

ENGINEERING FOR ARCHITECTURE 1981

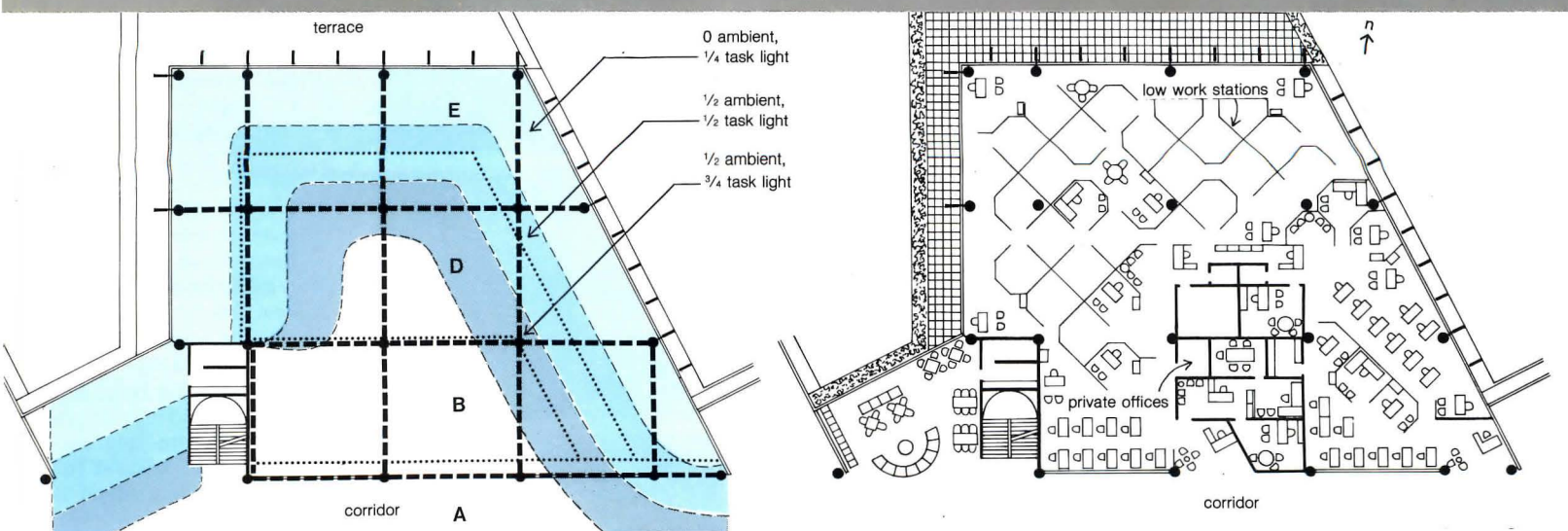
ARCHITECTURAL RECORD

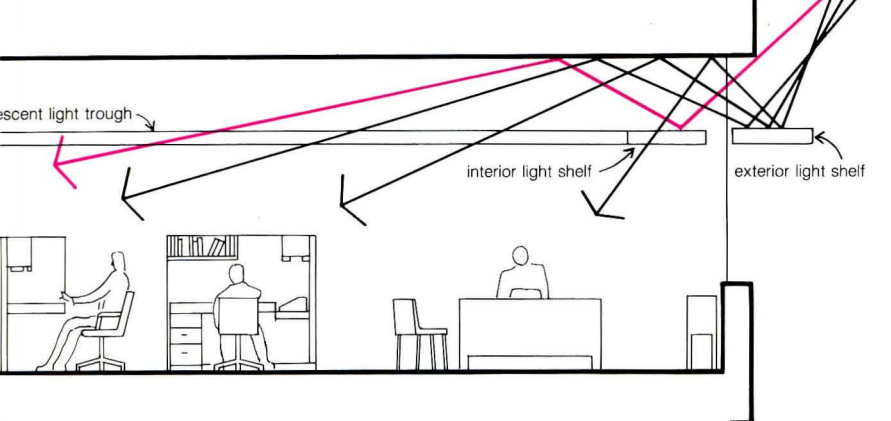
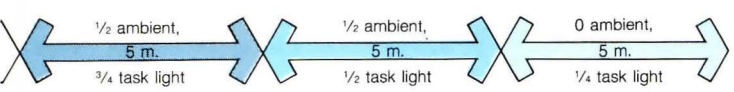
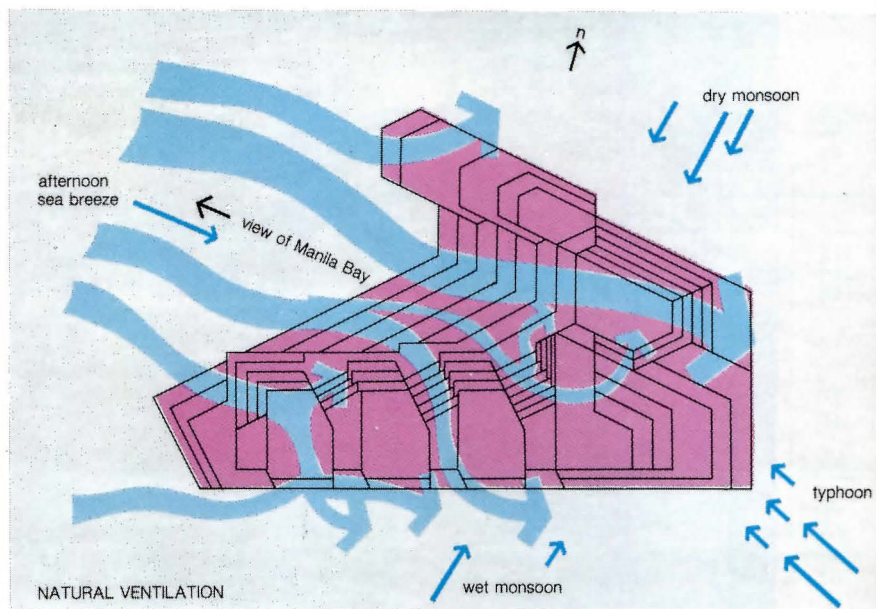
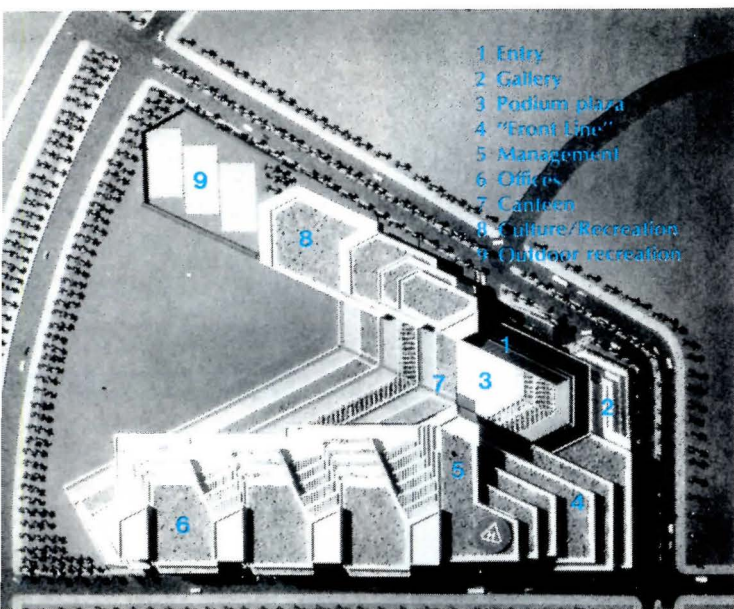
MID-AUGUST 1981



A MCGRAW-HILL PUBLICATION

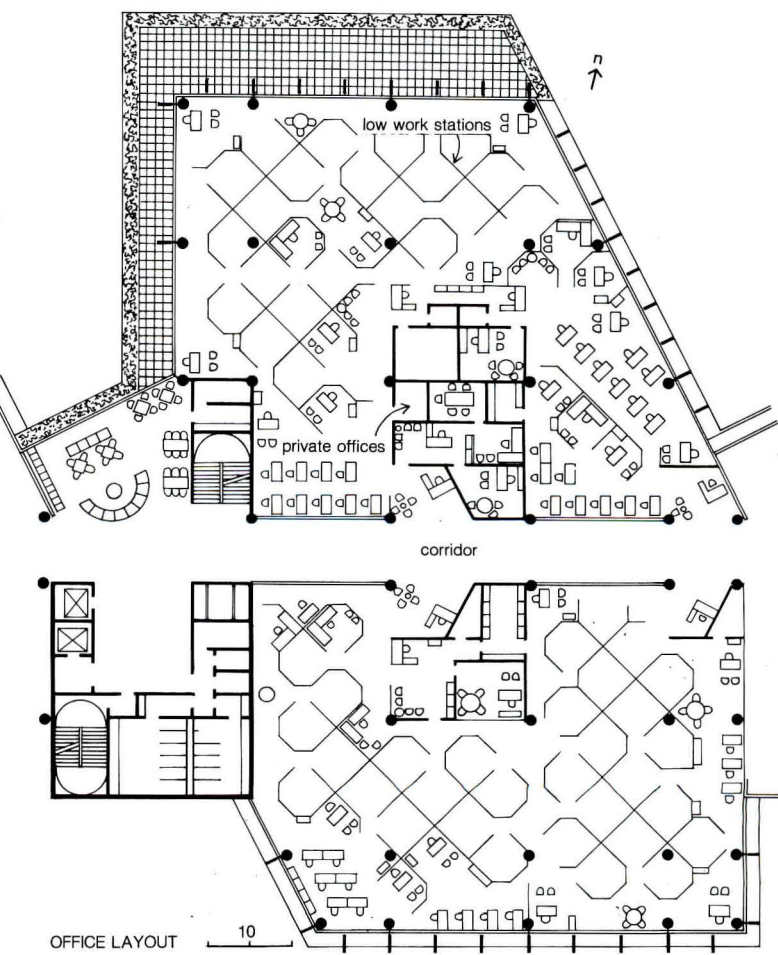
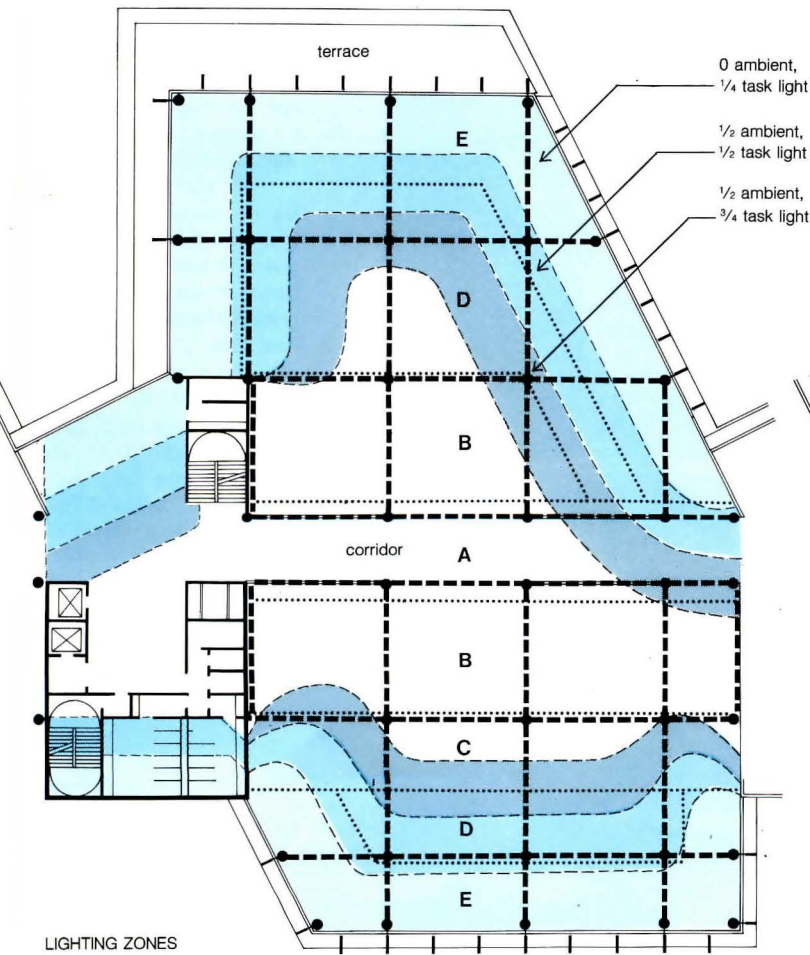
SIX DOLLARS PER COPY

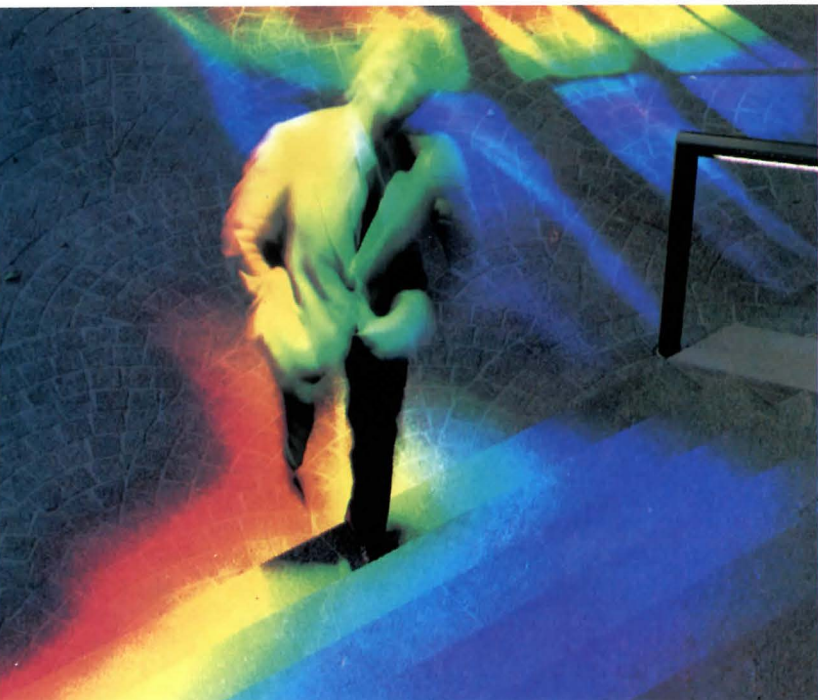




Prerequisites for the effective use of daylighting in work space are high ceilings and high windows. At GSIS, daylight enters through clerestories just below the 11-ft ceilings. A pair of light shelves, their top surfaces painted glossy white, further boosts daylight penetration (drawing at left). The outside shelf doubles as a sunshade, and the inner shelf bounces light 45 ft into the room. On a clear day in summer, workers at the perimeter should get about 40 fc of natural light, while even those inside should get 20-40

fc in summer. All desks will have task lighting, and zoned ambient lighting will be manually switched according to listed criteria (drawing below left). Clerical workers will sit at light-colored desks around the periphery, while private offices will occupy the center (lower right).
Oriented to take advantage of favorable air currents—especially the cool afternoon on-shore breeze—the V-shaped complex and notches between office pods will encourage exterior cooling and interior air flow.





Charles Ross photos

PRISMS

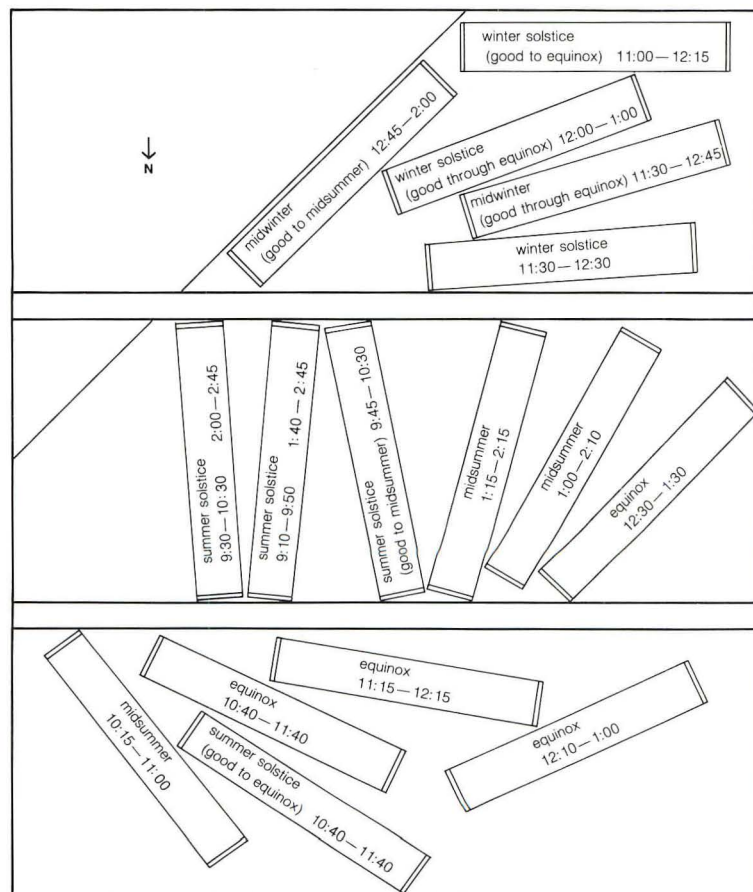
ATOP A 12-STORY ATRIUM,
THEY CAST KINETIC RAINBOWS
AND A SENSE OF WONDER

The Spectrum Building in Denver gets its name from the prism sculpture at the top of its atrium by Charles Ross. Rainbows created by sunlight passing through the prisms stream down the walls of the courtyard and drift slowly across the lobby floor. From time to time bits of spectrum penetrate the glass walls of the offices overlooking the court, so that each office has its own rainbow sequence. Groups of prisms are focused (see drawing) for different seasons and times of day to create evolving patterns of color. Ross used a model to help him determine the pattern and angular positioning of the prisms. The 16 prisms are 14 inches on a side, eight feet long, and are mounted 135 feet above the floor. The hollow interiors of the acrylic prisms are filled with a viscous liquid.

"Photographs of the sculpture, unfortunately, are like stills from a movie," says Ross, regretfully. "Rather, they give only a frozen glimpse of a presence that is constantly drifting, changing, evolving."

"After living with this art work, one notices how the light is orchestrated by conditions of sky and conditions of sunlight. There are many surprises, moments of personal recognition. The shadows of a plant turn colors. An extended hand catches the spectrum. Stepping into the rainbow, a person reveals its volume. The art gives a sense of personal connection to the substance of light. This is the work's real contribution to the architectural environment."

Thomas Obermeier of MCOG Architects, Denver, designed skylight details to facilitate installation of Charles Ross' sculpture. It was commissioned by Donald Todd, who is an art collector and president of Constellation Group, the building owner.





AN ANSWER TO THE ENIGMA OF FLEXIBILITY FOR MUSIC AND THEATER

Communities who find the need for community auditoriums more and more often elect to build a single multipurpose hall—one that can resolve the diverse wants of their citizens. Russell Johnson, acoustician, theater designer and member of the New York City firm Artec Consultants, has assembled a catalog of the assorted functions accommodated by these all-purpose halls: symphony orchestra, chamber groups, choral concerts, recitals, popular music, rock, jazz, country, Western and folk music, opera, musical comedy, modern dance, ballet, drama, variety shows, meetings, assemblies and speeches.

To compose differences in spatial needs, as well as acoustic demands "running the full gamut from heavy rock to solo recitals on the lute," in a phrase of Johnson's that encompasses acoustic extremes, civic groups and their designers seek infinite flexibility—a search that, alas, all too often produces the worst of all possible acoustic worlds. In order to expand seating capacity without putting the last rows outside the range of reasonable sight and hearing, designers of multipurpose halls frequently shorten the hall and arrange the back rows in an elongated curve. The resulting volume is thus fan-shaped in plan and horn-shaped in section, with a curving back wall; sound reflections from such splayed and rounded surfaces are misdirected, eccentric, and sometimes fail to find the audience altogether.

Kitchener, Ontario, when building its new multipurpose Centre in the Square for the performing arts, had the supreme good

sense to put first things first—to wit, natural acoustics for music. And the building committee stuck to its guns through three years of cost paring.

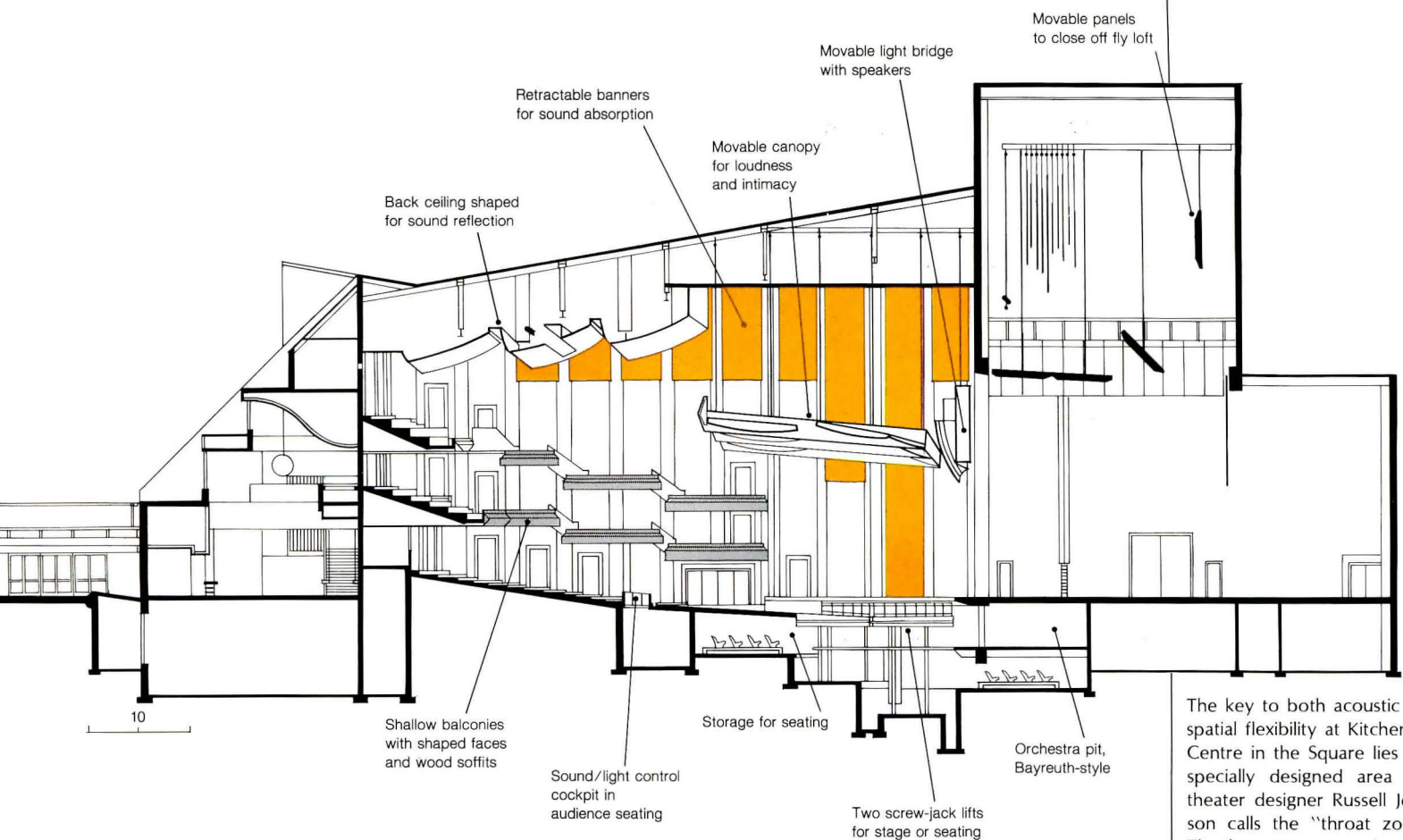
Architect A. C. Rieder, whose Kitchener firm Rieder, Hymmen & Lobban has been involved in the project since 1967, saw it "shrink in size and grow in time" as national and provincial funds were sought. The original goal, he reports, was a combined city hall, convention center, theater and art gallery. By 1978, when the architects received the go-ahead for working drawings, the complex included only the theater and the art gallery. The two buildings and their shared central lobby cost US\$10.9 million.

As the home of the Kitchener-Waterloo Symphony Orchestra, the theater's highest priority was one of the most elusive architectural qualities: good natural acoustics. Johnson's strategy for producing good acoustics, especially for "serious" music, necessarily involved the theater's spatial flexibility. When the resident orchestra, chamber groups or recitalists perform here, the plan of the audience chamber changes from rectangular to square, its capacity from 1,920 to 1,680 listeners. Most observers agree that 2,000 is about the maximum number for musical audiences (1,500 even better), except perhaps for the large orchestras and loud climaxes characteristic of Wagner and Mahler. Though many halls exceed that number for reasons of prospective audience size and box-office profitability, larger halls tend to put audiences at a distance and thus over-

Robert E. Fischer photos







whelm small groups acoustically; technical sound problems become correspondingly difficult. (The Kitchener-Waterloo symphony orchestra, now under the direction of conductor Raffi Armenian, usually fields about 50 musicians, but may add an equal number as occasion demands.)

Acoustically as important as room size is the relation of musicians to audience: in halls designed solely for orchestral performances, the players sit not within a theatrical stagehouse behind a proscenium but on a platform lying wholly within the audience chamber. At Kitchener, the platform consists of two lifts, operated by screw-jacks and set forward of the stagehouse. (The lifts, which can be independently raised and lowered, are shown on page 73.)

The shape of the Kitchener hall conforms in most respects to the general precepts set by the two halls that are cited by virtually every musician and critic discussing orchestral acoustics: Boston Symphony Hall and the Musikvereinsaal of Vienna. That is to say, the side walls are hard and straight and not too far from listeners in the middle of the hall. Further, the hard, shaped fronts and curved wood soffits of the balconies add to the complexity and richness of reflected sound, while their shallowness (Johnson calls the balconies "shelves") adds to its intimacy and prevents the "deadening" of sound absorbed by occupants or simply lost beneath the overhangs. The omission of carpets eliminated another source of sound absorption.

A shaped canopy of timber and fiber-

glass plastic, which can be raised or lowered to effect loudness or intimacy, hangs from the ceiling to reflect sound down to the front rows of the audience and to the conductor and musicians. Johnson calls this canopy "the workhorse of music acoustics." Beyond increasing loudness and allowing the musicians to hear one another, it is, he says, "the chief instrument for clarity, intelligibility and articulation."

Acoustics at the Kitchener hall also produce a refinement rare to multipurpose auditoriums: an audible decay, music that hangs in the air after the musicians have stopped. Johnson's technique for achieving this "tail" is to provide "reverberant chambers" around the orchestra—in this case a storage room for the towers, the rear stage and the stage itself. As Johnson describes the technique, "A portion of the acoustic energy from the musicians seated on the forestage trickles back into the stagehouse through the gaps between and above the air-castered tower units, is 'reverberated' (there are no sound absorbing materials back in the lower part of the stagehouse), and then the reverberated sound moves back into the audience chamber through the same gaps."

To make sure that music does not diffuse backstage or up into the fly loft, movable towers form a reflective curve behind the players (see page 73), and operable panels above the stage proper close off the fly loft.

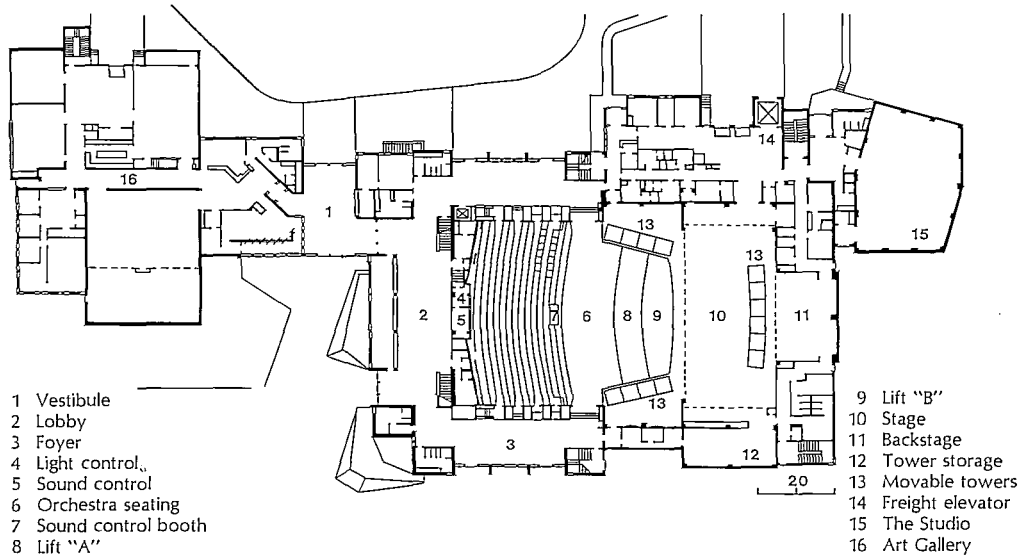
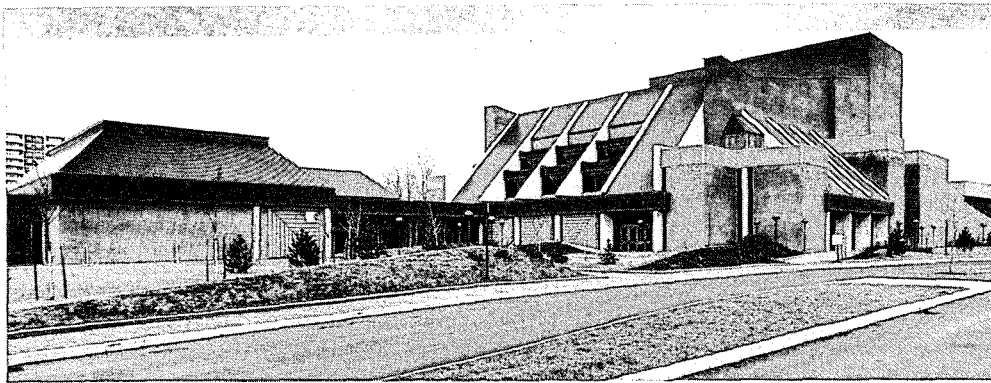
The acoustic qualities sought by pop and rock musicians and by actors contravert absolutely the lively reverberant sound

The key to both acoustic and spatial flexibility at Kitchener's Centre in the Square lies in a specially designed area that theater designer Russell Johnson calls the "throat zone." The throat zone occupies territory between the stagehouse and the audience chamber, and comprises two large lifts as well as a pair of generous side stages. Depending on whether one or both lifts are up or down, they may support orchestra, pit musicians, actors, or audience seating. The flexibility promoted by these throat-zone elements effectively allows a number of different theatrical houses to occupy one facility.

In the top photograph opposite, both lifts are fully raised to support the symphony orchestra on a jutting platform that lies entirely within the audience chamber. Four of the theater's movable towers stand on each side stage as boxes for seating, while eight others act as sound reflectors for the orchestra.

In the bottom photograph, audience seating (shown in transit) occupies both lifts to command views of the stage behind a conventional proscenium. The proscenium arch is created by black velour masking panels and pumpkin-colored curtains, and is capped by the lowered light bridge. (Other possible configurations are shown on page 73.)





sought by symphony orchestras and chamber groups. Both popular musicians and speakers want acoustically dead space with no reverberance whatever in order to maximize clarity. Johnson's principal strategy for this case was 18 sound-absorbing fabric "banners" screening the side walls of the audience chamber and horizontally drawn curtains at the back. Operating much like window blinds, the banners, which descend through narrow slots behind the side balconies, can be tuned by lengthening or shortening—as they might be for singers, whose acoustic requirements fall somewhere between the two extremes described. For the Centre's production of *Die Fledermaus*, about half of the fabric was exposed, but performers and stage crew are still tinkering with the disposition of acoustic elements in the auditorium.

Electronic sound systems as well as lighting are controlled from a console that occupies a cockpit in the center of audience seating, where the operator can monitor the effects of his equipment. The sound reinforcement system, also designed by Artec Consultants, comprises a three-way speaker cluster mounted on a bridge that can be lowered over the proscenium, as well as numerous microphones and a sound mixer. Seats next to the cockpit can be removed if visiting rock groups, who often travel with their own sound systems, want space and access to the house equipment.

In addition to the main auditorium, musical facilities at Centre in the Square include The Studio. A separate wing at the back of

the building, it is intended for chamber performances and small dramatic productions, as well as for orchestra rehearsals.

The acoustic success of the Centre's auditorium has been attested by both musicians and critics. The pianist Lili Kraus, recalling occasions on which either the musician or the audience was rendered hard of hearing by faulty acoustics, wrote in a letter about the Centre that "a euphony is produced that one can only regard as the blessing of the Lord." And critic John Kraglund, writing in the *Toronto Globe and Mail* about the Centre's production of Johann Strauss's *Die Fledermaus*, remarked that sound from the orchestra pit "emerged clearly, yet without swamping the singers on stage," while "vocal music was also clearly projected, with sufficient resonance to keep it interesting and verbally intelligible."

Kitchener has high hopes that the success of its new hall will spread beyond the 200,000-person city to complete a summer theatrical triangle in Ontario, including Stratford offering Shakespeare and Niagara-on-the-Lake offering Shaw. Already conductor Armenian and Kitchener music lovers envisage the first Canadian Wagner festival to feature all four operas in the Ring cycle.

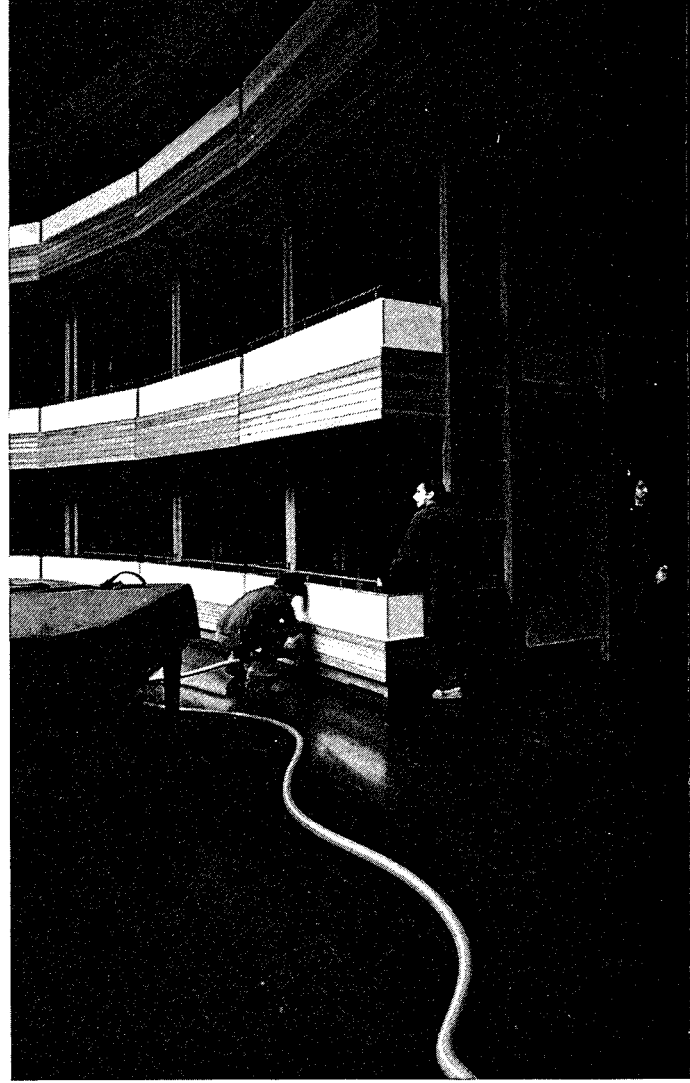
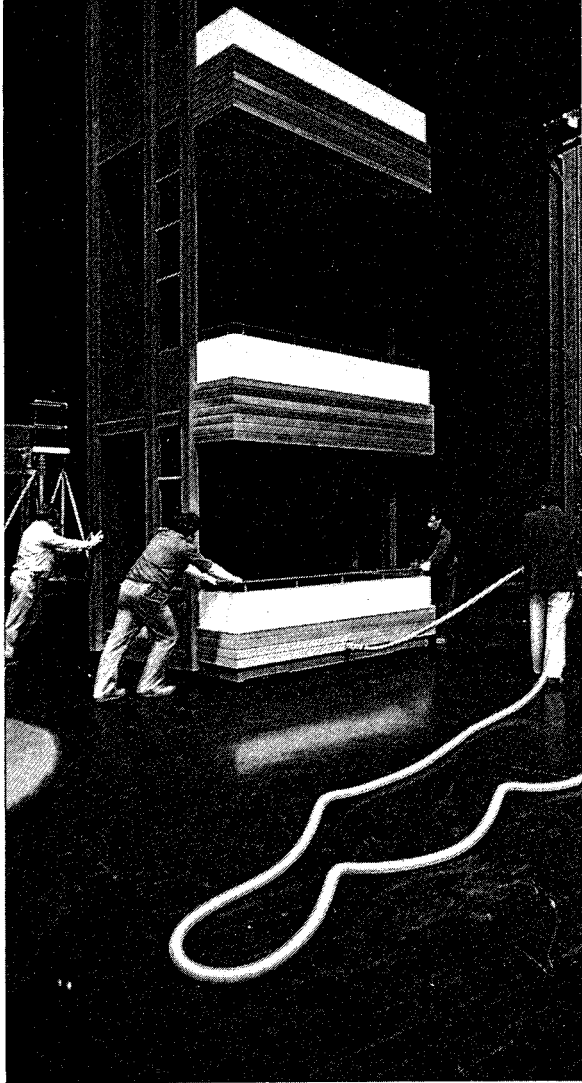
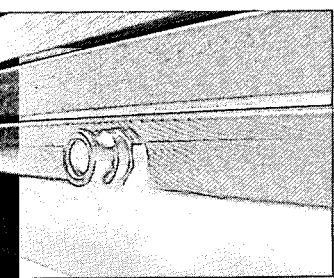
CENTRE IN THE SQUARE, Kitchener, Ontario. Architect: Rieder, Hymmen & Lobban, Architects. Theater and acoustics consultant: Artec Consultants, Inc. Engineers: Walter, Fedy, McCarger, Hachborn (structural, mechanical/electrical). General contractor: Ball Brothers, Ltd.

A truly innovative element at Centre in the Square is an array of 18 movable "towers" that contribute greatly to multipurpose flexibility. The oblong towers have three distinct faces: on one side, a bowed panel of wood running the full height to act as a sound reflector; on the opposite side, a tier of three box seats reached via the fixed balconies; on the outsides, ladders to receive lighting equipment.

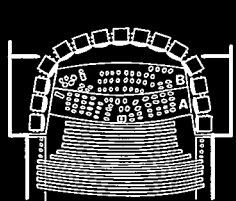
Each of the steel-framed wood towers, weighing about 14,500 lb, can be moved on air casters—four neoprene doughnuts inflated with compressed air, at 25 psi, injected through an intake connection at the base of the tower; beneath the doughnuts, a film of air lubricates movement. The casters raise the towers about an inch above the stage floor, allowing the crew to arrange them on stage, as in the sequence shown top right, or to store them in a room behind the stage.

Still another device for theatrical flexibility is a pair of large lifts between the stage and the audience chamber. Raised and lowered on screwjacks to varying heights and in varying combinations, the lifts can serve as stage, orchestra pit or audience seating—even as a runway when the rear lift is lowered and the front one raised. When both lifts are raised, they become either a platform for the resident symphony orchestra or a large forestage thrust forward into the audience chamber. When lowered, the lifts form orchestra pits of various sizes and locations. Theater designer Johnson, who has given considerable thought to the qualities and requirements of orchestra pits (far too many are tortuously small), has allowed at Kitchener the possibility of a Bayreuth-type pit, which for large opera orchestras seats some musicians beneath the stage while giving the conductor command of both stage and pit.

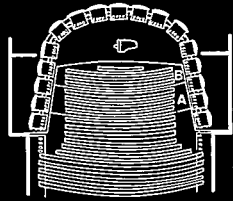
The lifts can receive one or two wagons with seating to be adjusted to the level of the auditorium floor. The wagons are stored beneath the stage and beneath the auditorium, and slide out somewhat like dresser drawers to occupy the lifts (see bottom right photo and section on page 70).



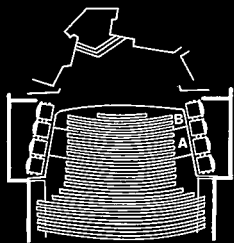
A few possible arrangements of movable towers and lifts:



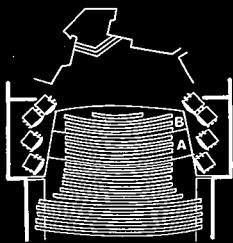
Both lifts at stage level as concert platform, with towers behind for sound reflection



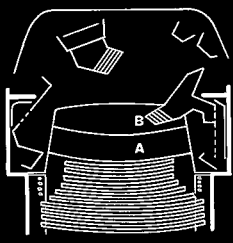
Both lifts lowered for audience seating, with pianist on stage in front of towers



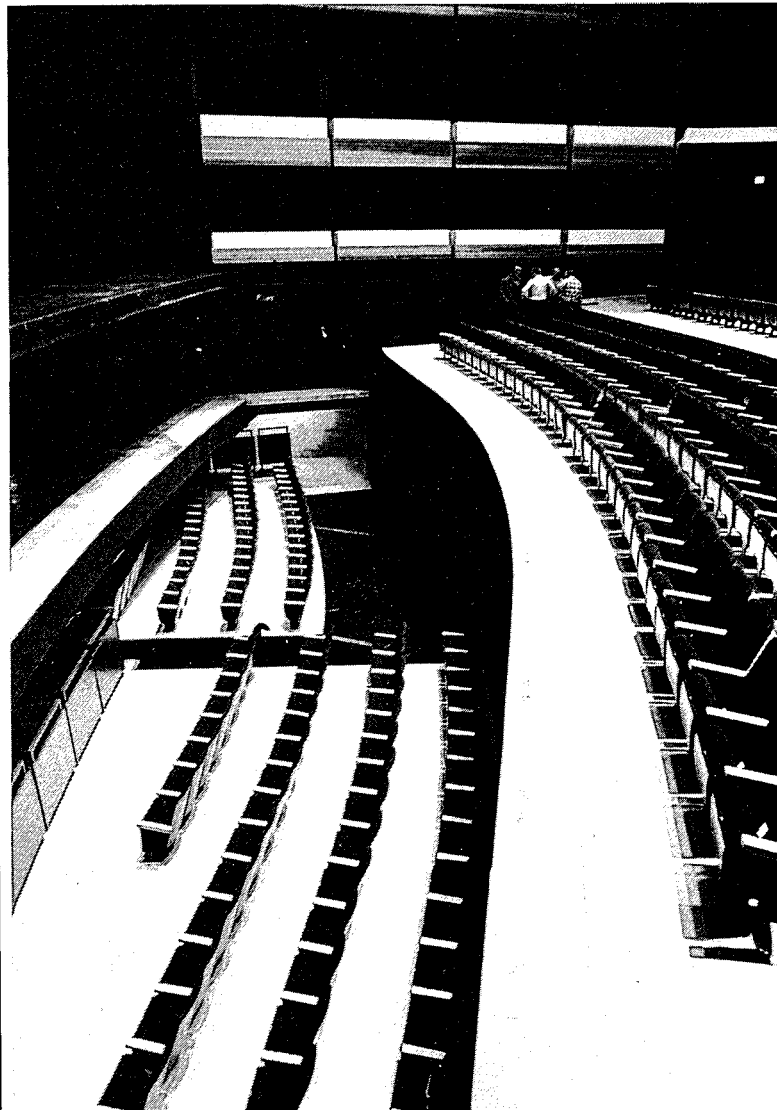
Masking creates proscenium for conventional stage, and towers add box seats at sides



Towers on side stages become light stanchions for dramatic productions on main stage



Front lift lowered for orchestra pit, back lift raised as forestage for opera productions



IN PITTSBURGH STEEL-PLATE WALLS THWART WEATHER AND REDUCE SWAY CAUSED BY WIND

Pacing a new upsurge in construction and revitalization of downtown Pittsburgh, with the upbeat appellation of Renaissance II, is the 54-story exposed-steel-clad skyscraper for Dravo Corporation, which is remarkable for its engineering design and contextual appropriateness.

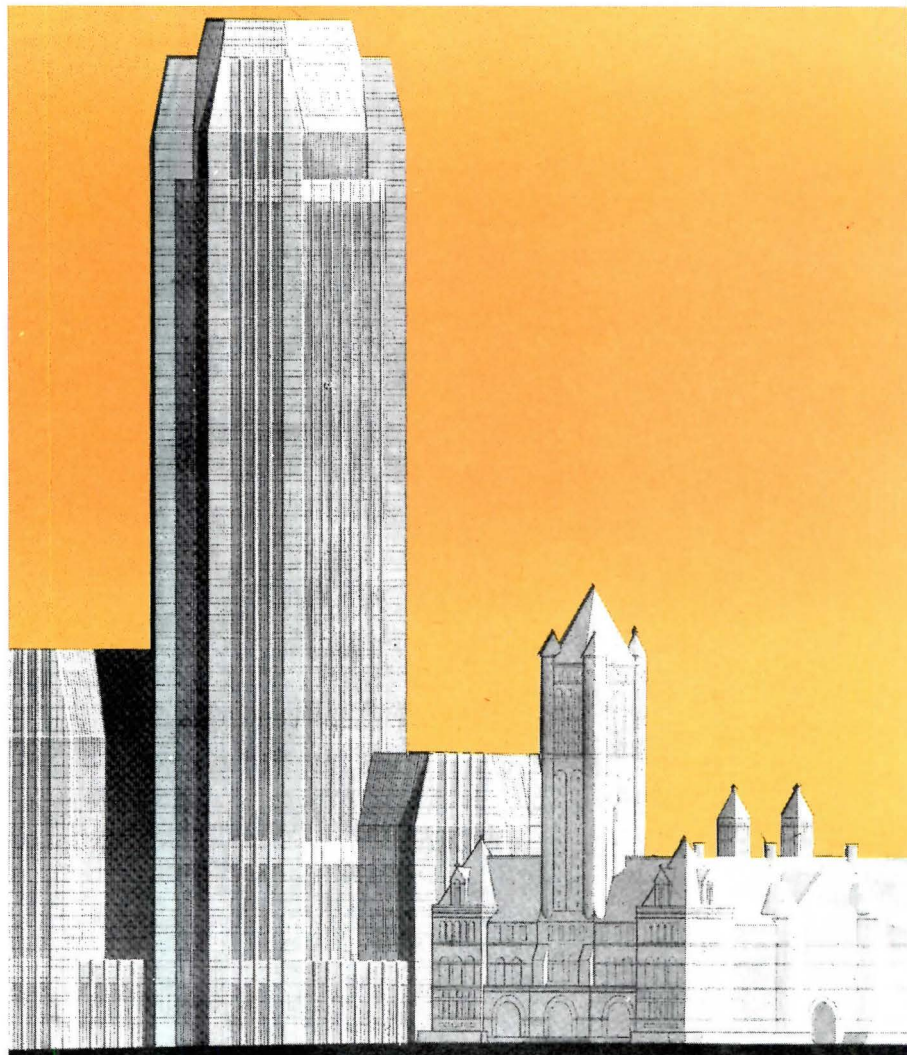
The exterior enclosure of Dravo Tower works as a stressed-skin tube to limit the sway of the building from wind. The massing and texture of Dravo Tower are sympathetic to historic buildings nearby, such as H. H. Richardson's courthouse, as well as more contemporary neighbors, such as the U. S. Steel Building. The area, called The Steel Plaza, will probably include also a hotel, a condominium, and a smaller office building.

Since the stressed skin resists all lateral loads, the core columns need take only gravity loads, which significantly reduces their size, adding 18 in. of rentable floor space around the core's perimeter. Furthermore, spandrel beams can be smaller and consist of rolled sections rather than built-up plate.

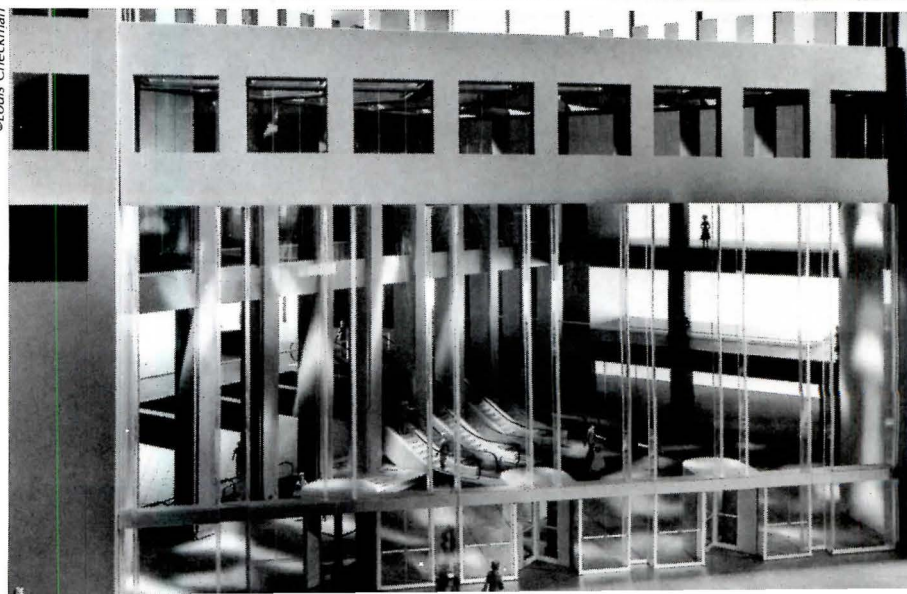
The stressed-skin, steel-plate exterior comprises steel-plate panels either $\frac{1}{4}$ - or $\frac{5}{16}$ -in. thick, that are applied in sections one-bay wide and three-stories high, with precut openings for windows. Horizontal joints are weatherproofed by neoprene seals, and vertical joints are concealed by non-structural column covers. Windows are frameless, the glass being supported by H-shaped neoprene structural gaskets pressed onto the edges of the window openings.

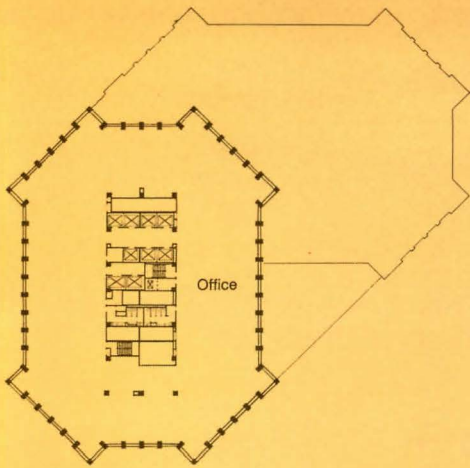
The building is structurally sound even without the stressed skin, explains engineer Richard Tomasetti, because lateral loads on the primary structure (i.e., columns and beams) are well within code limits. The steel skin, therefore, can be exposed without any fire protection.

DRAVO TOWER, Pittsburgh. Owner and developer: *USS Realty Development Division of United States Steel Corporation*. Architect: *Welton Becket Associates—director New York City office: Henry Brennan; project designer: David W. Beer; project director: Frank LaSusa*. Engineer (structural): *Lev Zetlin Associates, Inc.—principal-in-charge: Richard L. Tomasetti; project manager: Abraham Gutman; project engineer: Len Joseph; senior associate: I. Paul Lew*. Engineer (mechanical): *Lehr Associates*. Curtain wall consultant: *L. J. Heitmann, Jr.* General contractor: *Turner Construction Company*. Steel fabricators: *USS Fabrication Division (frame); Calumet Steel (panels)*; steel erector: *American Bridge Division*.

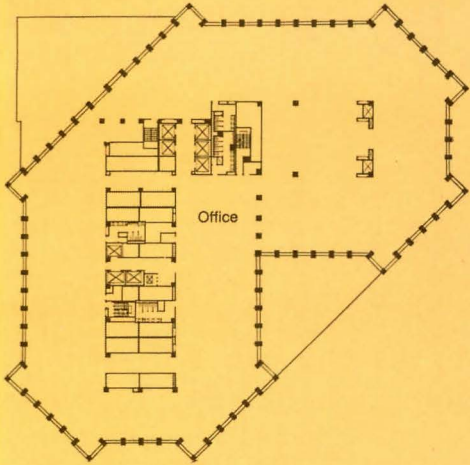


© Louis Checkman

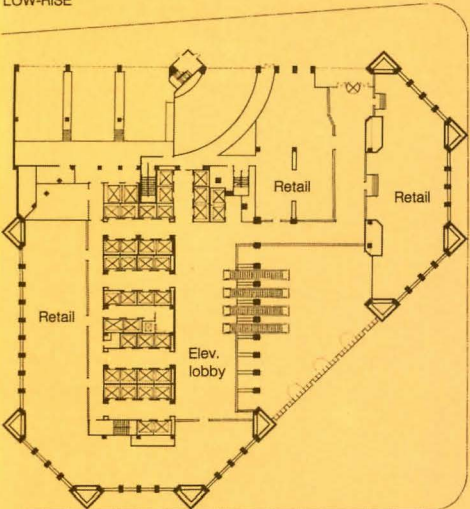




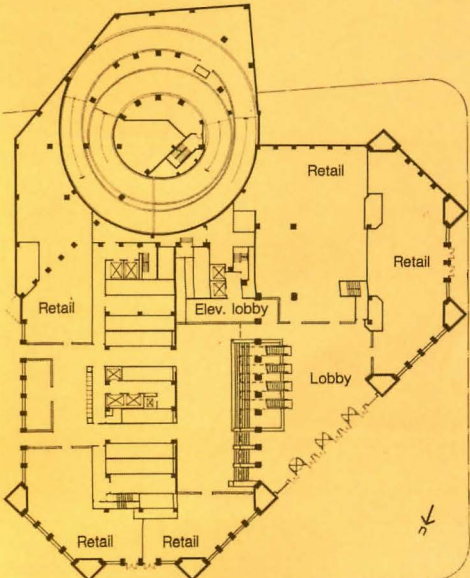
HIGH MID-RISE



LOW-RISE



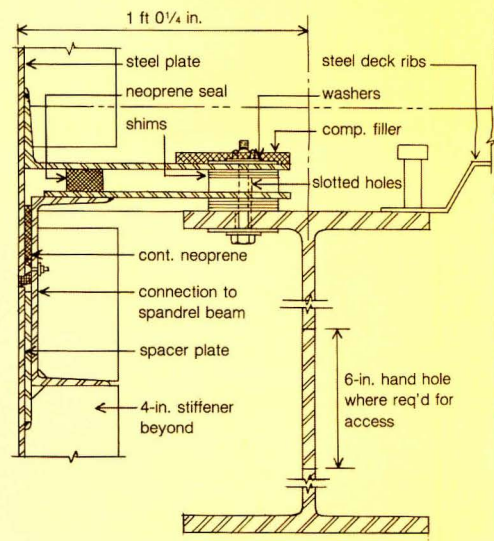
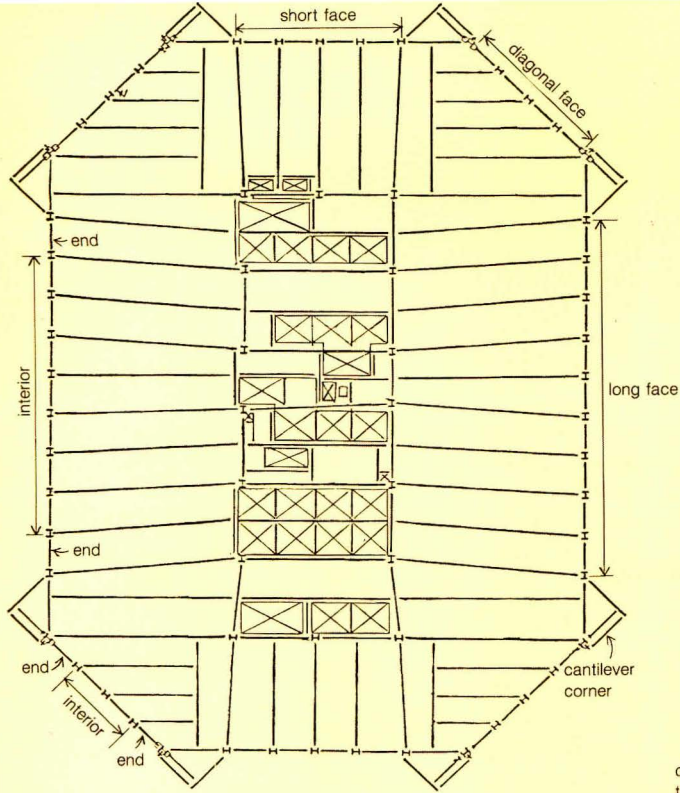
ROSS STREET



GRANT STREET

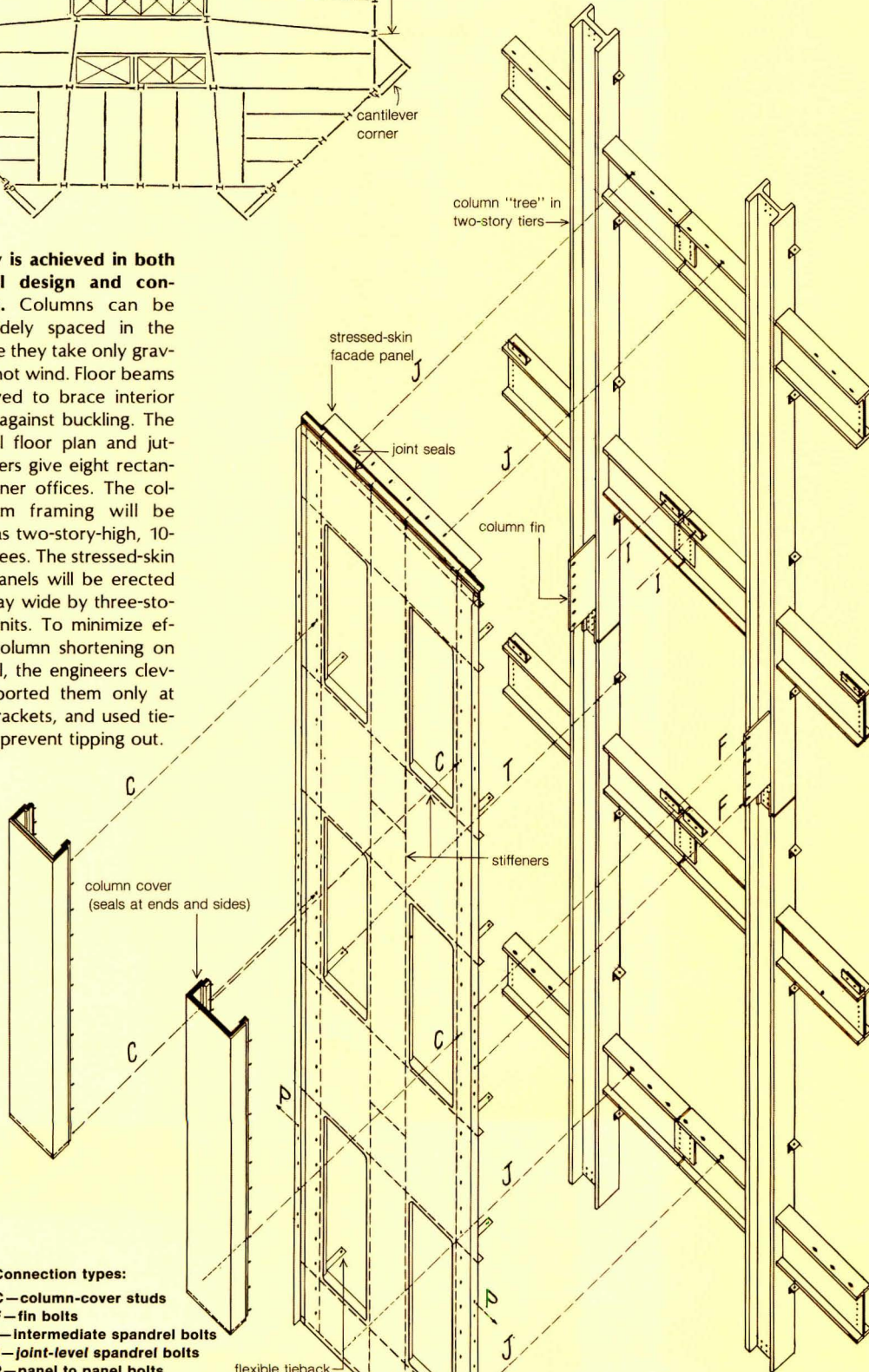
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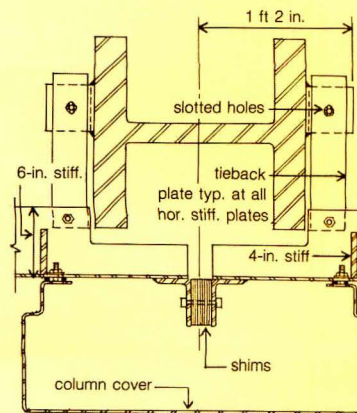
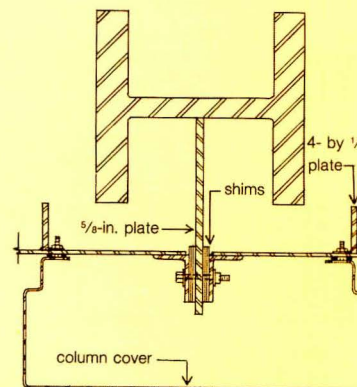


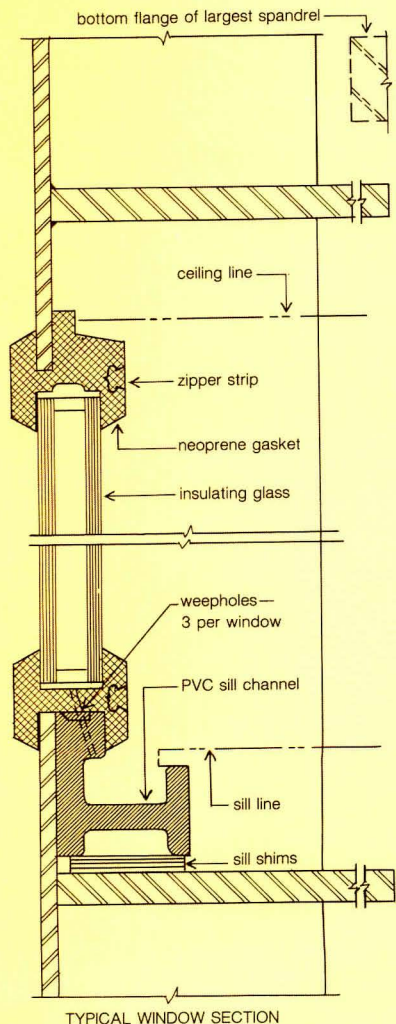
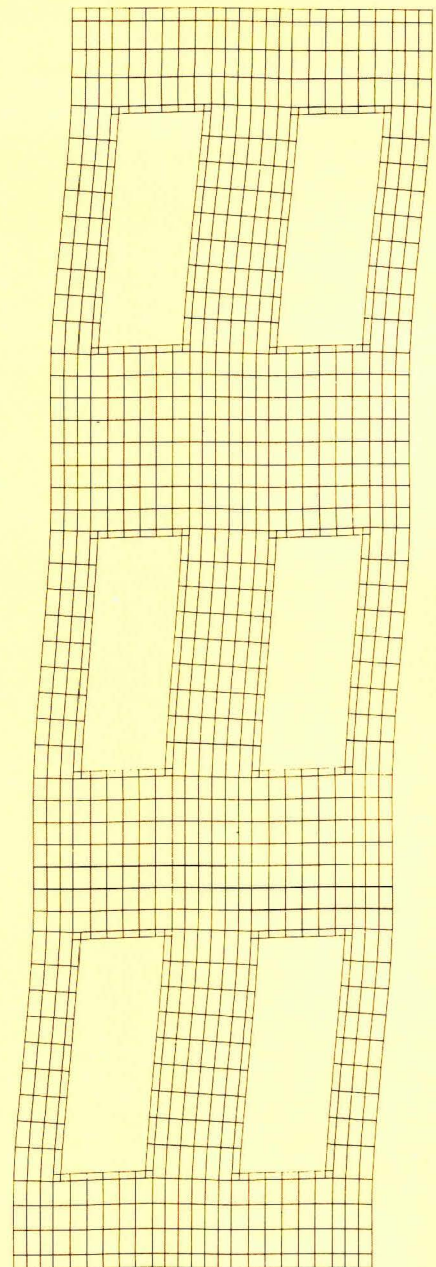
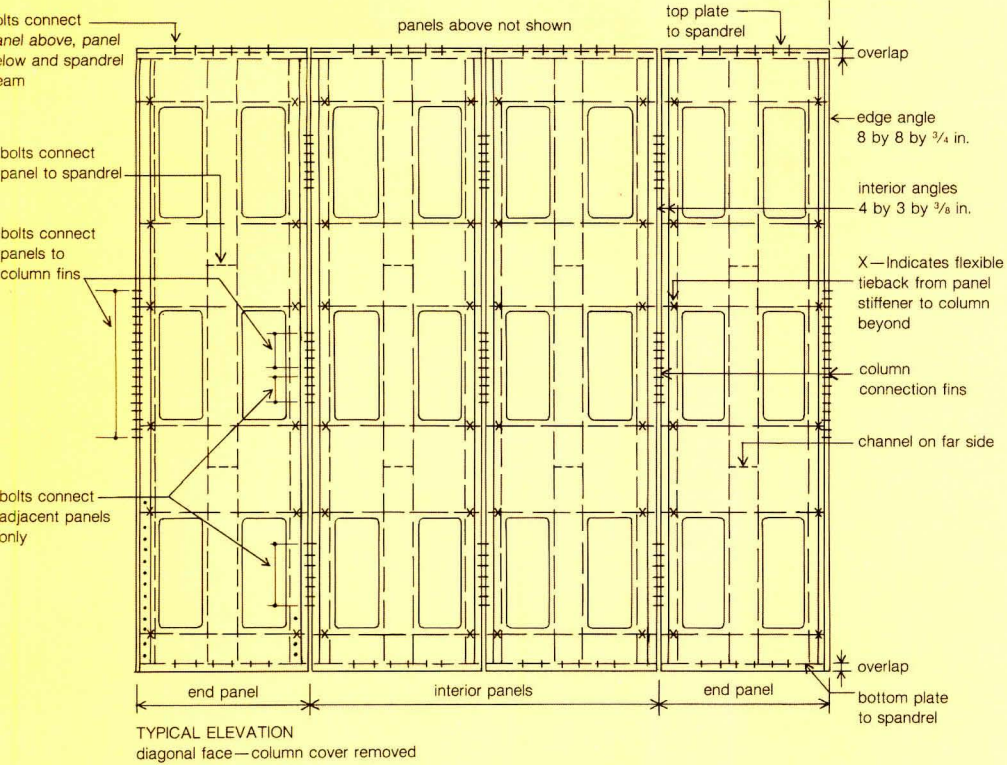
Efficiency is achieved in both structural design and construction. Columns can be more widely spaced in the core since they take only gravity load, not wind. Floor beams are skewed to brace interior columns against buckling. The octagonal floor plan and jutting corners give eight rectangular corner offices. The column-beam framing will be erected as two-story-high, 10-ft wide trees. The stressed-skin facade panels will be erected as one-bay wide by three-story-high units. To minimize effect of column shortening on the panel, the engineers cleverly supported them only at center brackets, and used tiebacks to prevent tipping out.

The structural engineers helped develop waterproofing details. They had to be closely involved because building movement caused by dead and live load and temperature is intimately related to waterproofing integrity. Horizontal joints (above) are protected by a continuous neoprene seal between the back of the panel and a channel. Vertical joints are protected by a non-structural column cover (below) that hangs from a column-mounted bracket. Movement of horizontal joints caused by dead load, live load, wind and temperature is predicted to be $\frac{3}{8}$ in.



- Connection types:**
C—column-cover studs
F—fin bolts
I—intermediate spandrel bolts
J—joint-level spandrel bolts
P—panel to panel bolts
T—tieback bolts





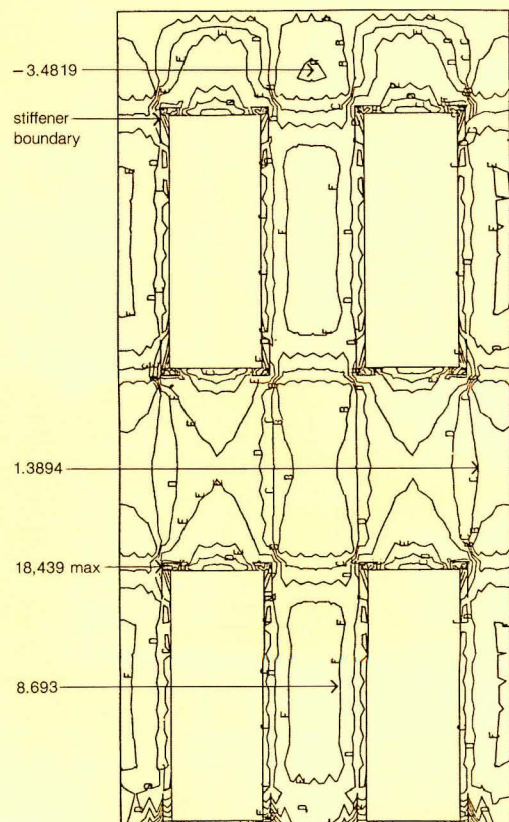
To minimize stress concentrations in the panels, the engineers curved the corners of the window openings. But the architects wanted to use rectangular lights of glass to avoid cost premiums. The engineers ingeniously solved the conundrum by bulging the corners slightly, which allowed the zipper gaskets to be rectangular and still have sufficient bite on the edge of the panel at the openings.

The panels develop shear stresses in resisting lateral wind loads, and distort as shown in the drawing, upper right (distortions exaggerated). The shear stresses are highest at corners of the window openings. The drawing, lower right, shows contours of shear stress for a 100 kip lateral load on a 5/16-in. panel. The stresses get higher for ascending letters of the alphabet. Shears are transferred from panel to panel horizontally and vertically, and are transferred to perimeter columns at the ends of each group of panels.

Cost of the wall was only \$28 per sq ft for wall panels, windows, gaskets and column covers.

Analysis by the engineers showed that only 40 per cent of the openings needed to be reinforced with angles, which saved about \$1½ million.

The panels are to be colored one shade of tan and the column covers another shade. The coating system includes: 1) zinc chromate primer, 2) epoxy coating, and 3) polyurethane finish coat.



shear stress for 100 kip horizontal shear on 5/16-in. panel

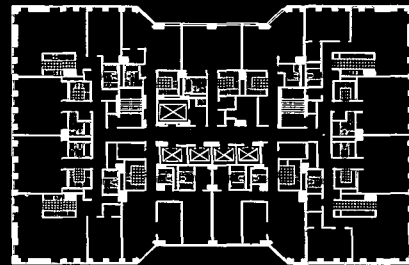
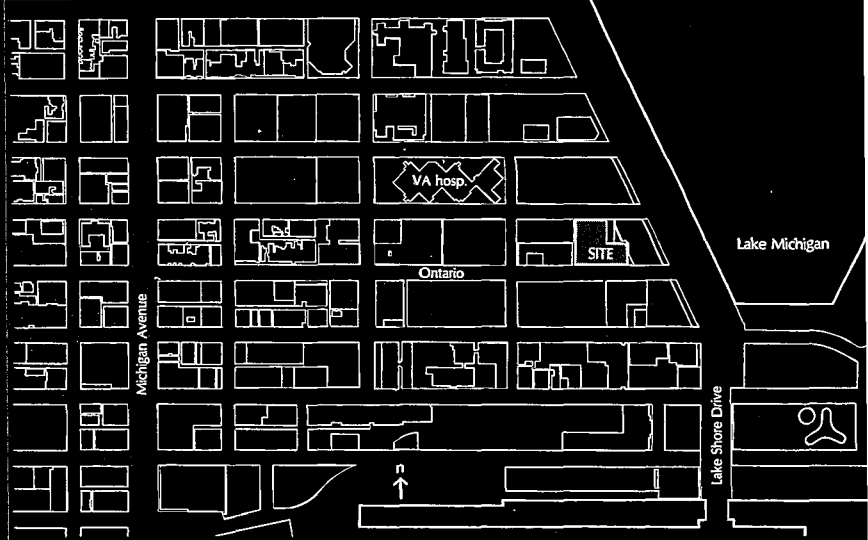
A TOWER, IN THE SPIRIT OF THE CHICAGO SCHOOL, ARTICULATES ITS CONCRETE FRAME

"This is very much a Chicago building, one in the tradition of the Chicago School," proudly says Dr. Fazlur Khan of SOM. "The inherent character of the structure is expressed, just as the columns and beams of the early 1900s buildings in the Loop are expressed clearly, while the windows are infill." The 58-story Onterie Center (the name comes from the intersecting streets, Ontario and Erie at the site) also is a Chicago building in the more recent context of SOM's skyscrapers, notably John Hancock Center and Sears Tower. It takes structural innovations from each: the cross-bracing of John Hancock, but the more closely spaced columns of Sears. Diagonals, columns and spandrels are designed to act together distinctly. All three buildings are structural tubes, with all wind load being resisted by the exterior framing, none by the inside core.

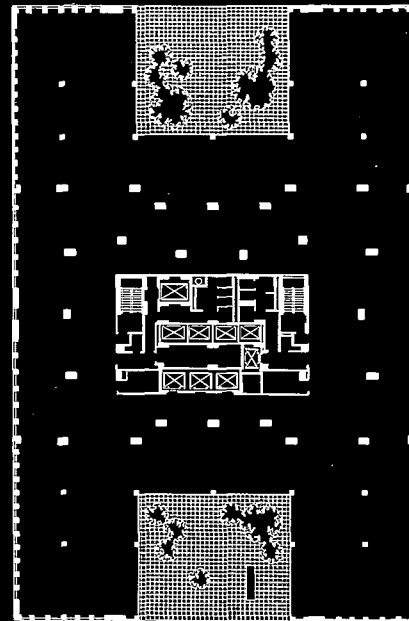
Unlike the other two, the frame for Onterie Center is concrete; principally because the tower is entirely apartment space. In a concrete tube, the columns can be much closer than in a steel tube. Joints in steel frames have a high premium cost so they are put as far apart as possible. With concrete, the situation is the reverse. Concrete columns are put as closely together as possible so that mullions and curtain wall can be eliminated, and the only infill is windows. Furthermore, the columns can be smaller and not intrude on interior space.

Another difference between Onterie Center and John Hancock is that the diagonals are created by filling the space between columns and spandrels with concrete in a diagonal grid pattern. While diagonal braces could have been put through the concrete tube leaving little triangular windows between columns and beams, this would have been too expensive to build. No matter, the diagonal still invisibly goes through the check-board, and the building construction-wise is just another standard building.

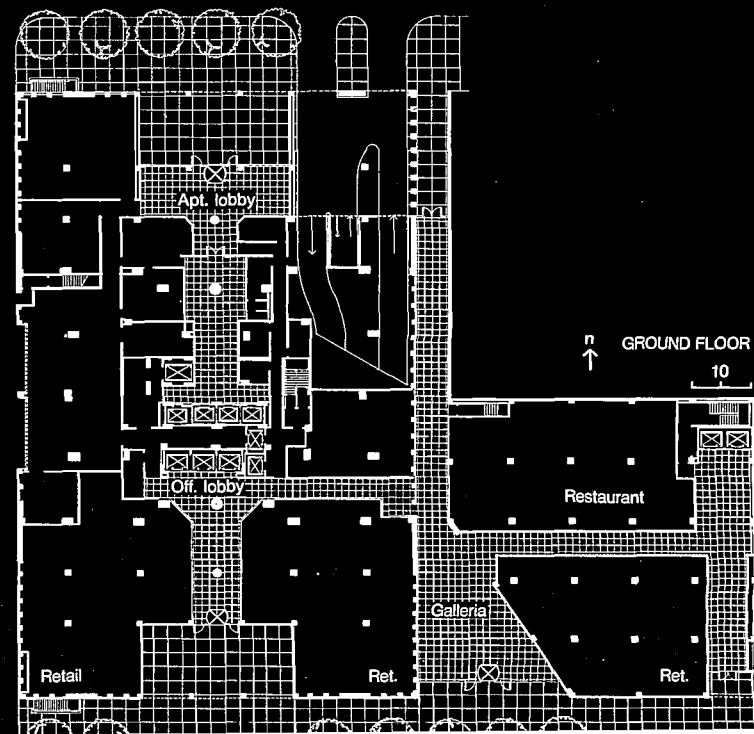
ONTERIE CENTER, Chicago. Owner: PSM International Corporation, Chandra Jha, president. Architects and Engineers: Skidmore, Owings & Merrill—partner-in-charge: Fazlur R. Khan; partner-in-charge (design): Bruce J. Graham; partner (mechanical engineering) Parambir Gujral; associate partner and studio head: Lucien J. Lagrange; project structural engineer: John Zils; project mechanical engineer: Paul Conkel; project manager: George Jarik.



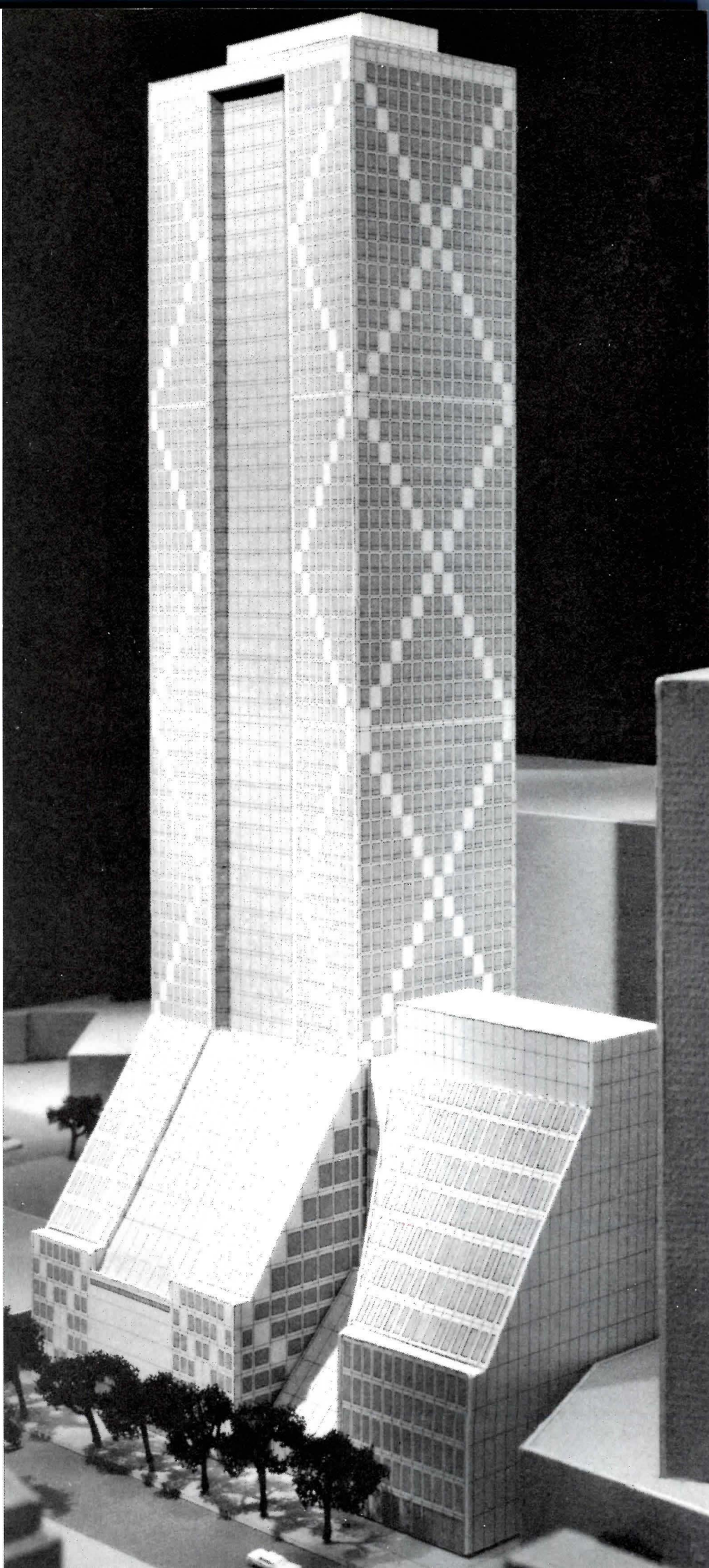
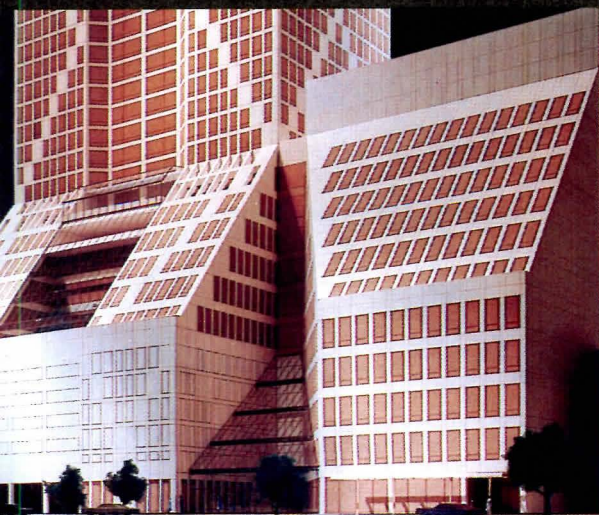
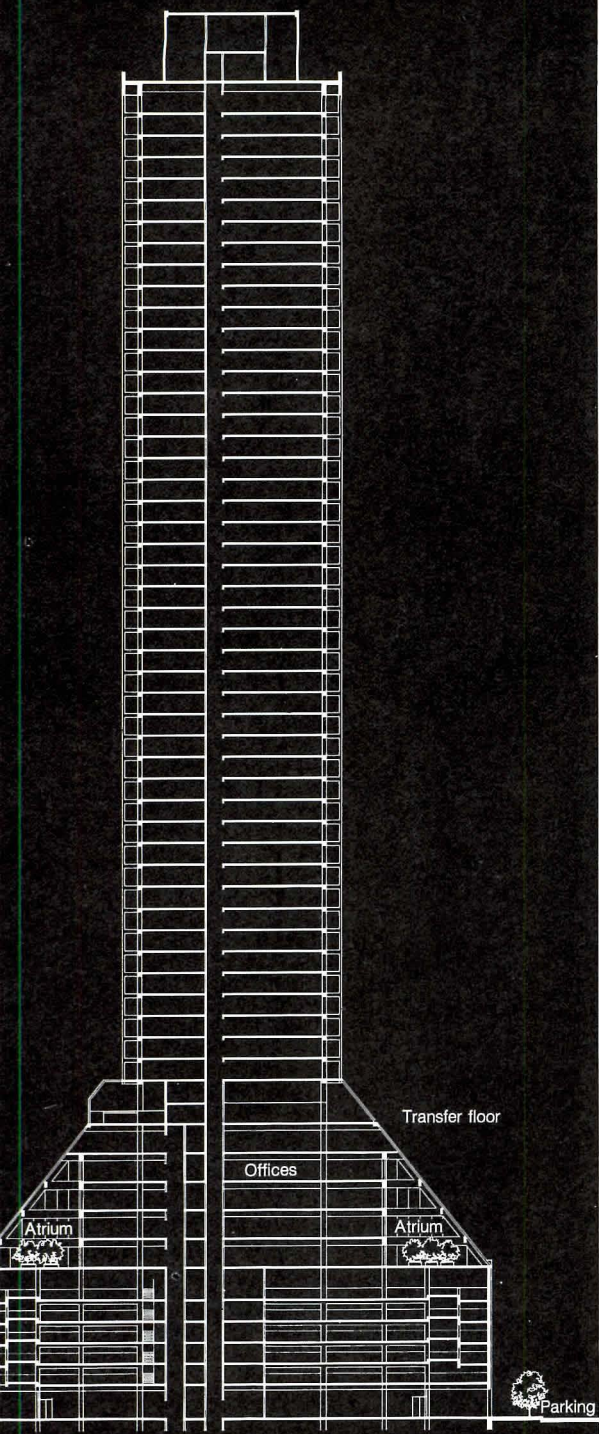
APARTMENT FLOOR

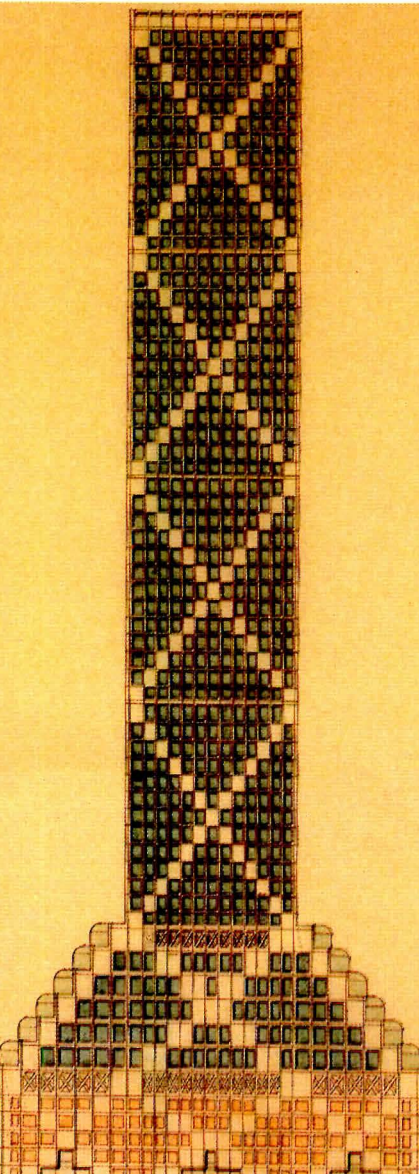
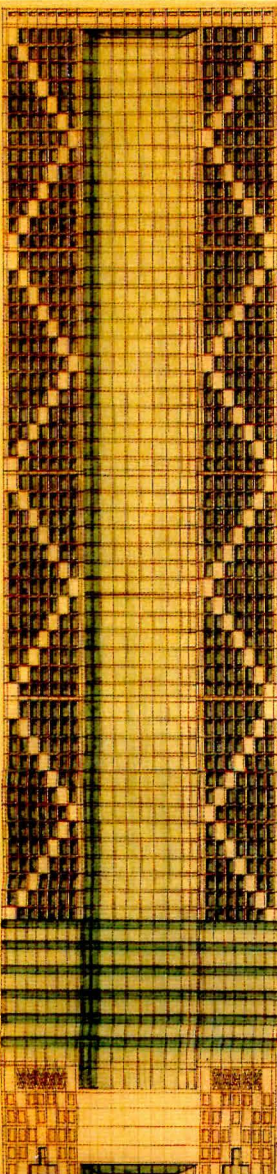
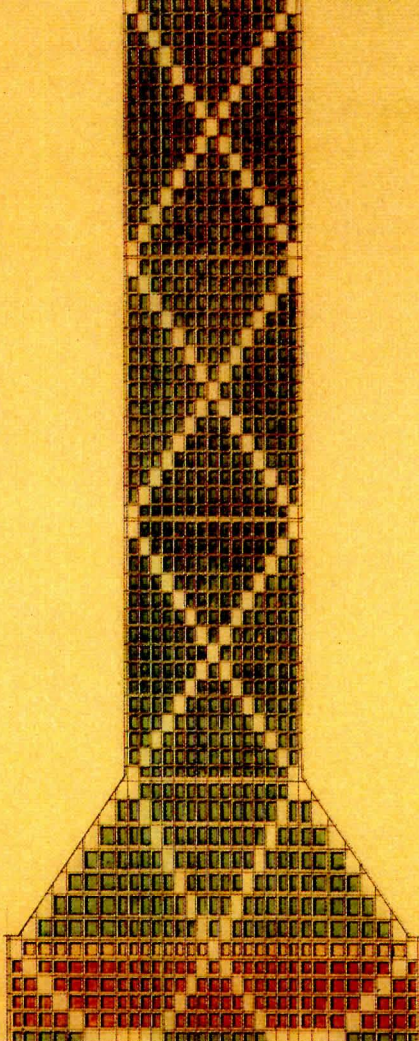
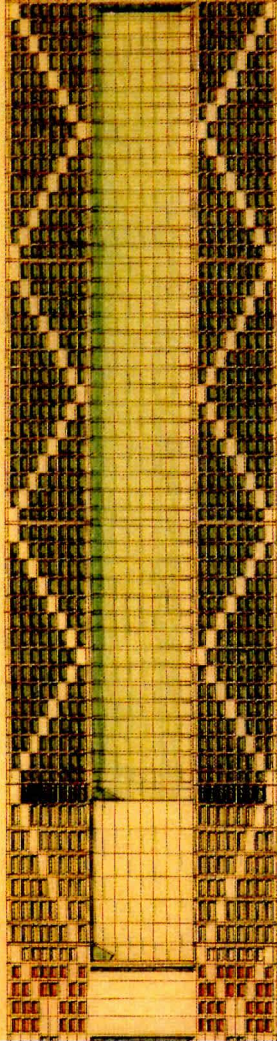


FIFTH FLOOR



GROUND FLOOR





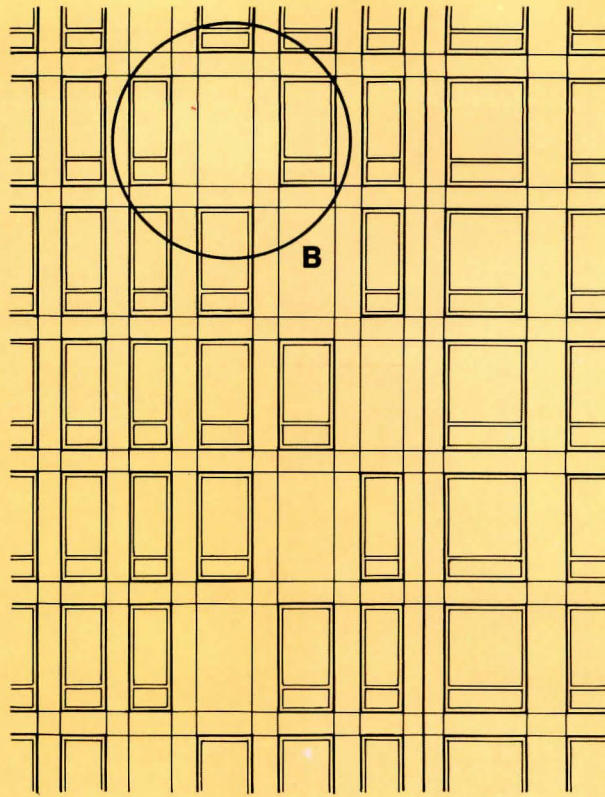
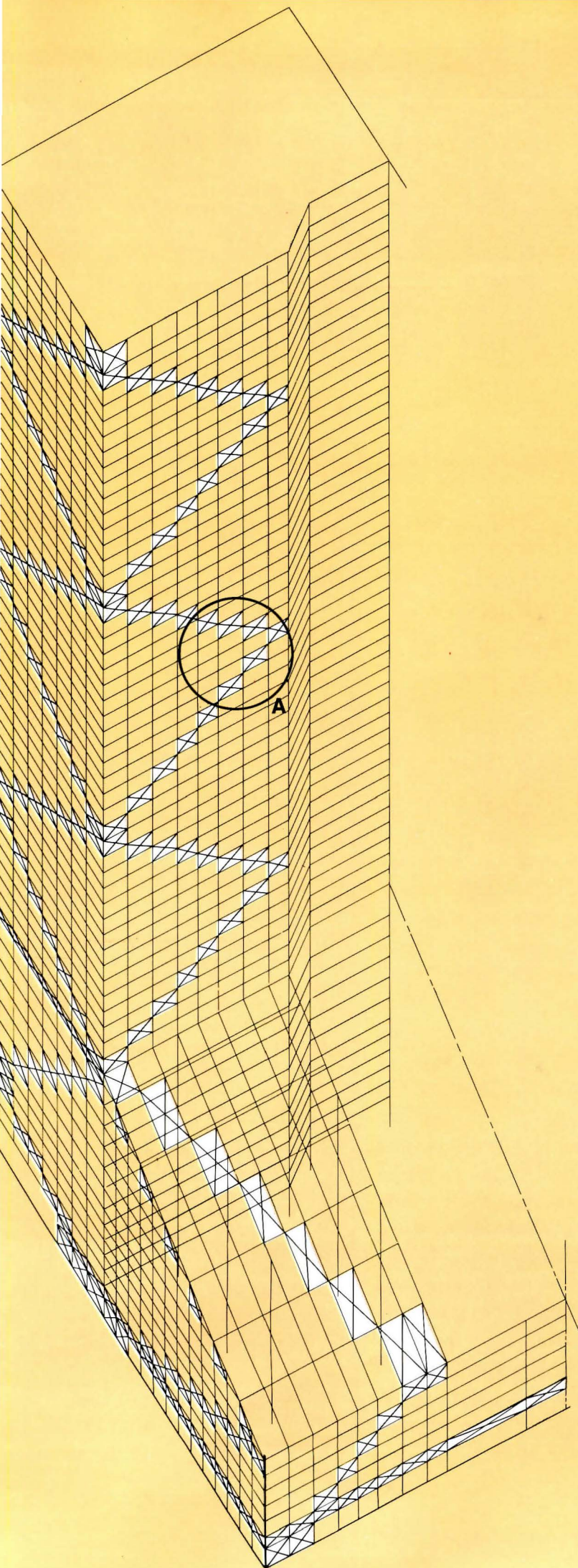
The esthetic implications of the diagonal bracing scheme are explored in the study sketches at left. The building works as a tube in resisting wind load and consists of essentially two "channels" in the tower portion, with legs facing each other (refer to apartment floor plan two pages earlier). The building does not work as a complete tube because of the indented sections in the center with more widely spaced columns. The building will be 58 stories as indicated in the upper drawings, though the resolution of the diagonal at the base of a more recent design is slightly different on front and back elevations, the brace for the first six stories being simply one diagonal coming down to the corner at ground level.

The column spacings, and therefore window widths, have been varied so that a through-the-wall air conditioner can be installed in every apartment room. The width of the diagonal panels varies as well, but because of the visual strength of the pattern, this will be unnoticeable.

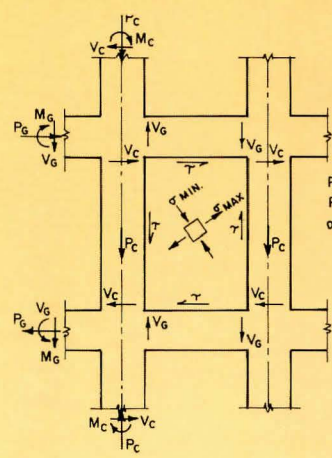
The 915,000 sq ft of the total building divide into five distinct rentable areas: On the ground floor of the tower and connecting low-rise building are 20,000 sq ft of commercial space. Parking for 404 cars occupies the basement and four floors above the lobby. Floors six through 10 of the tapering base have 100,000 sq ft of rentable office space. Because of numerous medical facilities in the neighborhood, the auxiliary building will offer medical rental space. The 46-story apartment tower begins at the sky lobby on the 13th floor. The apartment tower contains 594 apartments in studio, one-, two- and three-bedroom units.

The structure is a diagonalized framed tube in concrete.

In some ways it is a concrete version of the John Hancock Center, although the latter is a diagonalized truss tube. In a concrete building the joint has to be kept as simple as possible because it is built in the field. If only a diagonal strut had been used rather than a filled-in panel, the joint would have had to be quite complicated. With the solid panel, the forces have alternate routes to "seep" into the column and the spandrel—a lot of redistribution of forces takes place that makes the joint easier in terms of stresses.

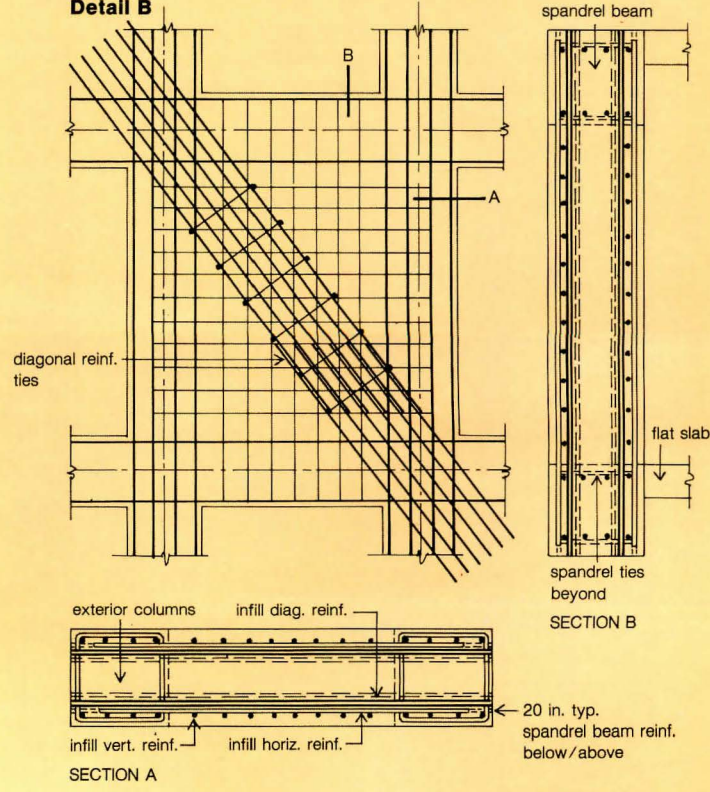


Detail A



P_c, V_c, M_c axial, shear and moment in columns
 P_g, V_g, M_g axial, shear and moment in spandrel beams
 $\sigma_{MIN}, \sigma_{MAX}$ principal stresses in infill panel
 τ shear stress in infill panel
Forces on Typical Infill Panel Caused by Lateral Wind Loads

Detail B



ROUND TABLE



The first, and the central, question asked the Round Table was this: Do architects, and especially the young architects just entering the profession, have sufficient awareness, sufficient knowledge, sufficient understanding of the engineering disciplines that are so integral a part of architecture? And if not, how do you create that awareness; the understanding by architects of what they know, what they don't know, and where to turn for help?

Structural engineer (and former dean of the Yale School of Architecture) Herman Spiegel: "The question is the same about all architects, young and old. As a teacher I find that a certain number of students are and want to be aware of the engineering inputs to architecture—they want to know, they want as much technical back-up to their architectural studies as they can possibly get.

"You have to concentrate on the ones who don't particularly care: the ones who don't feel the urge, the tug, to pursue technical disciplines; the ones really more interested in conceptual design, in esthetics, in history, in theory—all of course very important and valid subjects. The challenge for the teacher is to get these people interested. One way to do that is to point out the reasons they *should* be concerned. If the structural engineering accounts for 20 to 30 per cent of a building, it will have profound influences on the design, the esthetics, the manipulation of all the resources to make the most beautiful project. We try to show why they should get into the technical areas to meet their own needs, not any needs of mine or any other teacher.

"At Yale, we have three required structural engineering semesters and three elective—and we can tell how we're doing by the number of students who choose the electives."

Added Gifford Albright, head of the Department of Architectural Engineering at Penn State: "Many students tend to shy away from the engineering disciplines out of a concern that they are not as capable of

The engineering education of the architect: how much does the architect really need to know?

A group of 16 architects, engineers, academics, and leaders of the professional societies gathered in June to discuss this question. The Round Table, moderated by RECORD editor Walter Wagner and senior editor Robert Fischer, discussed not just the training of young architects, but their attitudes towards engineering study. It covered the different teaching roles and different attitudes of small firms and large firms; wondered about the impact on "need to know" of the growing computer technology. It discussed curricula in the schools and intern development, and how teaching might be changed. The Round Table talked about the effect of changing design philosophies—but ended on the note that, regardless of individual skills and attitudes, it's really all one whole thing called architecture.

John Ashworth photos

solving problems of that nature—like all of us, they try to do the things they do best, the things they are happiest doing. I am also concerned that because of our increasing capabilities in computer-aided design and analysis, the young architect may fall back on the idea that all he has to do is press a button on a black box and get an answer. I have been one of the very early advocates of computer use in architecture—but that isn't the way to look at the total picture.

"Encouragingly, I think there has been a much increased awareness of the engineering disciplines among young architects because of our concerns in energy conservation—not just design concerns, technical concerns, but the broad concerns of the general public."

Architect and engineer Karl Justin argued that for the student to become enthusiastic about engineering disciplines, the teachers and the school must be enthusiastic: "The teachers have to believe; and there is a wide divergence among the academicians in that area. Different schools take different approaches, put different emphases on engineering study. Some teach around the latest hot-shot technology; others emphasize the basic physical principles, which set the student up for long-term learning."

In any event, Karl Justin added, it is critical to make the necessary engineering information accessible: "One of the main reasons that we can't all know more about more things is that the material isn't properly abstracted. We *make* it hard—as soon as we find a specialty, any branch of engineering, for example, we immediately develop an impenetrable jargon, and then we start a society, and then everything turns inward and the shell gets harder and harder so it is difficult for a full-grown practitioner to penetrate through to what he needs to know. Too many youngsters just bounce off the shell without penetrating at all.

"It doesn't have to be that way. One of my best engineering-education experiences was reading with my son those little books like 'The First Book of Water' and 'The First

Book of Electricity'—I think maybe they did more to put really basic engineering in perspective for me than a lot of my college courses. . . ."

Architect Jim Foley, who not long ago headed the National Architectural Accrediting Board, which accredits architectural schools: "At a visit not long ago to one of the Ivy League schools I thought it would be nice to have lunch with the dean of architecture and the dean of engineering. They thought it was a fine idea, because they had never really met and had a good conversation. The dean of engineering asked: 'What do you fellows do there all night? I see the lights on, and often wondered what goes on in your place'"

"But I see the students demanding that they be taught more and more about more and more. At Ohio State, where I am on the Advisory Committee, they are considering a much more ambitious engineering program in the school of architecture, because so many students have asked for it.

"It's a problem of communication. I have always looked on the education of the architect as a pyramid: he ought to have a broad knowledge of a big base of things, he ought to have to good understanding of a good-sized segment of that pyramid, and he ought to have some particular skill at the peak. That's the charge to the universities."

Architect Bill Conklin related engineering disciplines to the beauty of design, and argued it should be taught that way: "It seems to me that the relationship between engineering and architectural disciplines is becoming more complicated. For one thing, architecture is really moving in very pluralistic ways, and certainly part of the current thought in architecture is very anti-technology. Many of our leading thinkers and most influential architects today are not at all concerned with engineering, but rather with architecture as art, with elements of historic recall, with expressing very different ideas than those of the Modern Movement.

"Many of the forms of Modern Architecture evolved from new views about structure and engineering. Today, with that whole package of design called into question—and no longer central in the searching eye of many young architects—we really have to establish quite a new definition of the relationship between the engineering aspects of buildings and the visual aspects.

"I think that, in our teaching, we need to emphasize engineering less as a necessity, and more as part of the beauty of building design; emphasize equally with the importance of function the elegance of the engineering problems that are part and parcel of architecture."

Tyrone Pike, an architectural graduate now with the Tishman Research Corporation, reminded the Round Table of the great variation in the skill levels of today's architecture students: "A school can have a great curriculum; but that curriculum has to assume a certain base knowledge—which some students have and some do not. You can be trying to instruct a class on the design of solar shading devices, and ask them to calculate



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head, department of
architectural engineering
The Pennsylvania State University



Samuel T. Balen, FAIA
executive director
National Council of
Architectural Registration Boards
Washington, D.C.



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Kohn Pedersen Fox Associates
New York City

the penetration of light. Then you find that half the class needs three weeks of remedial work in trigonometry."

And architect Yann Weymouth of Redroof Design reinforced Bill Conklin's concern about "Post-Modern" influence: "The work of the students that I see in job interviews or at juries is just not builderly. They couldn't care less about how to build things.

"To me, and of course to many architects, engineering and design are one thing—the way you put it together and way it performs and the way it looks."

Engineer Richard Masters argued simply that the architect *must* learn: "I have worked with architects for many years, and the more I work with them the more I understand the terrible responsibilities they have. An architect needs to be trained almost as you train a doctor in medicine—because there are so many and such inter related things to learn and work with.

"I just can't understand how anyone can think about training an architect without instilling in him the necessity of learning the basics. The design talent probably can't be taught, is usually built-in; but the engineering disciplines can and must be learned. I believe that the architect should be trained to think of himself as the master builder, in terms of being the one person who understands the project as a whole and takes responsibility for it. While it is impossible to expect any professional to know everything about all the parts and every detail, at the least he should be aware that they exist, be aware of what he really doesn't know. It is the person who doesn't recognize what he doesn't know who is dangerous."

Architect Michael Greenberg, director of specifications and research at Haines Lundberg Waehler, believes that technical disciplines would be better learned if they were taught very differently: "I think *architects* should teach engineering subjects to architectural students. They would not just teach how to design a column, but show how that column will affect the architectural design. A plumber can teach you how to plumb, but not how the plumbing system will affect the other systems and the over-all design. When I was studying law at night school, the teacher came in and opened his briefcase and said, 'Remember what we were talking about last week? Well, I was in court today and here's how it worked out in my case.' That's better, that's livelier, than reading it out of a book. Suppose an architect of reputation brought to his students his first preliminary sketches—and then showed step-by-step the impact that all of the engineering disciplines had on the design to make the building work. That would be memorable."

And, added specifications expert Greenberg: "There are courses in the engineering disciplines and in materials and in methods of construction—but I'm not aware of courses in products. And we need them. For example, what products are affected by the structural design of a building? You need to know before you can figure roofing expansion joints. What products are affected by the

mechanical aspects of a design? Or affected by environment? We just finished a large project where, because of air-pollution considerations from a site three miles away, we had to change the exterior cladding, and because of that make structural changes.

"Similarly, a full course on codes is essential—not just code technology, but the impact on design of local codes."

Dr. Donald Greenberg, who is director of the program of computer graphics at Cornell, and who teaches structural engineering at both the architecture and the engineering schools, sees the same dichotomy in schools as in practice: "Architecture is really a fragmented profession. Architects work with consultants who are in a separate firm, do separate work, and who all have to be coordinated. To a large degree, even if we try constantly to communicate, we are acting independently.

"The schools are set up the same way. We teach in a fragmented way, even within the school. It is easier to teach concepts in isolation—but it may not be the best way. We should be dealing in the schools with the fact that architectural design is a synthesis."

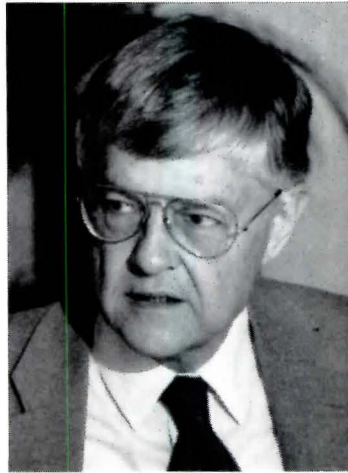
Sam Balen, executive director of the NCARB, sounded an alarm based on the history of the licensing exam: "I think one of the quickest ways for us (or for a young architect) to understand how much we don't know about the engineering disciplines is the licensing exam. Young graduates fail the new examination in great numbers, believe me. And most older architects remember the old seven-part examination—where the score on structures was almost always the lowest of all seven parts. A lot of us repeated that part of the examination several times."

Last year only 26 per cent of candidates passed the design test, though this may not be a meaningful figure because "we had an awful lot of young people taking the exam as an educational experience—to learn what it was like." Asked if NCARB was sure that "it wasn't a lousy exam," Balen replied that "we think it is a fair exam, and we evaluate our grading process pretty carefully. In studying 10,000 exams last year, and perhaps 12,500 this year, we find that on many test submissions the structure isn't quite evident; the mechanical systems are merely noted, and vaguely at that; there is no concept of how the building is to be heated or cooled; and there's not much there about lighting.

"And remember that the exam is being taken not by the just-graduated, but by interns who have a number of years in firms.

"Some of the knowledge these students need has to come from the schools, but more has to come from the profession. The profession has a responsibility to train young architects—and in that regard, I would like to urge support of the Intern Development Program being developed by NCARB and AIA. I think this kind of structured training during the internship period is very, very important—and I think our examination results make that point well."

Architect Ray Stainback of Thompson



William J. Conklin, FAIA
Conklin & Rossant Architects
New York City



James J. Foley, FAIA
Architect
Columbus, Ohio

Ventulett Stainback, and recent head of an AIA Task Force on the Intern Development Program, spoke of seeing some of the same weaknesses—in students and in schools: "Being in Atlanta on Interstate 75, we see a lot of students and their portfolios. They drop in on their way South during spring break. The range of skill and apparent basic knowledge is very wide. I'm disturbed by this range. Maybe we're accrediting schools we shouldn't. Maybe the schools aren't rejecting enough students. Maybe we're keeping too many faculties going.

"The best of the students from any school will do fine. But I am concerned about some of the others. We need young people who are not just designers—but who know the basics. Because that young architect will soon come up against a developer-client who wants to know—right away—"What do you think the pounds per square foot of this structure will be, or the watts on this electrical system; or the Btus per square foot of energy...?"

Ehrman Mitchell of Mitchell/Giurgola (and former AIA president) argued that the profession has the major responsibility for teaching engineering disciplines: "I don't think the architectural schools have enough time to make people vocationally proficient. In school, the student can learn only the beginnings, how to make the search and improve on the search for good design. They need to understand the importance of the engineering disciplines—but they don't have time to become engineers. The schools cannot educate to any depth in the engineering area. The profession must do that."

Herman Spiegel sounded a strong positive note: "Regardless of what any or all of us do, the good students really know what they need. They don't listen to us as much as we like to think. They take the best they can get from us and reject the worst that they get from us. . . . Students have to accept—and do accept—a lot of responsibility for themselves. They know they can't blame it all on Mom and Pop and Teacher; and we can't screw them up or make them great. There is a very strong undercurrent, in spite of the anti-technology that's currently making the rounds, of students who want to know how to put a building together and who are into engineering and want more of it. . . ."

The Round Table debated whether the small firms had the same "engineering involvement" as large firms—and concluded that they did

The debate began when Jim Scheeler, group executive for program and services management at AIA headquarters, wondered about the learning experience available for interns in small firms compared with large. He cited an annual AIA survey of firms in which an AIA member has an ownership interest. The AIA calculates that there are 10,600 such firms, and, reported Scheeler: "Seventy-seven per cent employ nine or fewer people, and given ratios of non-registered technical-support personnel, you are probably talking about 77 per cent of the firms having four or fewer

architects. Some 16 per cent are in the range of 10 to 24 employees. Those firms employing more than 25 are only six to seven per cent of the total, and of those only one per cent employ more than 100."

Large-firm architect Michael Greenberg asked: "Are all these smaller firms as concerned, as aware, of the engineering concerns we're talking about as the larger firms? I doubt it. For one thing, such firms tend to have a single entrepreneurial attitude, whereas large firms have input from several entrepreneurs running the firm who have different interests. The structure of the firm has to be less broad."

"I couldn't disagree more. I don't find it that way at all," said Herman Spiegel. "I don't think you have been west of Pittsburgh," said Ohio architect Jim Foley. "Or east," said Spiegel. "As a structural engineer, I deal with the less-than-nine firms and I deal with the giant one per cent, and I honestly don't find a difference. I find most of the small firms very, very concerned with technical matters, just as the large firms are. And there are some firms in both size categories that don't pay any attention at all to engineering. It all depends on the individual people, not on the size of the firm."

Ray Stainback concurred: "In Georgia, we have a tremendous number of small practices, and I find that they are necessarily more involved in the technical aspects because the principals are closer to the hot breath of the client. They don't have anyone to turn to, as we do in our firm, because they are out in the small communities where the best consultant engineer may be 200 miles away."

"I had the good luck to get a project in a Western state this year, and the bad luck to find that my NCARB certificate was obtained before the seismic portion of the exam was required. The preponderance of the other candidates taking the seismic exam with me were small practitioners who were going to be engineering the structures they were going to design. . . ."

Architect Bill Conklin returned to his concerns over the attitude toward engineering and technology held by those moving away from the functionalism of "Modern Architecture": "I think the relationship between architecture and engineering is determined not by the size of the firm or, as a matter of fact, by individuals and clients—but by something broader: the design theory that is held by the profession at a given time. I think of the late John Dinkeloo, who for a long time represented a beautiful integration of architecture and engineering with his development of mirror glass and gasketing and weathering steel, his engineering solutions to architectural design problems. He represented, I think, a design theory based on the totality of concerns of the architect perfectly integrating architecture, integrating engineering and visual form.

"But we should realize," Conklin argued, "that there are many who feel otherwise today about the relationship of the two fields—who don't see as the goal the integration of architecture and engineering, but the



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New York City

communication of design ideas and images. And in that case engineering has a different role. If we change the way we think about design, it is going to change our traditional way of thinking about the relationship between architecture and engineering."

Myron Goldsmith, while not disagreeing that we should be observing and "listening" to the Post-Modernists, argued that "I think the current movement, which seems to turn its back on engineering and, if you will, the rational side of architecture, cannot really make a very deep impression. Ninety-nine per cent of the work that is going on does try for efficient structures, for mechanical systems that work.

"In any event, I think that there must be a strong technical education of the architect—and luckily the architect has a couple of chances to learn. No matter what the school teaches, part of his education is, of course, the experience during internship—and it is not going to take him long to find out the importance of the engineering disciplines. When some of his most beloved ideas get shot down because they are too expensive to build, when that lovely long span proves prohibitive, when he gets into a technical problem by trying some new material—he is going to discover the importance of engineering disciplines whether he wants to or not. They soon find out where the limits are, and they soon find out where to turn for help when they need it."

Tyrone Pike reinforced the idea that energy conservation—and especially renewed interest in daylighting—will tend to force stronger integration of engineering

He did so in response to a comment from senior editor Bob Fischer, who said he "was really impressed with solar and daylighting designs I have seen recently on the West Coast—done by young people who seem to have very sophisticated analyses and design approaches well under control."

Said Pike: "Energy-conservation efforts, again especially daylighting analysis, force you back to the reality of understanding spaces as a whole, how light influences the space. We've talked about integrating structure and mechanicals with the form of a building—but in dealing with daylighting you must think not just about integrating the technical aspects, about engineering the lighting system to work with daylighting, but with integrating the *feeling* of the space you want. These issues bring a far more holistic view of architecture back into the design process.

"More and more architects who have long ignored the realities of solar loading on building, and who depended totally on mechanical heating and cooling and electric light, are reconsidering the micro-architecture of window design, the possible solar controls outside and in, as an integral part of both engineering and architectural design. The architect has to start lighting design not from an electrical-engineering point of view, but from the point of photometrics and the various light sources outside the building. That offers a great opportunity for a return

towards the master builder relationship between the architect and his design."

Will computers and other sophisticated tools change the architect's need for engineering expertise? Sure it will . . .

Said Don Greenberg of Cornell's Program of Computer Graphics: "Computer technology has outpaced our ability to use it. The major problem is no longer the cost, or the power of what these machines can do, but how to use it. Other industries are able to make more effective use of the computer than we do, not because their problems are more or less difficult, but because the computer designers and experts do not understand the mentality or the intentions or the objectives of the architect. This is an emotional issue for me because I was educated as an architect, am still deeply involved with architectural design, and dream that someday we will teach design using not a pencil and yellow trace, but something that looks like a pencil except that it has a cord attached to it and makes marks on a cathode-ray tube.

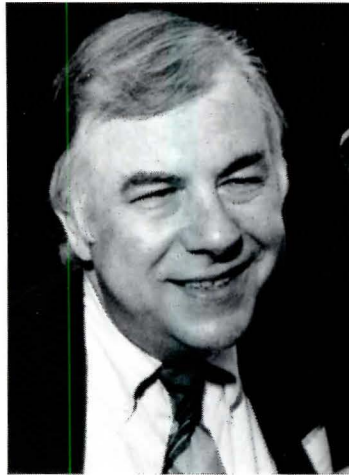
"Suppose as a teacher I could ask my students for the design of a house, with a given square footage and given budget. I would, of course, require skillful plans and elevation drawings. But I would also want to see how it would look from any angle as I walked around the house. I would like a complete structural analysis. I would like its energy bill if it were built in, say, Ithaca, New York. I would like a complete cost analysis. I might throw in a complete solar-energy and daylight analysis. And I would like it all turned in to me in two weeks.

"Well, I can do that *now*.

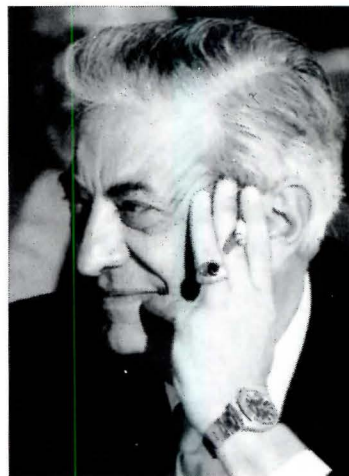
"As more and more simplified and sensitive computer programs become available, I foresee that the small firm we've been talking about will be able to do all the things that large firms can do. Those 77 per cent of firms will be able to take on large buildings and do the structural analyses and the thermal analyses and the daylighting analyses. We might see a change in the distribution of the sizes of offices because of the new capabilities of the smaller firm. And we could see changes in the administration of architectural firms, even the definition of what an architect is, as computer experts become principals in architectural firms or architects become computer experts. And don't forget that—unlike most of us—our children understand and are comfortable with these computers. . . ."

Tyrone Pike strongly supported the argument for greater use of computer technology in design: "I am young enough to be completely comfortable with computers, not the least bit worried that the world will blow up when I start playing with the terminal. Those of us who grew up with computers have the great advantage that we are at ease with computer technology and the flow of information back and forth. Talking with the computer is second nature.

"Nonetheless, it is true that many of the computer programs used by experienced experts are not yet readily accessible to the average architect. The programs used for a



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lot of structural engineering and mechanical design and energy analysis are 'hostile,' are very hard programs. I feel that for the use of the computer to grow in the building industry, and perhaps particularly among architects, the programs have to be soft, very graphic, with a minimum of those reams of numbers and columns. So we have been working with small micro-computers, and have been able to develop software that lets us make, for example, an energy analysis come up with very fast iterative results, and present those results graphically—in terms every architect can understand. Specifically, I am talking about taking the 50 or so parameters that describe the energy performance of a building, putting them into a computer that costs you less than \$5000 and sits right next to your drafting board, and getting the answer in both numerical and graphic form within nine seconds! With great ease, you can change one or more of the parameters, and get an estimate of the sensitivity of various design variables. And that is the issue that is so important in integrating these technologies into design—the ability to explore more variables with ease and in a very short time.

"This is all available now—with a \$5000 investment that will pay back its usage in three or four months. And of course it is all directly relevant to our question of the engineering education—the engineering ability—of architects, young or old."

Engineer Richard Masters agreed that "it is important to be grounded in the use of these computer tools." But he sounded three concerns:

"Just as there is a concern that the architect will lose part of his function to the technician, the corollary must be guarded against: the architect should not try, given these new computer capabilities, to go beyond his capability and training. There is so much to know in any of the disciplines that affect design that it takes almost a lifetime to develop the judgment that comes with true expertise. Computer programs do not offer judgment—only answers, if you ask the right questions.

"Second: I would caution against becoming over-enamored with this technology. We have a tendency to make things too complicated. For example, a computer-run energy-management system is fine for a large and complex building, but I would be hard pressed to justify one in a well-designed little 100,000-square-foot building.

"Third: I firmly believe that before you begin to work with computers, you have to understand how to use the slide rule, and how to do things longhand. Any architect or engineer should really know the answer in broad terms before he even attempts to solve the problem—and that comes only after good training and good experience. Even with the new computer capabilities, you have to pay your dues."

Architect Jim Foley called it "the Fiedler Syndrome": "Arthur couldn't play the first violin, but he knew enough about it so that when it was played badly, he threw the guy out, and when it was played beautifully, he

patted him on the head. If the architect is to orchestrate the building process, he has to have enough Fiedler Syndrome to know when the mechanicals are right, the structural are right. . . ."

If the architect is to orchestrate the process, be the generalist, how do you train the generalist?

"There are a lot of different views on that," said Karl Justin. "I have my own, which is that you train him by making him an expert in at least three fields—that gives him perspective. If you train a person *just* to be a generalist, you wind up with someone who is really not first-rate at anything, and you wind up with second-raters managing first-raters—and you run yourself up a tree that way."

Tyrone Pike disagreed: "I think you could be second-rate at five different things, but because you know how to look at five things, you are first-rate at managing the process. You can say, 'I can't make any ESI calculations, but I remember lighting designs that came in at 1.6 watts a square foot. How come you're at 2.5, expert consultant?'"

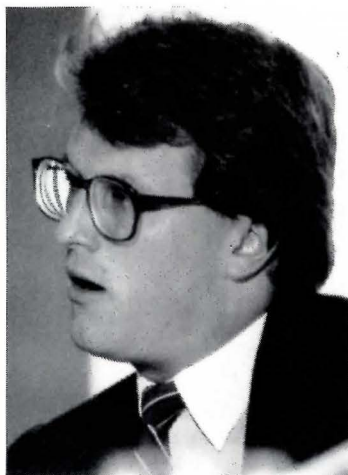
Engineer Herman Spiegel: "I disagree with both points of view. I don't think by being a good manager you will necessarily be a good architect. To be a good architect you have to understand that it's an art, that it's an intellectual pursuit, and that you sure better be good in that."

"Besides, if you are going to be an expert in anything, you better devote your life to it. If you spend two-thirds of your time on something else, you're not going to be as expert a structural engineer as I am—because that's all I do."

Said Architect Ehrman Mitchell: "I think that in practice what the generalist must be expert in is taking a broad view of things, continuing to search, taking on many many challenges. I don't think the architect need be an expert in any one of those disciplines or problems—but he has to know and use the pool of resources, the consultant expertise, that can be brought together to make the most of the architect's vision and ability. . . ."

Bill Conklin started a train of thought by reporting a lunch-table suggestion "which I deny being the author of: Is it possible that architects should just be excellent architects, and engineers just be excellent engineers, so that when each did his job beautifully there would be no need for a generalist?"

Said AIA's Jim Scheeler: "That is a very interesting point and leads to this question: Is it possible for the building-design professionals to come to any kind of real agreement on a standard of skill and care? One of the problems we had in developing our new professional development program in energy conservation was trying to define what the required knowledge base should be. We were trying to define what anyone who uses the title architect should know about energy in the design process. Maybe we could in fact establish standards of knowledge and care which would include all of the disciplines of design; maybe we can define what anyone



Tyrone Pike
Tishman Research Corporation
New York City



James A. Scheeler, FAIA
group executive
program and services management
American Institute of Architects
Washington, D.C.



Herman Spiegel
Spiegel & Zamecnik, Inc.
consulting engineers
New Haven, Conn.

who uses the title engineer or the title architect should have as a scope of understanding. The capacity of any individual to artistically express this knowledge is of course a different matter. . . ."

Question to the architects at the Round Table: How would you change the education of architects?

Would you change the balance of time spent in school on design as opposed to engineering disciplines? Do you wish students knew more about handling working drawings and specifications?

Bob Cioppa of Kohn Pedersen Fox got one of the best laughs of the day by suggesting that "what I would really like to have are architectural graduates with five years' experience."

"As I said before, we are very pleased with the graduates we've been getting, and the design skills they come with. But they do lack technical skills in what is considered basic architectural technology; never mind structural, mechanical, electrical, keeping water out, the basics of curtain walls, the basics of flashing a roof. We don't expect a new graduate to have great skill in any of these disciplines. But we expect them to have the basic courses that permit them to understand these problems and the solutions as they see and learn them in the office."

Bill Conklin: "I agree. I think also what you look for is an attitudinal quality. Regardless of his exact design orientation, one dreams of a graduate who is fascinated with technology and loves engineering. Does he see engineering as an elegant part of his total subject? If he has a positive attitude towards what he has to learn, he'll learn it."

Architect Yann Weymouth emphasized the importance of experience after school: "I think that I have a very good understanding of lots of different kinds of engineering and construction. It's in my bones, because I have been building for a long time, and have spent a lot of time around construction sites. I had a pretty good education, but today I can't tell you what the moment of inertia of a beam is. I can only tell you it ought to be about this big [*indicating with hands*] and ought to weigh about so much. You cram for NCARB exams, and then after the exam you don't remember how to do the calculations. Of course you can look it up if you need to—but the important thing for architects is to have the right intuition—and absolutely to know when something 'isn't right.'"

Herman Spiegel: "There is no single best mode of learning. Everyone around this table brings something different, a different point of view; yet we're all good bright people and successful at what we do. We each see the best way to train young architects in terms of our abilities and our experience and our likes and dislikes. There is no right and wrong. . . ."

"We all have different versions of what the basics are, and we define them differently. But as long as the young people pursue them, I don't care whose definition they use."

"During the three years of internship before you approach licensing, the young

architect must continue to learn—including learning by making mistakes. At any rate, it doesn't matter where you get the knowledge you need as long as you get it somewhere along the line. Of course it never stops. . . ."

Ray Stainback outlined the intern development program he began in Atlanta (which is related to, but seemingly less structured than the IDP program supported by NCARB): "Ours was really a supplementary education kind of thing, where local practitioners got together to see that their interns had available sources of information in all of these design disciplines we've been talking about. It's a monthly program, and we bring in people who are really knowledgeable in various fields. They were chosen as experts who could relate, say, mechanical engineering knowledge to the design or working drawing work the intern was doing. We have 30 to 40 young people turn out every month."

What subject matter is covered? "Over a 12-month period, we might spend three of the monthly meetings on legal affairs—bringing in lawyers, insurance people, documents experts. Then we might get into marketing—we assume they know how to design, so we bring in lecturers who are expert in presentations, in selling their design ideas to the client. Then we bring in engineers who discuss the best ways for architects to make efficient use of the engineers' time: How to convey to the engineer what you need, and how to listen to what the engineer proposes. Finally, we get topical. Right now, of course, we have sessions on energy conservation techniques. But we also get into waterproofing and all kinds of basics like that.

"Over each three-year period, we try to have it cycled so the intern has enough different subjects each year to keep it interesting. We try to keep principals out of these sessions, so the intern can ask stupid questions without embarrassment."

Architect Mitchell introduced the idea that it's not a one-way street, that engineers need architectural training

"Young architects think of themselves as creative thinkers, and when they enter a firm they think of themselves doing creative work. As they develop their skills in the technical disciplines—or even as they get involved in business development—it is from that base as a creative thinker.

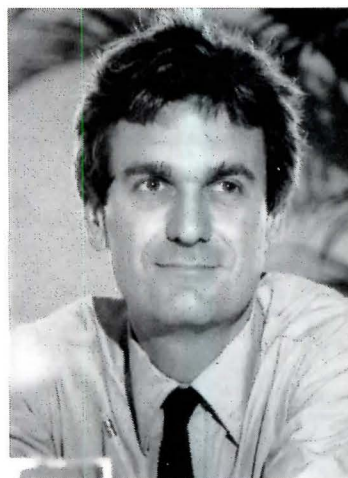
"I don't think we get the same kind of attitude, and response, from the young engineers. Not very many engineering students think much about architects and architecture, so when they come to work there is not much of a meeting of minds—and that meeting ground for creative thinking has to be developed."

Herman Spiegel: "I agree. Architects have been trying very hard to get into all the engineering disciplines; but engineers haven't really been trying at all to understand the architectural disciplines."

Added Gifford Albright, who heads Penn State's unique* Department of Architectural Engineering:



Raymond F. Stainback, Jr., AIA
Thompson Ventulett Stainback
Atlanta



Yann Weymouth, AIA
Redroof Design
Long Island City, N.Y.

"We would not be able to do what we are doing if the mechanical engineering department, the civil engineering department, and the electrical engineering department had a sense of understanding or interest in the building industry. I think if you look at most major universities—unless there are certain personalities or some other strong factor involved—you are not going to see many engineering students entering the building profession or working with architecture. The traditional engineering departments are not thinking that way; the deans of engineering are not thinking that way; the Engineers Council for Professional Development is not thinking that way."

Why are so few engineering students interested in building? Lower pay, less prestige, no security—and the lack of the dream that moves architects"

Said architect Michael Greenberg: "It's no secret that architecture doesn't pay as well as other professions. That's a tradition! Few architectural firms offer the kind of benefit package that most corporations do. You don't see much planning for retirement at the managerial level in architectural firms.

"Beyond that, few engineering graduates are informed about what engineers do in an architectural office."

Ray Stainback saw differences in the attitudes and problems of engineers (and engineering students) of different disciplines: "You can still find good structural engineers. They share the feeling that 'it's an art' that motivates so many young architects—the hope of making some significant contribution.

"Electrical engineers are being lured away by the electronics industry. That's our whole problem in that field.

"Mechanical engineers? There's a thankless job. Not one person ever says anything good about the lighting engineer or the air-conditioning engineer from the first day he takes out his Ductulator and goes to work. If the space in a building is comfortable, 'it cost too much.' And no matter what conditions you create, somebody is going to be too hot and somebody else is going to be too cold. There is no way a mechanical engineer can make people happy. . . ."

Herman Spiegel: "In part it is the schools' fault. The problem started back in the late 1940s when, if my memory is right, some of the Ivy League schools started looking at the engineering disciplines of building and started

* Penn State has a separate department of architectural engineering (separate from the school of architecture—which requires some courses in the architectural engineering department). In the architectural engineering department, the concentration is heavily on environmental systems and structural work. The architectural engineering faculty, which is interdisciplinary, teaches "courses based on very highly scientific physical concepts, coupled with courses in architecture (which are taught by the architecture faculty). The architectural engineering program is a five-year program—with an elected option at the end of the third year. One is the traditional architectural structures option. The second is the environmental systems option, which includes illumination, hvac, acoustics, and the like. The third is the building construction option."

saying, 'Why, all of this smacks of being a trade. You have manuals, and you hook up beams and pipes—and what is that kind of thing doing in a powerful liberal-arts environment? There's nothing wrong with it—but you better teach it somewhere else. . . .' And that attitude spread across the country."

Myron Goldsmith of SOM's Chicago office argued that, "I don't think the big Midwestern schools ever gave up training structural engineers in the traditional way; and I know that a fair number of structural engineers with masters' and doctorates are coming into our office. Of course, perhaps it is the very large buildings we do that gives them a reason to come." "We do have the advantage of having all of the engineering disciplines within the office—and what we have done is to take the structural and mechanical engineers and put them in groups with architects—it's a studio system that lets all disciplines work together, and that of course increases communication, lets architects and engineers work side by side.

"I suppose this is easier, or works at its best, on a fairly large project. But I think it is possible even on smaller projects, and that much smaller offices than ours could find their own system. . . ."

Tyrone Pike spoke of "the architect's dream," and the engineer's lack of a dream: "The dreaming—the hope of making a really important contribution to architecture—is part of the reason that the architecture schools are full and turning away students. Most engineering students are more pragmatic—they aren't as attracted by the glamor of a truly elegant solution, so they look seriously at the petrochemical industry and the benefit package laid out and that house in Houston.

"Architecture students—indeed architects—don't spend much time looking at the downside risk, and they don't spend much time thinking that 'if this doesn't work I can go into graphics or industrial design.' They're a little bit crazy—and that's one great part of being an architect. They have a dream. . . . Engineers are typically not trained to deal holistically with the many, many disciplines and pieces that go into a building; and thus the hope of an elegant solution and the hope of something great through an amalgamation of forces and disciplines just doesn't draw the best engineering students as it does the best architectural students."

And so the Round Table came to a final wrap-up, a final round-robin—and some fascinating final thoughts

Said Karl Justin: "I think the basics are essential, that the young need to learn from the experienced. Tennyson tells us, learn from Bartlett's, that 'The old order changeth, yielding place to new;' but also that 'The worst is yet to come.' Those who are anti-technology, or disinterested in technology, should understand that engineering is a science. Science means *knowing*—and if you don't know, you are guessing. In the end there is no place for a drunk to go but home; we have to wind up with a competent technology."

Bob Cioppa: "One caution: The design

integration of technology and esthetics—everything we've been talking about today—is important, and the marketplace judges our designs on the technological results. But we are judged by our peers for our designs, and our skill at design is perhaps even more important."

Bill Conklin: "I guess the aspect that interests me most I've mentioned earlier: the effect on the relationship between architecture and engineering that our evolving design theory and philosophy may have. For a long time, one of the givens, the goals, of architecture was to give expression to technology. That seems to be changing as we see more designs intended to express something else—a relationship to history, or a special image. I suspect this evolution may change our way of teaching and thinking about the relationship between architecture and engineering."

Myron Goldsmith: "As I said before, I am very opposed to the anti-technologists, those who are against the whole idea that technology has anything to do with architecture. On the other hand, I hope I am not perceived as a technocrat, interested only in the narrowest idea of technology and architecture. I think we, and our disciplines, need to work together. . . ."

Architect Michael Greenberg: "I believe in doing all we can to integrate the disciplines of architecture and the disciplines of engineering, and I believe there are three ways to approach that integration. The first is in school. I believe the schools should change their curricula somewhat to reflect more of the real world, more of what actually goes on in an architecture office—where architects and engineers do in fact work closely together on a day-to-day basis. Second, as an architect who did not graduate from architecture school but did it the so-called 'hard way,' I am a firm believer that you learn more 'by doing.' I think there should be more work-study programs, and more working periods integrated into our degree programs. Students should be placed in firms for five months at a time—summer vacation is not long enough. Finally, I would promote more student programs within the office. Our firm believes in, and has, a good program for work-study and a good internship program."

Ray Stainback: "As I mentioned earlier, we have an extensive intern-development program. We also take work-study, or co-op, students into the office—but I have a reservation. I think that you must be very careful with students still in school about introducing 'real-world' situations on too hard a basis. I think students should keep foremost in their minds that what they are really out to do is create good architecture. Office pressures can become the tail that wags the dog—and that's not good."

Ehrman Mitchell: "Just right. The core, the tap root, of everything we are talking about is understanding what we are all about. The question is not what architects are or what architects know—the question is what *architecture* is!"

Tyrone Pike: "The big opportunity is better teaching using better materials. We

need to capsulize the most important information, digest it, and present it to student and professional alike as efficiently as possible. We need to train and retrain not just the student, and the professional through continuing education—we need to train and retrain instructors and professors and give them the best possible tools with which to teach. Most of the faculty members teaching the engineering courses in architectural curricula have no idea what the architectural students really want to know, and they sure don't make it easy, much less seductive or attractive. . . ."

Jim Scheeler of AIA: "The term 'seductive' suggests that a program must not only include what the architect needs to know, but must compete for the professional's attention. Our new professional development program dealing with energy in design has so far been successful because it was established within the profession, and is a first priority of the Institute. Whether or not we can market or promote that program so that it will 'seduce' architects to take the time to go through a rigorous process of continuing education remains to be proven. We think it will be a successful program. . . ."

Ray Stainback: "Right or wrong, we insist that you have a professional degree in architecture to be considered for employment—because we think the design training you can get nowhere else is a critical part of being an architect. There is no time any more for sitting at the master's knee to learn design.

"Architecture does involve technology—and the student has to get part of that skill at school, and we'll try to help with the rest at the office.

"But it takes a pretty strong individual, a young person pretty confident about what he or she wants to accomplish, to get into this pot that's boiling over—and still remember that good architecture is the goal. . . ."

"As to the technical side of it all, I agree that the college courses are necessary, but I agree that at most schools they are deadly dull. Why can't they be as interesting, or made to inspire the same kind of interest, as the design courses, the esthetic issues?"

Herman Spiegel: "Once again, I think it all depends. As I've listened to all our discussion, including my own, I can agree with some of it, disagree with some of it. But I didn't hear anyone trying to ram their point of view down anyone else's throat. How much engineering should an architectural student have? It all depends. Some will seek out a lot of it, others will do with less, and there isn't a right or wrong. We tend to get as much as we need for themselves. There is no magic answer and we shouldn't look for a magic answer."

Architect Yann Weymouth had the final word: "Any architect is trying to make a beautiful building, a wonderful place. To do that you *need technology*—you need to understand the materials, the structure, the air conditioning, the solar load, the seismic problems. You can't have design without the engineering. It's a whole thing. . . ."

—Walter F. Wagner

THE WOOLWORTH TOWER: A TECHNOLOGY REVISITED, A MATERIAL UNDERSTOOD, A LANDMARK RESTORED



The Woolworth Company could have forsaken Cass Gilbert's famous skyscraper, but they didn't. The building long ago paid for itself, its prestige and its location (near New York City Hall) continue to attract tenants, and, no surprisingly, the firm rather likes its building. So Woolworth made the major commitment to repair the failing terra cotta facade—major in scale and in cost (the repair cost as much as the building did when completed in 1913).

Then, the tower's soaring steel frame took the most advanced structural knowledge of the day to new heights. And its elaborately detailed facade was clad in a material justly popular for its durability, fire resistance, light weight, and low cost no less than for its availability in an almost limitless range of colors and finishes as well as its capability of being molded to achieve an endless array of ornamental and decorative effects. The Woolworth Building, wrote the fabricator of its cladding, "was designed for Architectural Terra Cotta and could have been executed in no other material."

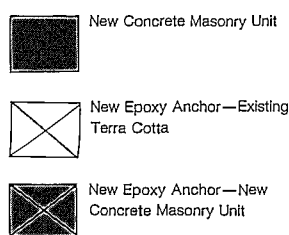
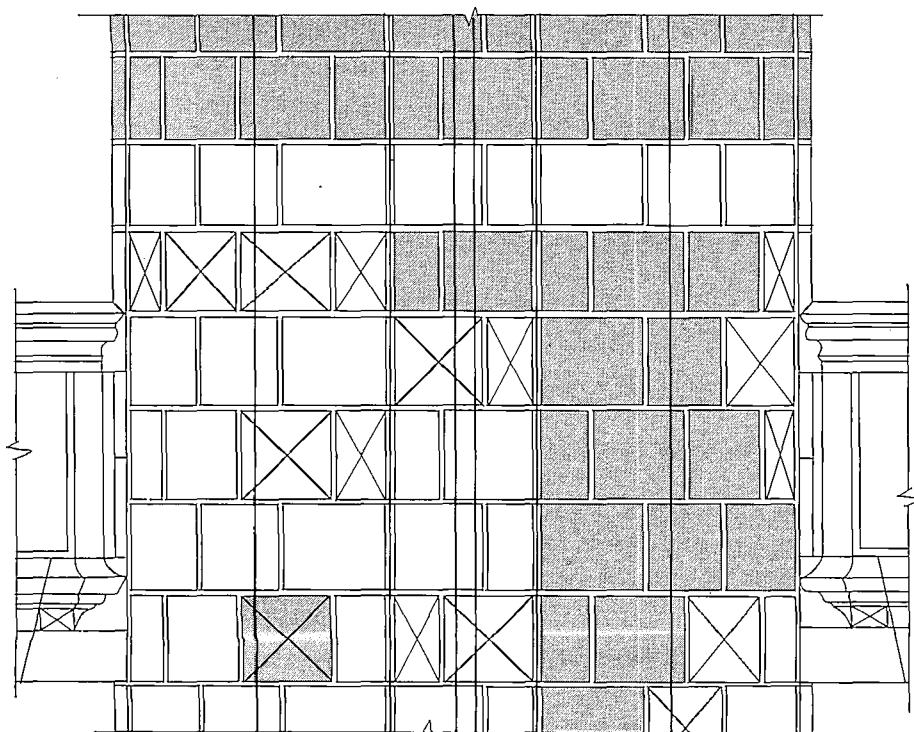
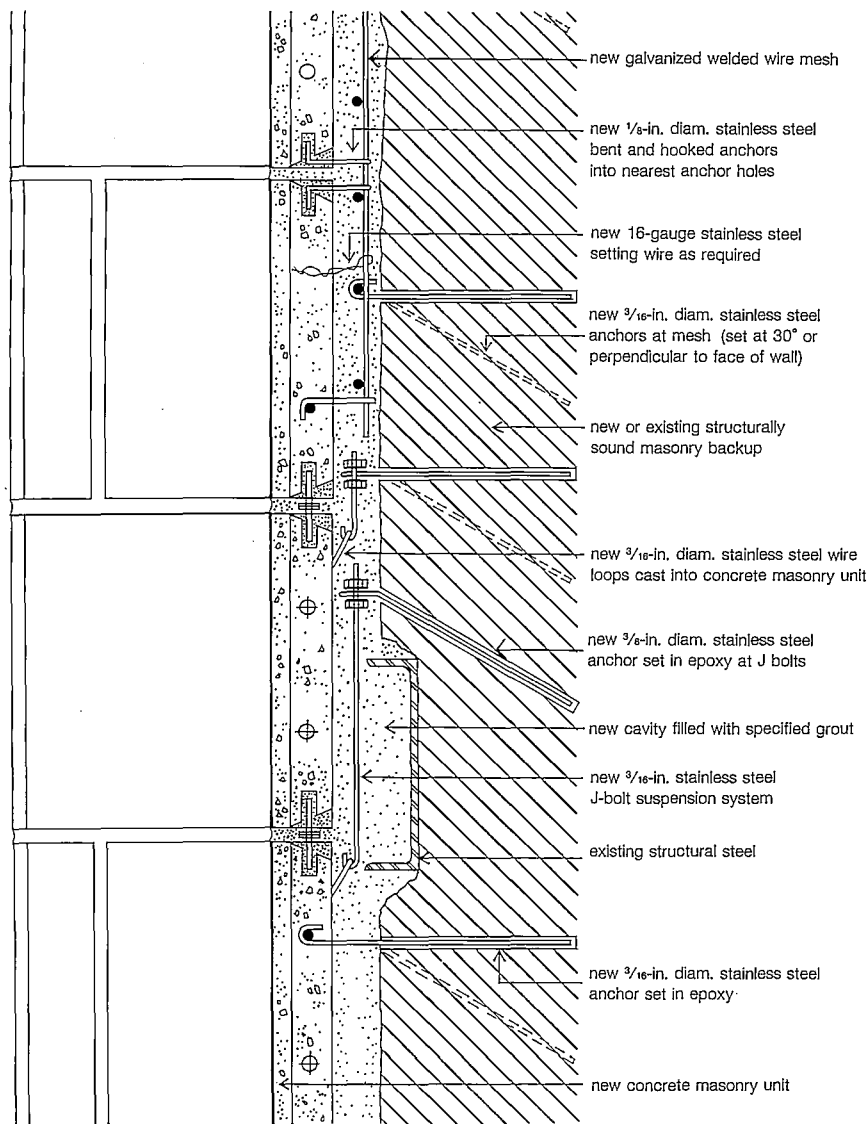
But the gleaming terra cotta facade of Gilbert's proud ivory-colored tower began to fail, says Carl Meinhardt of The Ehrenkrantz Group, the architectural firm now charged with its restoration, even as it rose.

Some 60 years later, despite a continuous round of pointing, caulking, and patching, the deterioration of the facade was outpacing the repair effort. Not only was the band-aid method of repair with cement mortar increasingly inadequate, it was, as the patches multiplied, increasingly unsightly.

With its maintenance holding action threatening to become a rout, the Woolworth Company took the offensive, retaining The Ehrenkrantz Group and Turner Construction Company to study the failing facade and recommend action to halt and reverse its decay. The paramount consideration, says J. R. van Leuwen, Woolworth's vice president for construction, was to restore the structural integrity of the cladding and ornament and so ensure street safety. But Woolworth's management were equally concerned that necessary repairs be carried out in such a way as to preserve and renew the architectural qualities of its landmark headquarters and that the techniques employed be readily replicable as a basis for ongoing maintenance and repair.

In 1977 the facade was cleaned, revealing for the first time in decades its rich detail and vivid coloring; double-glazed aluminum sash was installed to staunch the thermal hemorrhage through the original crumbling, copper-clad wooden windows; and by mid-1978 the laborious task of facade restoration was underway.

The Ehrenkrantz Group, meanwhile, had undertaken thorough studies to determine the nature and severity of the ills plaguing the troubled terra cotta as a preliminary to prescribing appropriate curative measures. Even with the benefit of hindsight—and the considerable diagnostic experience of the firm's restoration specialist, Theodore H.M. Prudon—the full etiology of the Woolworth Building's mutually exacerbating complaints is difficult to trace with surety.



It was early apparent, however, that the root of the problem lay precisely in the originally heralded housing of the steel skeleton in an ornate masonry skin: a 20th-century framing system wedded to an 18th-century cladding system in a marriage, as Prudon characterizes it, incompatible from the start.

For the cladding could not function as cladding. The egg-crate-shaped terra cotta blocks typically were keyed to a masonry backing and anchored by iron straps in construction rigidly bound to the steel frame with no provision for differential movement brought about by thermal fluctuation, wind loading, or expansion of the masonry as a result of moisture absorption.

Inevitably, all of these conditions occurred, starting with one-time (and unequal) moisture expansion of the terra cotta and its brick backup during construction. And inevitably, the terra cotta began almost immediately to show its distress in a cycle—not unknown in more recent masonry cladding—of self-reinforcing failure. Restrained from movement, the glazed blocks crazed and cracked, admitting moisture. This led to expansion that heightened the effects of thermal and dynamic stresses, leading to more cracking, more moisture penetration, and finally to the added expansive thrust of corrosion buildup on inadequately waterproofed support steel and anchors.

Because the resulting damage occurred spottily over the facade and because serious structural failure can lurk behind a seemingly innocuous hairline crack, the first step toward restoration was an inch-by-inch survey of the entire facade. From scaffolds, each of the building's nearly 400,000 blocks was inspected visually for cracking patterns indicative of underlying problems—long vertical cracks suggesting excessive stress in the terra cotta, more localized lateral or diagonal cracks suggesting corrosion of the anchors or support steel. In addition, each block was tapped for the give-away hollow sound indicating shearing of the webbing or other interior damage.

The survey results were then recorded on photographic blowups of manageable sections of the building facade (preceding page). These became the basis for partial elevations pinpointing the position and condition of damaged terra cotta and later for field documents specifying the recommended method of repair or replacement.

The prevalence of long lightning cracks and a repair history of blocks shattering or removal being clear pointers to unacceptable stress in the terra cotta, strain gauge measurements were made that confirmed stresses of two to three times the safe loading. Since the continued presence of such pressure would not only set the stage for further deterioration but would jeopardize the lasting effectiveness of the restoration work, attention turned early to measures for relieving this residual stress buildup—in effect providing the expansion joints omitted in the original design.

The structural engineers on the project failures specialists Wiss, Janney, Elstner and

Associates, suggested that this might be accomplished by cutting through horizontal joints and repointing them with a more elastic mortar mix. Accordingly, a three-story test wall section was instrumented and the joints at every floor opened to the full 4-in. depth of the terra cotta. When this was found to relieve the stress only in the blocks immediately adjacent to the cut, intermediate cuts were made. Again, stress relief was limited to adjacent blocks, but it also proved lasting; no buildup of stress in the affected terra cotta was measured after a year. So the groundwork for restoration was laid by stress cutting and repointing every other horizontal joint over the entire facade.

Meanwhile, further testing and analysis had led to the development of techniques for repairing or replacing the damaged terra cotta which would strike a balance between aesthetic purity and economic reality.

The increasingly elaborate ornamentation that marks the stages through which the building rises to its wedding-cake pinnacle presented special problems that demanded a repertoire of special solutions. The bulk of the facade, however, consists of angular but essentially flat-surfaced blocks cladding piers and of spandrel units with relatively simple relief decoration. For these, two methods of repair short of replacement were employed. The first, feasible when blocks were badly spalled but otherwise sound, was cosmetic repair by application of a waterproof coating. The second method, used on some 26,000 blocks that were cracked or hollow but sound on the perimeter, was to stabilize the intact pieces by pinning them to the masonry backup with threaded stainless steel anchors set in epoxy grout.

In the case of another 26,000 unsound blocks, the extent of failure dictated their removal and replacement. Candidates for this remedy were terra cotta units in which cracks were severe (larger than 1/16 in.) or jagged, resulting in pieces too small to pin, and those that evidenced signs of serious internal damage or had been extensively patched.

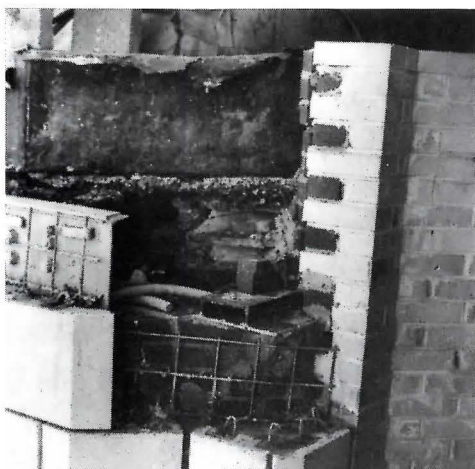
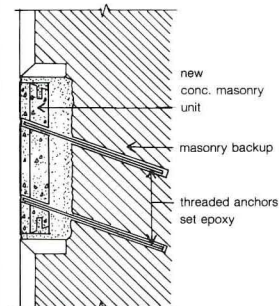
To fabricate blocks to replace the unsound terra cotta, literally dozens of materials and coatings were explored and tested. The final choice was a dense concrete specially developed by Art Cement Products Company. Cast in molds taken from the original units, the material allows a close intrinsic color match with the variegated creamy glaze of the terra cotta, and its faithfulness to the original is further ensured by a surface coating that weatherproofs the units, preventing their darkening due to water absorption, and provides the proper reflectivity.

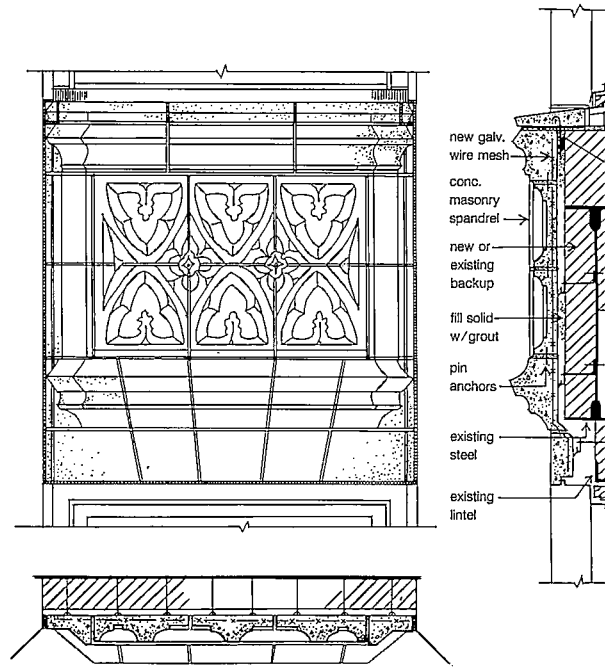
The development of a look-alike replacement material, however, was only the beginning. Even with the advantage of repetitive precasting, achieving the seamless integration of the new masonry units with the existing fabric of the building required casting new elements in more than 500 different shapes and sizes, including no less than two dozen individual molds for the spandrel panels alone.

Moreover, the challenges of installing the

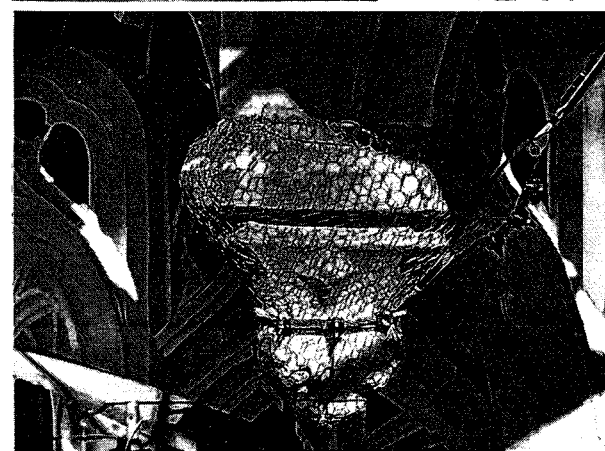
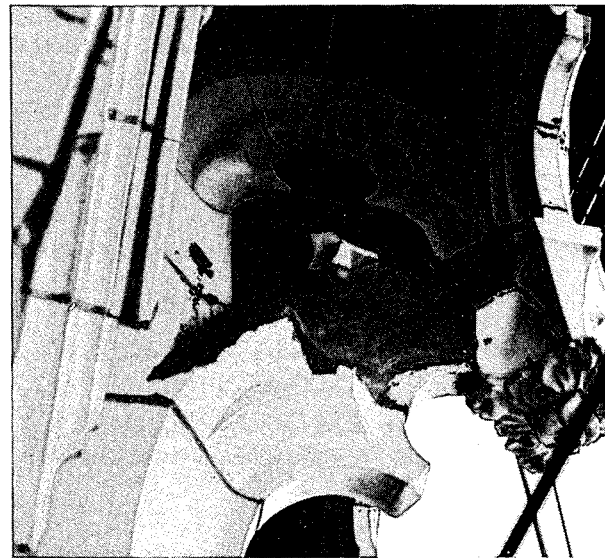
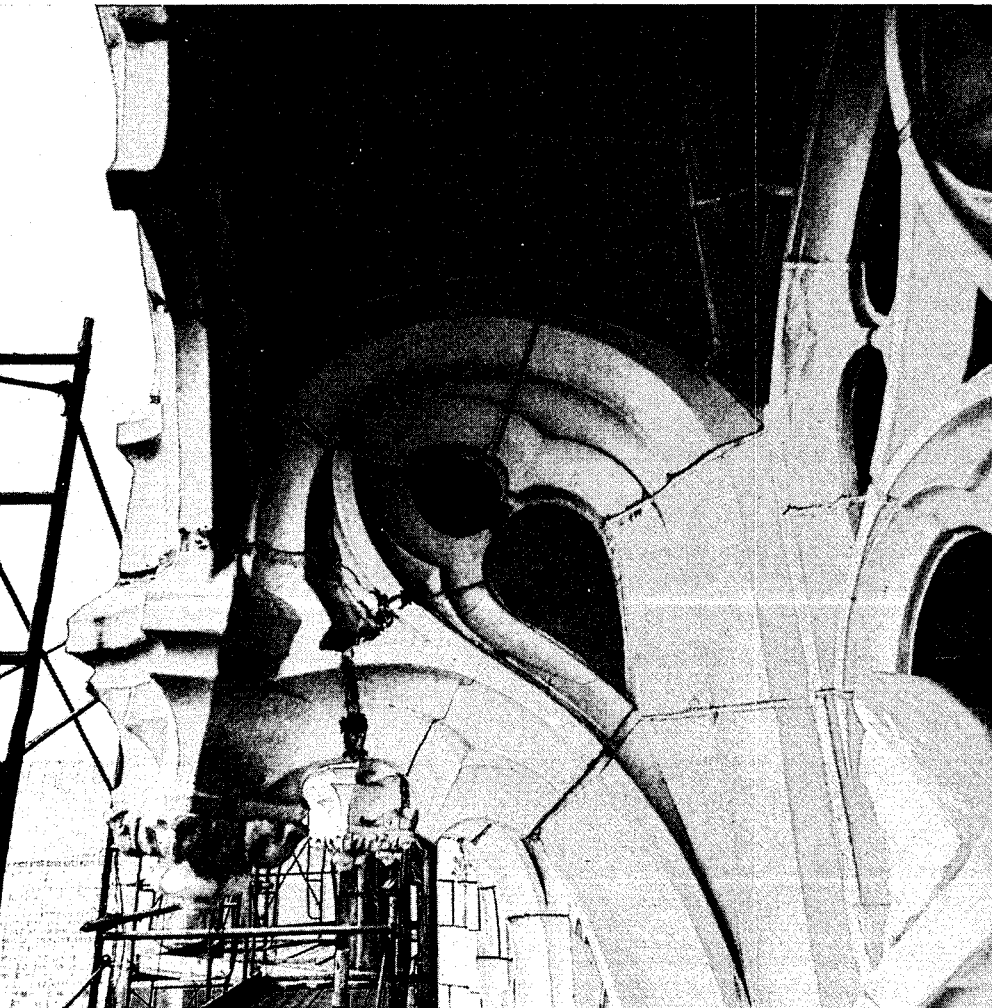


After repairable terra cotta blocks were stabilized by pinning with epoxy-set anchors (above), badly damaged blocks were replaced with look-alike precast concrete units. Installation methods differed somewhat depending on the extent of the contiguous block area requiring replacement and the condition of backup brick and support steel, but typically entailed the measures detailed at right and on opposite page.





Concrete masonry replacements for damaged spandrel panels were cast in molds struck from the original terra cotta. Two-step casting allowed replication of integral background color. Below: The complex curves of the haunches under the building's elaborate projecting canopies were matched in polymer concrete poured in place into fiberglass molds formed on similar haunches. Damaged pendants that could not be repaired by other means were strapped into wire baskets (bottom right).



ew units took up where those of fabricating them left off. Although standard details (see section page 92) were developed to meet the full range of conditions predicted by the survey, actual conditions encountered in the field, frequently proved neither standard nor as predicted.

Culling of blocks slated for replacement, for example, could reveal unsuspected damage to support steel or backup masonry or both, requiring quick decisions on necessary repair. Removing the blocks could also precipitate failure in adjoining units, enlarging the anticipated scope of replacement work.

Moreover, such eventualities demanded literally an overnight response. Because the building has remained tenanted through the restoration project, the noisiest and messiest work—jackhammering to remove damaged blocks, hauling out resulting debris, bringing in replacement units and other supplies—was relegated to off-business hours, necessitating the round-the-clock presence of the architects' site supervision crew, along with Colyer Associates, the wall subcontractor, to devise and authorize on-the-spot alterations in the work plan.

If the arduous but comparatively routine repair and replacement of damaged blocks in the piers and spandrels covering most of the building's exterior called for extensive custom fitting, the preservation of its highly decorative elements—balconies and buttresses, turrets and parapets—entailed nothing less than hand tailoring.

A number of cracked but intact ornamental shapes were stabilized by injecting epoxy into the cracks or strapping the pieces in place or both. Others were repaired by methods evolved from those used on the body of the tower: patching, cosmetic repair, pinning with epoxy-set anchors. Some recurring elements were replaced, albeit in simplified form, by molded concrete masonry units. A few details were patched with concrete poured in place. And in a particularly inventive variant on the patching technique, badly damaged or missing haunches beneath the ornate projecting balconies that punctuate the upper levels of the building's base and narrowed tower were replaced with poured-in-place polymer concrete cast in molds taken from surviving nearby haunches.

Perhaps the most problematic aspect of the refurbishing of the Woolworth Building's ornament was the decision not to restore, at shocking cost, the four tourelles at the tower's peak, which had deteriorated to little more than shapeless masses of rotting masonry and rusting steel. Like decayed teeth, the tourelles were instead simply crowned, after stabilizing repairs, with aluminum cladding that echoes the original color and shape but does not attempt to replicate detail.

In this and like decisions, the restoration of the Woolworth Building reflects an approach at once sensitive and pragmatic, answering each problem encountered with that solution judged to be on balance the most esthetically acceptable, practically achievable, and economically feasible.

—Margaret F. Gaskie



Representative of unusual conditions that demanded casting of so large a number of special shapes are the slender, intricately curved mullions. Below: Too badly deteriorated to be restored except at exorbitant cost, the highly ornate tourelles at the building's summit were instead capped with pressed aluminum cladding that approximates the originals in form and color (though not in detail) and will permit later restoration if desired. Nearby pinnacles were replaced with simplified precast concrete shapes.





LIGHTING FIXTURES / Hundreds of decorative and functional fixtures for the home are illustrated in a 162-page "Style Book" from *Thomas Industries*. Bath cabinets and lighting, mirrors, outdoor post lamps and lanterns, and fan/light units are also included in the catalog. ■ *Thomas Industries Inc.*, Louisville, Ky.

circle 400 on inquiry card



TOILET COMPARTMENTS / Laminated plastic toilet and dressing compartments, urinal screens and shower dividers are illustrated in an eight-page color catalog. Partitions can be coordinated with accessories, vanities and countertops in an expanded range of 32 colors. ■ *Bobrick Wash-room Equipment, Inc.*, North Hollywood, Calif.

circle 401 on inquiry card



PNEUMATIC DOOR CONTROLS / A 16-page color brochure, "Solutions to Barrier-Free Door Control" offers cost-effective methods to meet mandated access requirements. Removal of architectural barriers for various industrial materials handling applications is discussed. ■ *Reading-Dorma Closer Corp.*, Reamstown, Pa.

circle 402 on inquiry card



HVAC CONTROL / An optional component of *MCC Powers'* "Building Management System 600" is now available, called *Distributed Digital Control* which integrates building monitoring and control functions into one system. A bulletin describes end-user benefits and features, including greater system reliability and improved control for energy and building facilities management. ■ *MCC Powers*, Northbrook, Ill.

circle 403 on inquiry card



PAPER SHREDDER / Five large volume machines with feed openings of 12- to 25-in. are shown in a *Destroyit* brochure. Units destroy letters, continuous forms, punch cards, etc., without removing paper clips and feed the shreds into large bags or balers. ■ *Electric Wastebasket Corp.*, New York City.

circle 404 on inquiry card



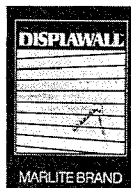
CEILING TILE / "Designer Ceilings" product folder contains specification sheets on *Aurora*, *Corona*, and *Luna* acoustical tile. Each sheet provides data on physical property and hazard classification, as well as color installation photos. ■ *Conwed Corp.*, St. Paul, Minn.

circle 405 on inquiry card



SOLAR ENERGY / A capabilities brochure describes solar energy systems, how they work, how they can be financed, and includes an F-chart computerized analysis which forecasts typical month-by-month energy savings. *Helioscience* systems are suitable for commercial, industrial, institutional, school and multi-unit residential buildings. ■ *Helioscience Inc.*, New York City.

circle 406 on inquiry card



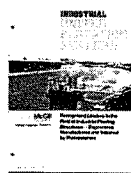
STORE DISPLAY / A slotted wall system that can be used for retail display, the *Marlite Displawall* comes in modules which accept all existing merchandising hardware. A color brochure illustrates the range of items which can be showcased by the *Displawall* system, installed in several geometric patterns. ■ *Masonite Corp.*, Dover, Ohio.

circle 407 on inquiry card



EXECUTIVE OFFICE / "Series 320" desks from *Steelcase* provide the warm look of natural woods in an executive office setting. A 20-page brochure illustrates the furniture in typical offices, lists 15 desk and pedestal options, and details specific dimensions of all 26 units in the "320" line. ■ *Steelcase, Inc.*, Grand Rapids, Mich.

circle 408 on inquiry card



FLOATING STRUCTURES / Flotation systems for industrial applications—pump platforms, floating lift assemblies, diversion booms, access walkways and docks—are explained in a color brochure. Systems are designed, fabricated, transported and installed by the manufacturer. ■ *United McGill Corp.*, Groveport, Ohio

circle 409 on inquiry card



ALUMINUM PLANTERS / Catalog presents a line of planters, building accessories, coat hooks and seating. Planters available in-stock include straight edge and curved lip planters, low profile containers for atriums, desk units and hanging bowls. ■ *Nevins Worldwide, Inc.*, Houston.

circle 410 on inquiry card



INTERACTIVE GRAPHICS / Written for architectural/engineering firms, a 14-page brochure explains how *CalComp's* interactive graphics system can save time and costs in design and drafting work. Capabilities discussed include design expediency, increased drafting productivity, automated bills of material generation and standardized drawing appearance. ■ *California Computer Products, Inc.*, Anaheim, Calif.

circle 411 on inquiry card



LIGHTING CONTROL / Brochure explains how the "Modulighting" computerized control system can cut lighting energy needs in most commercial buildings by up to 45 percent. "Modulighting" takes advantage of daylight, and uses sensors to adjust fluorescent lighting levels to provide constant illumination at the work surface. ■ *Honeywell Inc.*, Minneapolis, Minn.

circle 412 on inquiry card



STACKING CHAIRS / Color brochure features the 12 new polypropylene colors available in the *Max Stacker* chair line. Fabric-covered *Max Stackers* are also shown; all chairs stack 45 high for convenient storage. Bookracks and tablet arms, for classroom use, are also pictured. ■ *Steelcase Inc.*, Grand Rapids, Mich.

circle 413 on inquiry card



MILL DIRECTORY / A "Where to Buy" guide lists 18 Western Red Cedar manufacturers in the U.S. and Canada, giving production data on siding, paneling, dimension and specialty products. ■ *Western Red Cedar Lumber Assn.*, Portland, Ore.

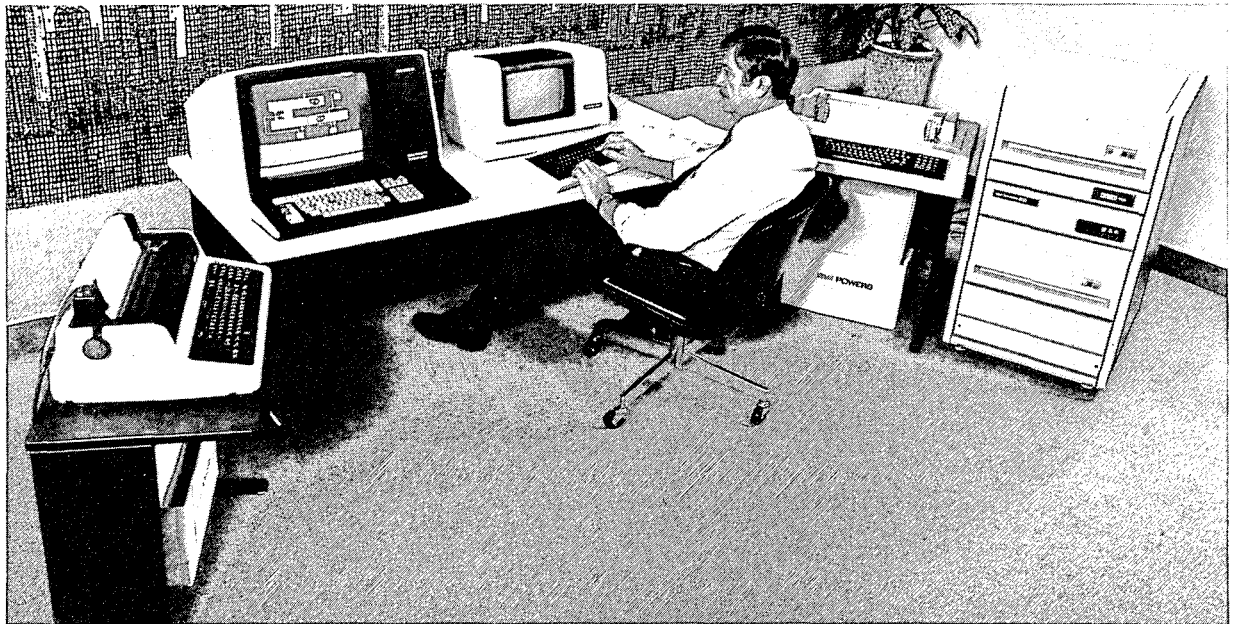
circle 414 on inquiry card

more information, circle item numbers on
 Reader Service Inquiry Card, pages 139-140

Building automation computer integrates environmental and energy management controls

MCC Powers' new computer-aided building automation system features "Distributed Digital Control," which integrates the functions of building monitoring and control in one system. The MCC Powers System 600/DDC console with new graphics CRT, complemented by new micro-computer-based "Remote Control Units," allows the user to mix and match components to suit individual building needs. Existing System 600/DDC users can easily up-grade their equipment by the addition of a new software package, a micro-computer-based board assembly in each of the "Remote Processing Units." ■ MCC Powers, a unit of Mark Controls, Northbrook, Ill.

circle 300 on inquiry card

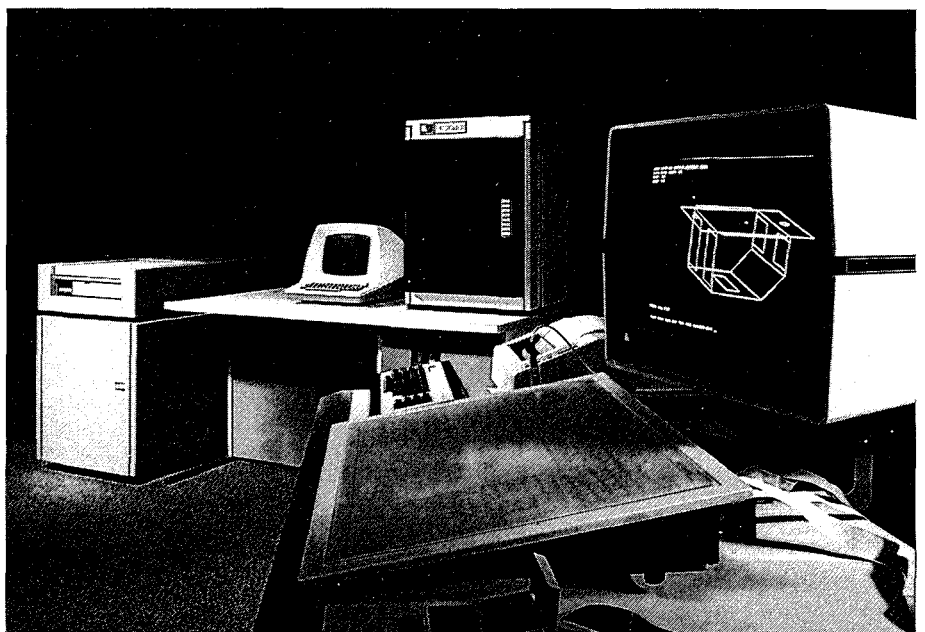


Color graphics system added for architectural and engineering services

Intergraph Corporation has added a high-resolution, flicker-free color graphics system to its line of computers, which increases the system's usefulness to architectural, engineering and construction disciplines. The fully compatible display system, which includes a 16-bit microcomputer features dual 19-in. raster screens—one color and one monochromatic. Each screen

can display two- and three-dimensional graphics, and the operator can pan and zoom on the screens. From a palette of 4096 colors, the user can select eight active colors for simultaneous display. An additional memory permits the user to rapidly change colors for individual applications. ■ Intergraph Corp., Huntsville, Alabama.

circle 301 on inquiry card

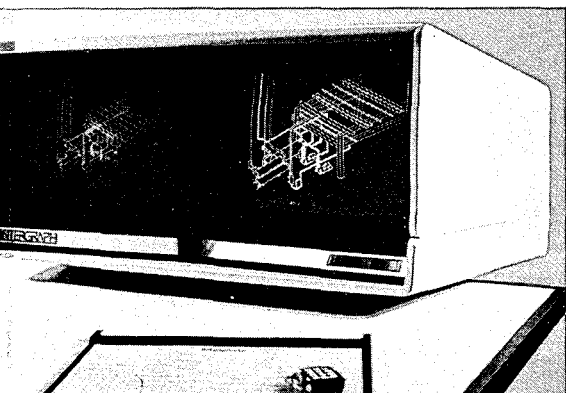


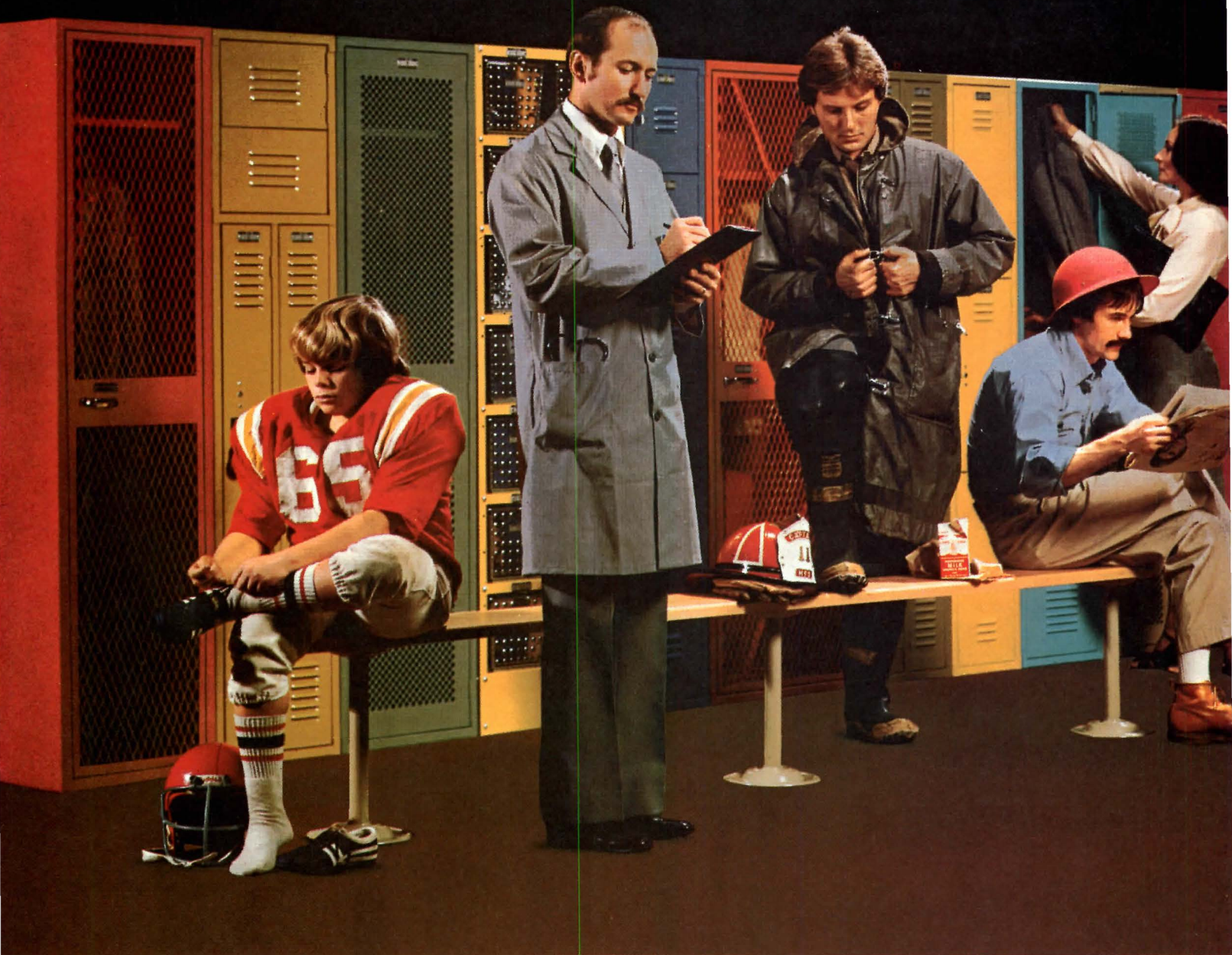
Multi-station graphics link for computer-aided design

A new large-scale turnkey high-performance computer-aided design and manufacturing system called *Designer V*, has been introduced, featuring the *Instaview* raster scan workstation (foreground of photo), random access disc storage module (far left in photo), and CGP-200 graphics processor (center of photo).

The *Designer V* utilizes "functional distributed process" to permit a greater range of capabilities for architectural applications—as many as eight separate *Instaview* workstations can be interconnected for complicated design work. ■ Computervision Corp., Bedford, Mass.

circle 302 on inquiry card
 more products on page 103





Put a lock on correct selection

Here's a sure-fire way to do it: let your local Lyon Dealer help pick out the exact size and type of lockers you need.

No one has a more complete or more readily available line. So when you need quick delivery of standard styles, count on us.

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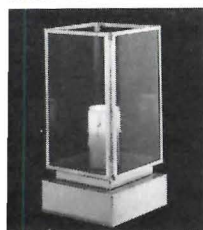
Circle No. 30 for storage planning kit PLUS regular Lyon mailings.

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Or Call your Lyon Dealer... in the Yellow Pages under LOCKERS, RACKS and SHELVING.



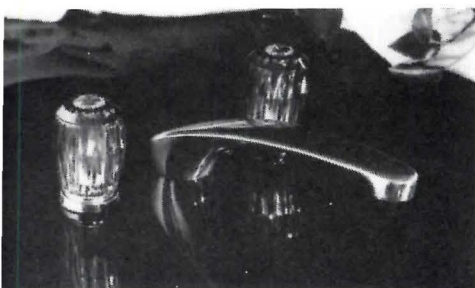
ABLE TOP LAMP / Suggested for restaurants and



clubs where the ambience of candlelight is desired without the hazards of an open flame, the 10-in.-high "Candlelight" lamp contains a convincing electronic light source that flickers with varying intensities.

conomical to operate, the "Candlelight" operates on a rechargeable battery with an expected three year life. A recharging tray, with a single contact probe for each light, recharges 24 lamps after 10 hours of continuous operation. Lamps are made of solid brass, rubbed wood and glass in a variety of traditional and contemporary styles. ■ Winona Studio of Lighting, Winona, Minn.

circle 303 on inquiry card



PLUMBING FITTINGS / "Designer Gold" single- and two-handle washerless faucets have an electrostatically applied epoxy powder coating over their special finish for a longer, more durable life. Also included in the *Valley* collection are widespread combinations, two- and three-valve tub and shower assemblies, and Roman tub faucets. ■ U. S. Brass, Plano, Texas.

circle 304 on inquiry card



STAIR REPAIR / American Mason's "Repair Tread Series 200" is a permanent, non-slip aluminum tread with a water-proof, epoxy filler for safe, sure footing and long life. Conforming to OSHA regulations, "Series 200" treads repair and protect new and existing stairways, platforms, landings and walkways, and can be butted together invisibly to cover large areas. ■ American Mason Safety Tread Co., Lowell, Mass.

circle 305 on inquiry card

TWO-COLOR WILTON



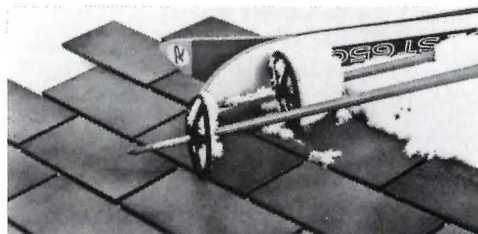
/ All 12 patterns in the "Stockholm" residential and commercial carpet line feature two-color motifs in contemporary designs. Color choices stress rust, beige, blue and green tones. Carpet is available in a new three-ft width. ■ Saxony/Soskin Carpet Corp., New York City.

circle 306 on inquiry card



TERRAZZO FLOORING / The *Novagard* flooring system is made with an emulsion resin terrazzo that uses various colors and sizes of marble chips to produce a bright ground terrazzo floor said to have better chemical resistance than cement terrazzo. Generally installed in thicknesses of 3/8- or 1/2-in., *Novagard* is suitable for such medium traffic applications as offices, nursing homes, condominiums and lobbies. ■ Selby, Battersby & Co., Philadelphia.

circle 307 on inquiry card



GLAZED FLOOR TILE / Imported from Italy, "Mono Forte Monocuttura" tiles are highly resistant to abrasion and shock. Floor tiles are frost-proof, and suitable for use indoors and out. Square and rectangular shapes are sized from four- by eight- to 12- by 16-ins., offered in a variety of earthen-tone colors. ■ Huntington/Pacific Ceramics, Inc., Corona, Calif.

circle 308 on inquiry card

more products on page 107

Chop energy costs!

Water coolers are only a small part of your total energy-cutting challenge. But we've proved our new generation designs can save thousands of dollars in life cycle costs. Because we cut energy usage and proved it with comparative research.*

Talk comparative energy costs with your Halsey Taylor representative or write to the Energy Department, Halsey Taylor, Route 75, Freeport, IL 61032.

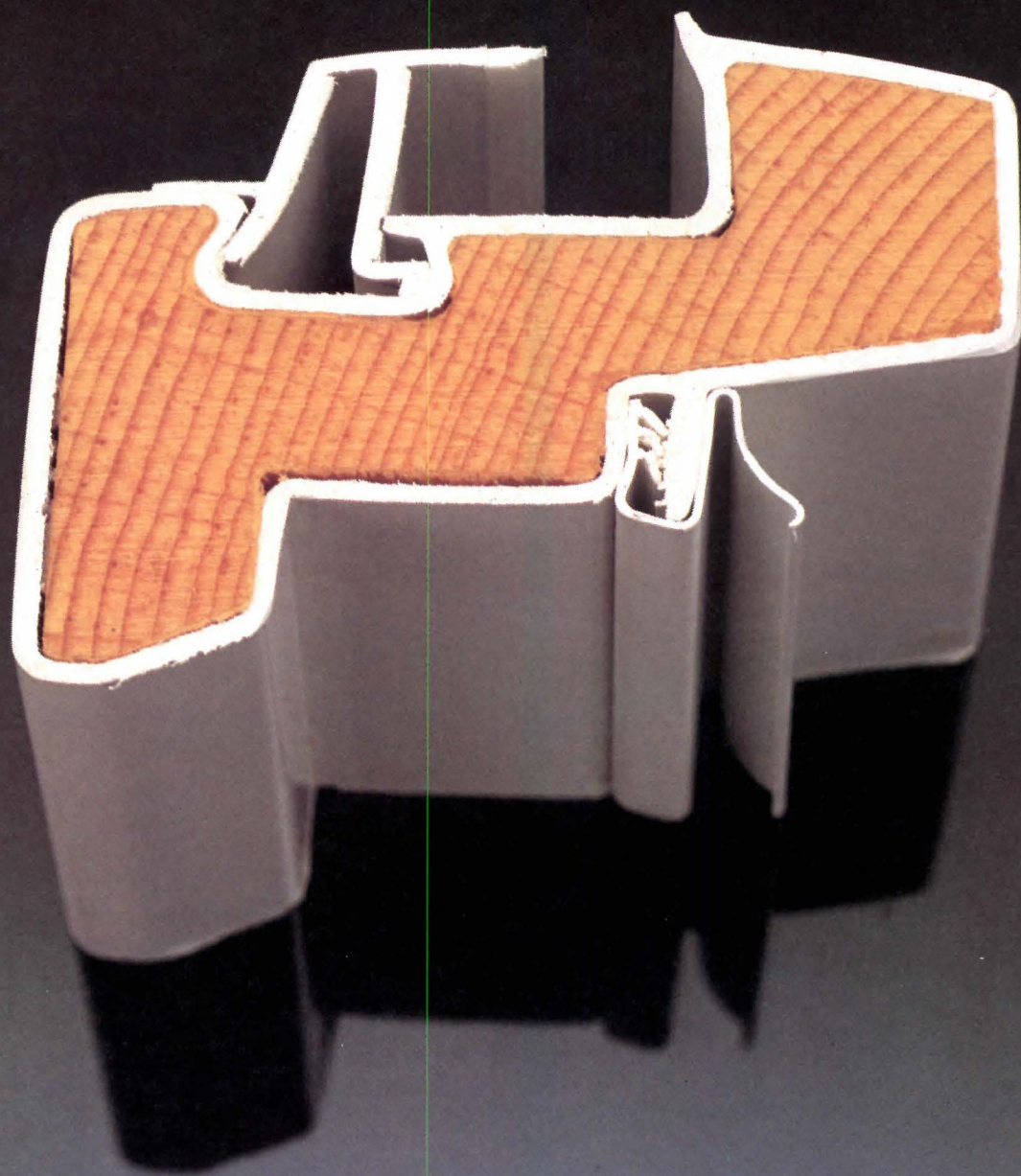
It's a waste of energy specifying anything but . . .

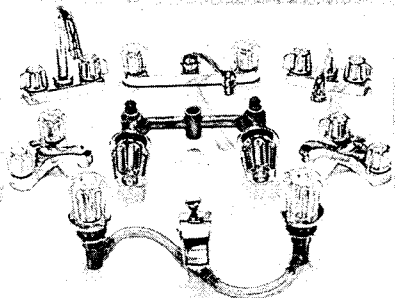
Halsey Taylor
KING-SEELEY THERMOS CO. ROUTE 75 FREEPORT, ILLINOIS 61032

*Comparative research available upon request.

Circle 32 on inquiry card

**In the 60's the Perma-Shield[®]
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WASHERLESS FAUCETS / Gerber "True Washerless" cast brass faucets provide positive, shearing-action water control, and eliminate seats, washers, O-rings and diaphragms: there is nothing to compress and wear out and leak. Faucet models are available for bath, kitchen, bar and laundry. ■ Gerber Plumbing Fixtures Corp., Chicago.

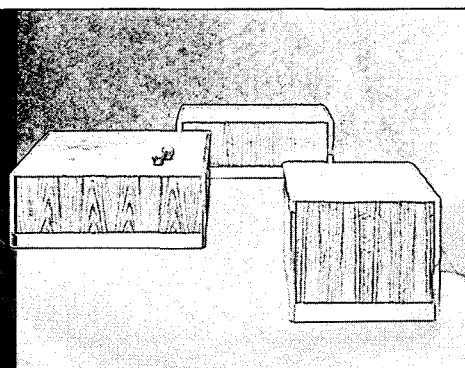
circle 309 on inquiry card

MOBILE FILING SYSTEM / Tab-Trac file carriages move along the flush tracks that are part of the system's carpeted, custom-fitted floor. Aisles are created only when and where they are needed, either manually, mechanically or electrically, depending on the size and weight of the file carriage. Existing shelving can be adapted to the Tab-Trac carriage base. Mobile systems are available for a variety of special applications, including the storage of microfilm, X-rays, computer tapes, museum pieces, small parts, etc. ■ TAB Products Co., Palo Alto, Calif.

circle 310 on inquiry card

WINDOW TREATMENT / Five new textured fabrics have been added to the Tontine line of vinyl-coated glass fiber window shade material. Used for vertical louvers, as pictured, or in standard or custom window shades, Tontine cloth is waterproof, fire-resistant, and will not crack or break when folded or in use. ■ Stauffer Chemical Co., Elmsford, N.Y.

circle 311 on inquiry card



OCCASIONAL TABLES / Designed by Warren Robinett for Modern Mode's "Trident I" series, these three cubes of various sizes work as occasional tables in office and contract applications. They are available in American black walnut or white oak with bronze or chrome detailing at the base and edges. ■ Modern Mode Inc., Oakland, Calif.

circle 312 on inquiry card



BASEBOARD HEATING / Intertherm Inc., a manufacturer of electric hot water baseboard heating units, provides residential builders and remodelers with a free heating requirement analysis, calculated from building plans. Softhead baseboard heaters, placed along exterior walls, are equipped with individual thermostats to turn electricity on or off as room temperature demands. ■ Intertherm Inc., St. Louis.

circle 313 on inquiry card



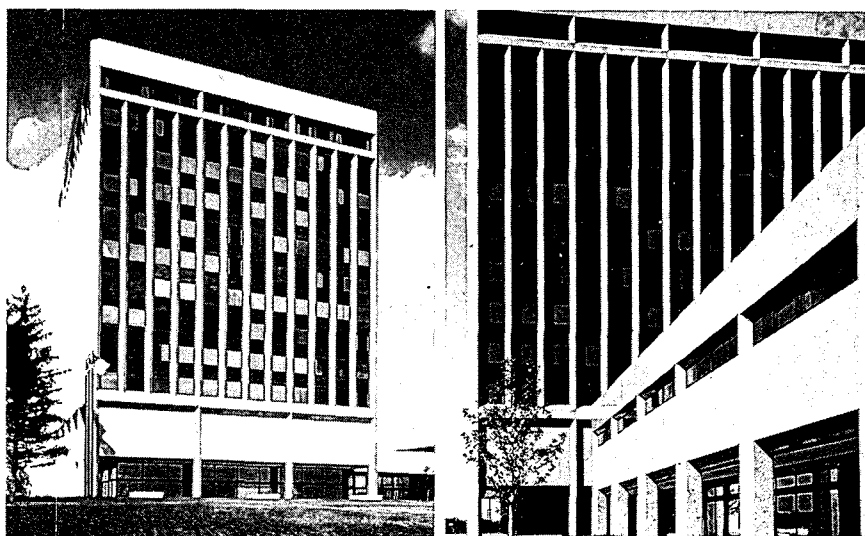
CONTRACT CARPETING / Developed especially for the heavy-duty contract carpet market, Antron XL nylon is made of an extra large, hollow filament yarn said to have superior crush resistance and soil repelling characteristics. The carpets shown here are from Karastan Rug Mills, one of 18 manufacturers currently producing contract carpeting made of Antron XL nylon. ■ Du Pont Co., New York City.

circle 314 on inquiry card

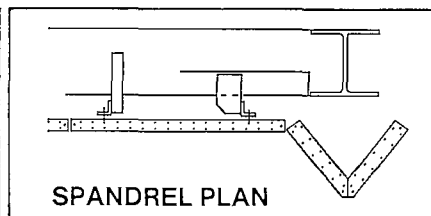
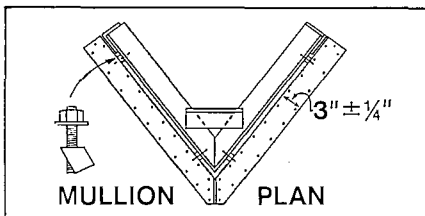
more products on page 109

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Architect: Graham Anderson Probst & White, Chicago, IL



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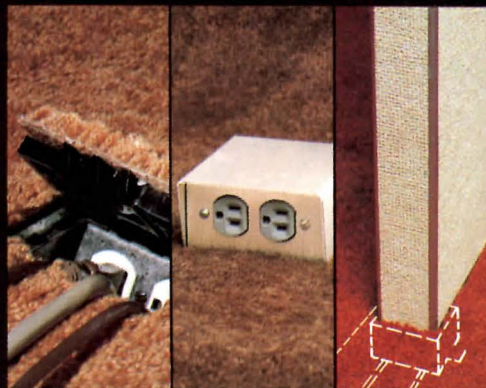
Circle 35 on inquiry card

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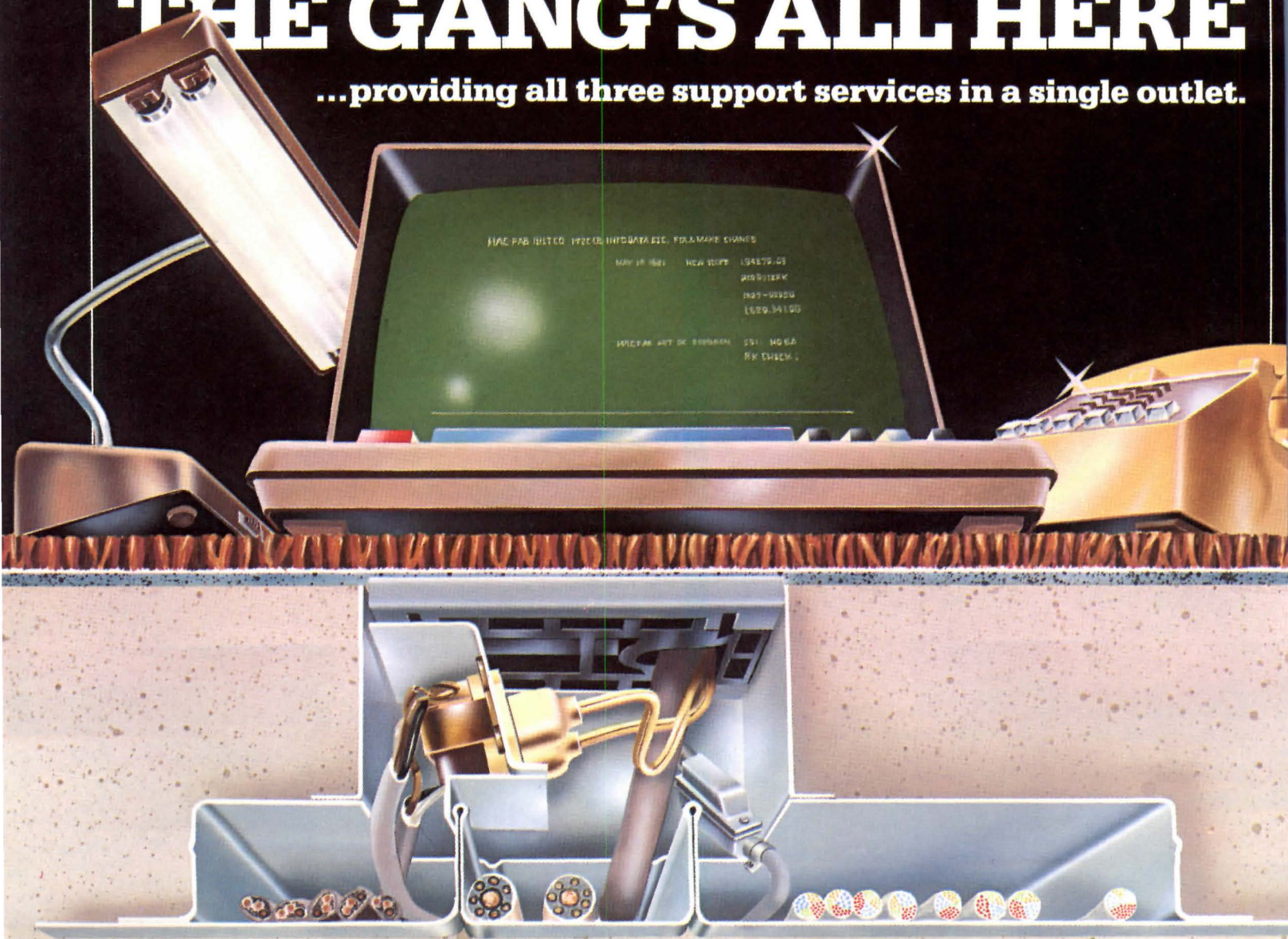
For more information send for Mac-Fab's new "Design Manual" which features five different in-floor electrification systems. Write Mac-Fab Products, 700 South Spring, St. Louis, MO 63110. Phone 1-314-664-9100.

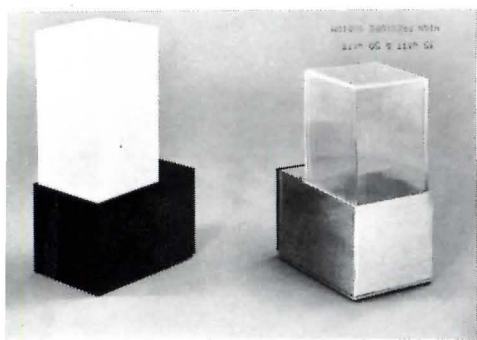


MAC-FAB

THE GANG'S ALL HERE

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OUTDOOR SAFETY LIGHT / Built to save energy and last indefinitely, the "Midas-Touch" outdoor wall-mounted light fixture uses either an 18-W low-pressure sodium or 35-W high-pressure sodium lamp. ■ Voight Lighting Industries, Inc., Leonia, N.J.

circle 315 on inquiry card



EXECUTIVE SEATING / Designed by Norman Cherner for the high-level corporate environment, these four chairs are light in scale, yet comfortable and strong. Frames are solid cherry, walnut and oak woods in a variety of oil and lacquer finishes; upholstery options include a full range of fabrics. ■ Modern Mode Inc., Oakland, Calif.

circle 316 on inquiry card

RESILIENT FLOORING / Scaled-down patterns and soft neutral colors are emphasized in Mannington Mills' new resilient flooring designs. "Segovia," a burl marble pattern, is available in five natural colors. Flooring comes in six- and 12-ft widths, and is suitable for either residential or commercial applications. ■ Mannington Mills, Inc., Salem, N.J.

circle 317 on inquiry card

REFLECTIVE BLINDS / "Cryotherm" mini-slat blinds are a recent addition to the "Riviera" line, and are designed to absorb the sun's rays or throw back its heat through the use of energy-aware finishes. While the "Cryotherm" blind is normally light-absorbing black on one side, and light-reflecting bright metallic on the other, decorative options include over 100 matching or contrasting edgings that help prevent light seepage and keep out drafts. Cost is about a third more than for standard "Riviera" blinds. ■ Levolor Lorentzen, Inc., Lyndhurst, N.J.

circle 318 on inquiry card

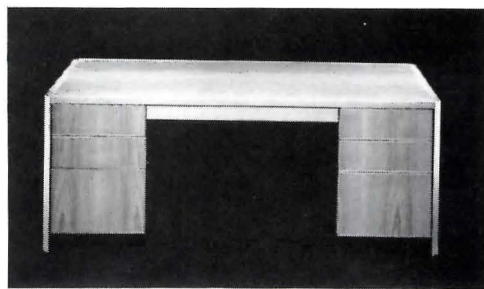
SPORTS SURFACE / *Tru-Flex* ready-to-use tennis



court coating is an all-weather acrylic compound that can be easily applied over asphalt or concrete surfaced with a squeegee. A typical tennis court can be surfaced for under \$800, a substantial savings over professional installations. Ready for use overnight,

Tru-Flex is non-glare, scuff-resistant, and its red or green colors will not fade. It is also suitable for basketball courts, playgrounds, and other hard surfaces. ■ *Tru-Flex* Recreational Coatings, Everett, Mass.

circle 319 on inquiry card



DOUBLE PEDESTAL DESK / An all-wood executive desk with seven pull-out drawers, this "Trident II" design by Warren Snodgrass is offered in three shades of oak and two tones of walnut. Standard features include solid hardwood drawers, fully dovetailed and glue-blocked. ■ Modern Mode Inc., Oakland, Calif.

circle 320 on inquiry card

more products on page 111



QUME, INC., Hawley & Peterson Architects.

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The most highly insulated light transmitting material.
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Circle 37 on inquiry card



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\$240,000.**
(And you're just using ordinary lighting?)

When Sylvania SuperSaver™ fluorescent lamps were installed in just one-third of the World Trade Center by the Port Authority, the center saved nearly \$240,000 in electricity that year. It was because the SuperSaver consumes less energy than standard F40 fluorescents with a negligible difference in light output. So the costs are much less in the long run. In fact, when it comes to cutting costs on lighting, no one beats Sylvania. We've got five different kinds of fluorescent lamps to help make the most effective use of anyone's lighting. Interested? See your local IED, Independent Electrical Distributor, or write or call GTE Products Corp., Sylvania Lighting Center, Danvers, MA 01923. (617) 777-1900, ext. 2650. These days it's awfully hard to get by with just ordinary lighting.

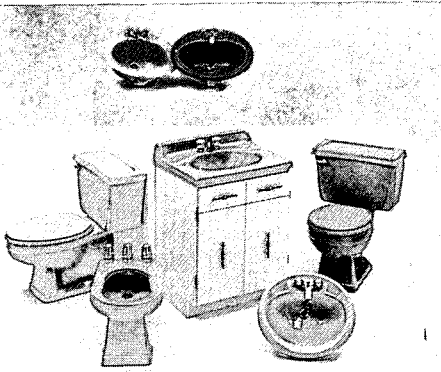
SYLVANIA

**Industrial/Commercial
Lighting**

Circle 38 on inquiry card

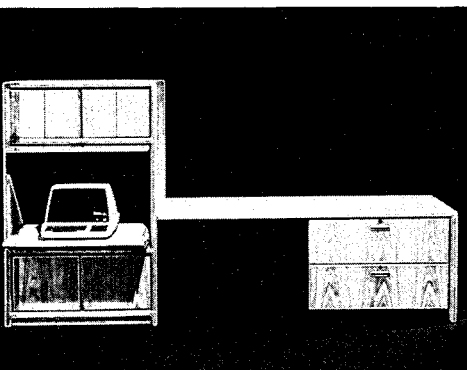
GTE





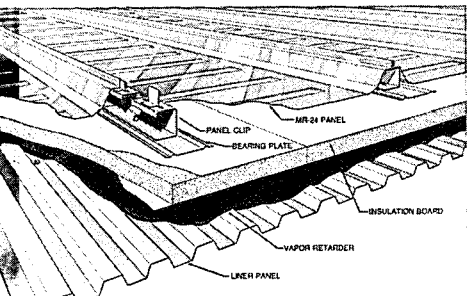
WATER SAVING FIXTURES / From Gerber, this line of vitreous china bathroom fixtures features water-saving closets that permit positive flushing action with only 3½ gallons of water per flush. Fixtures include round and oval basins, bidets, urinals and water closets. ■ Gerber Plumbing Fixtures Corp., Chicago.

circle 321 on inquiry card



WORK MODULE / Part of this maker's "V.O.S." (Vertical Office System) of self-contained cabinetry and work surfaces, this office component houses a CRT machine on a roll-out shelf. The door covering the shelf lifts up and into the unit, pulling down when not in use. All pieces in the "V.O.S." collection come in white oak, black walnut and cherry woods in a variety of oil and lacquer finishes. Modern Mode Inc., Oakland, Calif.

circle 322 on inquiry card



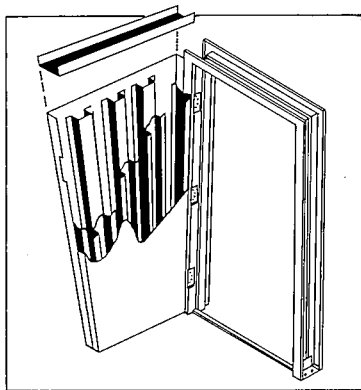
METAL ROOF SYSTEM / The CMR-24 standing-ribeam metal roof consists of interior liner panels applied directly to the structural system, topped by a vapor barrier, Thermax rigid-board insulation and a 24-gauge weathering membrane with double-lock standing seams that expand and contract. The CMR-24 roof system carries a UL Class 90 wind uplift and a FM Class 1 fire rating, and can achieve insulating values as low as .05 U. ■ Butler Mfg. Co., Kansas City, Mo.

circle 323 on inquiry card

more products on page 112

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- No hardware preparation restrictions
- Unlimited glass and louver cut-out sizes
- The exact door opening sizes required by design considerations
- Frame profiles, gauges, and depths to suit your design
- The broadest range of UL listed and approved doors and frames available

VALUE

Long life and reduced maintenance is assured by adaptable rugged construction and at a competitive price.

Special purpose doors such as X-ray, security, acoustical, blast resistant, bullet resistant, corrosion resistant, and many other special features are available from NAAMM members.

Write on your letterhead for the full list and addresses of NAAMM hollow metal manufacturers.

Acme Steel Door Corp.
Allied Steel Products, Inc.
American Steel Products
Amertex, Inc.
Bilt Rite Steel Buck Corp.
Builders Manufacturing Co.
-Div. of Jim Walter Doors
Bymoco Metal Fabricators
County Fire Door Corp.
Elco Metal Products Corp.
Emerson Engineering Co., Inc.
Eucatex S.A. Industria E
Comercio

Firedoor Corporation of
Florida
E. H. Friedrich Co.
Gateway Metal Products,
Inc.
Grand Metal Products
Corp.
Habersham Metal
Products Co.
Hol-O-Met, Inc.
Krieger Steel Products Co.,
The Philipp
Manufacturing Co.

Pioneer Industries
Precision Metals, Inc.
R. C. Hollow Metal Co.
F. L. Salvo
Manufacturing Co.
Irving Schaffer &
Assoc.
Superior Fireproof Door
Tex-Steel Corp.
Western Hollow Metal
Co., Inc.
Williamsburg Steel
Products Co., Inc.

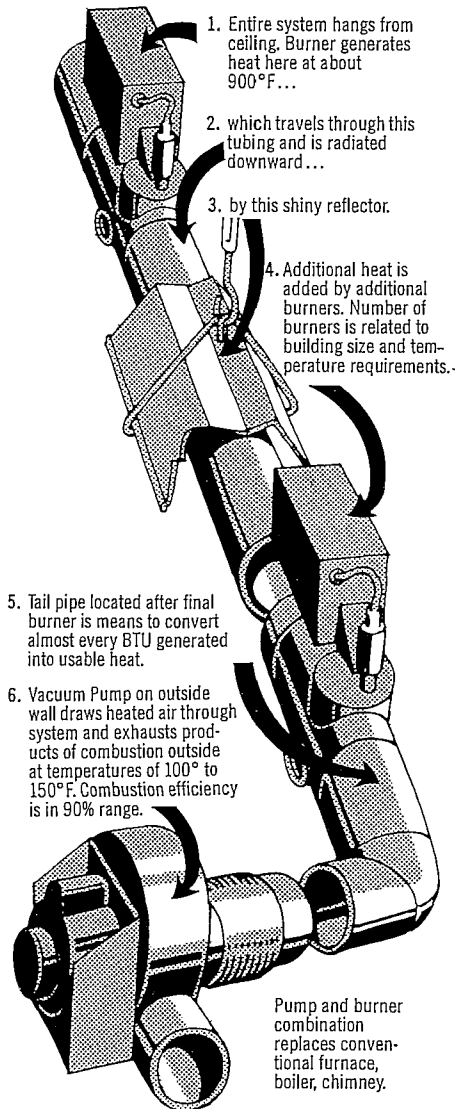


Hollow Metal Manufacturers Association,
a division of the National Association
of Architectural Metal Manufacturers,
221 N. LaSalle St., Dept. AR-1
Chicago, IL 60601 (312) 346-1600

Circle 39 on inquiry card

THE CO-RAY-VAC® HEATING SYSTEM

So energy efficient it cuts fuel usage up to 50% and more!



Gas-fired system designed for use in industrial and commercial buildings. People and objects at floor level are bathed in even, draftless warmth. Warm floors mean warm feet, warm feet mean happy employees. Fast heat recovery after opened doors are closed. Minimal maintenance.

MOST IMPORTANT OF ALL: Fuel consumption is reduced. Users report fuel reductions up to 65%. Savings of about 50% are most common. Building survey and life cycle cost analysis lets you know what original cost and operating costs will be before you start.

CO-RAY-VAC... The original radiant infrared heating system proved in thousands of buildings since 1962.

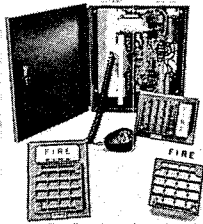


Roberts-Gordon

Appliance Corporation
Subsidiary of A.J. Industries, Inc.
44 Central Ave., Buffalo, N.Y. 14206
Phone 716/892-8400 AR-2

Circle 40 on inquiry card

VOICE ALARM / The Wheelock "870" Series Control

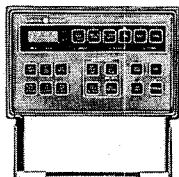


unit converts any ULI compatible electromechanical fire alarm control panel to voice communication, plus synthetic tone signaling and strobe light capability. Only three external line connections are required; additional power needed

comes directly from the DC power of the "870" fire alarm panel. The hand microphone for voice evacuation directions meets code requirements for places of public assembly. ■ Wheelock Signals, Inc., Long Branch, N.J.

circle 324 on inquiry card

COMPUTERIZED THERMOSTAT / The "DMC 2000" digital monitoring control

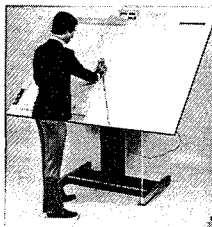


"2000" digital monitoring control works with the Weathertron two-speed heat pump to provide extra-efficient automatic temperature setbacks. The computerized thermostat is economical to

operate because its recovery logic limits the use of resistance heat in the recovery cycle. Small sensors located throughout the house relay temperature readings to the "DMC 2000," which provides both heating and cooling control. ■ General Electric Co., Louisville, Ky.

circle 325 on inquiry card

GRAPHICS DIGITIZER / A new product line, "Series 7000" translucent digitizers



provide a high degree of user control in such applications as architectural and engineering drafting, design, mapping—wherever graphic data need to be entered into a computer. Available

with active areas up to 42- by 60-in., Complot digitizers provide 40 user configuration controls not commonly found in comparable units, such as local or computer control of all functions and resolutions of 0.001-in., 0.005-in. or 0.01-in. Prices start from \$2950. ■ Houston Instrument, Austin, Texas.

circle 326 on inquiry card



SILICATE INSULATION / An easy-to-handle granule insulation with nearly twice the R-value of loose fill fiberglass, *Dacotherm* silicate will not burn, and is safe and non-irritating to install. *Dacotherm* will not settle over time, and can be poured over the top of existing loose-fill or batt type insulation to increase the R-value. ■ Diamond Shamrock Corp., Irving, Texas.

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more products on page 115

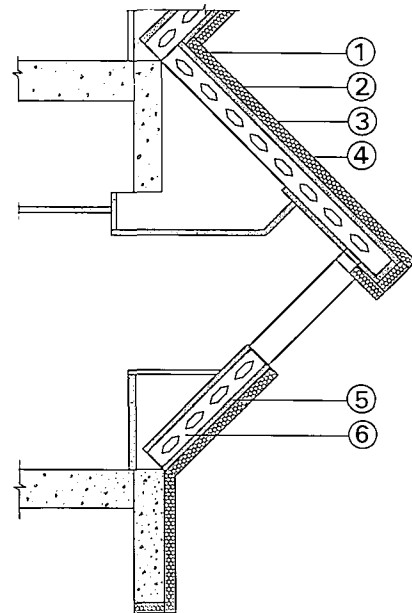


Panelization: the key to fast construction.

Dryvit brought a remarkable extra benefit to the construction of the Allergy Clinic (facing page): a fast erection schedule that not only saved time but cut overhead. It took just 5 months to build the clinic from scratch. Exterior grade gyp sheathing attached to steel stud panels were pre-fabricated and trucked to the site. The Dryvit System was then field-applied to provide a smooth seamless skin.

Look for Dryvit in the General Building File of Sweets Catalog under Section 7.13/Dr.

Cross-section of a typical panel shown:



1. **Dryvit Insulation Board:** expanded polystyrene with optimum insulating characteristics. Board sizes, thicknesses and shapes are available as required by design.
2. **Dryvit Reinforcing Mesh:** specially woven and treated fiberglass fabric is embedded in the Primus coating to prevent surface cracking.
3. **Dryvit Primus™/Adhesive:** Dryvit's unique plaster material mixed with Type 1 Portland Cement is used to adhere Dryvit Insulation Board to the approved substrate. It is also used to embed Dryvit Reinforcing Mesh on the face of the board.
4. **Dryvit Quarzputz™ Finish:** one of four finishes available. This synthetic plaster material has high bond strength, integral color and an applied texture that provides a weather-proof jointless exterior surface.
5. **½" Exterior Gyp. Sheathing**
6. **6" Steel Studs @ 16" O.C.**

Dryvit System, Inc.

420 Lincoln Avenue, Warwick, RI 02888
(401) 463-7150
Plant Locations:
Warwick, RI; Tulsa, OK; Columbus, GA

Circle 41 on inquiry card



There's a lot worth saving in this country.

Today more Americans who value the best of yesterday are working to extend the life of a special legacy.

Saving and using old buildings, warehouses, depots, ships, urban waterfront areas, and even neighborhoods makes good sense. Preservation saves valuable energy and materials. We can also appreciate the artistry of these quality structures.

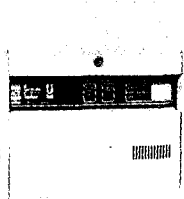
The National Trust for Historic Preservation is helping to keep our architectural heritage alive for us and for our children.

Help preserve what's worth saving in your community. Contact the National Trust, P.O. Box 2800, Washington, D.C. 20013.



National Trust for Historic Preservation
Preservation builds the nation

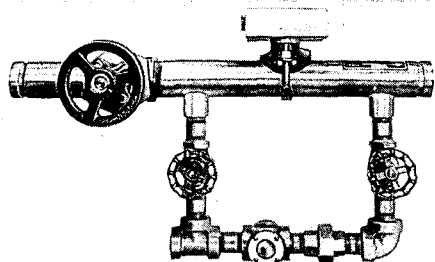
FIRE ALARM CONTROL /



A compact, two-zone fire alarm control unit for small and medium-sized installations where a high degree of life safety or property protection is needed, the *Unimode* Dual Unit features one Class A and one Class B

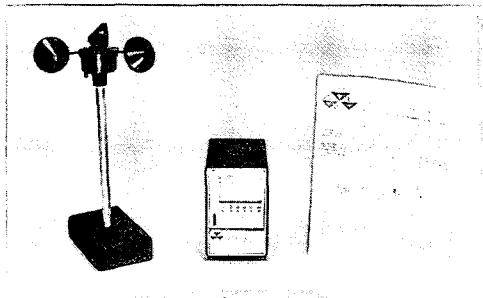
alarm receiving zone. The panel operates on a single-phase 120-volt power supply, with rechargeable battery standby power sufficient for 60 hours of system supervision. The *Unimode* meets NFPA 72A and 72C requirements for local and remote protective signaling systems. ■ ADT, New York City.

circle 328 on inquiry card



SPRINKLER VALVE / Factory assembled and tested, this floor control valve test and drain assembly is designed for fire protection systems in high-rise buildings. It is particularly suitable for buildings with a waterflow alarm device at each riser, or where there is more than one alarm device in one sprinkler system. The assembly is available in 2-, 2½, and 3-in. sizes. ■ Grunau Sprinkler Manufacturing Div., South Milwaukee, Wis.

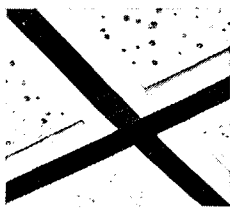
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WIND SITE ANALYSIS / An economical service that analyzes home, commercial, industrial and research sites to evaluate the potential for installing a wind driven generator, the *NEG* Wind Site Analysis program collects and evaluates localized wind data for three months or more. Reports include a yearly wind average, annual power production curve in Kw and dollars, effects of different tower heights, and payback rate for any wind generator. ■ New England Geosystems, Inc., East Derry, N.H.

circle 330 on inquiry card

CEILING GRID /



Revealok steel suspended ceiling grid is now available in ¾-in. and 1½-in.-wide versions. Both are compatible with all standard modular layouts, with lay-in or routed tile, and with partition attachments. The new *Visuline* insert

shown here, installed at cross-member intersections, achieves a contemporary "read through" appearance without routing. The ¾-in. deep reveal grid has an ASTM heavy-duty rating. ■ Lok Products Co., Fullerton, Calif.

circle 331 on inquiry card



This man can bring you what you need to know about metal framing.

He's sitting in your drawer, just waiting to bring you important information on Unistrut® Systems.

You'll learn how to solve complex problems such as dividing and multiplying space. We'll send you catalogues on support systems of all kinds.

But we can't do anything until you fill out this form, put it in an envelope and put that man to work.

To: Unistrut Systems, 35005 Mich. Avenue West, Wayne, MI 48184. Please send me what I need to know about:

12

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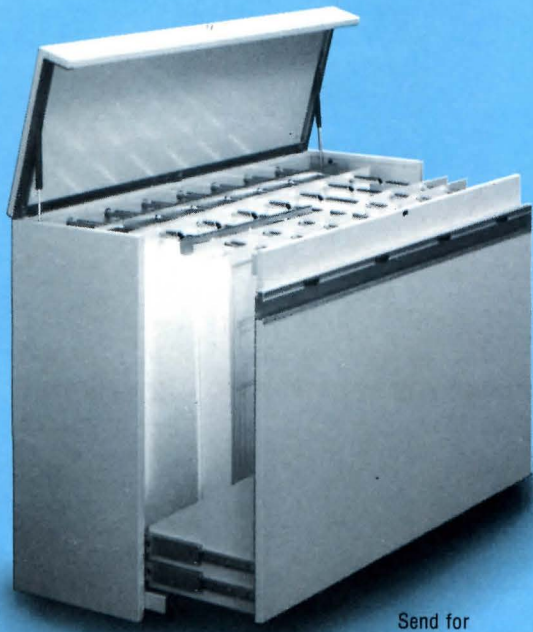
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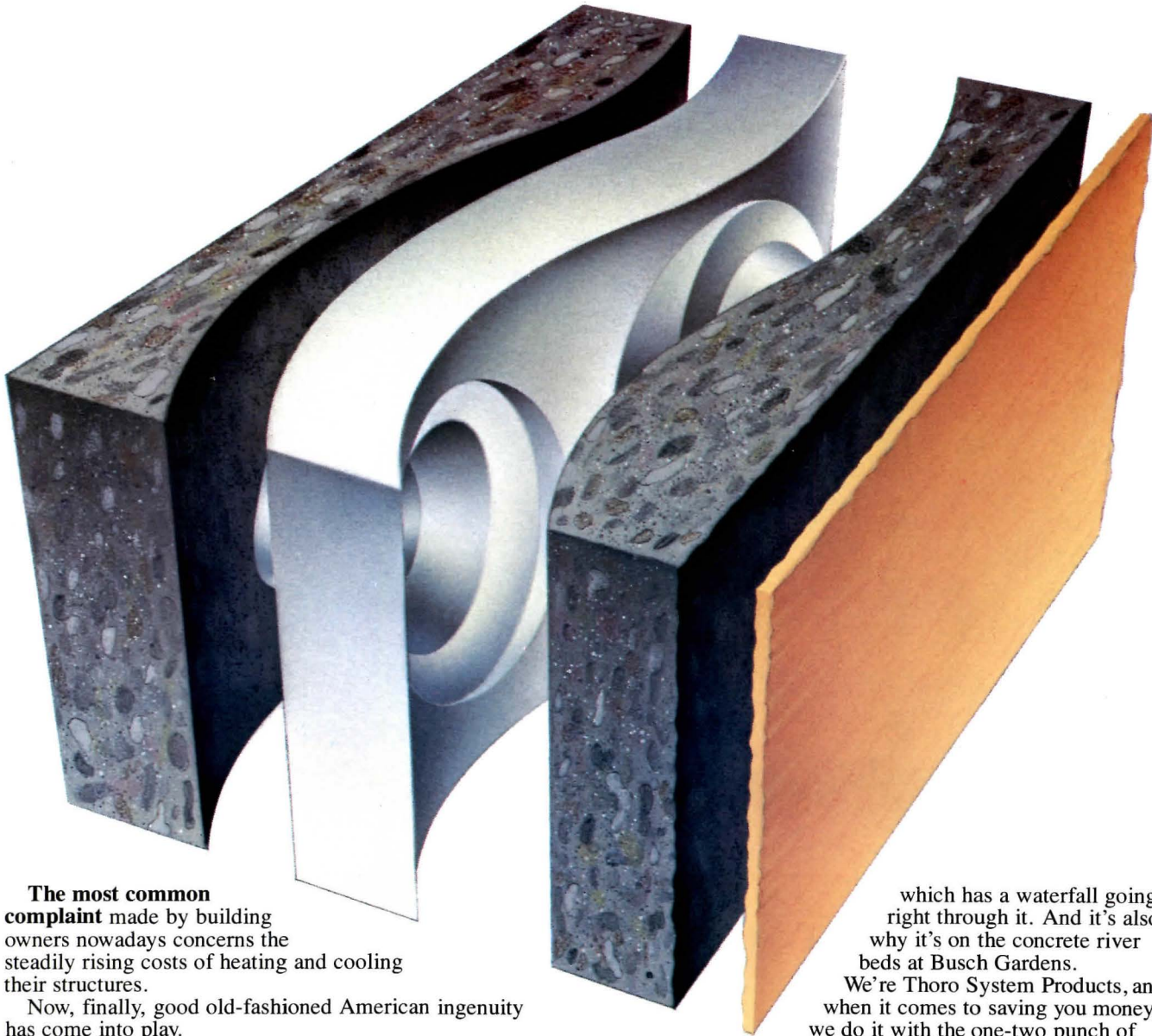
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ARCHITECTURAL RECORD

The Wall For All Seasons.



The most common complaint made by building owners nowadays concerns the steadily rising costs of heating and cooling their structures.

Now, finally, good old-fashioned American ingenuity has come into play.

Now there's a way to build in energy efficiency for the entire life of a building without sacrificing space, beauty or safety.

Thermocurve. A system consisting of uniquely shaped 2-inch-thick cellular polystyrene panels that are placed into concrete wall forms prior to pouring.

Easy and quick to use, Thermocurve cuts heat transfer by up to 75% without weakening the wall and eliminates about 25% of the expensive concrete needed.

Thermocurve is the first step in the right direction, a tough barrier against temperature extremes, and against a future of uncertain energy costs.

The second most common complaint concerns dampness and moisture penetration.

Thoroseal applied to the outside wall answers that. 100% waterproof, harder and more wear resistant than concrete alone, Thoroseal bonds so tenaciously that it actually becomes part of the wall. The toughest part.

That's why it's on the Meteorological Observatory at the top of Mount Washington, where the wind exceeds hurricane force 104 days each year. That's why it's on Frank Lloyd Wright's famous "Fallingwater" home

which has a waterfall going right through it. And it's also why it's on the concrete river beds at Busch Gardens.

We're Thoro System Products, and when it comes to saving you money, we do it with the one-two punch of Thermocurve and Thoroseal. Efficiency,

durability and convenience. For *all* seasons.

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Circle 62 on inquiry card



Solar system.

Here's an easy way to help eliminate one of the major causes of premature roof failure—moisture in the roofing system.

It's the Johns-Manville FP-10 One Way™ Roof Vent. This solar operated venting unit is designed to release pressure caused by water vapor trapped within the built-up roofing system.

The vent works simply. And automatically. When the sun's heat causes trapped moisture-laden air in the roof to expand, the vent's one-way valve opens, releasing the moisture. When the roof cools, the valve closes, sealing damp air out.

The valve also keeps out snow and wind-driven rain as well as water, even if submerged.

The FP-10 Vent is ideal for roofs where internal moisture may enter the system because of a faulty vapor retarder or lack of one.

In addition to black Noryl, J-M FP-10 One-Way Roof Vent is also available in white acrylic for use with single ply systems.

It's easily and quickly installed on both new and existing roofs. And is eligible for coverage under the J-M Guaranteed Roof Program.

For more information, consult Sweet's. Or contact George Constantin, Johns-Manville, Ken-Caryl Ranch, Denver, Colorado 80217, (303) 978-3281.

**For single-source
built-up roofing systems.**



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