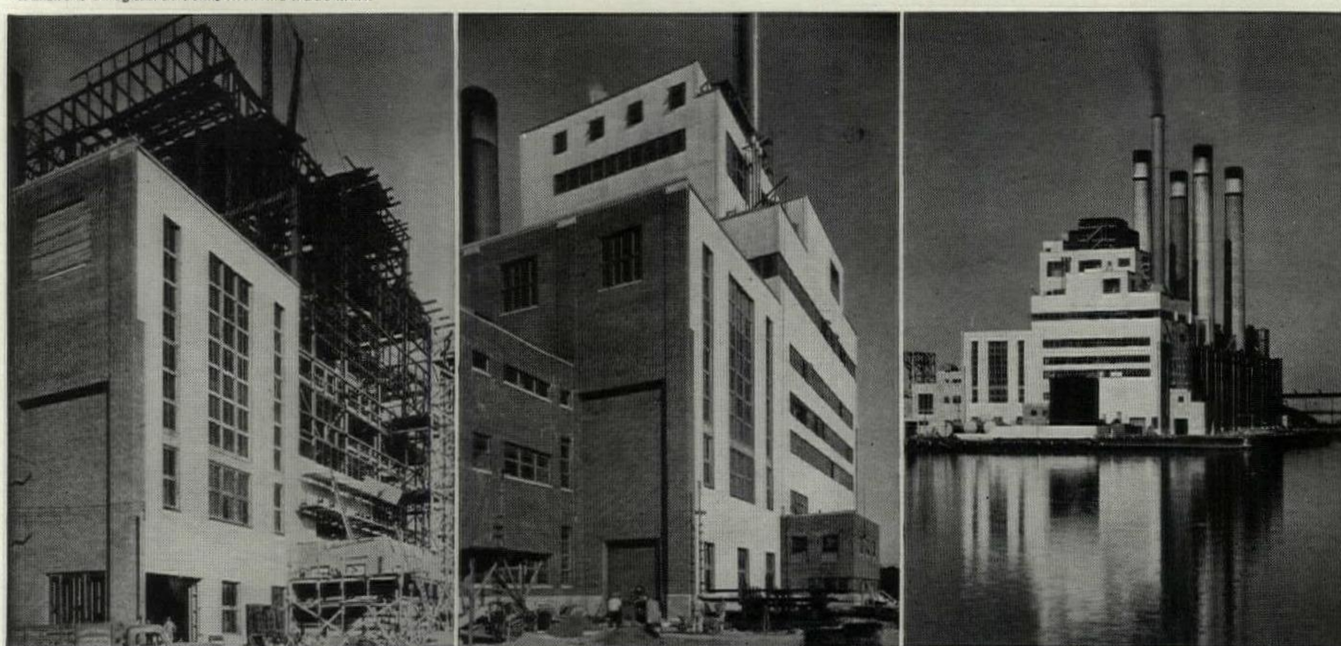
Manufacturers of Insulated Metal Walls; Steel Deck for Roofs, Ceilings, Floors, and Partitions; Rolling Steel Doors, Grilles and Underwriter's Labeled Rolling Steel Doors and Fire Shutters.

Bison Power Plant, built at Minot, N.D., for Northern States Power Co. Mahon Insulated Metal Walls with Stainless Steel Exterior Plates and Stainless Steel Flashing used throughout. Pioneer Service & Engineering, Chicago, Architects & Engineers.

MAHON

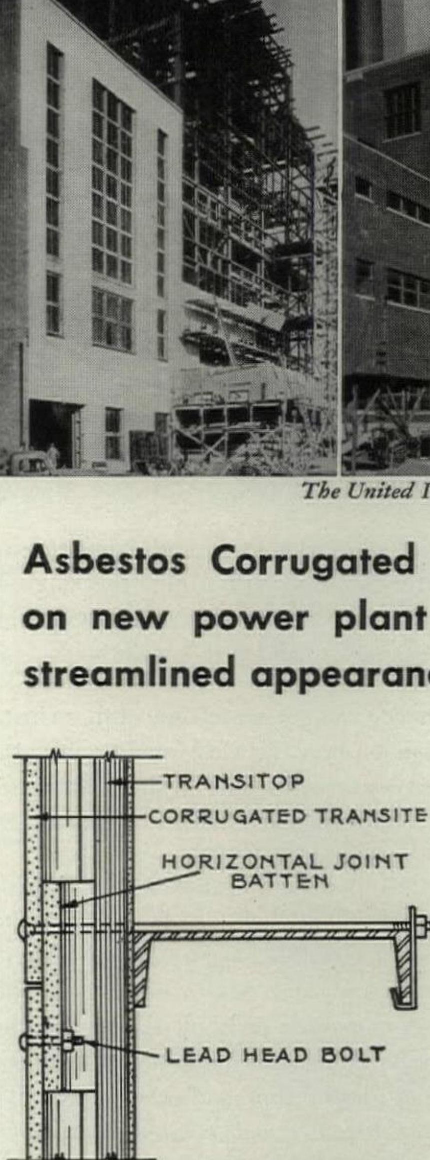
CORRUGATED TRANSITE* ... *for Curtain Walls*

*Transite is a registered Johns-Manville trade mark



The United Illuminating Co., New Haven, Conn.; Westcott and Mapes, architects and engineers

Asbestos Corrugated Transite reduces load-bearing factor 83% on new power plant addition! Transite sheets give attractive, streamlined appearance... and they can't rot, rust, or burn.



HORIZONTAL JOINT SECTION

• Here's a case in which a unique form of asbestos wall construction solved a tough building problem.

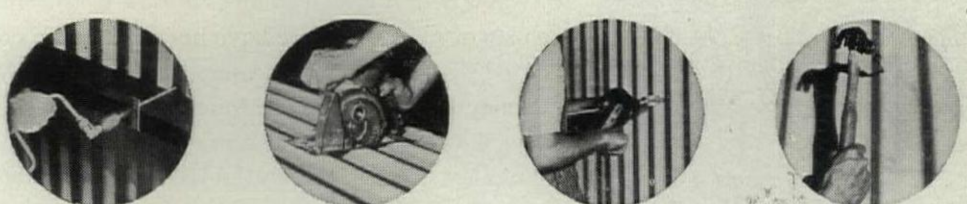
The addition planned was to be almost twice the height of the original building, yet where the two joined, existing foundations were to be used. This meant that the new bearing wall with all its extra height should weigh no more than the old wall.

After careful study, it was decided to use the Johns-Manville Industrial Curtain Wall, a system of dry wall construction which combines J-M Corrugated Asbestos Transite with J-M Transitop (Insulating Board faced with Flexboard).

This type of construction, compared with solid masonry, reduced the load-bearing factor from 120 to 20 pounds per square foot! It also provided fire protection, insulation, and permitted the use of less extensive pilings and foundations for the rest of the building.

Architects and engineers are constantly discovering new uses for J-M Corrugated Asbestos Transite, not the least of which is its surprisingly effective function in attractive, modern design.

Send for new brochure which may help you on your next project. Johns-Manville, Box 290, New York 16, N. Y.



EASY TO BOLT TO STEEL · EASY TO SAW · EASY TO DRILL · EASY TO NAIL TO WOOD

JM

Johns-Manville *Asbestos* **CORRUGATED TRANSITE**

ANACONDA Wall Panels

for metal-clad

curtain wall construction

d to Architects

aconda offers architects several useful methods
providing good-looking and durable metal "skins"
buildings of curtain wall construction;
rganized to adapt these methods to specific
hitectural concepts; and can supply appropriate
per, Everdur*, nickel silver and other copper-base
nels for carrying out such ideas practically.

eatherproof — Easily Installed

obvious advantage of copper, of course, is its
-rusting property and general high resistance
corrosion. Advantages to the installer, too, are
vided. Among these is an ingenious feature which
ilitates making water-tight joints, without solder
calking, and which adequately allows for expansion
contraction. Panels with specified die-pressed
rimped designs can be furnished if desired.

autiful and Lasting

haracteristic of ANACONDA Copper Panels which strongly
peals to the imaginative architect, building owner
city planner is the "changing landscape" effect
ch naturally occurs as the copper panels gradually
ather and acquire their final, beautiful and
manent patina.

U.S. Pat. Off.

5002

ANACONDA Wall Panels are weatherproof and easy to install.

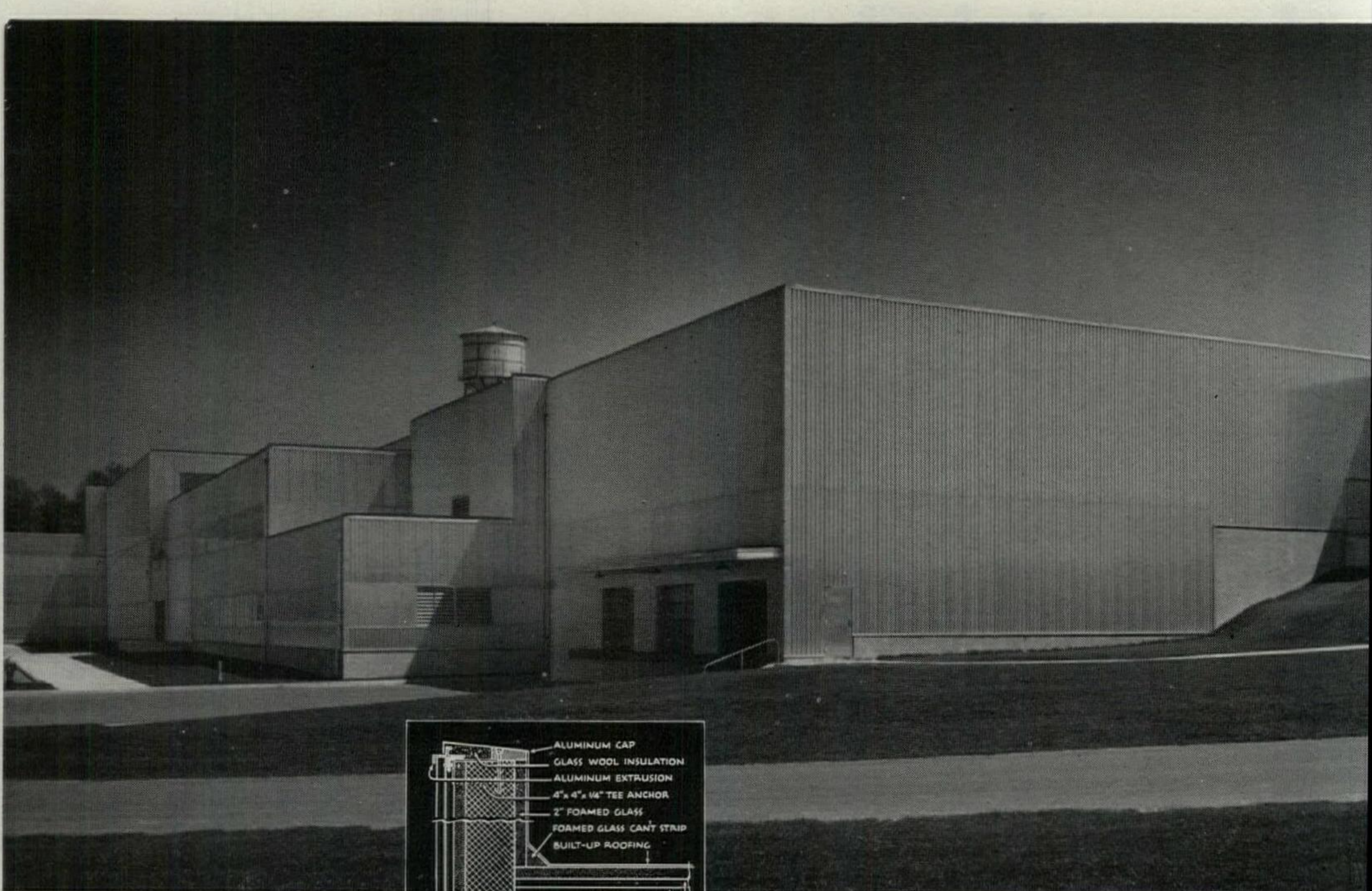
For further information:

write to The American Brass Company,
Waterbury 20, Connecticut.
In Canada: Anaconda American Brass Ltd.,
New Toronto, Ont.

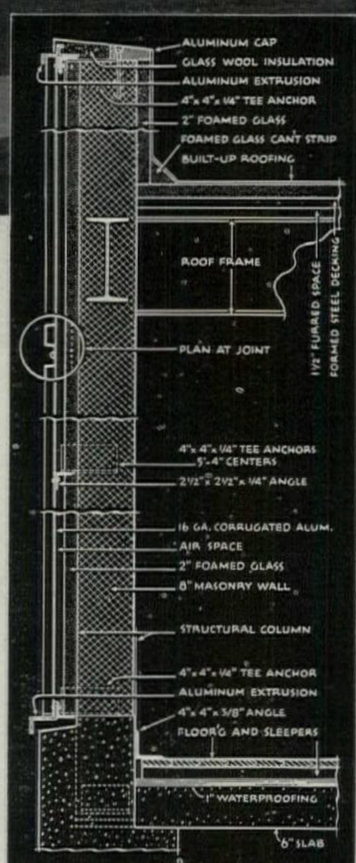
for modern construction ANACONDA®

COPPER WALL PANELS

THESE WALLS



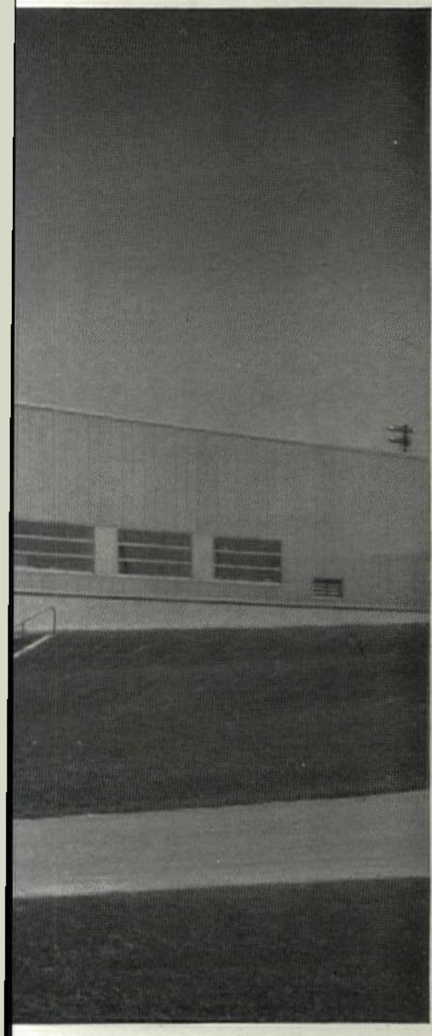
Nylon Throwing Mill, Duplan Corporation, Winston-Salem, North Carolina. Lacy, Atherton & Davis, Architects & Engineers. Alcoa Aluminum used for exterior walls, window sash, doors, copings and ventilation louvers.



Typical wall section showing method of attaching wall panels in Duplan Corp. mill.

Insulated aluminum wall panels weigh approximately 7 lbs. per square foot, can be erected in fair or freezing weather. Insulation factor is equal to a foot of masonry wall.

...EFLECT THE FUTURE...



Standing bright and clean in the hills of North Carolina is further proof of aluminum's place as a basic building material. This building functions as efficiently as it looks. Its walls, sheathed in rugged Alcoa Aluminum, help to maintain rigid temperature and humidity control for continuous-flow production of nylon. Use of Alcoa Aluminum helped to speed the construction; will further repay the owners by keeping maintenance costs at a minimum.

Today, in every part of the country, you will see gleaming, modern, aluminum-clad buildings. Aluminum has come of age as a building material, for it best combines workability, strength, weather resistance, lightness, economy and long life.

Alcoa offers building planners a fund of aluminum knowledge unmatched anywhere in the world. For a forward look at aluminum's place in the building world, ask to see the film or book, "The Davenport Story".

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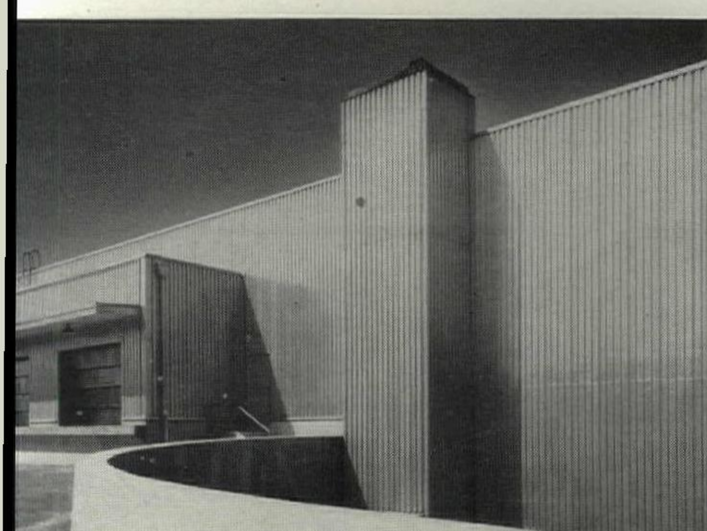
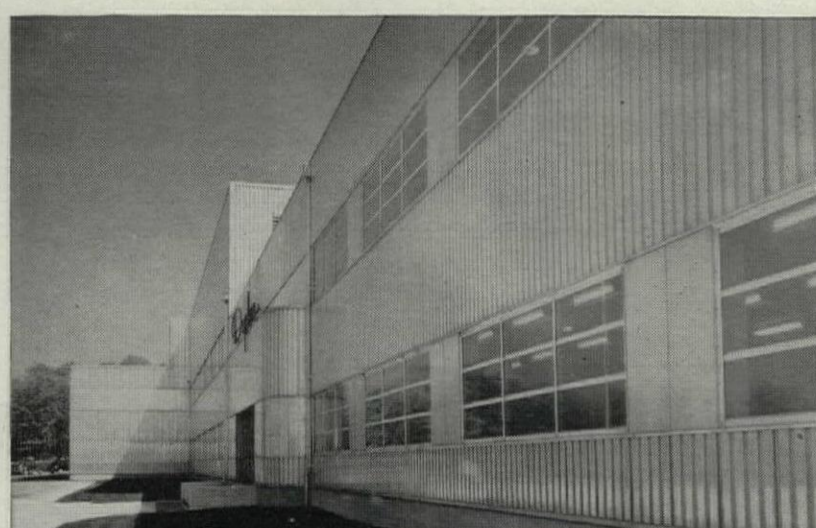
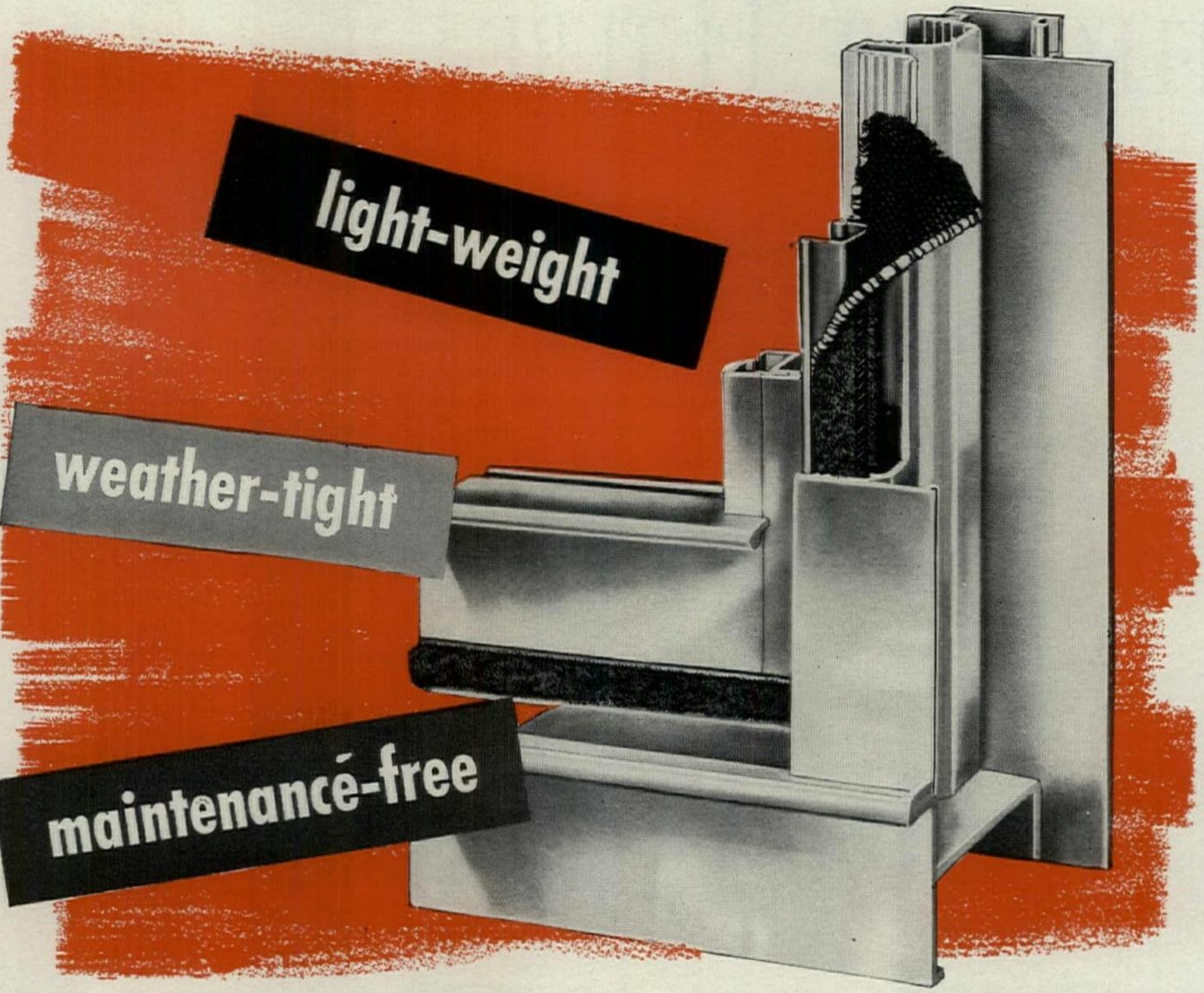
Held top and bottom by angle girts, aluminum-faced panels are quickly, easily installed. They combine good appearance with freedom from painting and maintenance.



Aluminum-faced wall panels are supplied by several manufacturers. Standard widths. Lengths as specified. Lighter weight simplifies design, speeds construction.





Adlake aluminum windows are ideally suited to curtain wall construction

Although designed for a lifetime of service in *any* building, modern or traditional, Adlake Aluminum Windows are a "natural" for curtain wall installations. Built of lightweight aluminum, they do away with the cost of painting and maintenance, and keep their smart good looks and finger-tip control for the life of the building!

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Once he figures the total cost of an Ultralite job, you can be sure he'll know that Ultralite is the best thermal and acoustical insulation buy. First show him a sample of lightweight fire-safe Ultralite. Tell him about Ultralite's long, soft glass textile fibers imparting dimensional stability. Show him how you can bend it, squeeze it, pound it and still have it spring back to shape and hold that shape. Then tell him how easy and pleasant it is to install. Long before he adds in the last item, he'll *know* that Ultralite costs much, much less—as much as 3c to 20c per square foot less, depending upon application.

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Yes, Ultralite is available in densities as low as .75 lbs. per cubic foot. When weight is a factor, it's the ideal insulation.

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Know how Ultralite can be adapted to "curtain wall" types of construction. Call in a Gustin-Bacon insulation engineer for consultation. A letter outlining your problems will bring immediate assistance. There's no obligation, of course.

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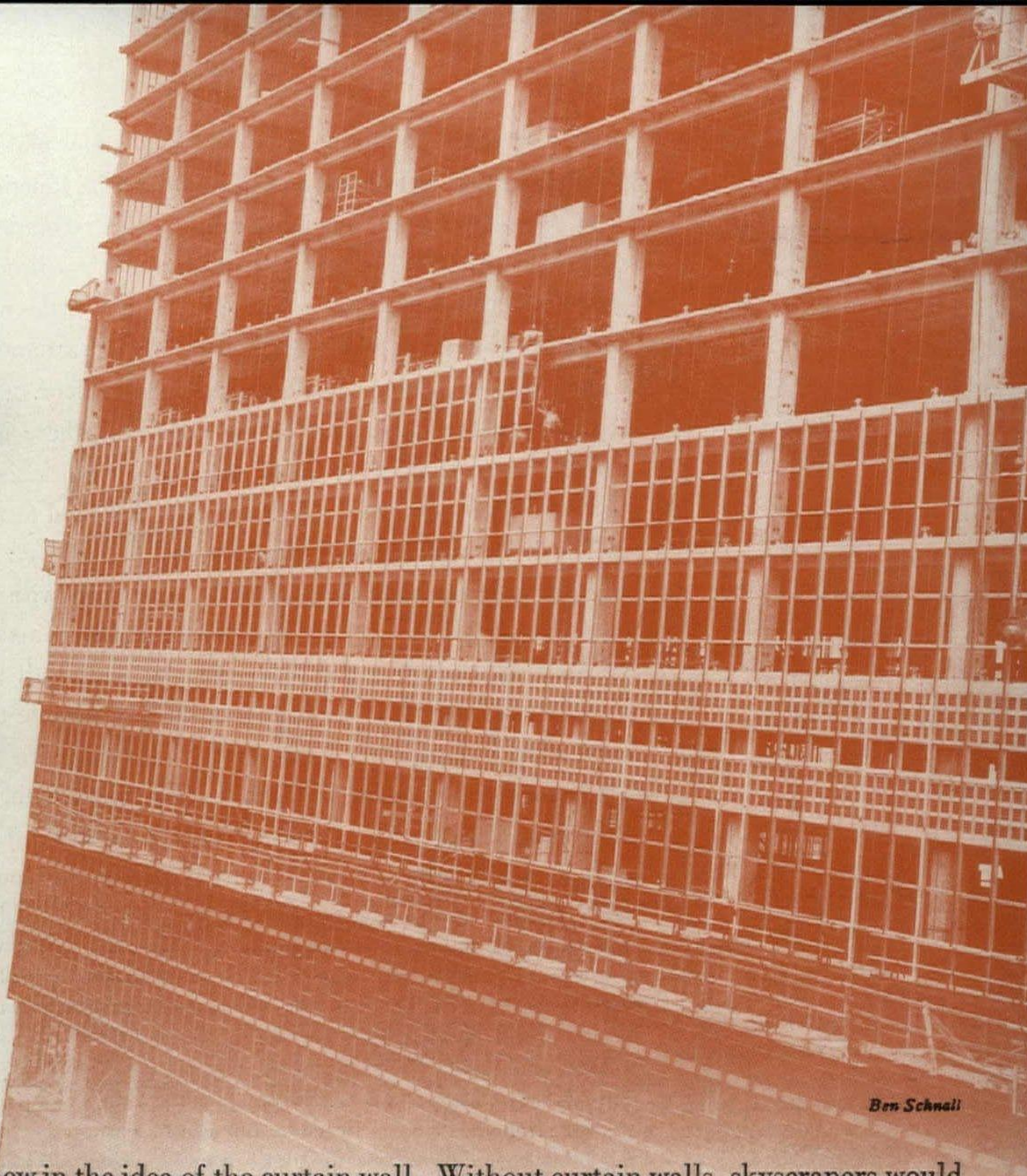

Ben Schnall

Thin, lightweight

CURTAIN WALLS

the long overdue counterpart of the structural steel frame, are rapidly emerging as the prime development of this era of skyscraper construction

by ROBERT L. DAVISON*

presentation by HENRY WRIGHT**

There is nothing new in the idea of the curtain wall. Without curtain walls, skyscrapers would have been impossible. The last tall building with self supporting walls was the 16-story Monadnock Building (Chicago, 1893), in which the walls reached a thickness of 15 ft. at the base, this being the amount of masonry needed to support the crushing weight of the superimposed masonry. After this, those who wanted to push their structures more than six or eight stories into the air have supported the walls first on cast iron columns, and later on steel columns, which can be depended upon to carry some 50 times the weight that can safely be imposed on the same cross section of masonry piers. In such buildings the walls have become a mere appendage—an appendage which rarely supports even its own weight for more than a single story, and never for more than two or three floors.

Thus the appellation "curtain walls." The term has also been applied to other nonstructural walls such as a false wall within an enclosing foundation, but its most common use has been to describe the facing and enclosure of the structural steel "cage" which supports the entire weight of the modern multistoried building.

As such, the term is only partly apt, since the kind of curtain in which most tall buildings have been draped is a substantial sandwich of 12 in. of masonry materials, or 10 in. of masonry and metal, plus furring, weighing somewhere between 100 and 175 lbs. per sq. ft. of surface area. In the case of a building as large as the Empire State Building, this ponderous shroud has a total weight upwards of 30,000 tons, all of which is added to the loads which must be borne by the structural steel columns and column footings.

What *is* new is that the building codes of New York and other major cities—which were the factor that forced the architects of the Empire State Building and other skyscrapers to load the building frames with all this dead weight—are beginning to recognize that much

* *Research Director for Howard T. Fisher Associates*

** *Technical and Promotional Consultant* of this masonry is unnecessary, and that many materials, including masonry, can be used to form thinner, lighter curtain walls capable of all the functions such an enclosure is called upon to perform. In a sense most building codes have always recognized this fact by permitting ordinary windows to occupy up to 100 per cent of the wall area—thus discriminating in favor of curtain walls of glass, and giving a decisive push to designs such as that of the new U.N. Secretariat, (page 81), which—legally speaking—has no outside "walls" at all on its east and west flanks, only windows which extend uninterruptedly from column to column and floor to floor. (The fact that on each floor, immediately behind the glass of the lower part of the "window" there is a parapet $2\frac{1}{2}$ ft. high consisting of 1 in. of asbestos insulation and 4 in. of solid cinder block, is legally significant only so far as the inside of the building is concerned; the parapet is designed to meet fire regulations, but in one direction only.)

This basic building-code inconsistency, revealed on a striking scale by the U.N. Secretariat and on a smaller scale by innumerable smaller structures with all-glass facades scattered through our cities, is embodied in all of our municipal codes and remains unresolved, continuing the Alice-in-Wonderland situation in which one part of an office-building wall (which may be all of it) is permitted under one set of standards, while another part, distinguishable mainly by a different name from the first, must meet more stringent standards. What has changed is that the second set of standards, under the new performance-type codes which have been pushed through in most large cities, has been sufficiently relaxed to close somewhat the gap between the two and to permit the use of lighter, thinner curtain walls than were hitherto possible. This has been done without dictating the types of material to be employed.

NEW YORK, one of the cities which formerly required the walls of multistory office buildings of Class I (fireproof) construction to be 8 in. of solid masonry and to resist a 4 hr. fire test (twin requirements which effectively bar thin curtain walls) now will accept nonbearing panel walls of any thickness so long as they will pass a 2 hr. fire test plus the tests for lateral strength. This is by code, but use of curtain walls has been delayed because, until recently, a simultaneous fire and load test procedure, not required by code, were requested by New York's Board of Standards & Appeals. According to Bernard J. Gillroy, Commissioner, Department of Housing & Building in New York, the fire test must be met only from inside sole fire requirement for outside is incombustibility.

CHICAGO's new code (approved December 1949) is most recent of performance codes of big U. S. cities, and has no specified thickness requirement for curtain walls. The general fire-rating of 2 hrs. is dropped to 1 hr. for the outside of exterior walls more than 30 ft. from another building area and 3 hrs. for inside exposure of exterior walls.

PITTSBURGH's 1947 code now accepts curtain walls of any thickness if they pass strength tests and get fire ratings of 2 hrs. (1 hr. if approved by Board of Standards & Appeals).

CLEVELAND's brand new code (June 1949) also accepts 1 or 2 hr. fire-rated curtain walls, depending on set back. No minimum thickness requirement.

LOS ANGELES—Spandrel walls fronting on streets may be constructed of any incombustible materials in Type I buildings. Curtain walls on property line exposures may be of 2 hr. fire resistive construction where the exposure hazard is light.

ST. LOUIS is an example of the numerous cities still hampered by the old requirement of 12 in. of masonry which inhibits efficient curtain wall construction. But a new bill backed by the Building Department and now before the Board of Aldermen will allow sufficiently strong sandwich panels composed of 22-gauge metal, as sheathing for 2 in. of incombustible insulation, for exposures 40 ft. clear, in the center of the city. Actual fire rating on these probably will be about $\frac{3}{4}$ hr.; connectors must have a 1 hr. rating.

Important in the national code picture—and about to become more important—are the model codes drawn up by several national groups. The **National Bureau of Standards** recommends an exterior wall fire resistance of 1 to 2 hrs., depending on exposure. Based on combustible contents of the building's interior, fire resistance would be 2 hrs. Next month, the new Basic Code of the **Building Officials Conference of America** will be published, and sections of it have already been adopted into several local codes. Significantly, this performance-type code will have no thickness requirement for curtain panel walls. Fire test will be 2 hrs. (interior) and from $\frac{3}{4}$ hr. to 2 hrs. (exterior) depending on exposure.

The Uniform Building Code of the **Pacific Coast Building Officials Conference** calls for 1 hr. fire resistance where unprotected openings are permitted, and 2 hr. fire resistive walls where fire protection of openings is required. Thickness requirement: none.

Southern Standard Code allows any noncombustible curtain, no thickness stated, which will meet a 2 hr. test where the wall fronts on a street or other public place, and 3 hrs. otherwise.

National Building Code (recommended by **National Board of Fire Underwriters**) still demands wall panels that will meet a 4 hr. test, but does not require masonry or any other specific material.

As both a result and a cause of these code changes, and in response to the demand of progressive architects, builders and building owners for thinner, weight-saving curtain walls, many of the producers of building materials have initiated the necessary research and development work to produce curta wall systems capable of meeting the new code requirements—and, almost as important, the Herculean task of convincing city building officials all over the country that code requirements have been met.

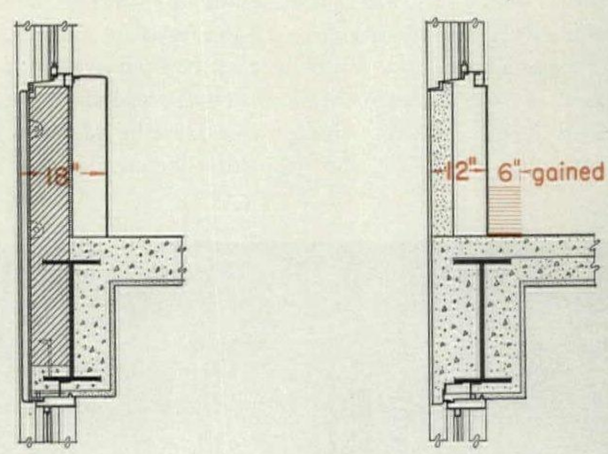
Aluminum Company of America, basing itself on long experience with cast aluminum spandrels (which until recently had to be used as a decorative facing for 8 or 12 in. of masonry), has given a great deal of attention to the development of thin, fire-resistant back-up materials for panels of cast, sheet, and most recently extruded aluminum. Steel companies, whose products enjoyed wide wartime usage for insulated panel walls for industrial plants and other non-code construction, have been equally active in their efforts to develop methods of rendering steel panels suitable for use in multistoried buildings and capable of meeting code requirements. (Companies now doing active development and promotion work in this field include such steel company giants as **Allegheny Ludlum, Armco, Carnegie-Illinois, Crucible** and **Republic.**) In addition, the major steel companies now making stainless steel have recently sponsored **Stainless Steel Producers** with headquarters at the **American Iron & Steel Institute** to undertake promotion of stainless steel in building, with particular emphasis on curtain walls. Among copper producer, **American Brass** has developed a curtain wall design, and in the field of back-up materials **Pittsburgh-Corning** (Foamglas), **Owens-Illinois** (Kaylo Division), **Great Lakes Carbon** (Perlite Division) and **U. S. Gypsum, Zonolite, Johns-Manville,** are all carrying on research and development work. Fabricators who have been manufacturing and selling curtain walls, largely in non-code areas, include **H. H. Robertson, R. C. Mahon, Detroit Steel Products** and **The Cemenstone Corp.,** with **Pullman Standard** now entering the field. Thus the curtain wall idea has a roster of sponsors of which the present list is necessarily incomplete, for it is beginning to read like a *Who's-Who* of the building materials field.

WHY CURTAIN WALLS?

The diagrams at the right show the reasoning behind all this excitement—the two big reasons why thin curtain walls make sense. Both reasons are economic: thinner walls, it is claimed, can save on construction cost and at the same time increase revenue—buttressing the profit column from both sides. Cost savings may be entirely in the structural frame, due to decreased weight, or in the wall as well, since the thinner wall may be cheaper to build—foot for foot—than conventional masonry. In a tall enough building, on the other hand, weight savings from use of lightweight back-up material will pay for the increased thermal insulation necessary for the thinner wall. In a 20 story building these savings run about $4 per lin. ft. of wall per floor, or enough to compensate for a difference of 60 cents a sq. ft. in the cost of a 6 ft. 9 in. high spandrel wall.

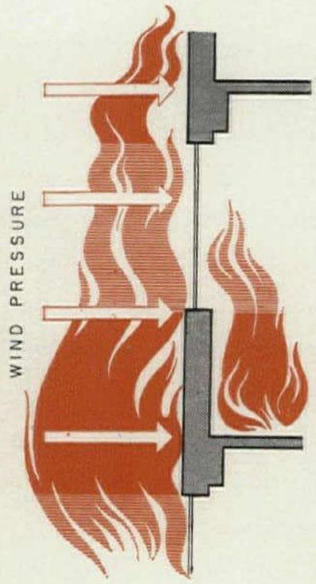
The increased revenue from the increased space which results from thinner walls is of greater relative importance, but requires careful statement to be convincing. It is sometimes argued, for example, that this advantage is illusionary, since "the few inches of space added to each office would not result in increased rents." As a matter of fact, under the standard methods used for computing office rentals, it would; but this is not the point. The point is, that in a building *designed* on the basis of thinner walls, maximum advantage would be taken of the added space, in whatever way made the most sense. Since such buildings are normally built out to the last inch of available space, this would most frequently take the form of increasing the rentable area; if this were not done, then the thinner walls would result in a smaller building and therefore lowered costs. With the average cost of office building construction above the first floor, including the prorated cost of land, running over $27 per sq. ft. of floor (1948), the value of the space saved or added for each 4 in. reduction in wall thickness is $9 per lin. ft. of wall per floor, or $18 per ft. for a reduction from a 12 in. wall to one 4 in. thick.

A third advantage to be gained from thin curtain walls in some instances is increased thermal insulation, with corresponding savings in heating costs. So long as the basic factor determining the design of such walls remains a matter of meeting fire regulations, this insulation is not likely to be realized to an important degree, since there is a conflict between the properties which make for good thermal insulation, in the ordinary sense, and resistance to the typical fire test. Where arbitrary code regulations need not be considered, however, this advantage can be realized. Many of the insulating materials suitable for thin curtain wall construction are more than 15 times as effective as thermal insulators than ordinary masonry, and it is no trick at all to put together a 4 in. wall with twice the insulation value of 12 in. of brick by incorporating such materials. The value of the resulting fuel saving is likely to be on the order of 2 cents per sq. ft. of wall per heating season, or as much as 50 to 75 cents over the life of the building. This is more than sufficient to pay for any added cost of the insulation, but of no great economic significance relative to the other costs involved in the curtain wall picture, unless the increased comfort, increased usability of space, and ease of heating resulting from the insulation are assigned economic value.



SPACE SAVING resulting from thin curtain wall construction as illustrated by a comparison between the typical wall section in Rockefeller Center, as actually built (left) and as it would work out with a thin curtain wall. Reduced thickness would add 2.62 per cent rentable area.

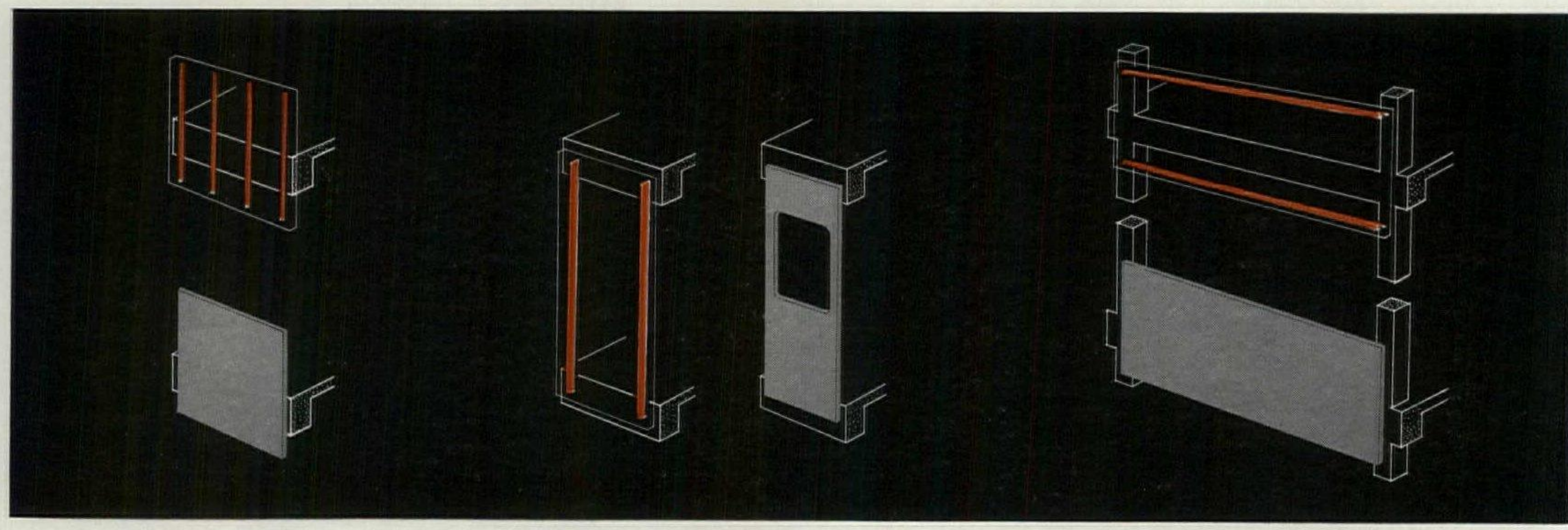
THE PROBLEM



The principal forces which the curtain wall is called upon to resist, under code conditions, are the legal powers wielded by building commissioners. Of course, the curtain wall must exclude the elements, provide reasonable security against unauthorized entrance to the building, conserve or exclude heat, according to the season, let in daylight, etc.—do all of the things that a wall is normally called upon to do except hold up the floors and roof. But the decisive forces which determine its design are wind and fire—wind and fire not in their real form, but in their fictionalized form as embodied in building codes. Thus while the actual wind load might vary widely according to the position of the wall in the building, its height, aerodynamic shape, etc., etc., the design wind load is a uniform pressure of so many pounds per sq. ft.—usually 30 lbs.—acting uniformly over the entire wall and window area. The need for fire protection, on the other hand, is assumed to stop quite magically at the window sill and jambs—the fire raging furiously below and beyond these points but nonexistent above and within them.

The basic theory of such fire protection is that of protecting the interior of the building, and its contents, from fires of external origin. This is generally broadened to include the function of containing a fire which originates within the building as well, but many codes are not clear as to whether or not this is required, and the point is entirely academic, since in any event the presence of window openings would prevent the wall from actually performing either function. To meet both requirements, the construction of the curtain wall must be such that one surface will not exceed an average rise of 250° F. within two hours after application of a certain amount of heat—equivalent to a raging fire—to the opposite surface.

Since a loading of 30 lbs. per sq. ft. is equivalent to that normally used as a roof load for light structures, and since the portion of the load acting upon the window area must be added to that acting directly upon the wall, this means that the curtain wall must possess a fairly high degree of strength, both within each unit of surface area, and as a membrane attached to the structure of the building. Assuming the typical office-building frame, the diagrams below illustrate the various ways in which the required strength can be achieved. For the sake of simplicity, they are based on the further assumption that the basic material of the wall (either the facing or the back-up material, or both together) is capable in itself of spanning 2 or 3 ft. under the required loading, but requires additional stiffening at about this interval to resist the cumulative effect of the wind load on the wall panel as a whole and the load transferred from the window surface. Each of the methods shown assumes complete neutrality of the curtain wall so far as the structure of the building is concerned; a fourth type would be one in which the curtain wall panel took the place of the regular spandrel beam, becoming a part of the structure of the building and utilizing the full height from window head to window sill to perform this structural function.



CANTILEVER

This solution takes advantage of the fact that in most multistoried buildings the depth of the structural spandrel-beam is relatively great, and the height of the wall beneath the window relatively small. By fastening stanchions—or the panel itself, provided it has the necessary stiffness—to the top and bottom of the spandrel beam, sufficient strength is developed to resist the inward thrust of the wind pressure on the wall and the window above. The cantilever method is understandably popular for ribbon-window buildings.

FLOOR TO FLOOR

Simplest of all methods is that of applying continuous studs to the face of the building frame which span the space between floors like simple beams. Chief disadvantage of this method, of course, is that the studs must be incorporated in the fenestration above the spandrel, but, depending on the type of window used, this can also be a virtue, as when the windows require such stiffening in any event. For the windowless building, or one with few and relatively small openings, this method is unquestionably the most feasible.

COLUMN TO COLUMN

Most logical of all methods where continuous radiator enclosures are to be used is a system of horizontal girts spanning between the columns at the level of the window sills and heads. While the upper member—that at the window sill—must posses considerable stiffness when columns are widely spaced the opportunity exists to give this member considerable width by using it as an inside sill over the normal radiator enclosure. The column-to-column solution leads naturally to the next logical step: use of the curtain wall panel as a spandrel beam.

FACING MATERIALS

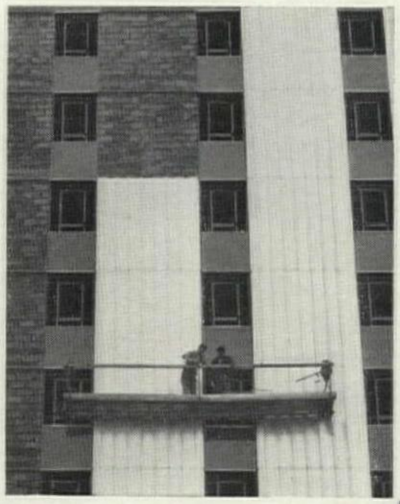
To date, most of the interest in lightweight curtain wall construction has centered around metal-faced walls and panels — most notably, panels faced with aluminum in cast, sheet or extruded form and steel, particularly stainless steel. Copper-faced panels have also been tried out experimentally. Porcelain enamel on steel, and porcelain enamel on aluminum, both obvious contenders because of their extensive use as a facing for masonry walls, and potentially low in cost have yet to enter the field with a developed system of curtain wall construction meeting the codes but will undoubtedly do so.

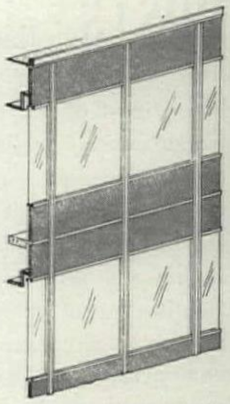
Appropriate facing materials for thin curtain walls are by no means limited to the metals, however. They include all of the basic types of conventional facing materials; metals, ceramics, vitreous materials and stone. (Two of the first large buildings to employ thin, lightweight walls—the General Petroleum Building in Los Angeles and the Federal Reserve Bank Annex in Detroit—are faced respectively, with terra cotta tile and marble.) The basic requirements remain the same as for any wall facing: durability, resistance to the elements, good appearance, etc., plus the added premium which the curtain wall approach puts on lighter weight and lack of bulk.

In respect to fire resistance, an aluminum facing is rated as "incombustible" but melts at 1215° F. It meets codes satisfied with incombustibility of wall facings but where fire-tests are demanded it requires a more strongly reinforced back-up than, for example, stainless steel or porcelain enamel steel, which are capable of withstanding the fire and contributing to the strength and impermeability of the wall. The bulkier facing materials, such as brick and terra cotta, have the advantage of combining the properties of a facing with some of those usually supplied by the back-up.

The variety of facing materials used for thin curtain walls will probably be greater than the variety used in conventional walls, with the color possibilities of porcelain enamel and structural glass vying with the texture of brick and stone, the ease of fabrication of aluminum, and the strength and fire resistance of stainless steel.

METALS
Fluted aluminum piers

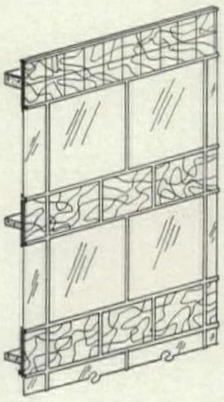


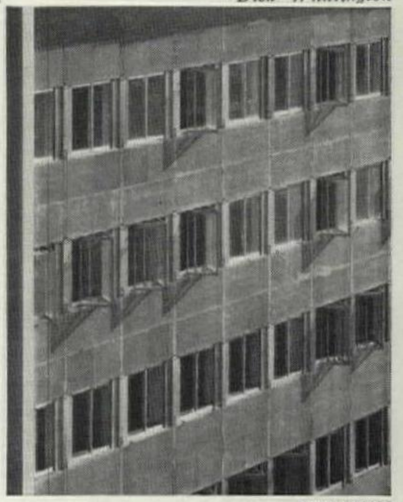


VITREOUS
Porcelain enameled panels

"Dick" Whittington

STONE
Marble slab inserts





CERAMICS
Terra cotta tile spandrels

FACING MATERIALS	APPEARANCE					PERFORMANCE		COST
	Color		Surface					
	Retains color	Choice of color	Choice of pattern	Shows oil canning	Shows glare	Weathering	Resistance to fire test	
ALUMINUM Type: Cast			Yes	No	Slight	Good	Fails	High
Extruded			Yes	No	Slight	Good	Fails	Medium
Sheet, flat			No	Yes	Slight	Fair	Fails	Low
Sheet, textured			Yes	No	No	Fair	Fails	Low
Finish: Natural	No	No			No	Fair		Medium
Alumilited	10 Yrs.	No			Slight	Good		Added
Porcelain enameled	Yes	Yes			Except white	Very Good		High
COPPER Type: Sheet, flat			No	Yes	No	Good	Fair	Medium
Sheet, textured			Yes	No	No	Good	Fair	Medium
Finish: Natural	No	Patina			No	Good		Medium
Lacquer	10 Yrs.	No			No	Good		Medium
CARBON STEEL	No	No	Varies	Varies	No	Poor	Poor	Minimum
PORCELAIN ENAMELED STEEL, flat	Yes	Yes	No	Varies	Slight	Very Good	Fair	Medium
Sheet with factory-applied concrete backing	Yes	Yes	No	No	Varies	Very Good	Fair	High
STAINLESS STEEL Type: Sheet, flat			No	Yes	Varies	Very Good	Very Good	Medium
Sheet, textured			Yes	No	No	Very Good	Very Good	Medium
Finish: Bright	Yes	No			Yes	Very Good		
Dull	No	No			No	Very Good		
CEMENT ASBESTOS	Yes	No	No	No	No	Fair	Very Good	Low
GLASS Type: Plain, transparent	Yes	No	No	No	Yes	Very Good	Fails	Medium
Wire	Yes	Limited	Limited	No	Varies	Very Good	Poor	Medium
Structural opaque	Yes	Yes	Limited	No	Varies	Very Good	Fails	High
Finish: Flat	Yes	Limited	No	No	Yes			
Textured	Yes	Limited	Limited	No	Varies			
MASONRY FACING 2" THICK								
Precast Concrete	Yes	Yes	Yes	No	No	Good	Good	Medium plus
Reinforced Brick	Yes	Limited	Limited	No	No	Very Good	Good	Medium
Terra cotta	Yes	Yes	Yes	No	No	Good	Good	Medium-high
Limestone	Yes	No	Yes	No	No	Good	Fair	Medium
Granite	Yes	Limited	Yes	No	No	Very Good	Fair	High
Marble	Yes	Limited	Yes	No	No	Good	Fair	Medium
Soapstone	Yes	Limited	Yes	No	No	Very Good	Very Good	Medium

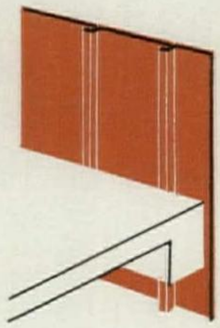
COSTS thickness and other properties of typical curtain wall construction systems, broken down by components

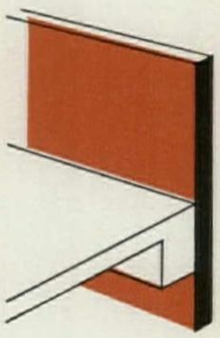
Since most of the advantages of thin, light-weight curtain walls hinge on the economics of construction costs and rental values, it is essential that architects, engineers and building owners who are contemplating the use of such walls have accurate information on the relative cost of various systems and comparative costs of conventional construction. Such comparisons, to be really reliable, must be made on the basis of actual prices for a given building, to be built in a given place at a given time. As a general guide to such comparisons, however, and in order to establish the broad outlines of the problem, the FORUM retained the Construction Survey Co. of New York, leading estimators, to prepare the cost estimates of various types of wall construction shown on this and the following two pages.

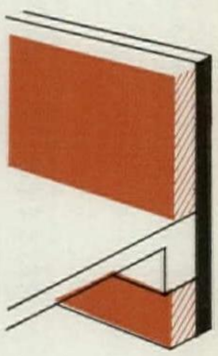
The portion of the table immediately adjoining, and on the facing page, shows the cost of the various *elements* used in thin curtain wall construction of various types—facing materials, erection, attachments, etc. Subtotals are shown for walls which, while complete in other respects, are not designed to meet a 2 hr. fire test, and on the right-hand portion of the chart the cost of the necessary back-up materials which must be added to produce a wall capable of withstanding such a test, the cost of the structure to support the wall, and the thermal insulating value achieved. On the following page these costs are summarized into *total construction cost*, *"rental value cost"* —the capitalized cost of the space the wall occupies— and *"total economic cost"*—the sum of first two figures.

Although these estimates have been checked by some of the leading authorities in the office building field, it must be borne in mind that the prices of each of the elements involved will inevitably vary in different parts of the country, and may vary in their relationship to one another as well as going up or down at different times in the building cycle.

To simplify comparisons, the FORUM'S figures are based on a curtain wall cantilevered from the face of the spandrel beam (see page 84), with the height of the wall from window head to window sill taken at 6 ft. 9 in. It has also been assumed, for the purposes of the cost study, that the space between one such spandrel wall and the one above will be filled by a continuous band of windows, and that the inside surface of the wall would not require finish for esthetic reasons since it would probably be covered by a continuous convector cabinet or air-conditioning cabinet (there *is* allowance for finish, however, on the inside surface of the wall between the head of the window and the ceiling). Prices in all cases are *per lineal foot of spandrel wall 6 ft. 9 in. high.*







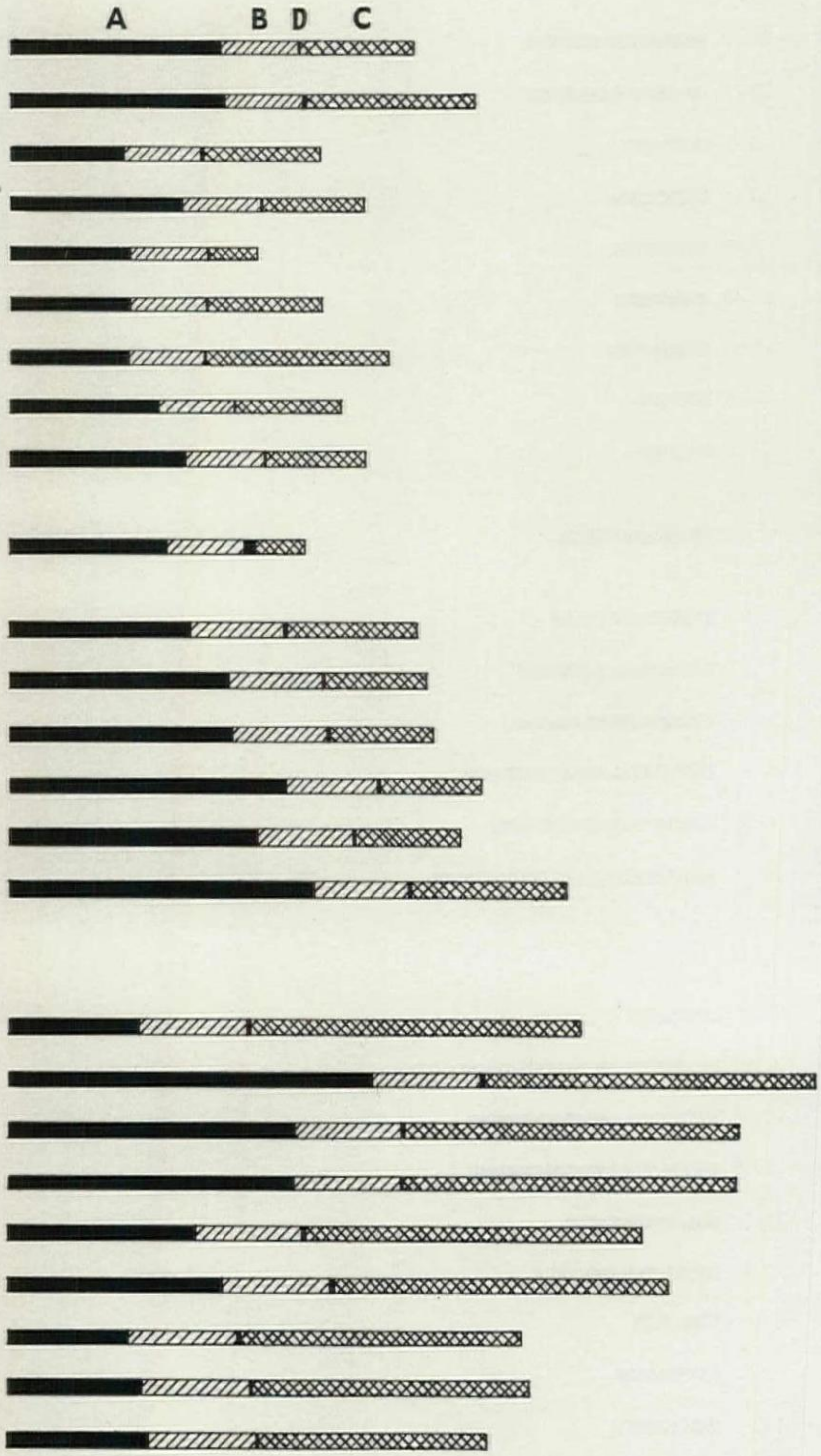
	DESCRIPTION		FACING		
	Thickness of Wall	"U." BTU.	Face Material F.O.B. Site $	Hardware for Attach. or Frame $	Window Head & Sill $
METAL PANELS					
Cast Aluminum	4"	.15	16.88	2.50	With Face
Cast Aluminum 2 hr. F. T.	6½"	.39	16.88	2.50	" "
Sheet or Extr. Aluminum	4½"	.30	5.66	2.50	" "
Porcel. Enamel Steel	4½"	.16	8.44	2.50	" "
Stainless Steel	2"	.15	7.28	2.50	" "
Stainless Steel 2 hr. F. T.	4"	.22	7.28	2.50	" "
Copper	7"	.22	6.75	3.50	" "
Stainless Steel & Concrete	4"	.12	3.38	2.00	" "
Stainless Steel, Concrete & Glass Sandwich	4"	.12	3.38	2.00	" "
GLASS WALL					
¼ in. Wire Glass	2"	1.13	8.44	6.75	—
MASONRY SLABS					
Reinf. Brick Masonry	4½"	.32	10.13	3.35	2.50
Precast Concrete	4"	.32	16.88	2.00	—
2 in. Limestone	4"	.32	13.50	3.35	2.50
2 in. Granite	4"	.32	20.25	3.35	2.50
2 in. Marble	4"	.32	16.88	3.35	2.50
2+2 in. Terra Cotta	6"	.32	24.30	3.35	2.50
MASONRY, METAL VENEERS with 8" Back-up					
4 in. Face Brick	13"	.34	3.38	—	5.25
4 in. Granite Veneer	13"	.35	30.38	—	5.25
4 in. Limestone Veneer	13"	.35	20.25	—	5.25
4 in. Terra Cotta	13"	.28	20.25	—	5.25
4 in. Cast Stone	13"	.35	10.13	—	3.25
Cast Aluminum	13"	.30	16.88	—	2.50
Sheet or Extr. Aluminum	11"	.26	6.75	—	2.50
Porcel. Enamel Steel	11"	.30	8.44	—	2.50
Stainless Steel	9"	.19	7.28	—	2.80

(1) includes plaster at ceiling at 23 cents per sq. ft.
(2) light weight concrete
(3) concrete sandwich
(4) does not meet 2 hr. fire test
(5) does not meet 2 hr. fire test without furring, lath and plaster

FACING		BACK-UP						
Erec- tion	Subtotal Face in Place	Thermal Insula- tion	Steel Inside Face	4" Cinder Block Back-Up[1]	Stl. Reinf. for Alum. Wall	Furring, Lathing, Plaster	Waterprf. Calking & Dampprf.	Total Cost 2 hr. F. T.
$	$	$	$	$	$	$	$	$
4.39	23.77	2.50	.75	—	—	—	—	27.02[4]
4.39	23.77	—	—	2.23	1.50	—	.71	27.73
2.70	10.86	.30	—	2.23	1.50	—	—	14.89
2.70	13.64	2.03	4.05	—	—	2.08	.71	22.51[5]
2.70	12.48	2.03	.75	—	—	—	—	15.26[4]
2.70	12.48	—	—	2.23	—	—	.71	15.42
3.38	13.63	—	—	2.23	—	—	—	15.86
3.38	8.76	—	—	10.13[2]	—	—	.71	19.60
3.38	8.76	2.03	—	11.25[3]	—	—	.71	22.75
5.06	20.25	—	—	—	—	—	—	20.25[4]
5.06	21.04	—	—	—	—	2.08	.71	23.83
5.75	25.63	—	—	—	—	2.08	.71	28.42
5.75	26.10	—	—	—	—	2.08	.71	28.89
5.75	32.85	—	—	—	—	2.08	.71	35.64
5.75	29.48	—	—	—	—	2.08	.71	32.27
5.75	36.90	—	—	—	—	2.08	.71	39.69
				8" Block				
.38	12.01	.30	—	2.88	—	—	1.59	17.01
.75	42.38	.30	—	2.88	—	—	1.59	47.38
.75	32.25	.30	—	2.88	—	—	1.59	37.25
.75	32.25	.30	—	2.88	—	—	1.59	37.25
.75	20.13	.30	—	2.88	—	—	.71	24.25
.39	23.77	—	—	2.88	—	—	.71	27.59
.36	11.61	—	—	2.88	—	—	.71	15.43
.70	13.64	—	—	2.88	—	—	.71	17.46
.13	14.21	—	—	2.88	—	—	.71	18.03

TOTAL COSTS for conventional and thin walls show that space saving has greatest effect on "economic cost"

	A	B (1)	C (2)	D (3)	
	Total Cost 2 hr. F. T.	Spandrel, Beam & Column	Rent Value Cost	Capital-ized heat loss	Total Economic Cost
METAL PANELS	$	$	$	$	$
Cast Aluminum	27.02 (4)	10.00	13.33	.23	50.58
Cast Aluminum 2 hr. F. T.	27.73	10.00	21.50	.59	60.30
Sheet or Extr. Aluminum	14.89	10.00	15.00	.45	40.34
Porcel. Enamel Steel	22.51 (5)	10.00	13.33	.24	46.08
Stainless Steel	15.26 (4)	10.00	6.67	.23	32.16
Stainless Steel 2 hr. F. T.	15.42	10.00	15.00	.33	40.75
Copper	15.86	10.00	23.33	.33	49.52
Stainless Steel & Concrete	19.60	10.00	13.33	.18	43.01
Stainless Steel, Concrete & Glass Sandwich	22.75	10.00	13.33	.18	46.26
GLASS WALL					
¼ in. Wire Glass	20.25	10.00	6.67	1.70	38.62
MASONRY SLABS					
Reinf. Brick Masonry	23.83	12.00	16.66	.48	52.97
Precast Concrete	28.42	12.00	13.33	.48	54.23
2 in. Limestone	28.89	12.00	13.33	.48	54.70
2 in. Granite	35.64	12.00	13.33	.48	61.45
2 in. Marble	32.27	12.00	13.33	.48	58.08
2+2 in. Terra Cotta	39.69	12.00	20.00	.48	72.17
MASONRY, METAL VENEERS with 8" Back-up					
4 in. Face Brick	17.01	14.00	43.33	.51	74.85
4 in. Granite Veneer	47.38	14.00	43.33	.53	105.24
4 in. Limestone Veneer	37.25	14.00	43.33	.53	95.11
4 in. Terra Cotta	37.25	14.00	43.33	.42	95.00
4 in. Cast Stone	24.25	14.00	43.33	.53	82.11
Cast Aluminum	27.59	14.00	43.33	.45	85.37
Sheet or Extr. Aluminum	15.43	14.00	36.66	.39	66.48
Porcel. Enamel Steel	17.46	14.00	36.66	.45	67.57
Stainless Steel	18.03	14.00	30.00	.29	62.32



(1) Allowance is made for the reduced cost of the structural steel frame in the case of the lighter walls. The figures used are based on a 20-story building with 25 ft. column spacing, and work out to $10 per lin. ft. of wall for the lighter walls and $14 per lin. ft. for the heavier walls.

(2) The "rental value cost" of each of the walls was computed as follows: the rental value of the floor space occupied by the wall was taken as $4 a sq. ft. per year—a realistic current figure—and this was capitalized by multiplying by 10 years, giving $40 per sq. ft. as the capitalized value of rentable space. On this basis, the space occupied by a 12 in. wall has a capitalized value of $40 per lin. ft., the space occupied by a wall 3 in. thick only $10.

(3) To show the effect of added heating costs, particularly in the case of the all-glass wall, an amount has been added to the economic cost of each of the walls corresponding to the average office building heating cost (in New York City) for a ten year period using steam supplied from a central source.

(4) Does not meet 2 hr. fire test.

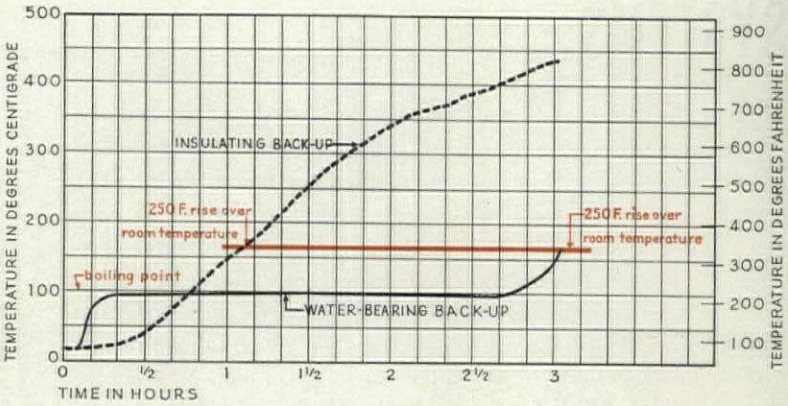
(5) Does not meet 2 hr. fire test without furring lath and plaster.

BACK-UP MATERIALS

Nowhere is the stultifying effect of the building-code fire test more evident than in the selection of back-up materials for the thin curtain wall which must meet code requirements. The reason for this has already been mentioned: there is a basic conflict between the properties contributing to good thermal insulation at normal temperatures and those required to produce a material capable of meeting the fire test. If the fire danger were real, this might be accepted as inevitable; since, in the case of the modern office building wall, it is largely imaginary, and since the protection the wall affords, if needed, is canceled by the nonfireproof windows, it is especially unfortunate.

The origin of this conflict lies in a peculiar physical phenomenon which enables some masonry materials to slow down the rate of heat transfer from the side of the wall exposed to the fire to the opposite side, because of the quantity of heat needed to evaporate the moisture present in the material in chemical combination with its other constituents. Until all of this moisture has been converted into steam, the temperature of the inside surface of the wall—away from the fire—does not rise above 212°, and thus remains well within the limit specified by most codes, which is usually a 250° F. rise over room temperature. Even a comparatively small quantity of constituent moisture is sufficient to delay the rise in temperature of the inside surface. Good thermal insulation, on the other hand, depends in most instances upon entrapped *air* which, while capable of delaying heat flow, does not have the property of putting a top limit on the temperature rise of the inside surface. Thus a wall which affords good thermal insulation may not heat up as quickly on the inside as one containing entrapped moisture, but it will heat up steadily, and go beyond the 250° F. limit well before the end of the test period.

The other property which enables a back-up material to satisfy fire-test requirements is sheer mass, resulting in a high "heat capacity" —the expression of the quantity of heat needed to raise its temperature a given amount. It is high heat capacity, for example which enables a brick wall to meet code conditions. But, unless the wall is separated from the inside of the building by insulation, this same property causes the brick wall to exert a drag on the heating system, making it slower to warm in the morning, and storing heat which may be given off needlessly at night.



CONTRASTING PERFORMANCE of basic types of back-up material under typical fire-test proceedure. Temperature of inside wall surface with water bearing material rises quickly to boiling point, then levels off until all water has been converted to steam.

Pound for pound, brick and other ceramic materials do not afford as much fire protection, as defined by the codes, as do the various forms of lightweight concrete and other cast materials such as gypsum block which frequently contain a good deal of water in chemical combination. At the other end of the scale the various forms of thermal insulation, being both light in weight and chemically dry are of least value, besides having the disadvantage of melting points, in most instances, that are below the temperatures to which they would be subjected in fire tests. For these reasons, it seems probable that the development of thin curtain walls to meet code conditions will center around the water-bearing materials, with perhaps the addition of a layer of thermal insulation, at least until these requirements are further modified.

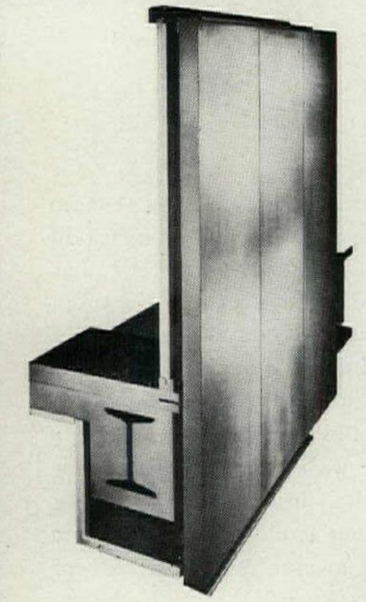
MATERIAL	GENERAL DATA			DATA ON 4 IN. CONCRETE BACK-UP					
	Aggregates								
	Wt. per cu. ft. lbs.	Cost per cu. yd. at points shown (1)	Concrete Mix & Comp. Strength per sq. in.	Wt. per cu. ft. lbs.	Wt. per sq. ft. lbs.	"U" Factor	Fire Test	Cost in place in wall (Incl. mortar or cement and reinforcing) (2) Blocks	Slab
Cinders	40—50	$1.50 to $3.00 at source	1c-2s-5ci or 1c-10ci 1100 lbs.	100—120	33—40	1.12	2 hr.	Mat. .20 Labor .20 Reinf. .65(3) $1.05	None
Expanded Slag	40—60	$2.50 to $4.50 at source	1c-4.9 fines— 5.25 coarse 700 lbs.	100	25	.51	4 hr.	Mat. .26 Labor .20 Reinf. .65 $1.11	None
Shale, Slate & Clay Base	$3.00 to $5.00 at source	40—60	1c-3.4 fines— 5.4 coarse 1000 lbs.	100	25	.75	4 hr.	Mat. .27 Labor .20 Reinf. .65 $1.12	None
Pumice	30—50	$1 to $4 at source St. Louis $ 7.50 Chicago 8.00 Pitts. 11.00 New York 12.50	1c-14 (3/8") 750 lbs. 1c-10 pumice 1000 lbs.	50 60	17 20	.23 .34	4 hr.	Mat. .34 Labor .20 Reinf. .65 $1.19	Slab .85 Labor .40 $1.25
Diatomite	28—40	$19 at source St. Louis $27.00 Chicago 26.00 Pitts. 34.00 New York 37.00	1c-6 (fines up to 3/8") 500/850 lbs.	55	18	.20	4 hr.	None	Slab 1.00 Labor .40 $1.40
erlite	5—20	New York $10.80 Pitts. 12.00 (approx.)	1c-7 to 1c-12 (fines up to 3/8") 800/1200 lbs.	55 40	18 13	.25 .19	4 hr.	Mat. .38 Labor .20 Reinf. .65 $1.23	Slab .85 Labor .40 $1.25
ermiculite	6—12	$9 to $12 at various pts. in U. S.	1c-4 240 lbs. 1c-8 70 lbs.	30 22	10 7.4	.20 .16	4 hr.	As Concrete or plaster	

Carloads or truckloads
Pittsburgh
Fire-resistant attachment

Chart prepared by: R. H. McClure

SYSTEMS

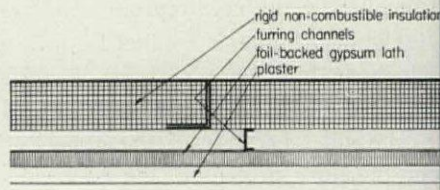
Most of the thin curtain wall systems developed to date, and all of the ones shown on this page, which have the more-or-less official sponsorship of various companies, use metal for the outside facing, either stainless steel, aluminum, copper or carbon steel. Only about half were designed originally to meet city code conditions; the balance have either been adapted to meet the fire-test requirement, or are not designed for this purpose. Taken as a group, the systems shown are remarkable for the variety and ingenuity in which the various problems inherent in thin curtain wall design are solved. Further rapid evolution can be expected from continued development research.



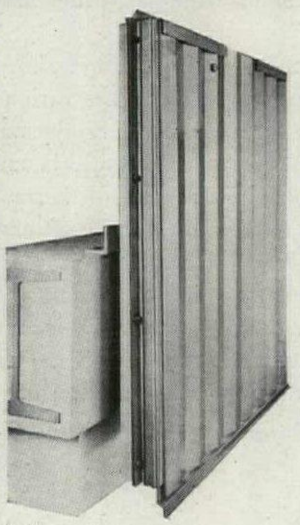
ALLEGHENY LUDLUM

Facing and back-up: flanged, stain-less steel panels, 2 in. deep, with fac-tory-poured calcium hydrosilicate in-sulation 2 in. thick. Inside finish: fur-ring, lath and plaster or foil-backed plaster board and plaster to main-tain stiffness of return edges of pane flanges and to meet fire test fron inside.

Allegheny Ludlum Steel Corp., Pittsburgh, Pa



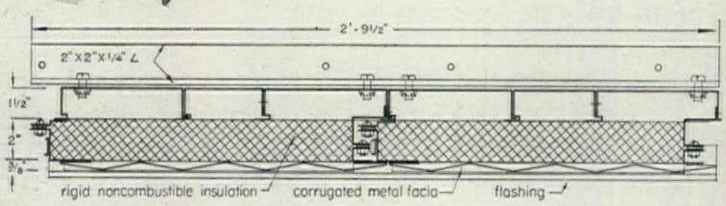
Expected to meet 2-hour fire test.



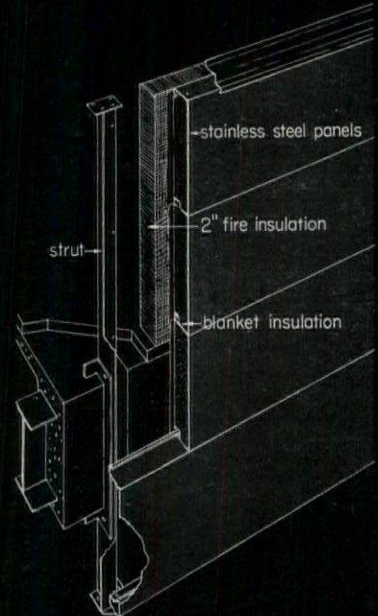
REPUBLIC

Facing, back-up and inside finish: stainless steel face backed with rib-reinforced panels of carbon steel with two-piece flanges to isolate front and back surfaces, and containing 2 in. of fire insulation. Metal panels form inside finish, may be painted direct.

Republic Steel Corp., Cleveland, Ohio.



Expected to meet 2-hour fire test.

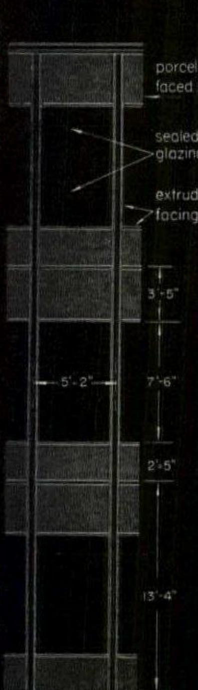


ARMCO

Facing: flanged (vertical or horizo tal) self-framing stainless steel pane Principal feature is simple joint a connector system. Back-up: any su able fire insulation, 2 to 3 in. thi Inside finish: optional.

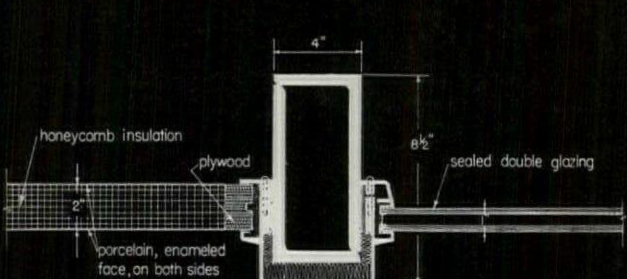
Armco Steel Corp., Middletown, Ohio.

Expected to meet 2 to 4-hour fire test.

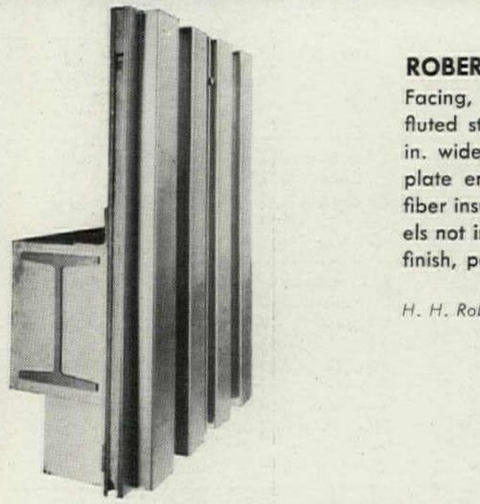


U. S. PLYWOOD

Facing, insulation and inside finish: factory-fabricated panels with porce-lain-enameled steel facings bonded to honey-comb insulating core. Inner and outer facings not in contact. Panels set in frame formed by in-sulated, extruded-aluminum column covers. Panel designed by Saarinen, Saarinen & Associates for General Motors Center, Detroit and engi-neered by *U. S. Plywood Corp., New York.*



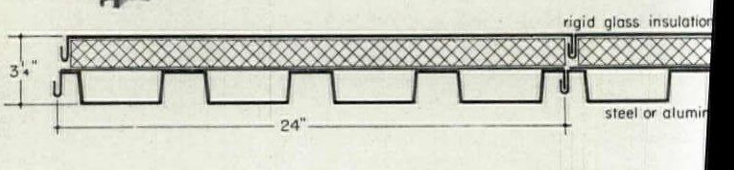
Incombustible; not designed to meet fire test.



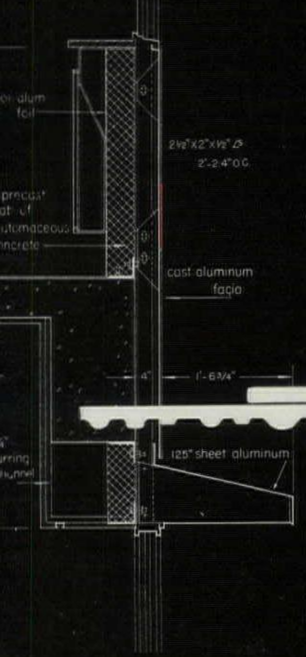
ROBERTSON

Facing, insulation and inside finis fluted steel or aluminum panels, in. wide, backed with flanged ste plate enclosing 1½ in. rigid gla fiber insulation. Inner and outer pa els not in contact. Panels form insi finish, painted direct.

H. H. Robertson Co., Pittsburgh, Pa.



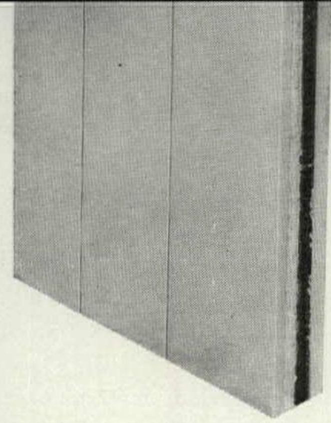
Incombustible; not designed to meet fire test.



ALCOA

Facing: ribbed cast aluminum, lugs bolted to vertical angle stiffeners. Back-up: precast diatomaceous concrete, 4 in. thick. Inside finish: aluminum foil, 1/1,000 in. thick, cemented to back-up with bituminous cement, provides vapor barrier. Covered by continuous convector enclosure. Designed by Thomas K. Hendryx, architect, for Bradford, Pa. hospital and engineered by *Aluminum Company of America, Pittsburgh, Penna.*

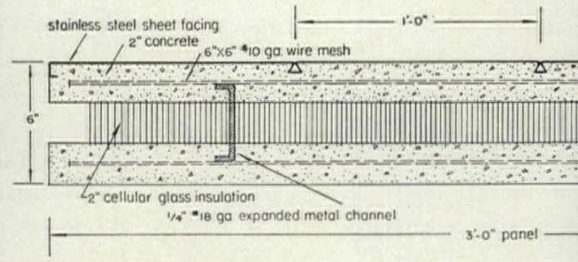
...ets 4-hour fire test.

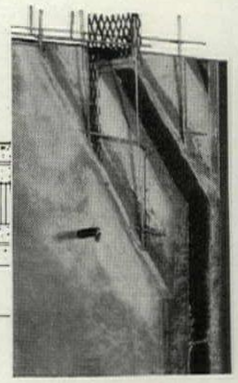


CRUCIBLE

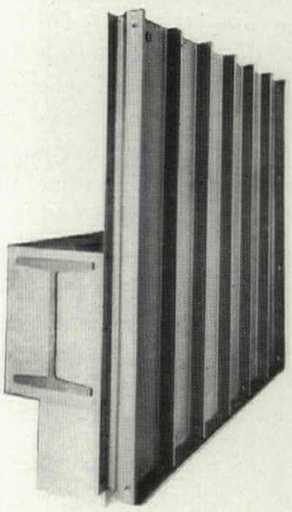
Facing and back-up: flanged stainless steel face integral with factory or site-fabricated sandwich consisting of cellular glass insulation between 2 layers of concrete with connecting reinforcing. Inside finish: inside surface may be painted direct.

Crucible Steel Co. of America, New York, N.Y.





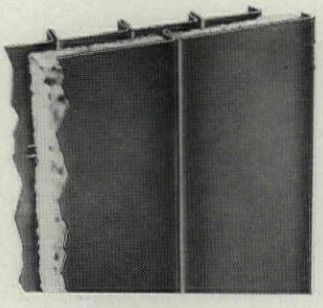
Meets 4-hour fire test.



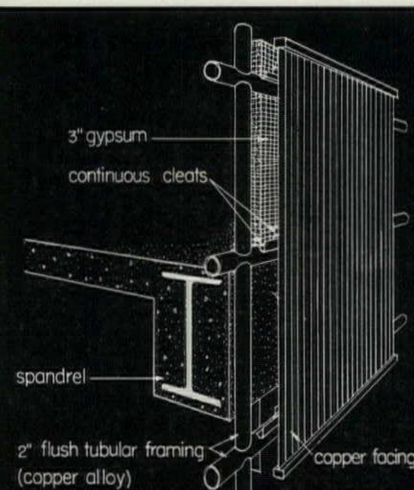
MAHON

Facing, insulation and inside finish: spaced, flanged panels of carbon or stainless steel or aluminum, containing glass fiber insulation (no fire-resisting back-up). Pans may be arranged as shown, with one set of flanges projecting, or with both sets of flanges turned in. Inner pan has factory applied finish.

The R. C. Mahon Co., Detroit, Mich.



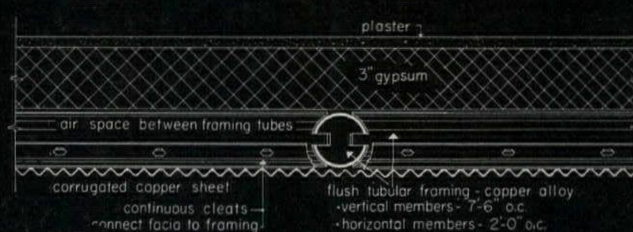
Incombustible; not designed to meet fire test.



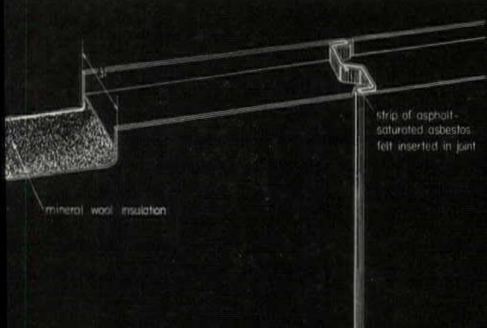
AMERICAN BRASS

Facing: ribbed copper panels, trimmed with extruded bronze, attached to tubular copper alloy frame. Back-up: gypsum block, 3 in. thick. Inside finish: plaster.

The American Brass Co., Waterbury, Conn.



Expected to meet 2-hour fire test.

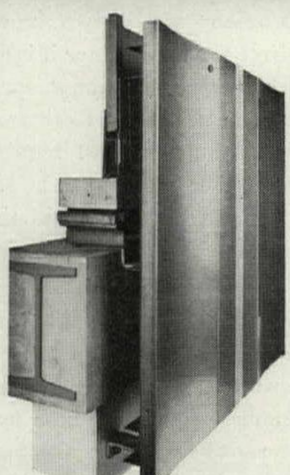


FENESTRA

Facing, insulation and inside finish: double, interlocking flanged panels of steel or aluminum (or combination of both), with panels separated by asphalt saturated felt to avoid through-wall contact, factory-inserted insulation; panels 3 in. thick. Panels can be used horizontally or vertically, available up to 14 ft. long.

Detroit Steel Products Co., Detroit, Mich.

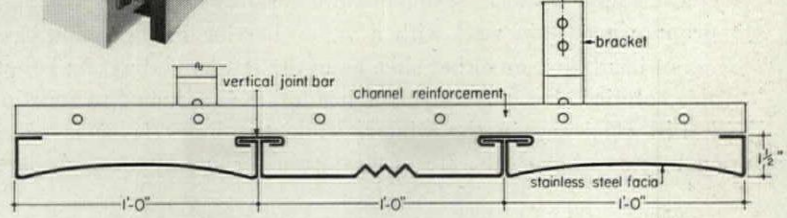
...mbustible; not designed to meet fire test.



CARNEGIE-ILLINOIS

Facing: stainless steel pans reinforced with horizontal carbon steel channels. Back-up and inside finish: optional. Sample illustrated shows steel panel back-up forming inside finish, cavity for optional insulation and/or fire protection to meet fire tests.

Carnegie-Illinois Steel Corp., Pittsburgh, Pa.



Incombustible; not designed to meet fire test.

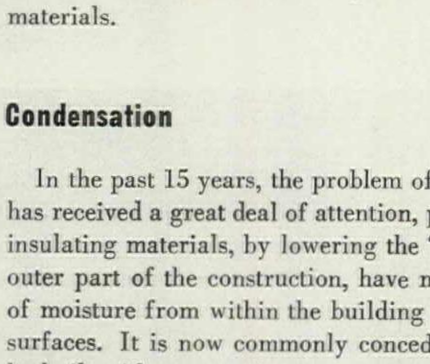
TECHNICAL PROBLEMS

Every radical change in construction method brings with it a host of new problems—or rather, old problems in new forms. The thin curtain wall is no exception. Internal condensation may be a problem, for example, in walls of all types. In many curtain walls, where the outside surface is formed of a vapor-impervious material such as metal, this problem becomes more acute than when the outer surface is relatively porous, as is true of masonry. The same is true of problems arising from expansion and contraction, moisture penetration, methods of erection, fastening and so on.

In an industry as wedded to empiricism as is building, new and untried methods have a special handicap, since new development must be guided, at least at first, by theory rather than by experience. Like Ceasar's wife, they must be above suspicion. Problems must be solved which are not even acknowledged to exist in the case of "accepted" materials.

Condensation

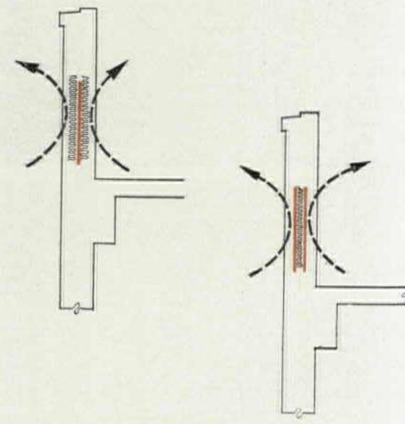
In the past 15 years, the problem of internal condensation in walls has received a great deal of attention, primarily because more efficient insulating materials, by lowering the "operating temperature" of the outer part of the construction, have made possible the condensation of moisture from within the building on the inside of the outer wall surfaces. It is now commonly conceded that insulated walls should be built with a vapor-impervious membrane on the warm side of the insulation, and ventilated on the cold side if possible. The first of the diagrams below shows the principles involved, as well as the theoretical relative vapor pressures on the two sides of the wall under winter heating conditions. With increased use of summer air conditioning, however, the question arises as to what should be done under conditions of summer cooling, when the warm side of the wall becomes the cold side, and vice-versa. This is illustrated in the second diagram.



As the arrows showing the relative vapor pressures indicate, the summer problem is not so great as is the winter problem; moreover, there is no danger of freezing, as is true in winter.

Where code requirements include the fire test, both problems are likely to be entirely academic, since it is unlikely that additional space will be sacrificed to thermal insulation once test requirements have been met, and consequently unlikely that the curtain wall will be sufficiently well-insulated to create a condensation problem.

Where the wall is not designed to meet a fire test, on the other hand, it is very likely to contain enough thermal insulation to raise the question of internal condensation in winter, and with the likelihood of summer air conditioning in summer as well. These considerations have led at least one manufacturer of insulating materials to propose a curtain wall with a vapor barrier in the center, and layers of insulation on either side, as in the left-hand diagram below. In this solution, the outer layer of insulation is assumed to function with full efficiency in the winter, while the inner layer is relied upon to slow down the rate of heat transfer in summer. Another way of accomplishing the same purpose is shown in the right-hand diagram, which pictures a wall in which the insulation is contained in a vapor impervious wrapping on both sides. The trouble with this solution, of course, is that if the vaporproof wrapping fails at any point the entering moisture will be trapped and will thus accumulate until the insulation is thoroughly saturated. It thus



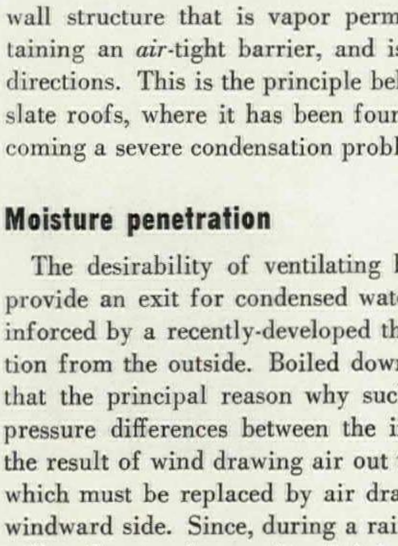
requires either a hermetically-sealed wall, or a type of insulatio which is in itself impermeable to vapor throughout its structure.

One moral to be drawn from all this theory is the desirability o ventilating behind the outer surface of the wall, especially whe the outer surface is metal, and thus vapor-impervious. It has bee shown that such ventilation has little or no effect on the total insulatin value of typical wall constructions, while providing a reliable guar antee against the harmful *accumulation* of condensed moisture withi the wall. Carrying this principle still further, it may very well be tha the ultimate solution of the condensation problem will be found in wall structure that is vapor permeable throughout, although con taining an *air*-tight barrier, and is thus able to "breathe" in bot directions. This is the principle behind the use of roofer's felt unde slate roofs, where it has been found to be the best method of over coming a severe condensation problem.

Moisture penetration

The desirability of ventilating behind the outer wall surface t provide an exit for condensed water vapor of internal origin is re inforced by a recently-developed theory regarding moisture penetra tion from the outside. Boiled down to its essence, this theory state that the principal reason why such water enters a vertical wall i pressure differences between the inside and the outside which ar the result of wind drawing air out through the cracks on the lee sid which must be replaced by air drawn in through the cracks on th windward side. Since, during a rain storm, the latter are covered b a film of water, the entering air brings water with it, causing leaks.

An easy way to avoid this difficulty, according to latest theorie is to create a cavity to act as a sort of buffer state within the wal sufficiently open to the outside so that its pressure will rise to nearl the point of the outside pressure. In this method, shown in diagram

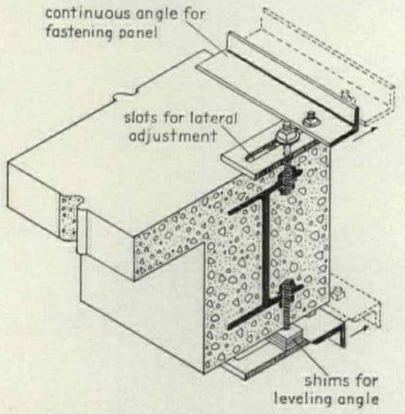


form on the right, the oper ings to the outside are delib erately made large enough s that they cannot become co ered by a water film, but a sheltered from direct rai drops and water runnin down the outer surface of th wall. Since it is a relative easy matter to provide suc a cavity with weep holes let out any water whic comes in, these are usual provided, thus incidental guarding against any conti gency which might arise he water should refuse to comply with the suction theory on which he ventilation is based.

A good example of a wall designed in accordance with this heory is the aluminum faced curtain wall shown on page 91, in which the space formed by the ribs of the aluminum panels becomes uch a ventilated "buffer state" between the outside and the inside, r, if you prefer, a vertical watercourse down which any water penerating the outer surface is led back to the outside. The big advanage of such a wall structure is that it does not require outside alking—a big expense in the case of tall office buildings—and ermits a consistent design in which the already well established ractice of applying spandrel waterproofing to the face of the spanlrel beam *within* the wall is tied in with an *internal* barrier unning from window head to window sill. It also combines very onveniently with many of the typical wall panels used in thin urtain wall construction.

Erection and fabrication

Most of the thin curtain walls developed to date consist at least in art of relatively precise, prefabricated units which must be comined with minimum tolerances and in accordance with a predeterined pattern. Since even a steel-frame building is still very far rom being a precision machine, this calls for considerable leeway n the attachment of such panel systems to the fireproofed frame. Various attachment devices have been devised which provide for as nuch as 2 in. variation (plus or minus 1 in.) both vertically nd horizontally, between the panel system and its support, and some uch attachment is essential, at least in the case of metal panels which o not provide for a cumulative adjustment in their assembly.



DJUSTABLE ATTACHMENT DEVICE or providing vertical and horizonal leeway in fastening curtain wall anels to structural frame.

heoretically a back-up consisting of large sized precast units should how a considerable saving in labor over a back-up wall built of mall masonry units. Although such precast units have shown savngs in factory buildings and two-story housing projects specifically esigned for their use, cost figures from actual jobs do not indicate preponderant price advantage for precast slabs when these units ave to be reinforced to withstand a 30 lb. wind load. There are everal reasons why the costs and the prices obtained to date do not how the theoretical savings which might be expected of large units. he principal reason is probably that which applies to any new onstruction method: an allowance must be made, in the first intance, for unknown contingencies, educating the workmen, etc. ther reasons include the difficulty, in multistoried office buildngs, of handling large back-up units on construction elevators. ypsum, cinder or lightweight-aggregate blocks can be much more fficiently handled than large slabs under normal construction conitions. Another factor of considerable importance is the competion which exists between the suppliers of traditional materials hich helps to keep prices down, whereas slab production has not rogressed to the point where a standard product is produced by everal competing companies.

Reliable cost and price data seem to indicate that if a large-sized lightweight slab is to be used in conjunction with a surface material, it is more economical to combine the two at the plant, rather than have two separate erection operations. The purpose of the facing material, in such cases, is to give a waterproof, attractive surface to lightweight, permeable insulating concrete. The back-up furnishes the thermal and fire insulation, and may also provide the necessary stiffening in the case of aluminum which melts at fire-test temperatures. (In this case a layer of bitumen is provided between the aluminum and the concrete, to prevent a reaction between the two materials). Other possible facings include porcelain enamel, stainless steel, terra cotta and brick. Aside from lightweight concrete, there are several other possible approaches to the large-slab curtain wall unit. One, which may well have an important place in future thinwall construction, is a sandwich composed of noncorrosive metal face backed with 1½ to 2 in. of concrete, 2 in. of thermal insulation, and 1½ to 2 in. of concrete, with the inner and outer concrete layers connected by reinforcing webs. The thermal insulation used in this unit is foam glass, which has the advantage of being impermeable to vapor penetration from either side of the wall.

Another system, offering a compromise between the large-sized prefabricated slab and metal spandrels backed-up with conventional masonry, is a metal pan unit approximately 2 in. deep and 16 to 24 in. wide, extending vertically from window head to window sill, and filled with lightweight, semi-structural insulating material at the plant. The factory-poured fill may be calcium hydrosilicate, lightweight perlite concrete, or cement-bonded vermiculite. Pumice aggregate might also be used, but its high strength characteristics are not as important in this application as its fire-resisting qualities. There are still other lightweight concretes suitable for this purpose.

The function of such a filler is primarily to increase the fire resistance of the wall and secondarily to stiffen the metal pan units. With this type of construction, it is obvious that the inner edge of the metal pan will exceed the temperatures permitted under the regular fire test early in the test period, due to the high heat-conductivity of the metal. For this reason, such walls require an inner finish consisting of furring, lath and plaster (with the plaster containing wood fiber or lightweight aggregate to increase its fire-resistant properties) or fire resistant insulating board. The added cost of the lightweight panel fill, and the necessary furring, will each run about 30 cents per sq. ft.

Beating the law

So long as our building codes contain the basic inconsistency of permitting a nonfireproof window of any size, but requiring fireproof walls, this will provide a powerful incentive for making office-building walls entirely of glass, in the manner of the walls of the U.N. Secretariat. Another way in which this inconsistency may be turned to advantage is by employing the common-sense argument that since an overall window is permitted anyway, thin walls which are demonstrably safer than window glass should also be permitted. This argument was employed successfully in the case of the Federal Reserve Bank office building annex in Detroit (see p. 116). Here the walls consist of a facing of 1½ in. of marble, backed with 2 in. of foam glass, held in a two-way steel channel frame attached to the outer face of the building frame. The inside surface of the wall, being covered by a convector cabinet, is left unfinished. This construction gives some idea of the thin curtain wall of the future, which should materialize just as soon as building departments in other cities decide to adopt the approach used in this instance in Detroit, and designers are free to devise the most rational, rather than the most expedient solution of the technical problems involved.

APPEARANCE

There is no inherent reason why thin curtain walls should look any different from the outside than many walls which employ the conventional back-up of 8 in. of masonry. Metal facings are already widely used for such conventional walls; conversely, thin walls can be constructed using conventional facing materials such as limestone, brick and terra cotta in new ways, but without affecting their exterior appearance.

Where the facing happens to be metal, the thin curtain wall presents certain problems which are common to all such uses of metal facing materials: problems involving the surface texture and profile of the metal face, avoidance of excessively shiny surfaces, "oil canning" etc. And, in common with other office building walls, thick or thin, it presents the problem of what sort of overall pattern is to be created: vertical or horizontal "stripes," a "plaid" having neither vertical nor horizontal emphasis, the smoothest possible surface or one which expresses the steel-cage frame.

Since the trend in such designs, whatever pattern is striven for, is distinctly away from any effort to make the wall appear massive, and towards a true expression of its real nature as an enclosing membrane, there is no conflict between any of the various design approaches and the thin curtain wall—in fact, the thinner walls are what is being "expressed" whether or not they are actually being used. And even if this were not the case, it would still be possible to create, with a thin curtain wall surface, the visual illusion of massive piers so popular in the Twenties, with the same sacrifice of rentable space always associated with such effects, but with the same relative increase in rentable area for the thin wall over one of conventional thickness. Thus, so far as the overall effect of the thin curtain wall is concerned, the designer is presented with much the same problems, and free to employ the same solutions, as would be true with any other type of wall structure.

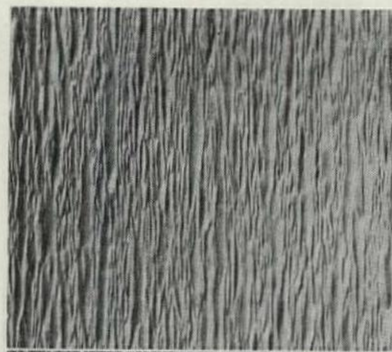
There are, of course, design opportunities above and beyond this. One of these is the opportunity to employ color, with the assurance of easy maintenance, which porcelain enamel and several other special finishes for metal panels afford. Another is in the use of decorative patterns and ornament, which, in the case of thin metal panels are functionally necessary to stiffen the surface and avoid "oil canning." One of the handsomest office buildings so far constructed—the Equitable Savings & Loan building in Portland, Ore., designed by Pietro Belluschi, employs a facing of contrasting cast and sheet aluminum panels to create a pattern which emphasizes the structural frame—in this instance reinforced concrete—and provides an ideal foil for the blue-green of the large panels of fixed heat-absorbing glass which constitute the fenestration.

The thing which the Equitable Building demonstrates with great clarity is that it is the imagination and skill of the architect, rather than the supposed limitations of any construction material or method, which determine the ultimate success or failure of such a design. It also shows in a very pure form how much can be accomplished through the avoidance of any visual symbols suggestive of weight, an objective which is, of course, highly appropriate to thin curtain wall construction.

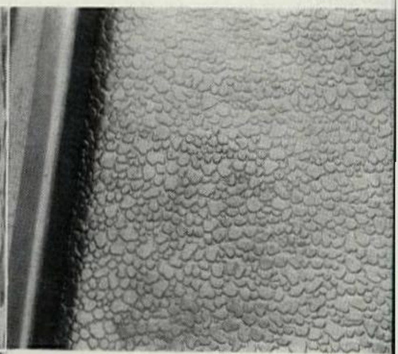
Before this article went to press, FORUM *submitted the text to various industry leaders—primarily producers and users of curtain wall materials—for their comments. Despite their understandable complaints that too little attention was paid to the materials and methods in which they have proprietary interests, practically all of these curtain wall experts endorsed heartily the article's underlying purpose and its broad conclusions.*

A summary of their comments begins on the facing page.

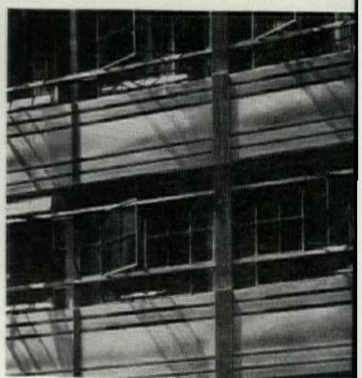
STAINLESS STEEL



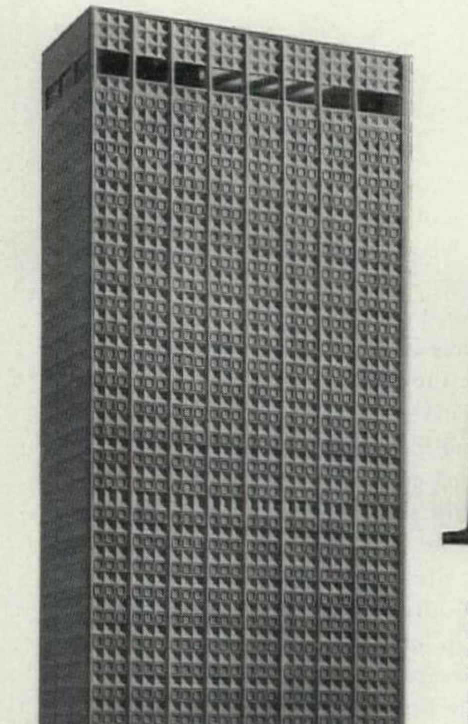
ALUMINUM



COPPER



SURFACE TEXTURES for sheet metal facing materials eliminate shiny reflections and obviate "oil canning" effect (right).



Photos: Newman Schmid

MODEL AND MOCK-UP of propose new office building for Aluminu Company of America (Pittsburgh designed by Harrison & Abramovi in association with Altenhof Bown, Inc. and Mitchell & Ritche Inc., show effect of stamped alum num sheet in inverted pyramid pa tern.

TWO HANDSOME BUILDINGS of very different appearance which employ thin curtain walls are the Equitable Savings & Loan building (Portland, Ore.) (above), Pietro Belluschi, Architect, and the Alcoa Administration Building (Davenport Iowa), Harrison & Abramovitz, Architects.

Photos: Roger Sturtevant; Photography, Inc.

INDUSTRY'S COMMENT

Forum:

Thank you for giving me the opportunity to examine the text and tables of the article on curtain walls. The various collaborators on this thoughtful and somewhat all-embracing symposium on the subject are to be congratulated. They have succinctly stated the facts of the case and presented therewith useful tabulations to guide architect, engineer and financial interests in their preliminary thinking on prospective building projects.

Individuals and groups will, without question, find fault with some of the statements made and with tabulated figures and comments. I, too, would question certain specific sentences, comments and items, taken alone. However, the readers to whom this material is directed primarily will recognize it as an able and honest effort to present a general picture of a current particular problem.

For example . . . I would be inclined to approach conservatively the "building code" situation—advances are being made against older, unrealistic regulations, and building commissioners, in general, do take their responsibility for protecting lives and property seriously, as they properly should—Mother Nature and other not-completely-predictable factors do not always operate within charted minimums and maximums. Good safety factors are still good insurance, in my opinion. In reference to the commentary on the first diagram on page 92, it should be pointed out that a *non* "sufficiently well-insulated" curtain wall will, at times, have a wet interior surface, with consequent unsatisfactory effects.

The tabulation of various exterior facings as to *Appearance*, *Performance* and *Cost* is, I think, an over-simplified presentation of a great deal of information, which may mislead some too-casual readers into difficulty—to reduce comment to a word or two is an invitation to criticism.

Richard A. Biggs
Director of Architectural Development
Stainless Steel Division
Crucible Steel Company of America
New York, N. Y.

Forum:

We know that this article will prove of great value to all concerned and should result in more permanent easily maintained buildings.

In your discussion of building codes, why not stress the point that the building codes have been changed from 4 hr. exterior walls to 2 hr., wherever unprotected window openings are permitted and, in at least one city, Pittsburgh, the code reads, "1 hr. exterior walls are permissible if the opinion of the Board of Standards & Appeals is that no undue hazard is deemed to exist." Manufacturers of building materials are becoming vitally interested in the building codes of the country as attested by the number of tests performed by the Bureau of Standards and the Underwriters' Laboratories as well as the wide attendance at the Building Officials Conference of America—Basic Code meetings.

A study of past disasterous fires shows clearly that a properly fireproofed structural framework will come through a damaging fire despite the fact that from 25 to 50 per cent of the exterior walls were thin glass windows which lasted only a few minutes.

Under the subject of *Why Curtain Walls*—there are a number of very important advantages in this type of construction which should not be overlooked:

During construction the minimizing of traffic problems for wall materials using lightweight large panels; elimination of wet construction; elimination of hundreds of miles of joints which are incipient points of failures from water absorption; the use of completely nonporous surfaces; steel surfaces permit no water absorption . . . which adds unbalanced weight during rains; no problem of dust or dirt going through the wall, through the cracks or air spaces; no problems of chipped materials falling on by-passers; the elimination of calking costs; practical elimination of maintainance costs; presentation of a material to the building industries which can be easily cleaned, an additional sales advantage; extreme long life of stainless steel and porcelain enameled steel; these materials will be ideal for complete air conditioning and even pressurizing a building to entirely eliminate dirt and dust; the ease of erecting this type of construction will consume less time on the job thus saving money for the owner; steel walls do not store heat . . . the ease of calculating the strength of sections assists in design; the complete uniformity of materials available in steel assists in design and cost estimates.

In our opinion, too much space is given to the subject of rental costs. The real advantage of steel exteriors is not the small saving made in rental cost, but more particularly in the ease of construction and in the long trouble-free life of stainless steel and porcelain enameled walls.

CARL F. BLOCK
Development Representative
Carnegie-Illinois Steel Corp.
Pittsburgh, Pa.

Forum:

The costs shown seem to be largely theoretical and, with the exception of the relatively few conventional types of constructions, apparently are not based upon construction experience. Certainly, the "rental value costs" of the walls are open to question and might be expected to vary greatly with different designs.

On the subject of costs, as well as building codes, I cannot concur with the broad generalization which the article makes. Frankly, the article impresses me as a studied effort to prove a preconceived conclusion: that thin panel walls are more suitable for use in skeleton frame construction than masonry walls. While it is quite possible that the occupancy and esthetic requirements of certain structures can best be met with thin panel walls, such use should, in my opinion, be based upon a study of the requirements for the individual structure, including costs, rather than upon broad generalities.

HARRY C. PLUMMER, *Director*
Engineering and Technology
Structural Clay Products Institute
Washington, D. C.

Forum:

A wall is a wall is a wall. I am sure that Gertrude Stein never realized that the FORUM would amplify so fully on this subject.

May I congratulate you not only on the amplification but also on the manner in which you have so ably posed the problem. To put it mildly, I believe that you have "covered the waterfront" on this challenging problem and hope that it will stimulate architects, engineers, industry and building codes towards a concerted action "to do something about it."

Leaving out the 3 in. or 4 in. sandwich which I believe to be still in the stage of research, I do believe it possible to reduce the wall to 6 in. or 7 in. However, the convector or air conditioning unit is still a pretty deep affair using floor space so that perhaps it is up partly to the mechanical engineer (not mentioned in your article), to find more effective use for his equipment which uses space not only on the perimeter, but in the interior also. It is customary to rent space in office buildings with the tenant paying for fan room areas on the interior. Are not the convector and cooling areas under the window somewhat in the same category? I am, frankly, not too impressed with arguments of "rental value cost" in connection with wall thicknesses until these other factors can be solved too.

Why not concentrate on a wall panel which can sit on the sill as does a window and with the same legal status? Incidentally, this might solve the battle of too much or too little light. Why not let the tenant design his space by making an insulated panel inter-changeable with a window? It certainly could be easily handled architecturally. At the same time why not also concentrate on the spandrel using durable metal to resist fire and wind, along with some proven type of back-up?

May I again congratulate you on getting our backs up!

ROBERT ALLAN JACOBS
Kahn & Jacobs, Architects
New York, N. Y.

Forum:

The use of lightweight curtain walls can result in some indirect savings not explicit in your article. Curtain wall units of the sort under discussion lend themselves to a much greater degree of sub-assembly than is possible in standard types of construction; they permit the omission of wet materials and as a result hasten the completion time of a structure. The logistics involved in the transportation and storage of prefabricated units can be more orderly and more carefully calculated than for a combination of small, large and plastic materials.

If the time for constructing a building can be reduced, temporary financing costs can be reduced, collection of rents can be started at an earlier date and the builders can profit by more rapid turnover of labor and materials.

Cost of temporary financing of a 25-story office building, plus an earlier rental date, could amount to as much as $4,000 per day.

EDWARD X. TUTTLE, *Vice President*
Turner Construction Co.
New York, N. Y.

Forum:

I am very well impressed with the presentation.

In this age of machines and metals it is wholly logical that the exterior surfaces of buildings, particularly those of skeleton frame construction, should be of metal. The chief obstacle to progress in that direction at the present time is the antiquated building code. By publishing an article on curtain wall construction, FORUM will awaken the architectural profession, the building industry, and building officials to this realization. What is more, it will also inspire the designer and inventor to work out details of construction for metal exterior wall coverings that will endure the service life of the building with ample strength and rigidity, being reasonably safe against fire and permanently storm tight. In addition, the facing will need to be free of unsightly buckling and the material must lend itself to a durable color treatment or to the application of color.

HENRY E. VOEGELI, *Development Engineer*
The American Brass Co.
Waterbury, Conn.

Forum:

Your constructive article on panel wall construction should be helpful in calling attention to the need for rationalizing building code requirements that make outmoded procedures mandatory. One gets the impression, particularly from the latter part of the article, that modification of building code requirements is being advocated in order to favor or allow the use of certain materials. This approach is not too convincing; a building code must concern itself primarily with safety, not with broadening the use of materials, however desirable that may be costwise. The article would be more convincing if it were made clear that the severity of the potential fire hazard which prevails does not require the high degree of fire resistance specified for exterior walls by the early codes and that reduction in the code requirements—and in building costs—therefore can be affected with no real loss of fire safety. Code requirements for walls are based on past practices in wall construction and a reluctance to depart from the past—not on actual hazards. It follows that through appropriate reduction in code requirements to make them consonant with actual fire hazards, materials now available, having desirable properties, would qualify for use. In the presentation of the article, the emphasis seems to be in the wrong place.

It is essential that spandrel or panel walls be adequately attached to the structural frame of a building so that there is no chance of their becoming detached during a fire. It is also desirable that the spandrel or panel wall remain intact and prevent the passage of flame, but it is doubtful whether there is any need for limiting heat transmission to the 250° F. rise in temperature criterion of the standard ASTM Fire Test Specification. Possibly, a special standard for testing spandrels will have to be developed by the ASTM. I mentioned this possibility at meetings of ASTM Committee E-5 earlier this week in Pittsburgh. Heat will be transmitted through the glass window above the spandrel wall much more quickly than through the wall itself. Manufacturers of spandrel walls are having difficulty in devising joints in spandrel walls that will meet the heat transmission limitation of the standard fire test without adding unduly to cost. Paradoxically, this is a feature that is of minor importance so far as fire safety is concerned.

The basic fire-safety function of the exterior walls of a building is to prevent the entrance of fire from outside exposures. Fire protection authorities recognize today that relatively small distances of separation effect a substantial reduction in the severity of fire exposures. It would appear that spandrel walls of 1-hr., incombustible construction would afford reasonable fire safety in any locations where the building code permits windows to be installed. It, therefore, seems undesirable to give the impression that a 2-hr. requirement is the proper one for spandrel walls. That requirement represents the first step in rationalizing code provisions and in reducing the old 4-hr. requirement toward 1-hr., which probably will eventually become the standard requirement for nonload-bearing panel walls.

In discussing costs and construction advantages, speed of erection is a factor that might be stressed. The erection of walls made up of millions of small masonry units—at increasing cost from year to year—merely for the purpose of providing shelter and a reasonable degree of fire protection, seems fantastic in this day and age.

B. L. WOOD, *Consulting Engineer*
American Iron and Steel Institute
New York, N. Y.