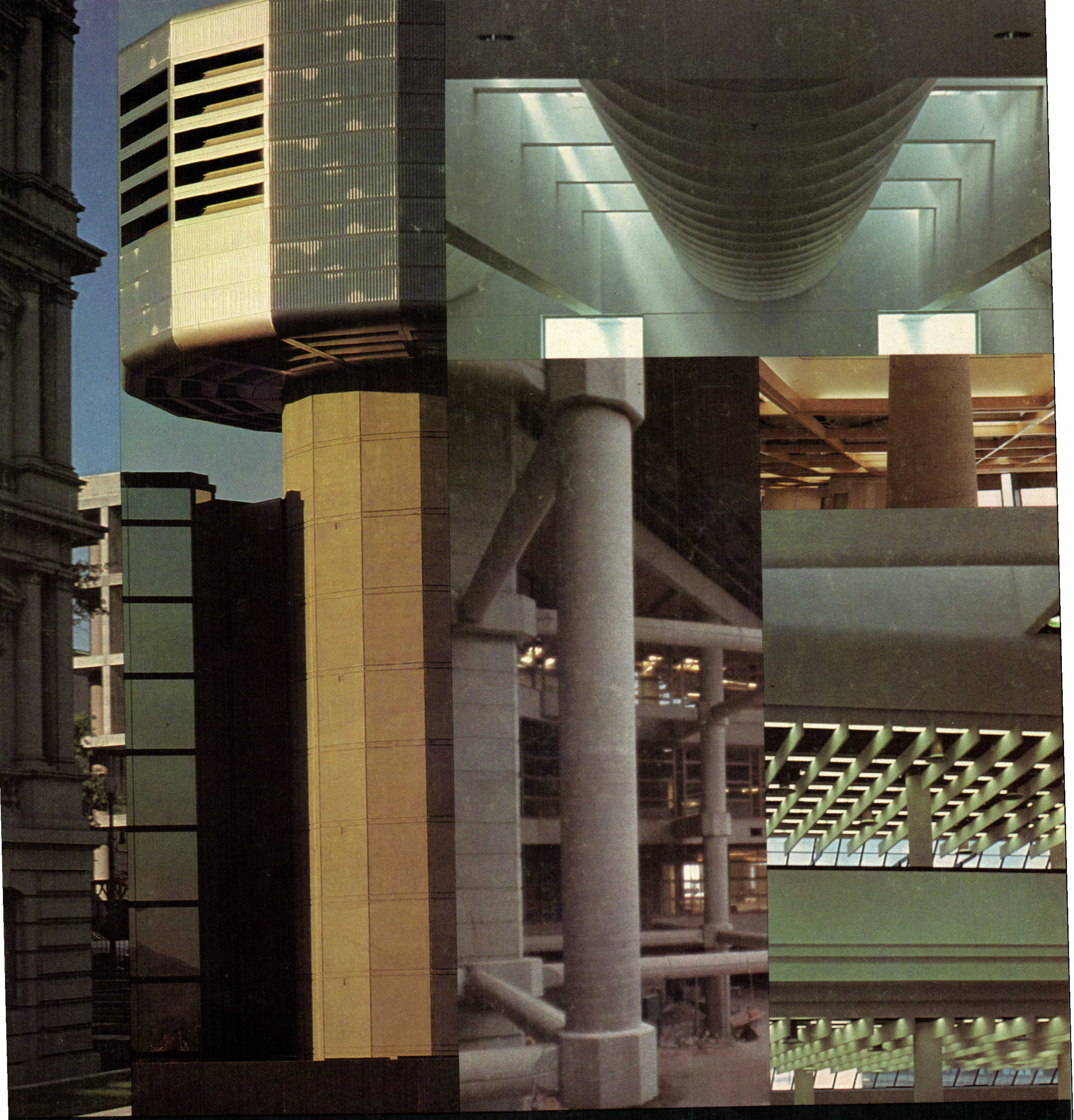

ENGINEERING FOR ARCHITECTURE 1977

ARCHITECTURAL RECORD

MID-AUGUST 1977 A McGRAW-HILL PUBLICATION FIVE DOLLARS PER COPY


ROAD DESIGN MANUAL
BRIDGE DESIGN MANUAL

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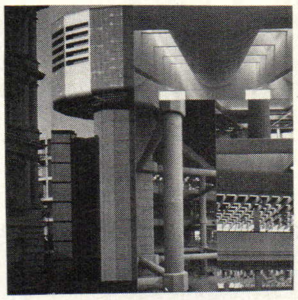
ENGINEERING FOR ARCHITECTURE



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Architecture, engineering, and education: The newest idea is going back to some old ideas

During the day-long Round Table conversation on energy conservation (reported on pages 92-97) the talk was mostly about codes and comfort levels and terminal reheat and other matters semi- or highly technical.

But as is inevitable when you assemble thoughtful architects and engineers in a room, there was some considerable philosophizing about "Whither the professions?" and "Where are we headed in our design thinking?"

Colorado architect John Anderson started a train of thought when he said: "These days we can pump back into the design equation things we have known but ignored for years. We are finally doing things that we learned how to do in school—and I think we are going to see some real design innovation. . . ."

And New York architect Karl Justin, who never fails to turn a memorable phrase, agreed that "we are again talking about things we used to talk about, but that got lost along the way when we found there was no design error technology could not correct. . . ."

These comments grew out of a growing understanding, as the Round Table progressed, that given the marvelous bag of technological tricks that we have been given, some plain common sense had somehow gotten lost. Common sense about siting and sun angles and window direction and the uses of daylight. One panelist observed that a great many European buildings are designed narrow enough that daylight can reach into most of the spaces for most of the day—instead of the design and orientation being defined by the shape of the city block on which it happens to be located; and being identical on all four sides despite the fact that the solar load scarcely arrives equally on all four sides.

Some of the design opportunities require a little more care by the architect in design. The same is true for the engineers: it is harder to design an efficient and flexible hvac system than it is to supply the maximum possible requirement for cool air and then, when necessary, reheat it for what a hundred different thermostats call for. It's harder to design an efficient lighting system that supplies the right amount of light for various uses than it is to lay down 100 footcandles everywhere. But . . . .

The important point was that all of the architects and engineers alike at the Round Table were clearly challenged by the new design constraints and clearly delighted at the challenge of solving them.

Said architect Earl Flansburgh: "If you really work with the engineer from the start, you find out how much he can help you—how much easier he can make your life. It's like the running back who has always gotten all the publicity—but suddenly discovers those guards and tackles who've been making the way for him."

Running through the day's comments was what seemed to me a renewed belief in an ancient truth—that the best buildings are always the result of effective collaboration between a good architect and a good engineer, and that, as we wrote in our first "Engineering for Architecture" issue three years ago: "The place to search for solutions to our problems in building—problems like cost and energy conservation and larger scale—is with people."

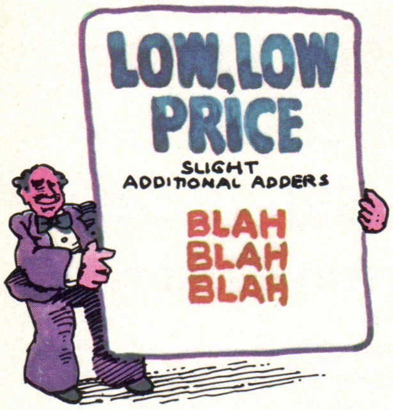
In thinking of the future, architect Flansburgh raised a question about the education of future architects and engineers—and their ability (not just their need) to work together: "Twenty-five years ago, students in the schools of architecture were required to take courses in mechanical engineering. Today, most schools of architecture don't even acknowledge the fact that mechanical engineering is an issue. Conversely, many of the great engineering schools don't teach architectural or building engineering. Maybe what we should try to do is blend the training of architects and engineers so that—when they get into practice—the engineers have more understanding of the architect's goals, and the architects don't wait until the beginning of working drawings to say 'Who are we going to use for mechanical engineering on this job?'

"The idea would be to stitch the professions together more effectively—not just so we can get better answers, but so that we're sure we're asking the right questions. . . ."

Mechanical engineer Jack Beech agreed, but he argued: "There has been some split between architecture and engineering. In the past, architects have not always realized the engineering implications when they should have—and the engineers have not always been receptive to what the architect was trying to do. But we don't have to wait for the students to come up—the talent, the expertise, and the desire are all here right now."

As these "Engineering for Architecture" issues have been saying—and demonstrating by case example—all along: There's really nothing to it but people.—*Walter F. Wagner Jr.*

The low, low price.



It could prove to be the most expensive part of your lighting purchase.

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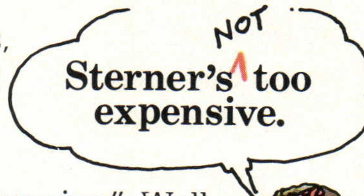

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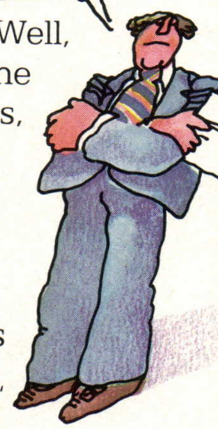
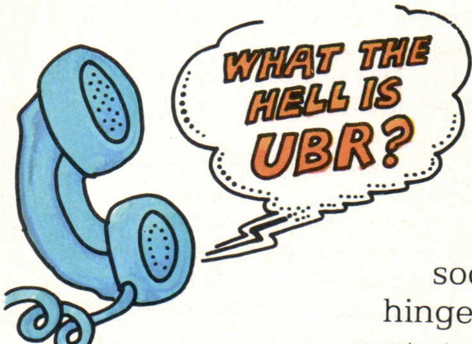
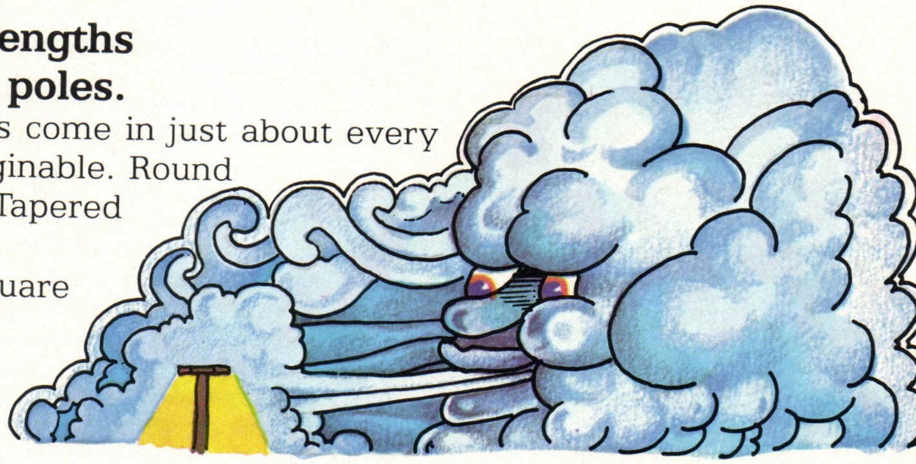


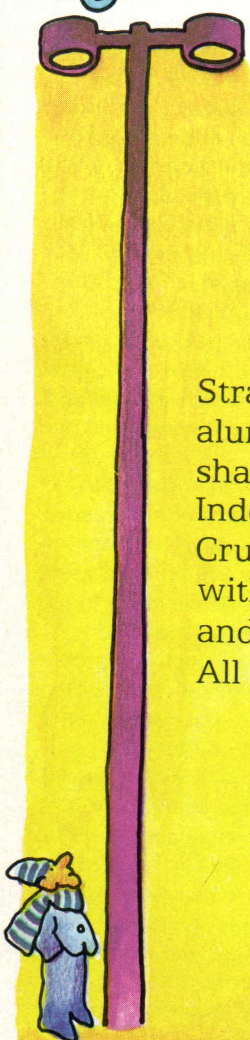


What the hell is a U-B-R?

Sterner's Unitized Ballast/Reflector assembly. It's a complete system that includes capacitor, ballast, socket, lamp, and hydro-formed reflector in a single, hinged, removable module. It contains a quick connect and disconnect system, and also provides easy access for installation and maintenance. All this plus precision photometrics. Neat, huh?

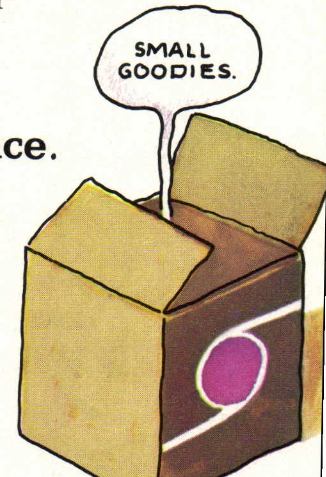


We go to great lengths with our light poles.



Sterner light poles come in just about every size and style imaginable. Round Tapered and Square Tapered in steel and aluminum. Round Straight and Square Straight in steel and aluminum. Plus special shapes in aluminum; Indented Corner, Cruciform, Octagonal, Hexagonal, and H-Form. Even aluminum poles with wood accents. If you can't find what you need, give us a call and we'll build it for you.

All poles are engineered for a wind load of 100 MPH.



Small goodies that can make a big difference.

Prewiring is an excellent way to save time on the job site. Our prewired poles and luminaires contain premium electrical wire, a ground wire and lug, a strain relief, multi-tap CWA ballastry, stainless steel hardware, and waterproof fuse holders for HID systems with base ballastry. Then, just to make sure your life is not complicated by problems, we test all systems before shipment.

System of energy codes will govern California building

California has adopted building performance standards to conserve energy in residential and nonresidential new construction. These new standards will affect the practice of every architect in the state and have a tremendous impact on the future of design. While California is not the first state to consider or enact energy-conscious legislation, it is the first state with such an extensive program.

The regulations have been adopted by the Energy Resources Conservation and Development Commission (ERCDC), established in 1975 by the Warren-Alquist Energy Act. Continuing work begun by the Department of Housing and Community Development, the Commission was charged to "prescribe by regulation lighting, insulation, climate control systems, and other building design and construction standards which increase the efficient use of energy." (Other powers include approving or denying construction permits for new power plants, conducting research and development of new energy technologies, planning and forecasting the state's future energy requirements, and drafting contingency plans to deal with energy and fuel shortages.)

Energy requirements for residential structures, focusing on crucial aspects of insulation and glazing, have been in operation for a year. Some of the major code requirements: glazed areas may not exceed 20 per cent of the total floor area; double-glazing is required in most areas of the state, according to defined climatic zones; buildings must be subjected to extensive life-cycle analysis. (Recent changes will reduce the permissible glazing to 16 per cent of floor area.)

The most recent action has been the adoption of regulations for all nonresidential building (with some exceptions, including hospitals, prisons, reconstruction and restored historic buildings), to take effect on January 1, 1978. These regulations affect the building "envelope," hvac systems and equipment, electrical systems and lighting standards. Initially, these standards were of "prescriptive" nature; after litigation in late 1976, the Commission was directed to develop "performance" standards. It is these performance-type standards that will go into effect at the first of the year. Proponents of performance-type standards include the California Council of the American Institute of Architects (CCAIA), which stated in a Position Paper that "performance standards. . .will give the building industry the design freedom to evaluate and implement systems which will result in the greatest net energy savings."

There has been a debate over the feasibility of the January 1, 1978, effective date, as to both the distribution and the enforcement of the codes. Enforcement of the codes is to be aided by a public-domain computer program with associated instructional manuals (now being developed by Lawrence Laboratory in Berkeley), and by training workshops for local building officials. Most building departments, however, are understaffed and it is not uncommon to find them lacking knowledgeable people who would act as enforcement officials. (The City of San Francisco Building Department, for instance, does not presently have a mechanical engineer on its staff.)

In addition, what is called the Cal/ERDA Computer Program User's Manual—a necessary element of the over-all education process, and required to prepare computer analyses demonstrating a building's compliance with the codes—will not be available to the public until August 1978, seven months after the January applicability date.

These logistical problems will no doubt cause a delay of at least six months in building departments' approving any new construction.

In addition to these problems, the codes do not deal with retrofitting or operational regulations, where great conservation potential exists.

"It remains to be seen whether all buildings designed under the new code will conserve energy in a truly cost effective way," said Michael O'Sullivan, chairman of the CCAIA's Energy Task Force.—*Janet Nairn, Architectural Record, San Francisco.*

California licensing boards may add energy requirement

The state of California contemplates opening a second front in its war to conserve energy. Apart from codifying energy standards for building, the state may also make competency in energy matters mandatory for licensed professionals. Though the most likely targets for such licensing standards are architects, engineers, landscape architects and contractors, accountants are being singled out, too.

"While this relationship is less obvious than the building trades or design, accountants are in a position to educate their clients about emerging Federal and state financial incentives for energy conservation, commercial energy audits and the concepts of life-cycle costing. Also, as more lending institutions provide low-interest loans, accountants can help make their clients aware of financial advantages," states a report prepared for the State Energy Resources Conservation and Development Commission. It has been reported that the California Society of Certified Public Accountants generally agree that the project on licensing standards be pursued.

The other professional licensing boards also agree that this new licensing requirement would be a good idea, but it would add one more burden to the professional board members—a smaller number than ever before due to recently enacted legislation to build up the number of laymen on the boards (see RECORD, January 1977, page 36).—*J.N.*

Agency plans fire safety courses for architects

A Federal agency which believes that architects seldom receive adequate training in fire safety is planning a series of 30-hour courses for practicing professionals, beginning this fall.

About 500 architects are expected to receive the course in their home cities during the first year, and the program will be expanded in subsequent years.

The training is necessary because education in fire safety is "underplayed or nonexistent in most architectural schools," says Anthony B. Granito, deputy superintendent of the National Academy for Fire Prevention and Control.

As soon as the program for architects is functioning, the Academy plans to add similar programs targeted first to interior designers and then to builders and city planners. The interior designers were selected for early attention, Mr. Granito says, because of their involvement in building remodeling and the importance of fire loads that may be added by building contents.

The builders' program will be directed at general contractors and developers in the hope that they will gain an early appreciation of fire safety planning. The program for city planners will be geared to fire safety factors "external to buildings," like the availability of water for fire fighting.

The Academy plans to offer the course through the local chapters of the American Institute of Architects.

The Academy will not charge attendance fees for the courses, but there may be a nominal charge for renting meeting rooms. So far there is no textbook for the course, though participants may use a course outline prepared for the Academy by the Department of Architecture at the University of California in Berkeley.

A trial course presented in six sessions this summer at AIA headquarters in Washington, D.C., listed these subjects: "Understanding the Fire Phenomena," "Fire Behavior in Fire Resistive Buildings," "Building Conversions," "Current Developments in Fire Research and Testing," "Codes and Standards," and "Fire Protection Systems."

Academy officials say they remain flexible on how to present the 30 hours of instruction. In some cases the course might be presented for three hours a night over a 10-week period. In other cases, the entire program may be offered during a single three- or four-day period.—*William Hickman, World News, Washington.*

Commerce offers handbook covering overseas practice

Architects considering work in foreign countries might find a Commerce Department publication developed for engineers useful to them as well.

The newly revised publication—"Engineers' Overseas Handbook"—offers a brief rundown on practice conditions in 122 countries as a basic guide for U.S. firms operating abroad. Commerce does not produce a comparable book for architects.

Data in the 295-page publication is based on a 12-part questionnaire prepared with the aid of engineering societies and construction groups.

For each country, the handbook covers legal requirements for licensing, local representation, local participation and contracting taxation and special costs that must be borne by the employer.

It also details which countries insist on consortium or turn-key bids for engineering, construction, material and equipment, and notes the countries where price bidding or negotiations are routine and those where prequalification is possible.

The handbook is available at $3.50 a copy from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, and from many Commerce district offices.—*William Hickman, World News, Washington.*

Specification writing: a new CSI program provides a "one-stop" approach to locating references

Keeping specification information current, accurate, and organized for quick retrieval may become simpler thanks to a new, on-going program of The Construction Specifications Institute in Washington, D.C. Announced in early June, the Technical Aids Series (TAS) program provides a concise directory of manufacturers, applicable standards, specification aids, publications and regulations for all building materials and components listed in the Uniform Construction Index. TAS not only provides a format for filing volumes of specification information; it also identifies *what* to file—it is a "Table of Contents" of reference data needed to prepare specification text. The TAS program's intent is to establish a standard form of document usable nationwide by the entire construction industry.

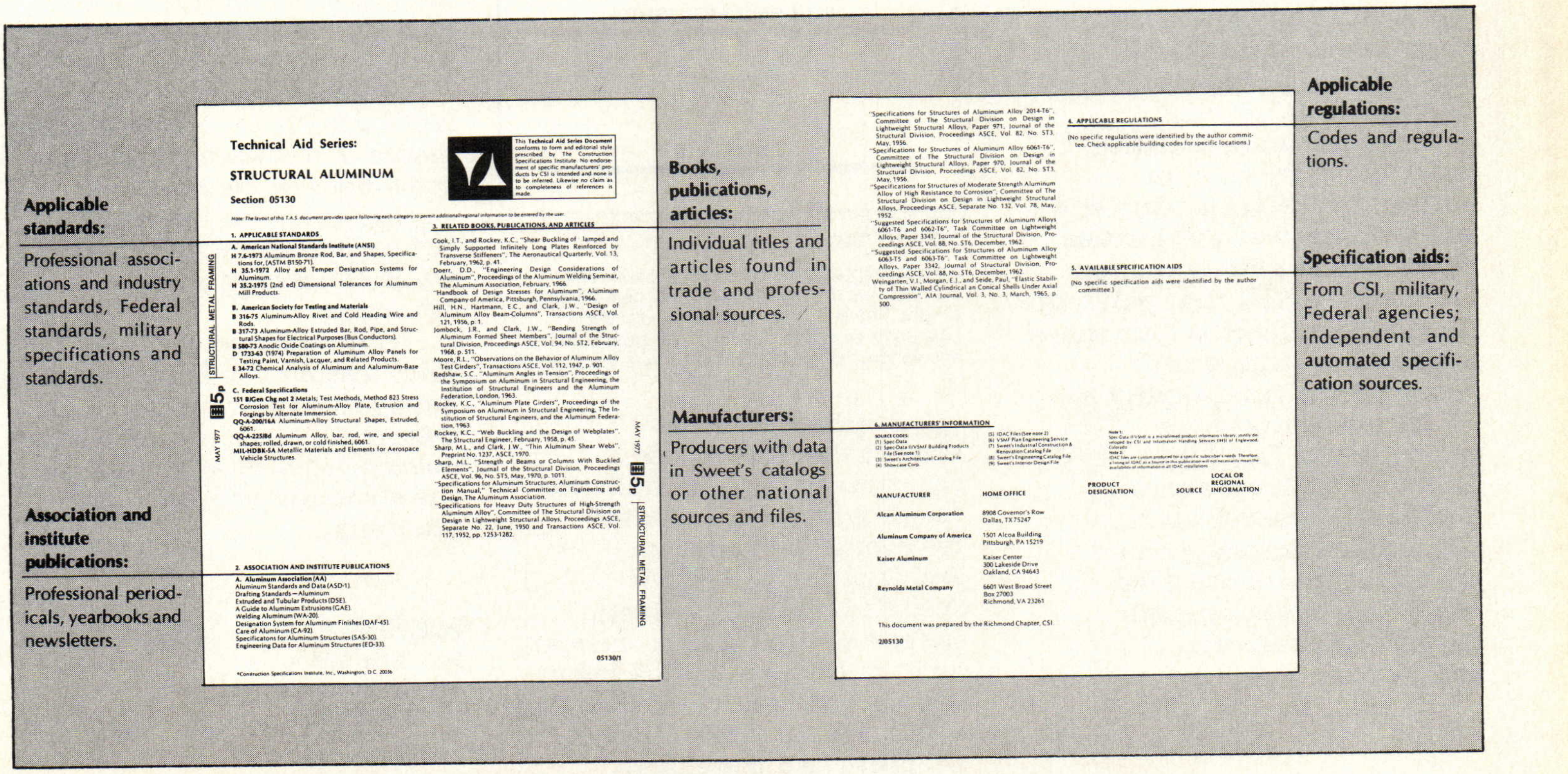
A typical Technical Aid from the series, on structural aluminum, is shown below. It contains all of the applicable standards for such aluminum: ASTM or Federal specifications; association and institute criteria; relevant books, publications and articles; regulations such as identified building code requirements; available specification guides such as Masterspec; and a list of names and addresses of all known national companies producing the specific product. The latter category also refers to the location of the manufacturers' technical data, such as Sweet's Catalogs or microfilm services. The format and criteria for the TAS Documents Program are derived from established procedures and formats developed by various CSI chapters and individuals for gathering information. All information listed in the Technical Aids must be available nationally. No regional or local sources are given, although space is provided for the individual user to record them.

Individual Technical Aids are bundled into sets of fifty that are sold to CSI members for $15 per set, or to non-members for $30. The first set of fifty covers soil compaction control, concrete admixtures, brick masonry, standard steel joists, asbestos cement shingles, and built-up bituminous roofing among others. The second set will include lightweight concrete, glass unit masonry, aluminum doors and frames, and weatherstripping and seals. The complete series is expected to cover over 300 types of building products and systems and be available by fall 1978.

CSI chapters are doing the research for TAS, each chapter receiving an assignment at the beginning of each CSI fiscal year. The Technical Documents Committee of CSI makes the assignments, matching them with the knowledge, expertise and interest of chapter members. Ninety days after the assignment is made, the chapter is expected to submit a manuscript. Currently, 118 of the 125 CSI chapters are working on the TAS program.

Authors represent the spectrum of the 11,000 CSI members: those who specify the materials and processes under study; industry members who manufacture or sell the products; and contractors who install them. CSI has formated a thorough investigation process that—in operation—leads to a well-organized—though admittedly not complete—document. For example, the person assigned to research all standards applicable to the product under study would do the following: search all manufacturers' literature for reference to ANSI and ASTM Standards and Federal Specifications; check the applicable PSAE Masterspec section; check ANSI and ASTM Indexes; check microfilmed standards libraries; and survey manufacturers.

According to Thomas R. Hollenbach, administrator of CSI Technical Programs, requests for the first set of Technical Aids are substantial, coming primarily from contractors. Plans call for updating the Series with addenda that will be mailed to those purchasing the sets.



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In 1956, Naturalite organized a daylight research program, the first in the industry. Its purpose; to determine the interior daylighting characteristics of materials being used in Naturalite skylights. One of the many things we have learned from these studies is that on the average, BTU heat gain per footcandle of light is four times greater from fluorescent fixtures than from skylights!

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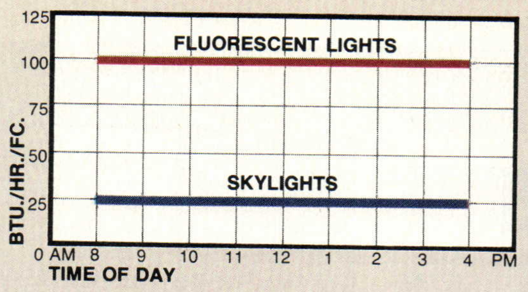

Solar heat grain per unit of illumination. This curve shows the comparative heat gain per unit of light. The BTU per Hr. heat gain for each footcandle of light is four times as great from the fluorescent fixtures as compared with the skylights.

Southlake Mall at Merrillville, Indiana, is a beautiful example of how well the program works. After reviewing the research, architect Louis Resnick specified dramatic polygon shaped skylights to be custom built by Naturalite. The result is a lighted environment that is comfortable and beautiful for shoppers and merchants . . . as well as the profusion of greenery within the regional mall.

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ENGINEERING FOR ARCHITECTURE

INTRODUCTION

This is our fourth annual mid-August issue on Engineering for Architecture.

Like its predecessors, we hope this issue serves not just to educate and enlighten—but also to give recognition to engineers in all disciplines for their inventiveness and resourcefulness as they work with architects to achieve economical, rational, and beautiful buildings.

In this issue you will find—for obvious good reasons—a heavy focus on energy conservation. Many of the case examples of really quite dazzling engineering innovation (which begin overleaf) emphasize new techniques in energy conservation—in lighting, in more efficient air handling, in daylighting, in thermal storage. The Round Table, beginning on page 92, focuses on what some of the country's most thoughtful architects, engineers, owners, government officials, and manufacturers feel are the most cost-effective strategies for energy conservation in building. You'll also find (on page 108) a thoughtful discussion of today's realities and practicalities in solar design; and on page 114 a look at the very newest in wiring devices.

There is, of course, a broader diet as well: for example, a look at some of the newest structural techniques, and a report on the frontiers of computer-aided design.

And everywhere in the issue, you will find reinforcement of an idea which we expressed in that first Engineering for Architecture issue four years ago: "What is most important in building is not any of the new techniques. . . . What is most important is the people involved and their inter-relationships as each contributes his experience and expertise. What is most important is knowing the right way to use the right people at the right time."—*W.W.*

Ceiling task lighting and innovation in hvac systems provide a showcase for energy conservation

A whole series of energy-reducing steps in design, including two strikingly new departures—one in ceiling lighting, another in thermal storage—held consumption in this Canadian federal office building in Toronto to 66,600 Btu/sq ft/yr without sacrificing the quality of working space.

Indeed, few buildings whose office floors cost only $33/sq ft, as did these, offer such amenities as provided by architect Macy Dubois. The zigzagged facade of this building, for example, provides more perimeter wall than a square building twice its height, and thus opens pleasant vistas for office workers. In addition, three atriums offer interior views. The main atrium, shown across page and in plan, is five stories high, and is entered from grade. Reason for the opaque wall was anticipated construction of a parking garage adjacent. Columns support the sloping roof and skylight structure, and were braced for lateral stability. Another large atrium (see top photo) will have a louvered exterior wall to exclude direct sunlight.

Undoubtedly the most dramatic advance in the design of the building is the ceiling task lighting, which requires only 2W/sq ft to provide 100 footcandles (required by union contract) on desktops. This feat is accomplished by movable, plug-in, two-lamp luminaires that can be dropped randomly into an exposed 5- by 5-ft raceway grid.

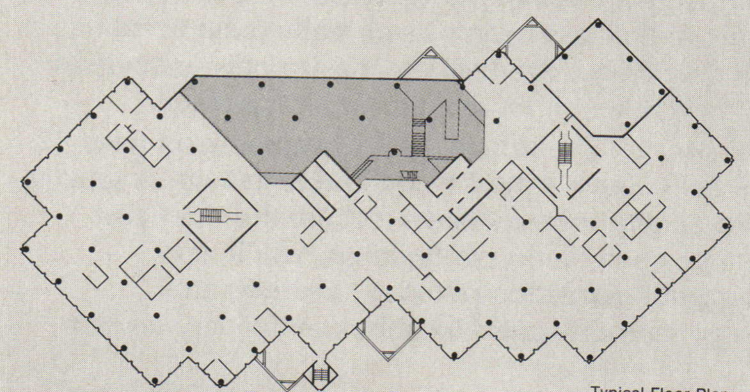
The exposed 2½- by 6-in. raceway is multifunctional: 1) it carries 347-v power (Canada) for the plug-in lighting, 120-v power for convenience outlets, and telephone wires; 2) it supports luminaires and acoustical panels; 3) it accepts linear diffusers, designed to issue up to 265 cfm per 5-ft length; 4) it accepts sprinkler heads, partition anchorages and service poles.

A large percentage of the energy savings in the 825,000 sq ft building is attributable to the design of the hvac system, which allows very large reductions in fan energy as compared with conventional installations. Moreover, a considerable amount of heat is recovered from lights, people and machines, and stored in four 75,000-gallon concrete tanks in the basement.

Reductions in fan energy are effected by 1) variable air volume distribution, 2) the use of low-temperature salvage heat in under-window radiation heaters, rather than air at the perimeter, and 3) the substitution of small air-handling units (two per floor, 26 altogether) for larger stations, substantially lessening total friction loss.

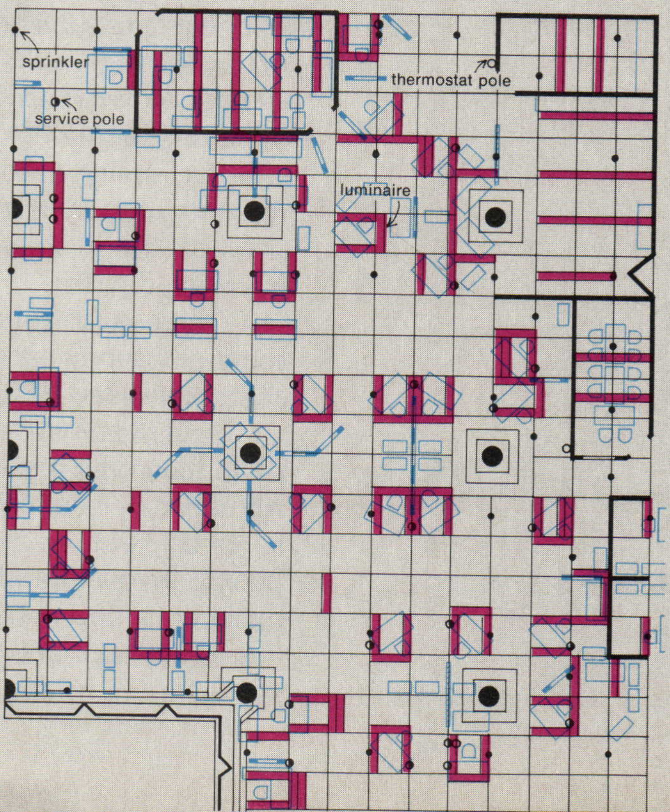
According to mechanical engineer Robert Tamblyn, the storage of salvage heat yields energy savings comparable in magnitude to the air side of the hvac system. Indications are that thermal storage will reduce heating costs by as much as 60 per cent. On the cooling side, furthermore, thermal storage makes it possible to reduce the size of the chillers by 30 per cent, and to save 20 per cent on cooling costs by cutting electric demand 30 per cent by running chillers during off-peak periods. Chilled water will be stored year-round.

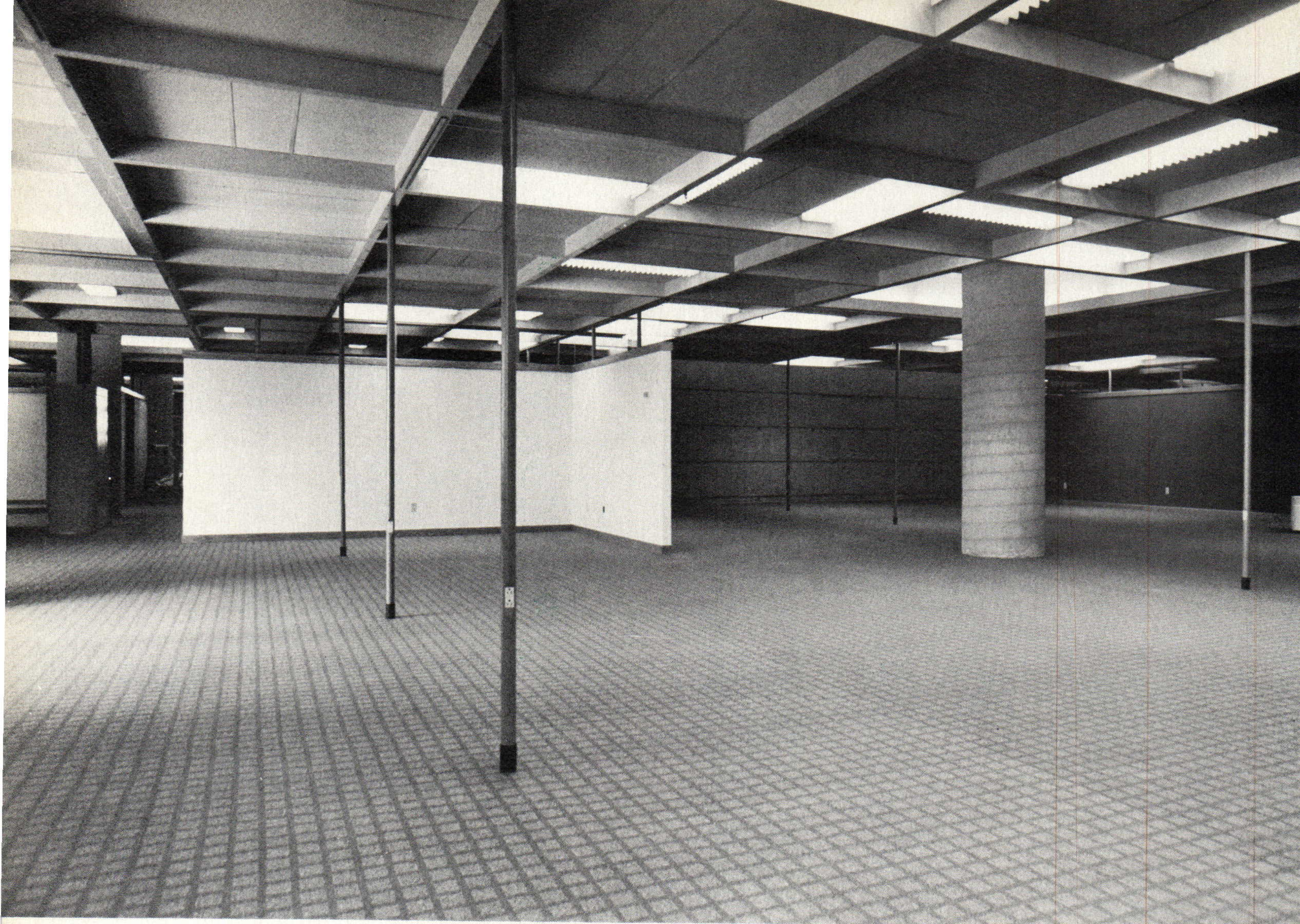
GOVERNMENT OF CANADA BUILDING, Toronto. Architects: *DuBois-Strong-Bindhardt and Shore Tilbe Henschel Irwin, associated architects and planners.* Engineers: *R. Halsall & Associates Ltd.* (structural); *Engineering Interface Limited* (mechanical); *Jack Chisvin & Associates Ltd.* (electrical). Project manager: *Public Works Canada, Ontario Region.* Construction management: *E.G.M. Cape & Co. Ltd.*



Typical Floor Plan

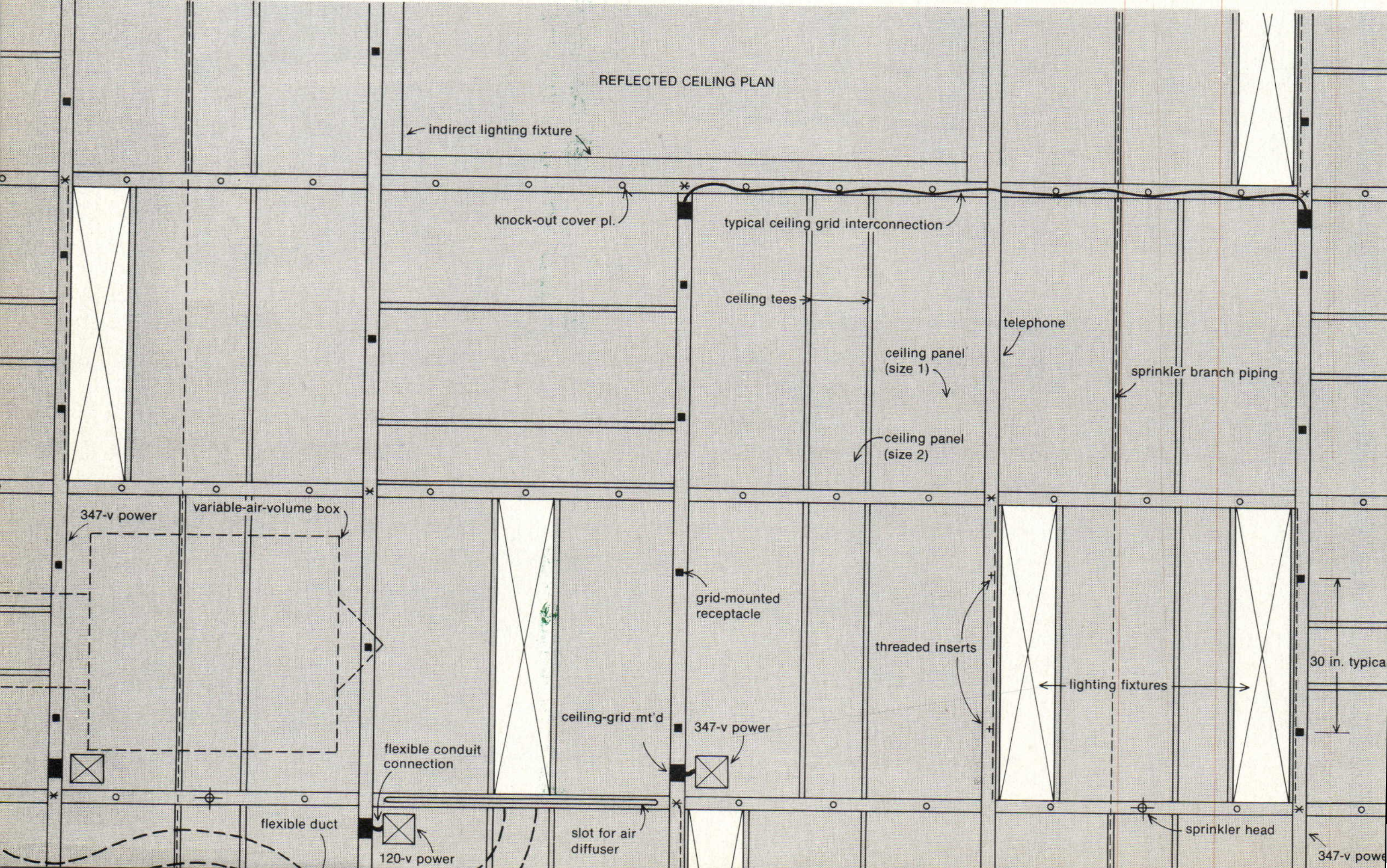
Ceiling task lighting providing 100 fc at desks is by two-lamp, plug-in luminaires, dropped into the ceiling grid over the desks. Uplight at columns is for accent and nighttime lighting.

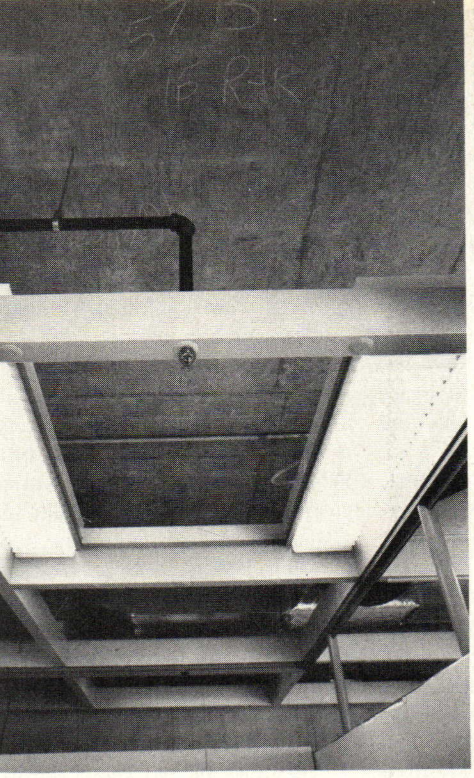


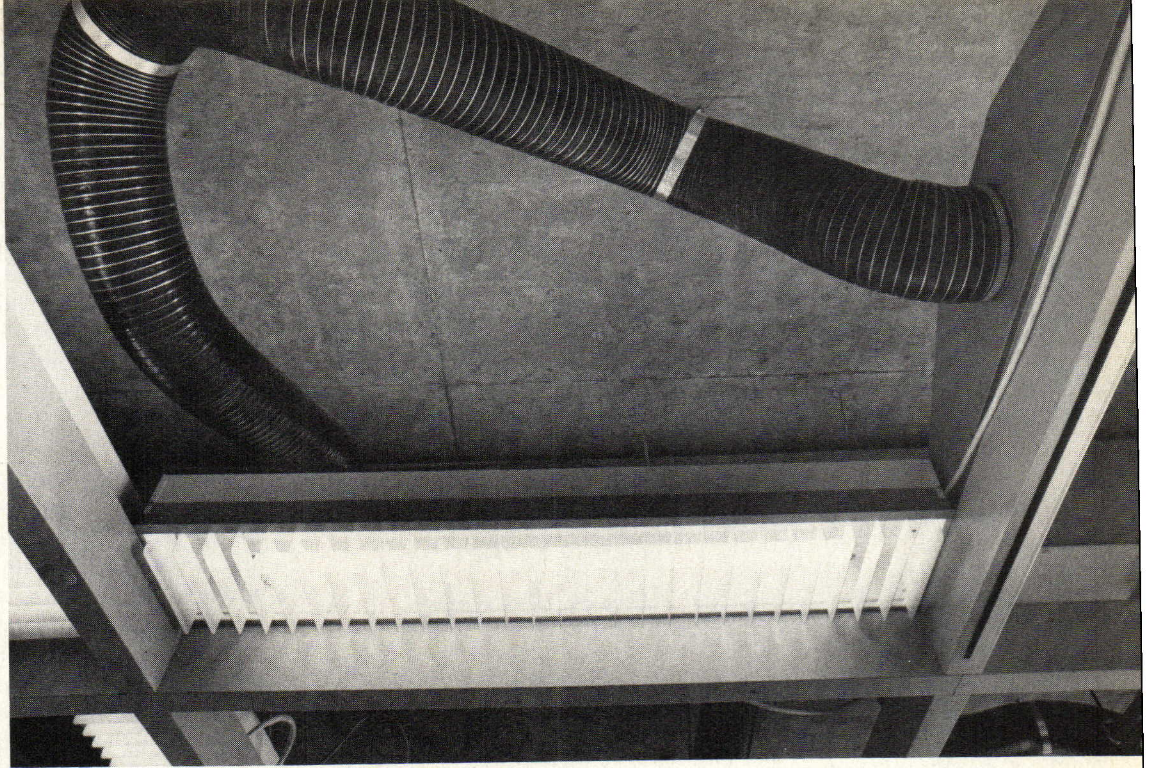


Robert E. Fischer photos

GOVERNMENT OF CANADA BUILDING





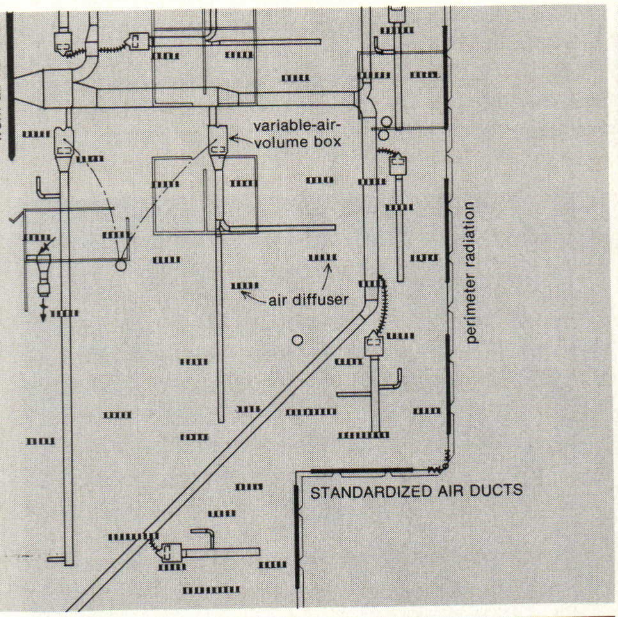


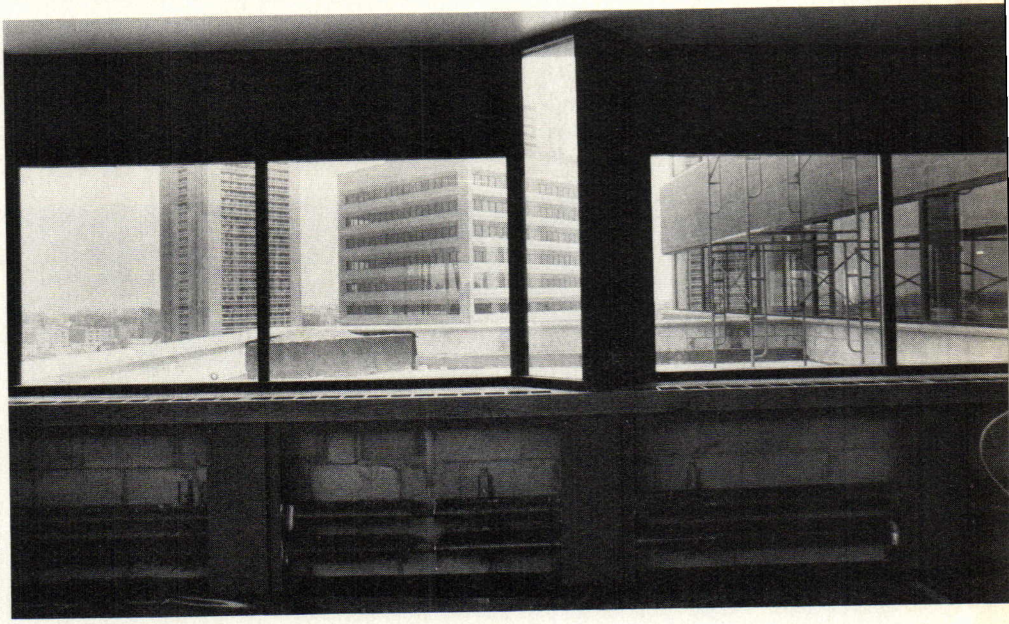
The ceiling grid performs multiple architectural and engineering functions

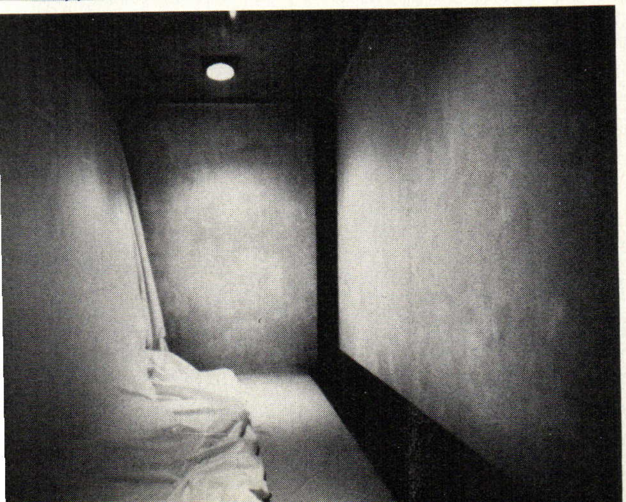
The first purpose of the grid system is to support luminaires for task lighting—and to allow variation in their placement according to the location of work stations. The grid further incorporates raceways to power the luminaires, which are plugged into twist-lock receptacles via power cords. Though luminaires are arranged in a more or less random pattern, the regular spacing of the 6-in. deep grid helps organize the ceiling visually. Orange-colored acoustical panels, matching the grid, come in two standard sizes to fill the 5-ft module whether one, two or no luminaires are inserted.

Every other raceway carries 347-v wiring for lights; they alternate with raceways for 120-v receptacle power and raceways for telephone wires. The 347-v raceways are on 10-ft centers because power cords for luminaires are limited by code to 6-ft lengths. Cords for 120-v power to service poles can be 12 ft, however. Telephone wires and 120-v cords to service poles are enclosed in the dummy grid members running perpendicular to the raceways. The raceway spacings thus give complete flexibility in the location of work stations.

Grid members running perpendicular to the raceways provide for a number of functions: slots for linear air diffusers, button-type knockouts for the installation of spring-loaded service poles, and round holes for sprinkler heads. The raceway grid has threaded inserts for partitions.







The hvac system combines energy savings with a low first-cost

Four 75,000-gallon concrete tanks like the one at left will store "waste" heat recouped from lights, equipment and people. During cold seasons, this stored heat will provide 100F water for finned radiation at the perimeter. Chillers will run in offpeak periods to reduce demand charges, and cooled water will be stored in the tanks. A problem in storing chilled water is that supply and return water may not mix, or else the supply water will not be cool enough for dehumidification. Engineer Robert Tamblyn's ingenious solution to this dilemma was to provide a plastic baffle in the shape of a huge square bag, which moves back and forth as relative volumes of supply and return water vary at night and during the day. The storage tanks cost $175,000, but saved $75,000 in chiller costs and promise to save $10,000 a year in demand charges. Six standard sections of ducts rather than many different sizes cut hvac costs. The total system bid cost under $3.40/sq ft.

Robert E. Fischer photos

New federal building exhibits new standards in public accessibility and energy conservation

In its design of the facade of the new Federal Home Loan Bank Board Building, Max Urbahn's office has been properly deferential toward the Executive Office Building across the street, which a Washington architecture critic has said is "treasured for its robust immodesty." In the facade design the architect also has been mindful of GSA's energy-use guidelines, inasmuch as GSA is the client of record for the building.

The walls comprise bays of glass outlined by exposed concrete ledges and limestone-faced fins, and punctuated by exposed concrete columns—the glass bays being interrupted by sections of limestone-veneered masonry.

Masonry walls are insulated to achieve a U value of 0.07. The double-glazed clear glass occupies roughly only 35 per cent of the wall. To help building energy usage approach GSA's guideline of 55,000 Btu/equivalent gross sq ft/yr, the remaining glass is backed by panels of rigid insulation and gypsum board. On the exposed elevations, Venetian blinds will block unwanted sun. Sliding doors at balconies (identified by the double-thick ledges) are more deeply recessed, and are shielded by the ledges.

The mechanical engineers, using the AXCESS computer energy-use-simulation program, estimate annual energy consumption at about 77,700 Btu/EGSF/yr. If kitchen usage, 13-hr operation, and commercial lighting (the ground floor will be leased to stores) are accounted for, this figure would drop to 57,000.

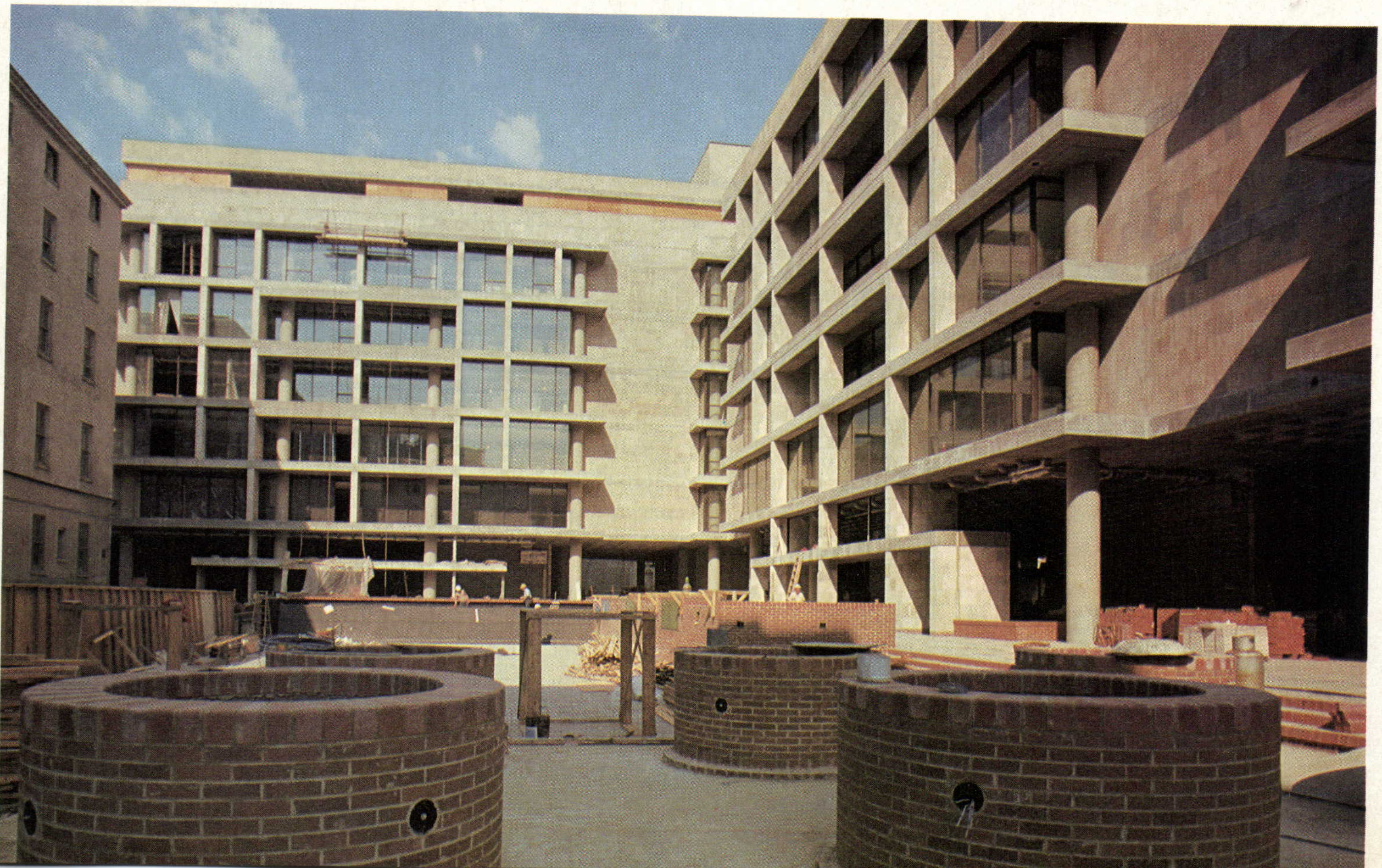
The architect and consulting engineer Syska & Hennessy collaborated closely in developing systems and architectural elements for delivering air, light and power to the open-plan floor areas as inconspicuously and as efficiently as possible. For example, three air systems are used rather than the usual two; lighting (2¼W/sq ft) is entirely from the office work stations (task/ambient); and power and communications wiring is run below the 4-in.-high access/raised flooring that is used for all office floors.

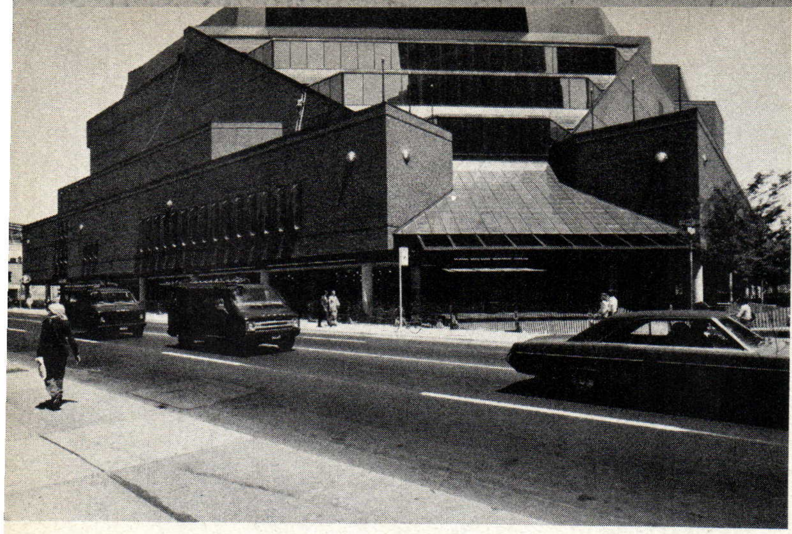
Other energy-saving steps by the engineers were: 1) use of variable ventilation and unheated ai for garage areas, and 2) supply o only 105 F water to lavatories by a single pipe instead of both cold and 120 F water. Also the building includes a building automation/ fire/security system for hvac monitoring and control, fire and sprinkler alarm, automatic smoke purging and security.

The choice site of the building was not easy to acquire. In fact, one of the client's obligations is to rehabilitate the adjacent Winder Building—a five-story cast-iron office structure built in 1842. The plaza between the two buildings will have an ice-skating rink that, in summer, will be turned into a reflecting pool bridged by duckboards for umbrella-shaded tables. And Sasaki Associates has designed a two-story glass pavilion to abut the Winder building.

Because of two levels of underground parking plus a basement, Lev Zetlin Associates, the structural engineer, had to be careful in their foundation design to minimize underpinning of the Winder Building. Superstructure of the FHLBBB is waffle slab.

FEDERAL HOME LOAN BANK BOARD BUILDING, Washington, D.C. Client: *General Services Administration.* Architects: *Max O. Urbahn Associates, Inc.* Engineers: *Lev Zetlin Associates (structural); Syska & Hennessy, Inc. (mechanical/electrical).* Sitework: *Sasaki Associates.* Interiors: *Max O. Urbahn Associates, Inc.* Contractor: Turner Construction Co.





In a balconied library, lighting system provides flexibility, function, and sumptuous drama

The powerful and sensuous interiors of Toronto's new Metropolitan Library proceed directly from architect Raymond Moriyama's concern that users enjoy freedom of movement and quick comprehension of the library's organization.

Openness extends to the ceiling planes, too, though this is as much functional as it is esthetic. The ceiling is a series of baffles that not only help shield the lighting fixtures from view but also absorb sound.

But technically, the most significant feature of the ceiling is the variation in luminaire spacing and location to permit variation in lighting levels for different space uses—reading, stacks, offices, conference rooms, etc.

The basic lighting discipline comprises continuous, single-lamp, fluorescent strip lighting, spaced 7 ft apart; over stacks, however, density is increased to 3½ ft. But a further innovation is the movable, plug-in task luminaire (3-ft, two-lamp), which can be mounted above the ceiling-baffle system where required over a reading desk or work station. Lighting levels will range from about 30 fc, maintained, for the wide spacing to 75 fc for the higher density strips, and spaces under the task luminaires.

Though they were unable to use it in the Scarborough Civic Center (RECORD, July 1974), Moriyama and his engineers first considered the ceiling-lighting arrangement for that building, which in its interior spaces has some similarities to the layered-tray interior of the Toronto library. In some ways design goals were similar, too. At Scarborough, Moriyama wanted to encourage contact between residents and borough employees, and to open up the building to the public.

The library, however, is not a borough library, but a Metro library. It is located in a very busy and lively commercial area of Toronto on the edge of downtown that is full of high-rise office buildings, stores, shops and restaurants. But, more importantly, it is right next to the intersection of the north-south and east-west subway lines.

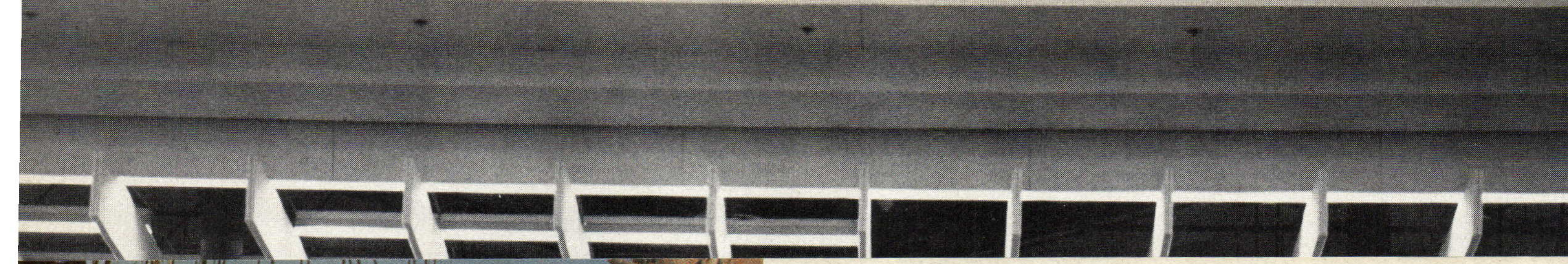
The architect, wanting to encourage public use and enjoyment of the facility, designed landspaced arcades on two facades of the library, and an interior "street" along which the public may stroll without having to pass through security.

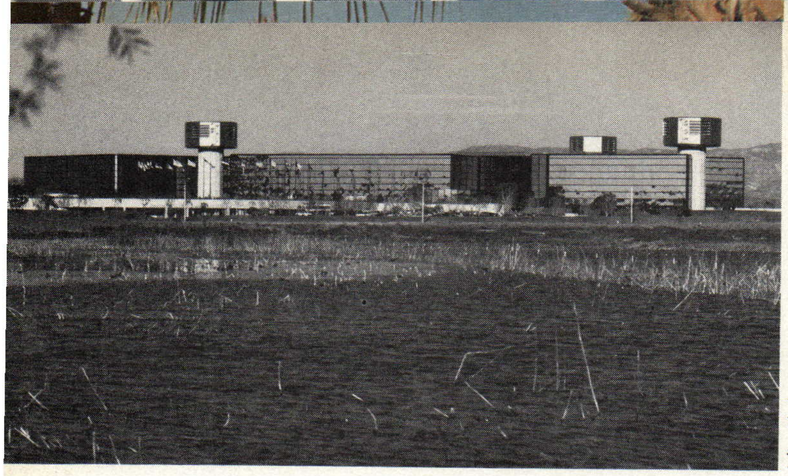
The lighting design, of course, yields energy savings with load averaging out at about 2.2 watts per gross square foot, including a fair amount of incandescent lighting on the main floor, such as the track lighting along the interior "street."

Energy savings also accrue from the well-insulated building shell (polystyrene-insulated wall and roof, U = 0.1, and reflective insulating glass); from the heat recovery system (internal heat extracted by a heat-pump system is sufficient to balance shell losses down to −5 F); from reducing lighting levels and ventilation air at night; and from using one faucet per basin in lavatories with 105 F water.

METROPOLITAN TORONTO LIBRARY. Architect: *Raymond Moriyama, architects and planners.* Engineers: *Robert Halsall & Associates Ltd. (structural); G. Granek & Associates (mechanical); Jack Chisvin & Associates Ltd. (electrical).* Contractors: *The Charles Nolan Company.*

Robert E. Fischer photos





Julius Shulman photos

Perched atop stair towers, fan rooms accent design of energy-conserving California office complex

An effective, uncomplicated, energy-conscious design for Fluor Corporation's new office building in Southern California is a result of the total integration of engineering and architectural concerns that also achieve a showcase for the client. A consolidation of seven offices in the area, the building provides 1.3 million square feet for nearly 4,400 persons—expandable to 7,000—wrapped in silver reflective glass and punctuated by three visually prominent mechanical towers.

Because of the mild climate, there is no central heating plant or boiler. Rather, a combination of electric radiant heating panels, fluorescent lighting and body heat provide heat for the entire building. The mirror glass (3/8-in. thick and single-glazed because of warm winters) obviously is a key factor in maintaining a comfortable atmosphere.

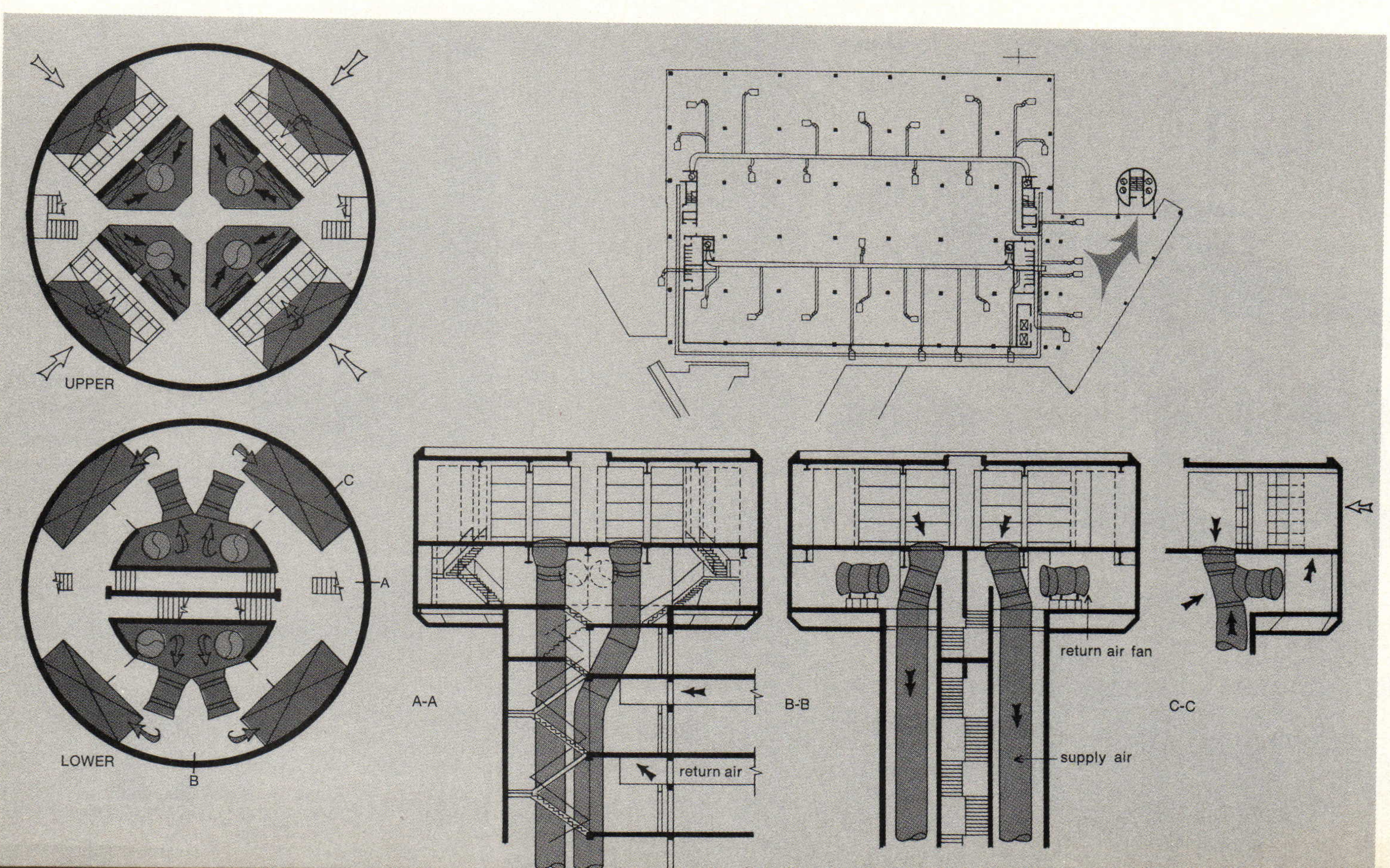
A total of 1,300 radiant heating panels is located either above a narrow perimeter corridor (not used for circulation) or in the relatively few private offices. They are activated only on the rare cold days. Fluorescent lighting provides 110 footcandles fully illuminating the open-plan work areas.

Placing the fan rooms atop the freestanding stair towers, and using them as visual elements, accomplished several objectives. The separation permits an esthetically-pleasing roof line and isolates noise and vibrations. Furthermore, this allows flexibility in future building expansion, as each tower at maximum capacity can serve two sections (called "pods" by the architects). Presently, only one tower is used this way and it incorporates two supply and two return variable-pitch, axial-flow fans. The remaining towers have only one supply and one return.

Air returns to the towers from the work areas through slots in the recessed light fixtures. These systems are controlled by a central computer which "reads" outside temperature and humidity before the workday begins and determines when to turn on the lights and radiant heating panels and to start the fans.

OFFICES FOR FLUOR ENGINEERS & CONSTRUCTORS, Southern California Division, Irvine, California. Architects: *Welton Becket Associates—Alan Rosen, director of Los Angeles office and project director; John Parr, assistant project director; Karl Schwerdtfeger, project designer.* Engineers: *Brandow & Johnston Associates (structural); Leroy Crandell (soils); James A. Knowles & Associates, Inc. (mechanical); Brad Karr of Welton Becket Associates (electrical); Shuirman Rogoway & Associates (civil).* Landscape architects: *Fong Jung Nakaba Associates.* General contractor: *C. L. Peck Contractors.*

Three identical 93-feet-high mechanical towers house variable volume fans and cooling equipment to serve two building sections. Their shape directly reflects their function, and they have become an important over-all visual element and also separate vibrations and noise from the building.



A major building in a rural setting suffuses its spaces with daylight

Robert E. Fischer photos

Architects, it seems, are beginning to rediscover the wonderful qualities of daylight, though with more impressive results, as here, when inventive designers develop new concepts through modern materials and technologies.

John Carl Warneke's office (William Pedersen, designer) created this remarkable daylighted space that has the relaxing ambience of an art museum, yet the greater interest of outdoors because of the modulating effects of its ceiling design elements.

No museum this, however, but rather a 525,000-sq-ft office building (expansible to 1-million) for the Aid Association for Lutherans, the world's largest fraternal insurance organization. The new headquarters sits in the open countryside, amidst farm fields, a few miles from Appleton, Wisconsin, within commuting distance of Oshkosh and Green Bay.

Outwardly, the dramatic ceiling forms on the upper floor of the two-story structure are devices for controlling and suffusing daylight, or supplemental electric light during dark periods from tubular luminaires directly under the reflective-glass skylights.

Because of the balanced brightnesses within the spaces (one never sees the skylights without looking nearly straight up), an observer can hardly believe that lighting levels at midday in summer are about 200 fc.

The ceiling elements do much more than might be guessed, however. The unique cylindrical shapes in the ceiling, called "socks" by the architect—and now, too, by the building's tour guides—house all the mechanical paraphernalia for delivering and controlling conditioned air, sprinkler piping, roof drainage, and even speakers that create masking sound.

The ceiling also traps sound and absorbs it by means of the "socks" which have fiberglass cores behind the white fabric, stretched in a smooth, taut double-curvature between hoops. The panels are clamped by a special plastic molding.

Because AAL continues to grow, and because support services, such as electronic communications, are changing so rapidly, AAL decided to have a complete access/raised floor for all office areas—nearly 218,000 sq ft.

Mechanical systems and components were selected always with energy savings in mind. Air-handling equipment is in four long, extendable penthouses, running perpendicular to the skylights. Altogether there are 28 air-conditioning systems using packaged air handlers and return-air fans with controllable-pitch blades that are efficient even at low-capacity air delivery.

On the upper level, which has much wider swings in air-conditioning load because of the skylights, three different types of air-handling systems are provided: 1) an interior-zone, variable-air-volume cooling system; 2) a single-zone system for perimeter areas (all glass is double glazed); and 3) a multizone system for areas with large, variable loads.

On the ground floor, perimeter zones are handled similarly to those on the upper floor. Interior zones, however, use air-powered induction boxes, because cooling load stays fairly constant.

Electric heaters are used under the skylights to keep air temperature near them in winter at 72 F to prevent downdrafts. Electric draft-barrier heaters also are provided at all perimeter glass, which turn on at 25 F, and step up to 100 per cent capacity at –20 F.

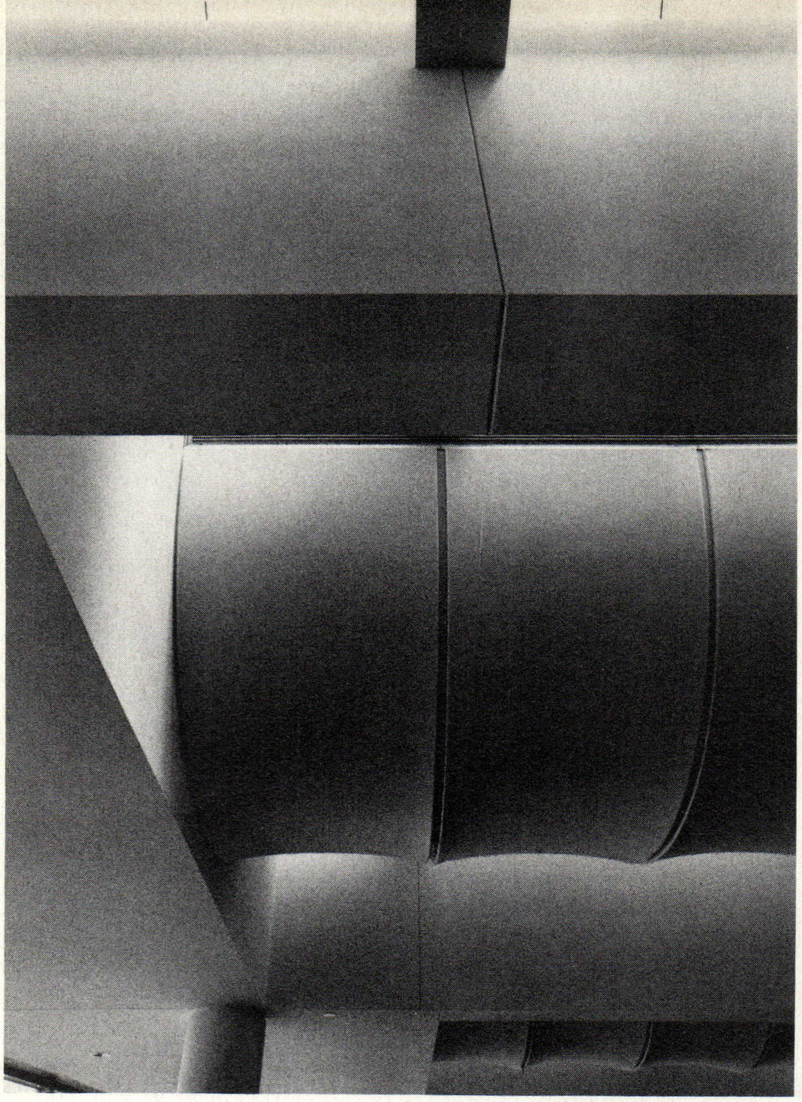
The all-electric building has three chillers, one of them operating as an internal-source heat pump. Two 25,000-gal tanks store hot water when it is efficient to do so. The heat pump can be supplemented by two electric boilers.

To implement energy conservation, and also for security and life-safety, the building has a computer-type building automation fire/security system.

The tubular, lensed, twin-lamp luminaires under the skylights can have either half or all lamps switched off as daylight varies. While the control center can provide automatic switching, the owner is doing this manually to learn what is really needed.

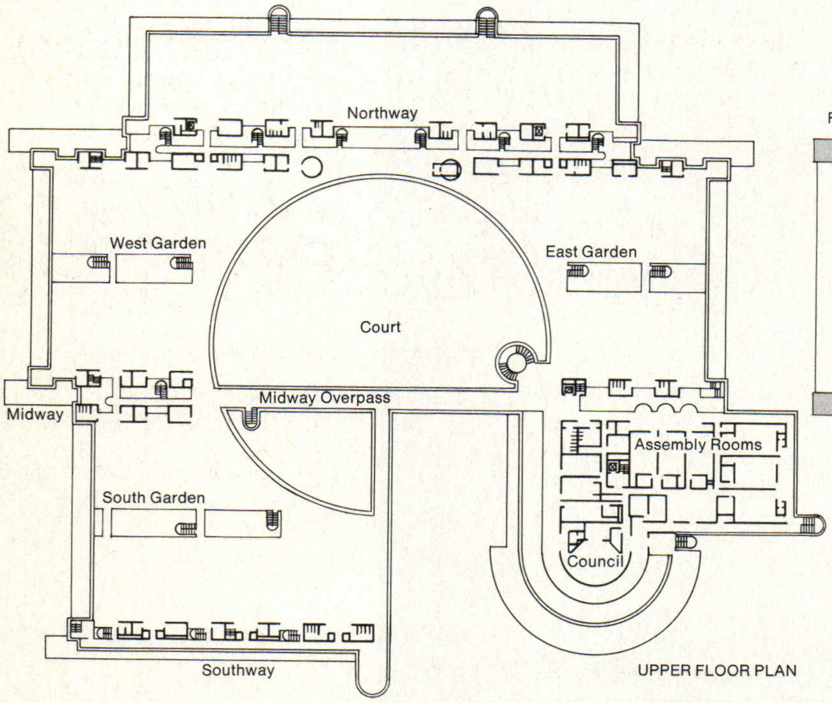
AID ASSOCIATION FOR LUTHERANS HEADQUARTERS, Appleton, Wisconsin. Architect: *John Carl Warneke & Associates, Architects and planners.* Engineers: *Paul Weidlinger Associates (structural); Joseph R. Loring & Associates, Inc. (mechanical and electrical).* General contractor: *Oscar J. Boldt Construction Co.*

Two different areas of the AAL building demonstrate the soft, modulated ambience created by the cylindrically-shaped "socks" and deep, sheathed girders that control and disperse daylight from skylights (and supplemental fluorescent fixtures) overhead. The area at top is directly behind a two-story skylit passage on the north side. The area at left is between this passage and an interior garden to the south.

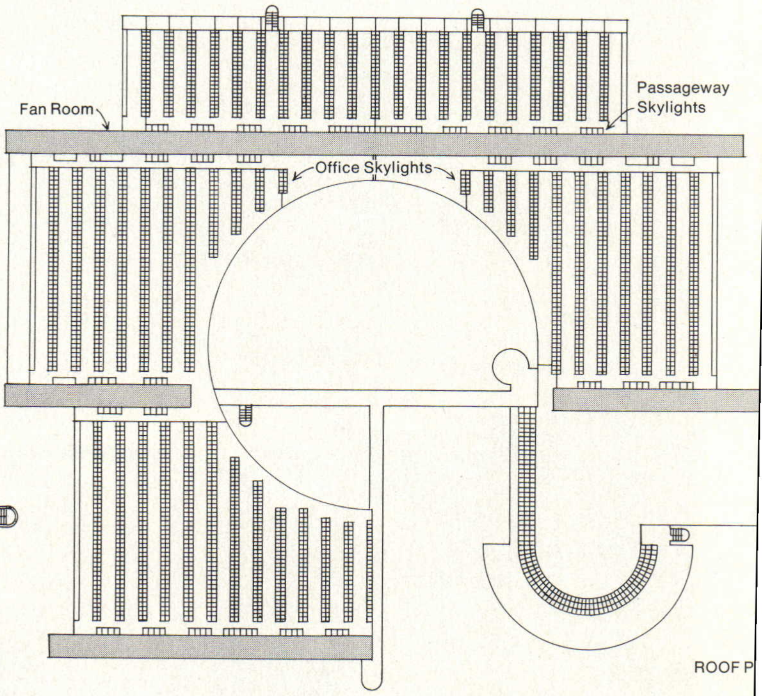


AID ASSOCIATION FOR LUTHERANS

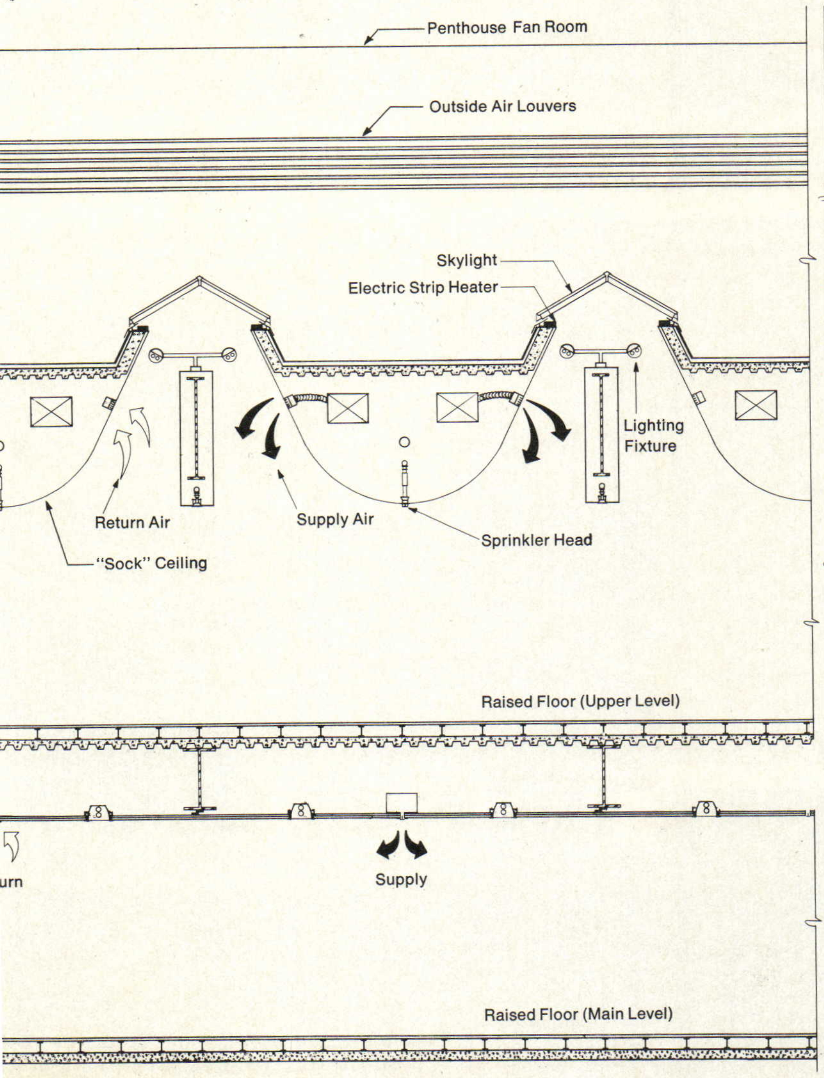
In addition to their light-control function, the fabric-covered ceiling "socks" neatly conceal supply-air ducts and their associated volume-control boxes, and sprinkler piping. Further, they integrate linear diffusers for supply and return air. The "sock" itself serves as the plenum for returning air to fan rooms. A row of fluorescent fixtures used at night or during marginal daylight conditions can be seen above, right. The one luminaire that is lit is on the emergency circuit. The deep rectangular members are sheathed, long-span girders that span as much as 88 ft, and the cross members are roof purlins. While the skylighted office space is only on the upper floor, the ground floor, lighted by low-brightness fixtures, shares the two-story-high skylighted passages and interior gardens.

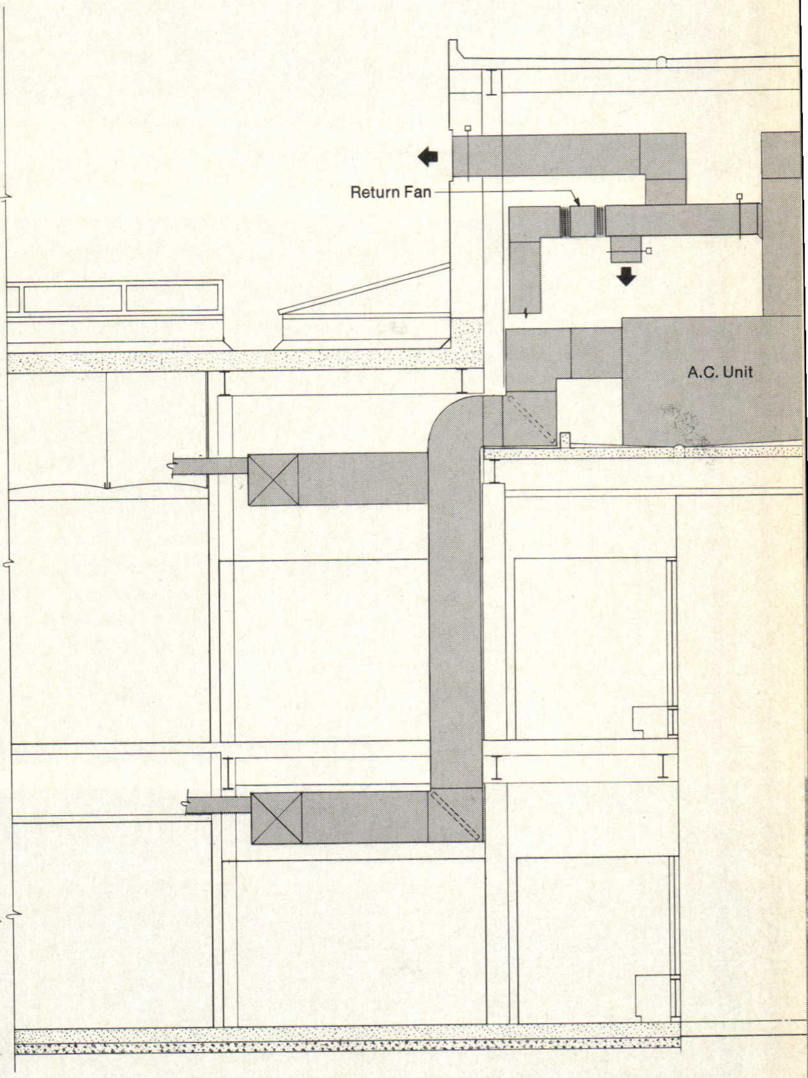


UPPER FLOOR PLAN



ROOF P





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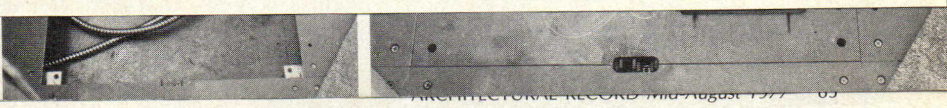
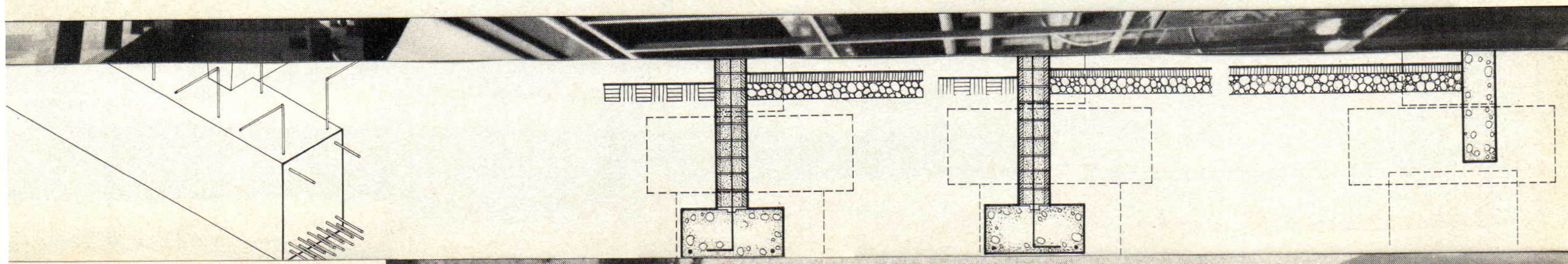
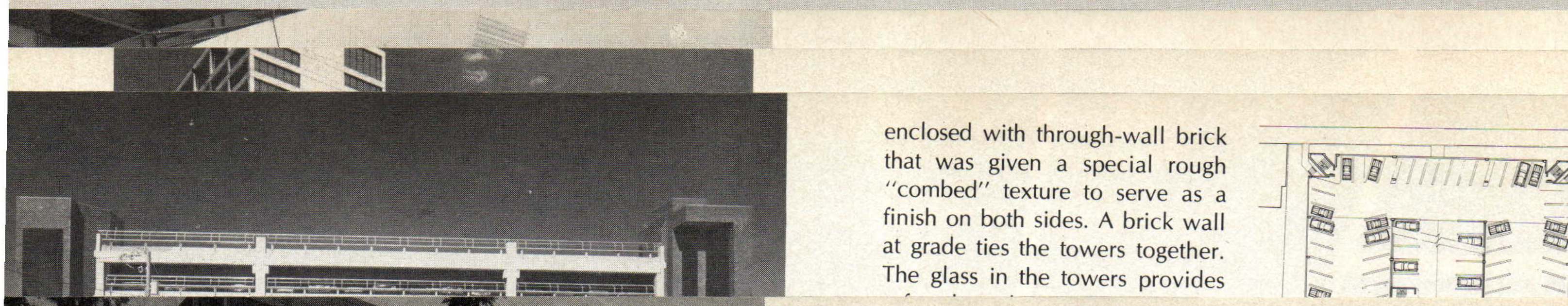






ROUND TABLE

ON COST-EFFECTIVE STRATEGIES FOR SAVING ENERGY IN BUILDINGS

John D. Anderson, AIA
John D. Anderson and Associates
Architects PC

This is RECORD's third Round Table on energy conservation. The first was published in January 1972 and explored (how long ago and far away it seems!) whether or not there was an energy crisis—and what if anything architects and engineers could do about it. It is a tribute to those original Round Table panelists that the concerns—and possible remedies—developed at that meeting over five years ago still read like an action plan for today.

The second Round Table, published in mid-August 1975, asked these questions: "Since there is just no doubt that we have the cost-effective technology to reduce energy consumption in both new and existing buildings by a third, or maybe even a half, why don't we get on with it? Why can't we set reasonable goals and establish policies for energy conservation in building that spread the costs and sacrifices and effort evenly across the industry—and get on with it?"

Albeit with frustrating slowness, we do seem to be getting on with it—and this Round Table explores the cost-effective strategies that are working today. What became clear at this Round Table is that clients are more receptive to energy-saving proposals—even when, as they often do, some investment is involved; and that as a result . . .

1) Engineers are now able to design systems the way they knew all along they should be designed, and

2) Architects are able to design for energy conservation ("we're dealing with design concepts we haven't used since architecture school") and letting the forces of nature work as a design imperative.

In this Round Table, the panelists outlined the energy-conserving approaches that are working for them. A new degree of sophistication and enthusiasm is clear, and—it seems to Round Table moderators Wagner and Fischer—we now seem on the track. . . .

We began by talking about where we've gotten with standards:

The impact of ASHRAE 90 has clearly been considerable

Engineer Larry Spielvogel said: "It's been adopted in all the major codes, and being made available to the communities that use these codes for adoption. While it is not in effect in large areas of the country at the moment, within the next few months it probably will be.

"More importantly, perhaps, many architects, engineers, and owners have seen the value of the guidelines and have begun to implement them on a strictly voluntary (and cost-effective) basis.

"But it needs to be noted that Standard 90 by no means provides the most energy- or cost-effective building. 90-75 is a set of minimum criteria that represents minimum good practice."

Engineer Jack Beech commented: "The major impact of 90-75 has been a better envelope—it improves the insulation and the glass and a lot of other things that should have been there for 20 years but which we couldn't design in because they didn't have a three-minute payback. The envelopes that come from 90-75 are excellent—startlingly better than we were doing five years ago. It's left to the mechanical and electrical engineer to meet the intent of 90-75 on lighting and mechanical."

Consultant Elliot Wilbur of Arthur D. Little put some burden on the architects and engineers: "I submit that ASHRAE 90-75 is a brilliant code—because what it really says to the architect and engineer is 'Here is a base standard. If you guys are so smart, go ahead and beat it. Either put up or shut up.' Through the options or through Sections 10 and 11, you can be as innovative as you like. If you think innovation is the answer, make it work. . . ."

Performance standards are still a long way off—but they're working now as a goal

Said Dick Wright of NBS: "We're grappling with the problem of energy budgets—but right now we are looking at more problems than solutions. One problem is that we really don't know enough about how buildings use energy to provide rational targets. We can get gross consumption from utility bills—but we have very few buildings that are well enough metered to provide good data on use within the building.

"We can develop energy budgets similar to GSA's 55,000 Btu/sq ft/ yr, and then vary them for different climates and different building types. But that seems—considering the number of variables—very unwieldy."

Dr. Wright had a suggestion that would seem to ease the use of performance budgets: "If you think in terms of an energy budget as a design budget or a 'rationed' amount of energy—based on class figures or any other kind of analysis—the entire burden is on the architect and engineer; not at all on the user.

"But suppose the energy budget was a target figure, and actual energy consumed each year were compared with that budget. Those owners who are below the budget (perhaps some kind of class mean) would receive a benefit; those above would pay for those benefits. This would be a continuing program; energy use would be evaluated every year. . . ."

Said Chris Law of the Public Building Service: "We were able to establish what we found was a reasonable design budget—for one kind of building [Federal office buildings] operated five days a week. That's not the kind of budget that could be used in a rationing situation. But it works on an annual usage basis: Studies we made with the NBS indicated we could save some 34 per cent of the energy by design; but we have saved 26 per cent just by optimizing the operation of the building."

Owners are clearly beginning to respond to the savings possible through conservation

Said John Honeycomb, director of energy programs for IBM, which occupies hundreds of buildings: "In existing buildings, significant savings can be made with very little capital investment. One of the quickest ways to save energy is simply not to run something when you don't need it—just better operational control. About two-thirds of our savings were made just that way. Our savings—for 34 major plant, lab, and headquarters locations totalling something like 28 million square feet—has been a 36 per cent reduction in energy consumption over pre-conservation levels. With that kind of savings, at today's high energy costs, we can make an investment in conservation in existing facilities.

"On new buildings: We have had the objective since 1974 to reduce energy consumption (vs. 1970 designs) by 30 to 40 per cent. We have easily achieved that objective—by a change in design criteria, using ASHRAE 90-75 as a minimum, and by computer simulation during the design stage to optimize the trade-offs."

John Kmetzo, now a consulting engineer but at the time of the Round Table director of systems engineering for Rockefeller Center, discussed some of the economics—and the way the cost equations change: "In the older

Jack Beech, P.E.
vice president
oseph R. Loring &
Associates, Inc.

Karl I. Beitin
senior associate and director of
mechanical engineering
Geiger Berger Associates, PC
consulting engineers

David C. Bullen, AIA
executive director of
energy programs
The American Institute of Architects

Alfred B. Calsetta
corporate load management
administrator
Long Island Lighting Company

Benjamin H. Evans, AIA
professor of architecture
Virginia Polytechnic Institute
and State University

buildings of Rockefeller Center, air conditioning was added in the late 1950s, generally small discrete units every other floor. There was no centralized control on this equipment. A couple of years ago we did a study of the costs of centralizing that equipment, and came up with a four-year payback—which was not quite attractive enough. . . ."

"A year later, the local utility introduced a steam demand charge—a new operating constraint that would increase our costs unless we balanced peak usage. Our auditors took this information, studied the escalation clauses in the leases, looked at the anticipated increase in utility rates, the cost of borrowing money, and established various scenarios. One extreme was to pass all anticipated savings on to the tenant and establish the base lease rate as low as we could; the other extreme was to do nothing. The big factor is being competitive—right now there is a lot of empty space in other buildings in the area. We decided to go ahead, and the savings in energy costs that we pass on to the tenant is approaching one dollar per square foot per year, against a typical lease cost of 10, 12, 13 dollars per square foot."

Consultant Wilbur argued: "There are two points which are essential to define cost-effective energy conservation. The first is that conservation is not binary—a choice of this or that. There is an infinite variety of investment opportunities you can make—with the classical law of diminishing returns setting in very quickly.

"The second point is that there is a normal distribution of responses to investment opportunity (or the cost of energy conservation), ranging from the dedicated conservationist to his Arab cousin. The public agency with six per cent bond money sees it differently from the speculative builder.

"When you realize the two curves, then you can begin to develop strategies which will save the most energy. . . ."

Changing utility rate structures may soon prove a very effective incentive for conservation

Utilities and public service commissions are presently examining new types of rate structures that will encourage customers to use existing generating capacity, and that still to come more efficiently. Adding new capacity to meet peak loads is counterproductive because it costs so much more to build these days. Furthermore, there are problems simply of getting new capacity built because of environmental requirements, trouble acquiring sites, and lead time. Added to higher and higher fuel costs, all this means of course higher rates—a process well underway across the county. But within this framework, the utilities are examining their rate structures—especially in terms of penalizing users which increase their peak load. There is no consensus on the best ways to manage load, but Round Table panelist Alfred Calsetta of Long Island Lighting Company offered some thinking on the subject: "It is coming to be a kind of pay-as-you-go world in terms of rates. There is certainly a sense that we need to develop time-of-use rates. I think many utilities have tried seasonal rates, but we are now being asked to cut the time line finer and develop rates by hours. Most utilities are involved now in some form of voluntary time-of-use rates—still experimental, but everyone knows that something like that is going to exist soon."

Mr. Calsetta summed up: "The utilities are moving out on two fronts. One is demand management, the load management concept. There is also the energy management front—providing service under a rate structure which will encourage the development of storage, of solar systems, of interruptable rates that say 'you can use power, but use it some other time.' "

Question: Shouldn't we be worrying about what to do when the energy runs out?

A Round Table auditor (name alas not recorded) asked this telling question: "Our motivation at this meeting has been cost-effective strategies to save energy. But we haven't addressed the problem of what happens when energy runs out. Why aren't we trying to save twice as much energy right now in order to help delay that date. . . ."

Architect Anderson responded: "In talking to the joint budget committee in Colorado about funding our solar-energy project (see page 113 of this issue), we found it ten times more effective to talk about finite resources and the fact that conventional energy could run out within the life of the building as it was to talk about pay-back.

"The problem is right now. There is no substitute for natural gas. Right now, we don't have enough natural gas to produce ammonium-based fertilizers, and our productivity of food could go down this summer. We have got to stop using it as fuel. Whether or not we can make conservation pay off is not as important as the fact that our fuels are going to run out. We have a moral responsibility to get on with exploring alternatives. . . ."

Architect Rittleman summed up; "Back in 1927, Will Rogers said: 'We Americans think we are pretty good! We want to build a house, we cut down some trees. We want to build a fire, we dig a little coal. But when we run out of all these things, then we will find out just how good we really are . . .' "

What are the priorities in saving energy? Here are the Round Table's thoughts . . .

Early in the discussion of priorities, Dick Wright of NBS made a broad point about the impact of energy considerations on design: "Any architecture student would agree, I think, that the most difficult design problems are those where there are no constraints: the flat site, the unlimited budget, the miracle material with ultimate tensile strength. In contrast, the most difficult site often produces the most exciting solution.

"Energy conservation will become such a useful constraint. Even though, right now, we are having to spend a bit more time and effort, a sense of order and priority is being established—criteria that the architect can work with from the start, that exclude a lot of erroneous options, and that may reduce design costs along with energy costs. . . ."

. . . on siting

John Anderson: "One good thing that could come out of the concern for energy conservation is getting the architect more involved in site selection. We've been handed some real duds in terms of energy—our problem in Denver is that we like to look at the mountains; but the weather comes out of the mountains.

"Architects can help decide whether the site is a good one for a particular kind of building. We can see possibilities of digging a building into the ground to save energy; or

Earl R. Flansburgh, FAIA
Earl R. Flansburgh and Associates, Inc.
architects

Stanley F. Gilman, P.E.
professor,
College of Engineering
Department of Architectural Engineering
The Pennsylvania State University

John W. Honeycomb
director of energy programs
IBM Real Estate and
Construction Division

J. Karl Justin, AIA,
partner
O'Brien & Justin
architects

James D. Kaloudis
lighting consultant
Meyer, Strong & Jones
consulting mechanical and elec
engineers

concentrating the openings on the side less susceptible to weather. We can pump back into the design equation things we have known but ignored for years. We are finally doing things we learned how to do in school—and I think we are going to see some real excitement, some real innovation in how buildings relate to their site. Clients are responsive; in fact they are anxious."

Travis Price: "You can take a site and camp out on it and try to figure out how to survive on nothing. Where is the wind coming from, the light, what are the advantages micro-climatically? Your design ideas come from there; and your costs go down because you are designing with those elements in mind."

Architect Karl Justin: "As John Anderson said, we are talking about things that we used to talk about and that got lost along the way when we found there was no design error that technology could not correct."

. . . on building envelope

Engineer Jack Beech: "We can always advise the architect on the best energy-saving envelope—which would probably be a fallout shelter. But our best role will be to advise the architect on the impact, the trade-offs, of his design options."

NBS economist Rosalie Ruegg: "We're learning more, through research, about the use of windows. Our research shows that by orienting windows properly and covering them at night, by taking into account useful daylighting, and by using shading devices, we can demonstrate energy savings compared with having no windows."

On daylighting, architect Ben Evans: "As has been said earlier, we're simply going back to where we were 25 years ago, when we designed for natural ventilation and daylighting and didn't use any energy all day. That approach would not be appropriate in a tall building in the middle of a big city, but we can make best use of what we have. There's no doubt that skylights in a one-story building save energy and costs on a life-cycle basis. As Ms. Ruegg has pointed out, so do properly handled windows. One of the problems is that most architects really don't know much about the daylight that is out there available to use, so we all use conservative figures. There are some exceedingly sophisticated techniques for calculating the amount of daylight that one might use in building design. But we need much more research, and it needs to be better disseminated."

John Honeycomb of IBM: "In Europe, architects make much more effective use of daylighting. Our buildings there are narrower—so that more people have a window; and they open those windows so our air conditioning requirements are less. This does give us more perimeter, and I don't know what the energy trade-off is—but it's something to consider. . . . Another point: we've gone back and installed individual switching in our perimeter offices. We find the savings are far more than we thought they would be because people like to work in natural daylight, and they *use* those switches."

Engineer Norman Kurtz: "Doors and windows are a serious retrofit problem in existing buildings—like a college campus with 4000 beds in dormitories that date back to 1900 with only one thermostat. Finding some efficient way to seal up windows is a real challenge. . . ."

Added architect Meyer: "We recently analyzed a 12-story co-op building in Manhattan, and found that heat loss through windows and cracks accounted for more than half of the operating cost. And this is a structurally sound building, built in the 1930s, typical of hundreds of buildings in every city!"

. . . on lighting

What are the most promising trends in energy efficient lighting? Lighting consultant Sy Shemitz: "Task lighting. I'm not talking just about task ambient lighting as part of furniture for office environments—which has proved to be highly efficient and popular. The broader concept of putting an appropriate quantity of light in the place where you are doing the work is equally valid in industry, hospitals, schools . . . any place that you can think of. Task lighting is also the most appropriate way to get a successful architectural environment. . . . When the energy crunch came, I went back and looked at jobs we'd done earlier, and found we'd long been putting high light levels where we needed them and letting the rest of the space go to a relatively low ambient level. Some years ago, we did a junior high school using 2.1 watts per square foot and a lot of our strip shopping malls came in at 1.2 watts."

Lighting consultant Jim Kaloudis sounded some concerns: "Task lighting within the space as opposed to in the ceiling does require some trade-offs—of energy vs. the quality of the environment or the human performance. Do people really like the lighting environment? There are lots of other techniques available to save energy: new driving mechanisms for fluorescent light that can make them 20 per cent more efficient; new luminaires that create better quality light—not higher intensity, but better quality. . . .

"Further, as suggested earlier, we haven't done nearly enough in using daylight. Lighting is lighting, whether it is daylight or artificial light. The question is not how light is produced—it is how it is controlled and modulated and used in space. Any lighting consultant worth his salt can use and control both."

Kaloudis also brought up some practical questions with furniture-mounted task lighting: "One deals with the National Electric Code: You can't use many of the high-efficiency sources below eight feet; and if you want the flexibility of easy plug-in changes, you are compelled to go to a 120-volt system. Further, if you put the light source within the room as opposed to having it in the ceiling, our figures show that you need something like 30 per cent more fan horsepower because of the amount of air—not refrigeration, but air—needed to create the same comfort conditions.

John Honeycomb agreed with this approach: "Getting down to two watts can be done in many different ways—but I think more work should be done on rearrangable ceiling systems, as well as the furniture-mounted task lighting. . . ."

Engineer Bob Tamblyn commented on the innovative lighting system in Toronto's Federal Office Building (detailed on page 62): "We simply hung a grid of sheet metal fitted with electric raceways. The grid provides a strong design esthetic, yet we can create light wherever and in whatever quantity we want simply by "plugging in" lights or a cluster of lights wherever it is needed. In practice, the level has dropped from something like four watts to two and a half watts per square foot; and we can continue to operate at 347 volts. . . ."

Sy Shemitz: "If you provide enough plugs and circuit breakers and copper to handle any reasonable amount of load, you can solve the problem, whatever it turns out to be, three years from now or twenty years from now. . . . We can provide systems which are

hn L. Kmetzo, P.E.
E. Linden Associates
ormerly director of
ystems engineering
eller Center Corporation)

Norman D. Kurtz,
partner
Flack & Kurtz
consulting engineers

Charles C. Law, Jr.
Deputy Assistant Commissioner for
Construction Management
PBS/General Services Administration

William T. Meyer, AIA
director of energy conservation
The Ehrenkrantz Group
architects and planners

Travis L. Price, III
president
Sun Harvester Corp.

flexible—wherever the lighting may be . . ."

Auditor George Clark of Sylvania added an important perspective: "It is regrettable that so much of the emphasis in the lighting area concentrates on prescriptive end-use constraints or on power rather than energy. The former emphasizes the reduction in what many consider benefits of lighting, while doing nothing about what nearly everyone will agree is waste in usage. Watts per square foot provides an opportunity to consider the efficiency of the lighting system—but is not a measure of energy or use of the system. If we have building standards expressed in Btu/sq ft/yr (or, as I suggested last year, Btu/person/yr); why not lighting standards in terms of kilowatt-hours/sq ft/yr (or kilowatt hours/person/yr)? This would provide the greatest opportunity for flexibility in both design and usage trade-offs while still establishing a constraint in energy terms—in performance. . . ."

. . . on hvac

Progress in this area, the participants agreed, is being made by a combination of techniques. Said engineer Jack Beech: "There are certain systems which are now *non grata*. You don't use reheat systems or constant volume systems. You reclaim heat where you can, you store heat where you can, you tend to use heat for forced loading of chillers to obtain key efficiency. In the last two years, we have been able to apply all the techniques we have known for many years—but couldn't get into the job because they cost a few extra bucks. With oil at seven cents a gallon and electric power at one and a half cents a kilowatt, no one paid much attention to heat-pump systems—today they do.

"We're refining our ventilation rates.

"We are finally rigorously applying all the techniques that have been in the ASHRAE guidebooks for as long as I can remember."

Engineer Kurtz: "We're simply taking a different approach to design. For years, we designed the mechanical system to meet the peak conditions—and you put in enough equipment to meet that peak. Today, we can design primarily for the in-between conditions and secondarily to meet the peaks, and you come up with a much more energy-efficient system. Variable volume systems are like motherhood. So is variable speed pumping, and incremental boilers."

Canadian engineer Bob Tamblyn argued for the effectiveness of thermal storage (which he has used in a building described on page 65 of this issue): "If you are going to do solar heating for an office building and find you have a ten-year payout—and then look at the system carefully—you will find that the storage part of the system pays out in two years. So, when it comes to commercial building which have a lot of their own internal heat, the concept of storage makes sense with or without the collector, but probably makes the best economic sense without it."

Stanley Gilman, a long-time manufacturing executive now at Penn State said: "There is no question at all that the manufacturers are responding to energy conservation demands—for example, 90-75's requirement for a COP of two today and 2.2 by 1980."

Gilman also raised the question of ventilation: "It seems to me we are wasting a lot of energy bringing in outside air." Engineer Beech answered: "The ventilation requirements have been arbitrary and randomly chosen; and now everyone is looking carefully at those standards. A lot of people are just shutting it off, and probably very few have noticed any qualitative difference." Engineer Tamblyn: "The lavatory exhaust requirement averages between 10 and 15 cfm per person—and you leak that much through the skin." NBS's Wright added: "We recently reported on an experiment in a New York City school where the air-change rate was cut from four per hour to one. The difference was not noticeable to the teachers and students. It seems as if there is a good deal of opportunity to examine the standards here in the interests of energy conservation."

On the question of comfort standards, John Kmetzo of Rockefeller Center said: "There is a big rise in complaints if you let the summer temperature get beyond 76 degrees to 77 or 78. On the winter side, 70 degrees is acceptable. Below 70 you start getting a lot of complaints."

Said Chris Law of NBS: "The number of complaints in Federal office buildings relates to three things: temperature, humidity, and distance from Washington. One of the things that has let us operate at higher temperatures in the summer and lower temperatures in the winter is a change in the dress code—no ties required, summer dresses allowed, sweaters encouraged in the winter. Our summer temperatures ran at 78-80 . . . the winter, 65."

. . . on solar

At the Round Table, architect John Anderson described his 300,000-square-foot community college in Colorado with its 35,000-square-foot solar collector and 200,000-gallon thermal storage tank; essentially a solar-assisted heat pump application; Travis Price, his experiments in New York City housing rehabilitation using solar heating and windmill generation of power installed on a self-help basis; Stanley Gilman, a careful study of the performance of the Bridgers & Paxton office building in Alberquerque; Bill Meyers, his work with solar heating applications in fifty housing units for the Defense Department. Since this work does not lend itself to purely text description it is not further reported here, though some good insights on solar application will be found in the article beginning on page 108 of this issue.

But the Round Table did go on to examine the strategies for introducing solar energy technology into design:

Said Elliot Wilbur: "My passion is to make solar work; and I think there is a very clear strategy to make it work. I think the industry should start with domestic hot-water. Solar is totally competitive in domestic hot-water systems when you are competing with electricity. That can logically lead to the follow-up development of incremental space heating. We do not think that solar energy can make it in cooling for quite a while."

Rosalie Ruegg agreed that "Solar energy is likely to be cost-effective first in residential applications, and probably hot-water heating in non-residential applications where large amounts of hot water are needed—such as schools and hospitals. But Ms. Ruegg pointed out: "One of the problems with commercial application of solar is current tax treatment. The fact that fuel costs are deductible as business expense really disadvantages the economics of solar. A tax credit for solar installations could of course help offset this.

Notwithstanding this conservative advice, John Anderson did offer some attractive numbers for his huge solar installation (again, see page 113): "A life-cycle cost budget indicates that with the expenditure of about 8½ per cent more in first costs, the State could expect to get a return on the investment in about 10½ years. This was based on very conservative projections on the increase in the cost of natural gas, which is the fuel we use. The

P. Richard Rittleman, AIA
Burt, Hill & Associates
architects

Rosalie T. Ruegg
Economist,
Building Economics Section
Center for Building Technology,
U.S. National Bureau of Standards

Lawrence G. Spielvogel
Lawrence G. Spielvogel, Inc.
consulting engineers

Sylvan R. Shemitz
Sylvan R. Shemitz and
Associates, Inc.
lighting design,
electrical engineering

Robert T. Tamblyn
president
Engineering Interface
Limited

D. Elliott Wilb
senior staff co
Arthur D. Littl

legislature also reacted—not running scared, just reflecting real concern—to the fact that we are dealing with finite resources; that we may someday not have natural gas to burn. So it is not just a matter of cost-effectiveness; it is a matter of getting on with conserving resources. We are naive enough to have gotten on with it. . . ."

In a summary round robin, the Round Table panelists put priorities—at least for their own discipline—on the techniques for getting on with energy conservation

Engineer Larry Spielvogel re-emphasized his belief that—above everything else—careful operation of buildings is the single most effective way to conserve energy; and that the "single most effective tool for energy conservation is the screwdriver—in the hands of an intelligent man." Said Spielvogel: "I think that every designer ought to take a sabbatical every few years and go out and operate some buildings to see where the action is."

"The second most cost-effective technique, with pay-backs measured in terms of months, is improved controls. You cannot operate an energy-efficient building unless the designer incorporates the means of control—especially the switches to let you turn off what you don't need when you don't need it, and the metering that lets you know how much energy is going for what purpose in your buildings.

"From those simple, fast-pay-off beginnings, you take the next step of modifying what you have for greater efficiency, and finally move to major replacements of the various systems and equipment in the building."

Elliot Wilbur of Arthur D. Little: "My wife stopped using the electric toothbrush, but still leaves the door open for ten minutes to say goodbye to guests. We have to put our effort where the action is. The goal is not the energy efficiency of various components, but aggregate energy efficiency. . . ."

Several panelists, in their "final word," spoke of the incentives:

Economist Rosalie Ruegg, of the National Bureau of Standards: "We need incentives that can be implemented quickly; because incentives not implemented quickly become disincentives. We need to be sure of the impact of economic incentives so that we are sure we choose the right ones. And I hope we might pay less attention to 'pay-back' and consider other measures that take a longer view. . . .There is a great deal of public interest in energy conservation—people *can* be persuaded that we must conserve energy."

Architect Karl Justin: "The highest priority problem is getting action. Any consulting engineer, sight unseen, will tell you he can save 20 per cent in energy costs in a building; and if he gets right down to it you hear about 30 per cent and 40 per cent. So the question is simply: Why would you not want to save energy? Why would you not want to save money?"

Architect Dick Rittleman suggested a kind of "zero-based" energy-usage budget for buildings: "One technique is to start with a conventional design, and start taking away load. The other way to look at it is to build from zero—you don't put in anything that is not needed for the specific job. That gets us to a very basic architectural function: programming. The most effective technique is very early involvement of the client with the architect and engineer—you ask the client, before a line is ever put on paper, what the physiological requirements are for the tasks to be performed, and discuss the energy use vs. energy ramifications. At least you get an idea of what the client's priorities are; and you educate him as to the problems and trade-offs. Frankly, the decisions aren't (and probably don't need to be) made on hard economics—hard cost-effectiveness or hard pay-back times. A lot of softer economic considerations are going into decision-making."

Travis Price: "My goal is to never go to bed at night without utilizing fully every energy conservation technique and being totally dependent upon renewable resources. Two strategies could make this work: 1) If the techniques we talked about—like grid lighting or solar systems—could be put into package form, more architects would use them. 2) Then we would have to make that technology fit the goals of the lender, or push for a financing mechanism that lets us use that technology when it does make economic sense."

Architect Bill Meyer suggested competition on a life-cycle-cost basis: "Based on the assumption that competition will help to increase innovation and reduce costs, energy consumed by buildings from depletable sources might be reduced if usable and enforceable policies and/or incentives were developed whereby private-sector owners (as well as the GSA) would make bid awards for either new construction or renovation on the basis of the present value of both installation and operating costs."

Chris Law of the Public Building Service spoke of the effectiveness of "enforceable policies:" "We think we do have new Federal buildings under some kind of control, and we think our goal of 55,000 Btu/sq ft/yr needs some adjusting downward. But the point has been made that 80 per cent of the buildings that we will have in the year 2000 are here right now; so retrofit is now our No. 1 priority. Without any major systems changes—doing the easiest, quicker-payoff things first—we've been able to make reductions of 30 per cent. The next 20 per cent will come harder. . . ."

John Honeycomb of IBM made four short but telling points: "We need to factor into the cost equation the matter of energy availability. Not many of us want to handle coal because of the materials handling problem, but if oil and gas end up being heavily taxed, that may change the rules. If the only way you can heat an operation is with solar, you might consider a solar heating system.

"Point two. I don't think that enough architects are truly using the tools available to them—the computer simulations—early enough in the design process. I think that too often they make up their minds what they are going to do, and then verify what they think is right—and don't make the trade-offs soon enough.

"Point three. I cannot endorse more emphatically what has been said earlier about careful operation of a building. That is the single biggest opportunity for energy saving—and cost savings.

"Finally, I think we need to stop talking about energy budgets for buildings; we need to have them. We need a true performance standard to challenge architects and engineers to get on with designing more energy-efficient buildings. . . ."

Ben Evans, daylighting expert: "We need hard cost-benefit analyses to give us a handle on which alternatives make the most sense. Certainly, from the standpoint of energy, we can see very quickly that by designing for the summer (with small areas of glass and skylights) we throw away a lot of potential 'winter heat' which is worth real money to us.

N. Wright
rector,
for Building
hnology
NBS

"And if we designed buildings properly to take advantage of daylight and natural ventilation, we would not only save a lot of energy, but we would be forced into thinking more clearly about what it is in the environment that satisfies people. . . ."

Stan Gilman: "I am appalled by the philosophy of 'you tell us what the energy budget is and we will meet it.' Who is 'you?' The architectural community should be providing leadership, not following—and the mechanical engineering community is far from blameless. Any architect or engineer knows that an envelope with a U factor of 1.13 is going to waste energy; or that we should not use new energy for reheat purposes; or that double-duct and multi-zone systems waste energy.

"We simply do not have the *right* any more to waste the energy we have left—just as we do not have the right to continue to pollute our air and water. The time has come to stop bickering and get down to the business of exercising our professional responsibilities to design buildings and systems that will keep the lights on for our descendants as long as possible."

Architect Earl Flansburgh emphasized the long-run point of view: "We really need a national policy on energy research. We ought to fund it, and we ought to find a way to disseminate the information we get from it—because all of the things we have talked about today simply stretch out the time before the inevitable problem comes upon us. . . .

"This is not the first time our society has faced an energy crisis. You may remember that England switched from wood to coal not because of foresight on anyone's part; they switched because they ran out of trees.

"We can do things on the scale necessary. In the 1880s Edison was experimenting with little filaments, and by 1910 a giant infrastructure was in place. In the 1930s we were barely producing enough food for the country, and today we are producing twice as much food on much less land. That was the result of research—applied. It dealt with science, with banking and economics, with manpower and psychology.

"We have to deal with this problem—because if we have this kind of meeting five years from now and are talking about the same things we are talking about at this Round Table, it will mean the amount of time that we have left is very short indeed!"

These building-industry manufacturers and others audited the Round Table:

Joseph Anderle
Levolor Lorentzen, Inc.

Paul A. Anderson
Copper Development Assn., Inc.

Joseph R. Anghinetti
Wasco Products, Inc.

Lloyd E. Bastian
Libbey-Owens-Ford Company

Walter J. Bienko
Joy Manufacturing Company

James W. Biglow
Simplex Time Recorder Company

Jeremiah Blitzer
Lightolier, Inc.

Jerry Blomberg
Blomberg Window Systems

Richard G. Bohaker, Jr.
American Buildings Company

John K. Bowersox
Producers' Council, Inc.

Muriel Burns
Preco Industries, Ltd.

Jay Capaul
Acoustiflex Corp.

Nick Carter
Ludlow Corp.

Mario J. Catani
Portland Cement Assn.

George W. Clark
GTE Sylvania, Inc.

Robert Connolly
CertainTeed Products

Paul Kenton Corrad
Libbey-Owens-Ford Company

Donald Durdan
Mobay Chemical Corp.

Nick M. Dye
Owens-Corning Fiberglas Corp.

George W. Eldridge
American Heliothermal Corp.

Andrew J. Fagereng
Simplex Time Recorder Company

Philip L. Frank
Westinghouse Electric Corp.

Burton P. Gendron
ARCO/Polymers, Inc.

Alan B. Goldberg
Thiokol Corp.

Arthur Sworn Goldman
Arthur Sworn Goldman & Assoc.

Steven C. Haarmann
Kawneer Company, Inc.

Donald C. Hegnes
PPG Industries, Inc.

Richard S. Heilman
H. H. Robertson Company

Frank W. Hetman
DeVAC, Inc.

M. E. Hiltman
The Stolle Corp.

Werner F. Itzel
Jamison Door Company

Woody A. Jensen
CertainTeed Corp.

John Jones
Cem-Fill Corp.

John J. Kemendo
Naturalite, Inc.

Robert W. Leeds
Zero Weather Stripping Company

John E. Longenderfer
Lutron Electronics Company, Inc.

Asit Majumdar
Pioneer Industries

Stanley L. Matthews
Rockwool Industries, Inc.

David S. Miller
David S. Miller & Assocs.

Robert Mohr
Steelcase

Alan Moore
Simplex Time Recorder Company

Paul B. Nelson
ARCO/Polymers, Inc.

Jack D. Ogren
Rohm & Haas Company

Carl Olm
Pittsburgh Corning Corp.

Thomas C. Orr
GEO Energy Ltd.

Robert J. Rader
Ford Glass Division
Ford Motor Company

Travis Randolph
Herman Miller, Inc.

Philip W. Rich
3M Company

William M. Rogers
General Electric Company

Robert P. Ross
Westinghouse Electric Corp.

Fred M. Sanders
U. S. Steel Corp.

Richard H. Schliem
E. I. DuPont

William T. Shepard
The Wiremold Company

Dr. Norman Sidley
Consultant
Honeywell, Inc.

R. J. Slonina
Monsanto, Inc.

George F. Smith
Aluminum Company of America

Lewis Tagliaferre
National Electrical Contractors Assn.

Walter W. Treichler
Carrier Corp.

Vincent M. Waropay
United States Gypsum Company

Jerry B. Werner
Koppers Company, Inc.

Ken Whittington
Robertshaw Controls

Armen D. Yazujian
Thiokol Corp.

Computer graphics for architecture: techniques in search of problems

A visitor to Professor Donald P. Greenberg's computer graphics laboratory at Cornell University walks into a room in Rand Hall (where the architecture department is located) that is nondescript, save for its banks of computer equipment, regular and color TV monitors, and some unrecognizable hardware. But then, the lights go off, and the magic show begins!

From a simple plan, walls and columns grow in isometric, hidden lines are erased—behold, a three-dimensional drawing.

Building blocks are retrieved from the computer memory, joined and set on a contoured site—behold, a massing study for an apartment project.

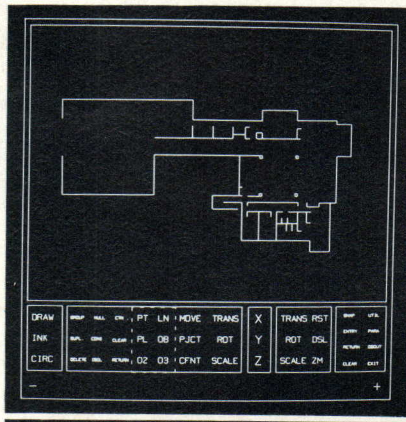
Freeform contours are traced by hand on an electronic tablet, next several circular contours, then the drawing is put into perspective—behold, a television tower on top of a mountain that the viewer can "walk around," or even "zoom in" on.

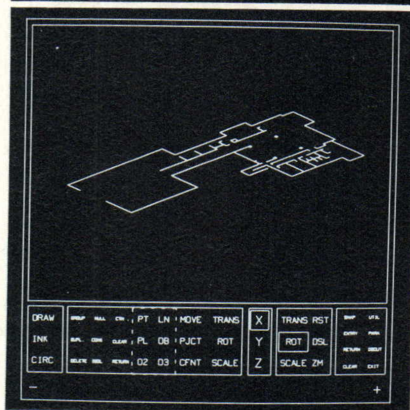
A colored picture of a house comes on a screen, the operator asks the computer for the sun to come out—behold, the house casts shadows on the ground, and an adjacent barn casts shadows on the house.

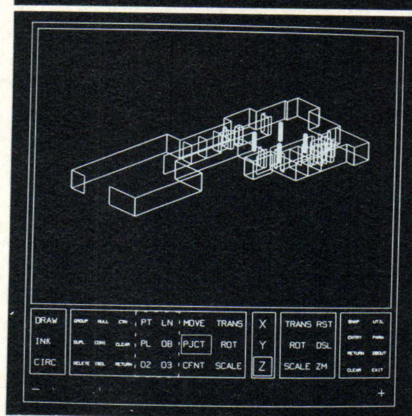
Another colored picture of a house with a plain background comes on the screen, the operator flicks a switch—behold, the house nestles in a scene of the viewer's choice.

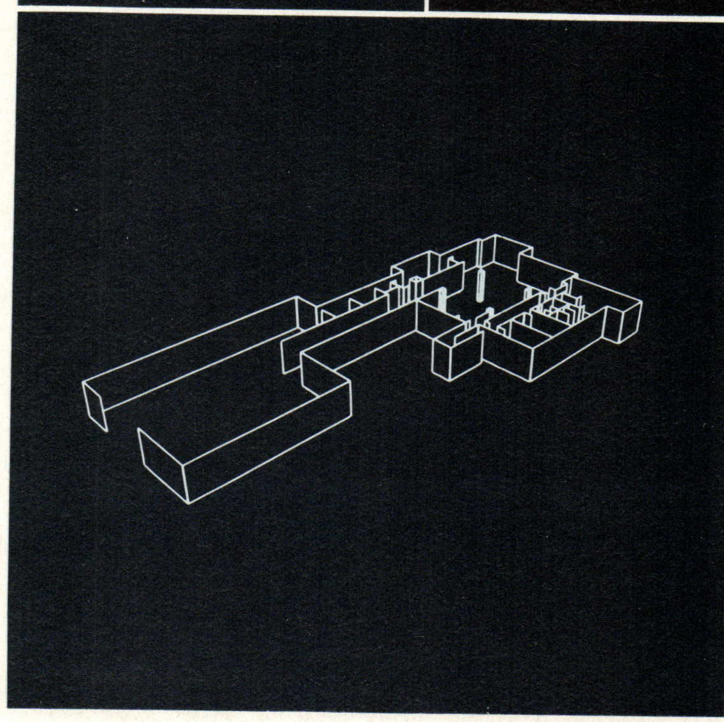
A plan of a dome structure appears on the screen, the operator tells the computer what the loads are—behold, the articulated members acquire colors: red for fully stressed, white for understressed, and blue for overstressed, with gradations in between—and all quantified. The operator adds unsymmetrical snow load, and the colors shift.

A plan drawn on an electronic tablet "grows" into an isometric picture



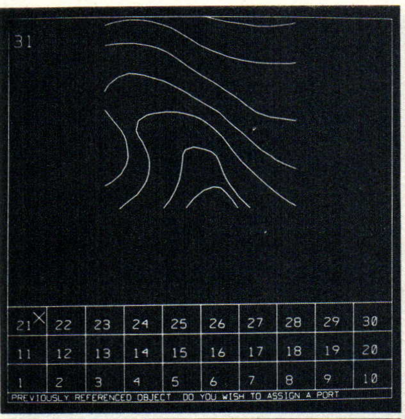


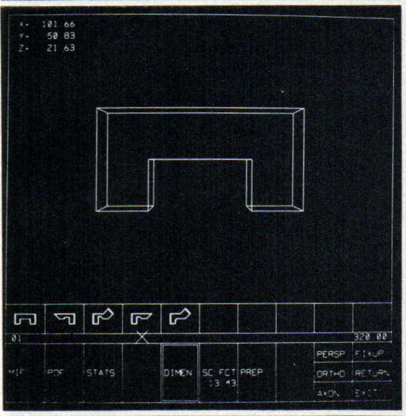


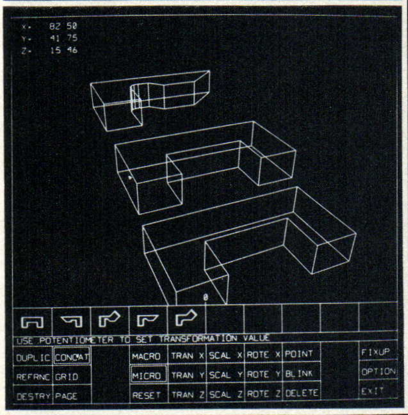


These steps illustrate how the computer can create a perspective with a program called EXTRUDE. A floor plan was traced onto the computer using a digitizing tablet and stylus, with the drawing being displayed on a cathode ray tube. The digitizing tablet is a drawing surface embedded with a grid of wires that can detect the position of the pen at any time. Drawing information into the computer thus is similar to methods normally used. In this case, except for columns, lines have been constrained to be parallel/perpendicular and straightened using a technique called "rubber banding." This is a process in which a line is defined by its two end points. After the first point has been positioned, the computer continually redraws the line to the current position of the pen. As the pen position is moved, the continuous display creates the illusion of a line being stretched. By means of graphic commands, the user can rotate the plan to any desired isometric view. Walls can then be "extruded" to any desired height. To avoid confusion, hidden lines not seen by the observer can be automatically removed. (Program by Harvey Allison)

"Primitive" shapes selected from computer memory are multiplied, joined, rearranged and . . .

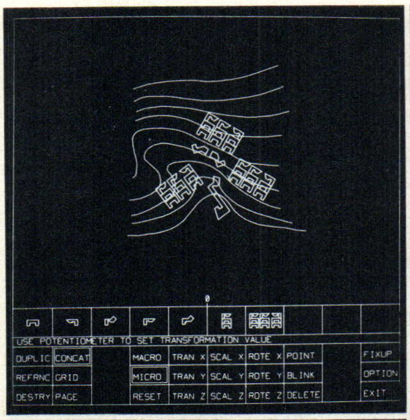


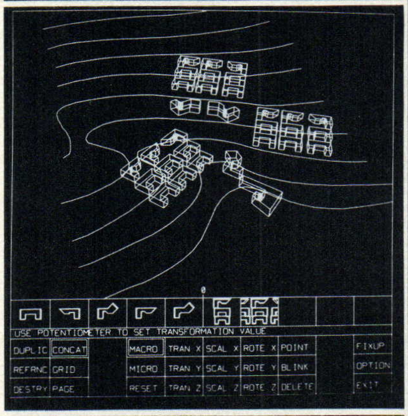


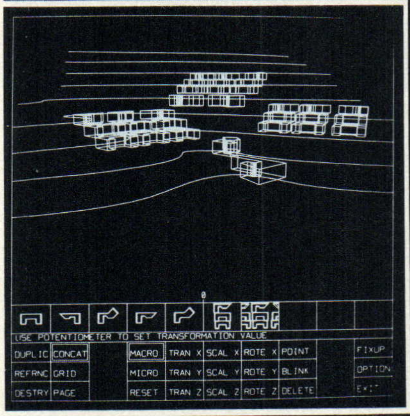


The computer can store many different elements—cubes, prisms, whatever—which the architect can interactively manipulate to create larger and more complex volumes. These elements, called "primitive volumes," can be scaled or distorted, used repetitively, and positioned anywhere. This scenario shows how the architect can use the process to create a housing development on a hillside. The site contours first are drawn and stored in the computer. Then a predefined module is retrieved from storage and displayed on screen. This element is duplicated and a second module is also retrieved. The three volumes are "joined" and duplicated three times to form a nine-unit configuration, though only two original modules needed to be defined.

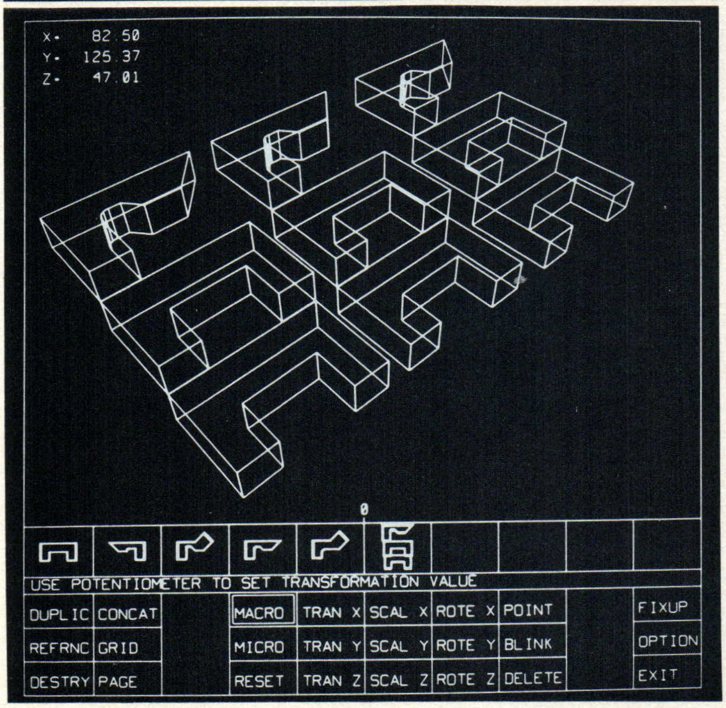
. . . set on a hillside site

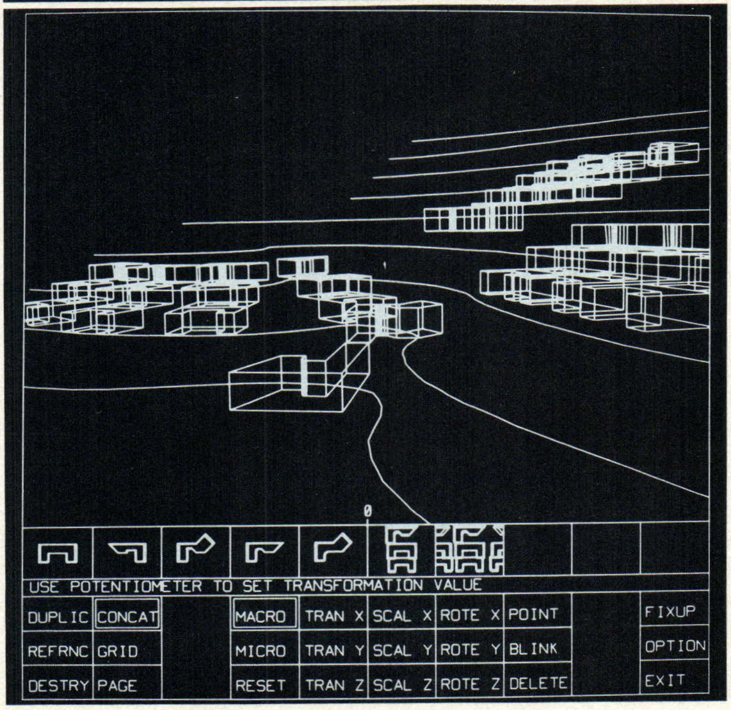




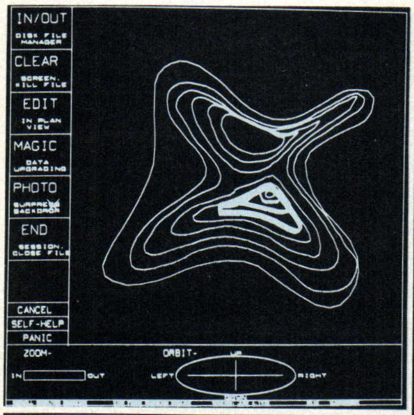


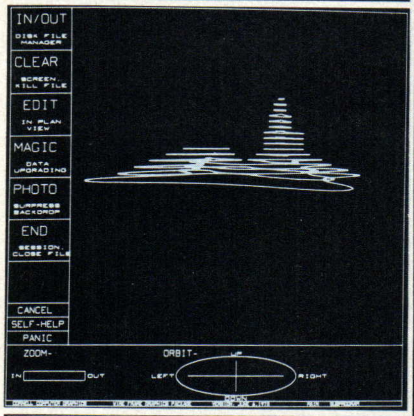
Each set of nine can then be placed on the site, and more units added in plan. The composite image can be viewed from any vantage point. The method is particularly useful for design and massing studies, and also for engineering studies such as excavations, cut and fill or quantity surveys. (Program PRIMITIVES by Nick Weingarten)

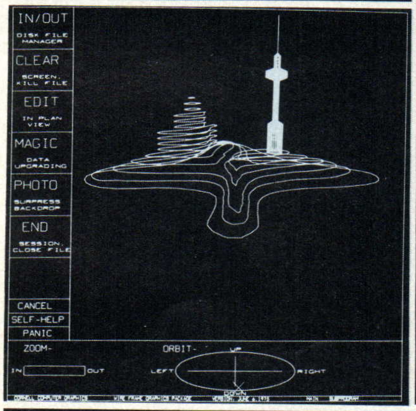




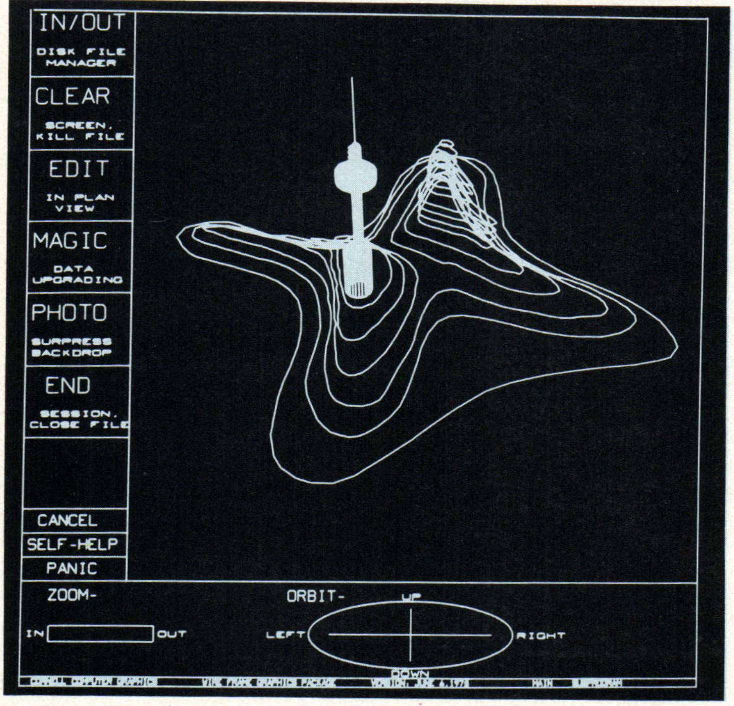
Contours, drawn by a process called "inking," form a television tower on a mountain



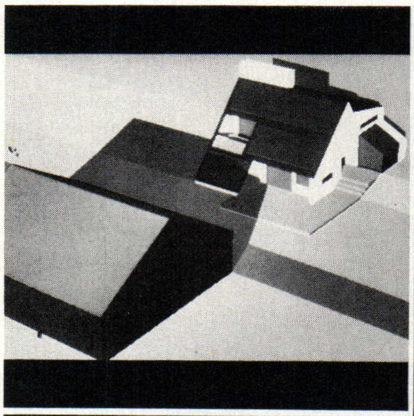


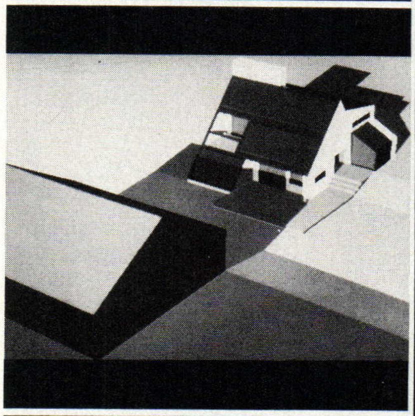


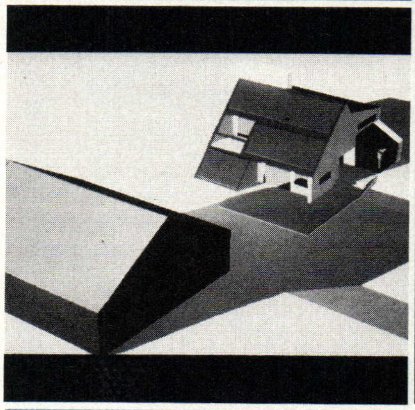
Freeform contours at any specified elevation can be traced into the computer using a process called "inking." As the stylus is moved, a trail is left in a manner similar to using a conventional pen. The program, which stores information in contour-map form, is useful for drawing freeform objects and for topography. The perspective image can be dynamically rotated and translated, creating the illusion of moving around a three-dimensional environment. To create the display of a surface, the contours can be automatically "webbed." This display of a television tower on a mountain was described in less than a minute. The tower was created by repeating the same circular contours at many elevations. (Program WIRE by Marc Levoy)



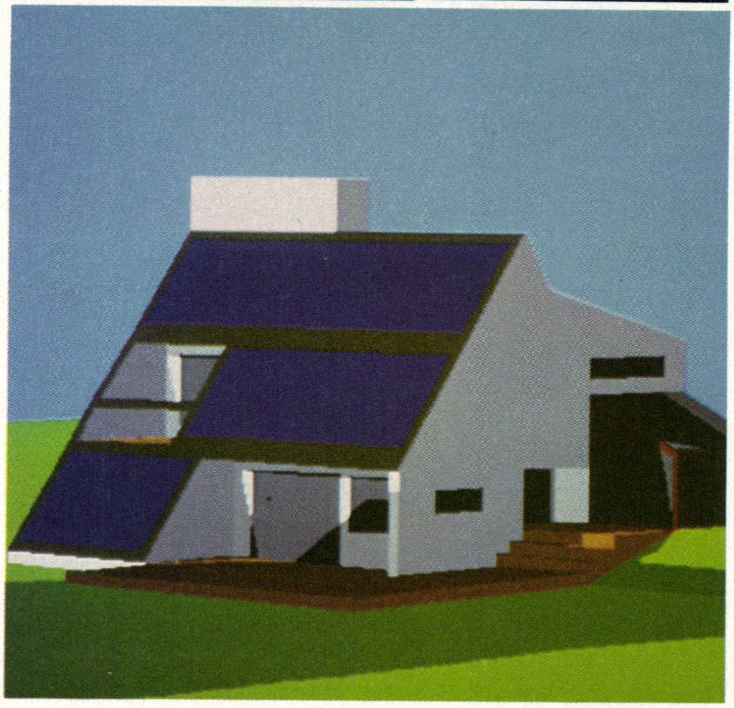
Once the geography is specified, the computer can cast shadows from the sun







Not only can perspectives be created, but they also can be any color the architect wants. These pictures depict a solar house and barn from two different perspectives. Shadows can be generated automatically if the solar position is known. An orthographic view of the environment is first computed from the sun's position to determine shadow locations. The shadows can then be rendered subsequently on any perspective image. These pictures show shadows at different times of day. The shadow information also can be used to study shading devices and to predict energy usage. (Program by Kevin Weiler and Pete Atherton)



A flat mesh with an oddly shaped contour appears on a black-and-white tube, the operator tells the computer to "inflate" it a bit, then more and more—behold, a pneumatic structure.

A perspective of a typical house appears on a black-and-white screen. An operator removes it and calls for a display of wall sections, doors and windows from the computer's memory. Then, with the house back on the screen, the operator points to the location of windows and doors and indicates what construction will be used for the walls. Now all he has to do is specify occupancy factors and the geographical location, and the computer comes up with the annual energy consumption. And, wonder upon wonder, once the shadow routine is initiated, the computer will predict the solar load.

As magical as these techniques might seem initially, they are illusory only in the mind-stretching first impressions they make. They are firmly based mathematically. For any of the operations to be performed, the geometries of objects have to be defined numerically for the computer.

From a practical standpoint, these techniques are within reach of the architectural and engineering professions. Every 4½ yrs, the cost of computer equipment is cut in half, and its power increases 10 times, according to Greenberg. The cost is dropping so rapidly, he says, that these techniques should be available, at least to a limited extent, within the next five years.

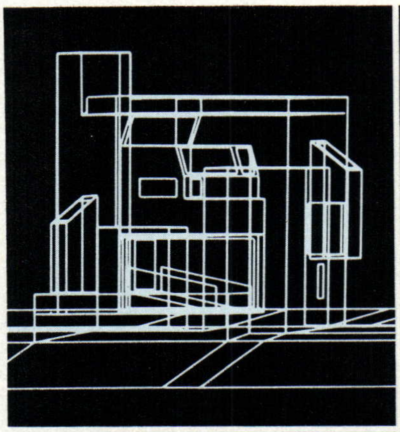
Why and how did Greenberg, an engineer, and professor of architecture at Cornell, get into computer graphics? First of all, he was frustrated by the difficulties he has had trying to explain a building by "having to draw many different sections of the same detail." Also, he saw students and consultants spend days trying to interpret numerical computer printouts, when a picture of the results would be much easier to understand.

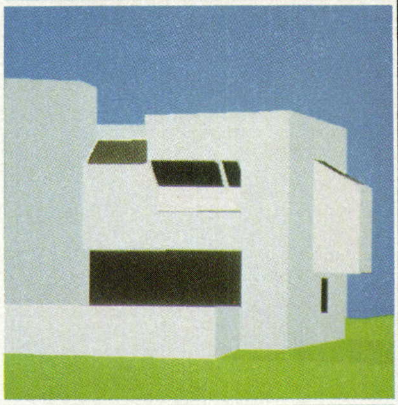
Greenberg's laboratory has been in operation for about 30 months. In 1974 he received a $500,000 grant from the National Science Foundation for research on graphic input techniques and graphic display techniques. The grant paid for ⅓ of his equipment and for a small staff for 3½ years.

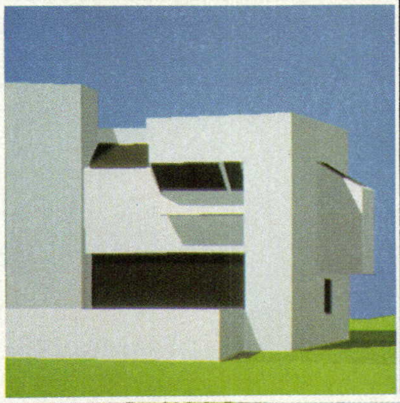
The problem requiring the most attention in computer graphics, Greenberg says, is input techniques. This observation is based upon his experience as a structural engineer doing conventional computer structural analysis. About 80 or 90 per cent of the cost of doing such analysis, he found, was in the preparation of input. If graphics were used, he reasoned, drawing in the information would be the fastest, simplest, most understandable way to truncate the process. For example, he says, if one misplaces a decimal point in feeding information to the computer numerically, the error is not caught until the results are printed. With graphic display, on the other hand, one can't miss the fact that a point is out of line.

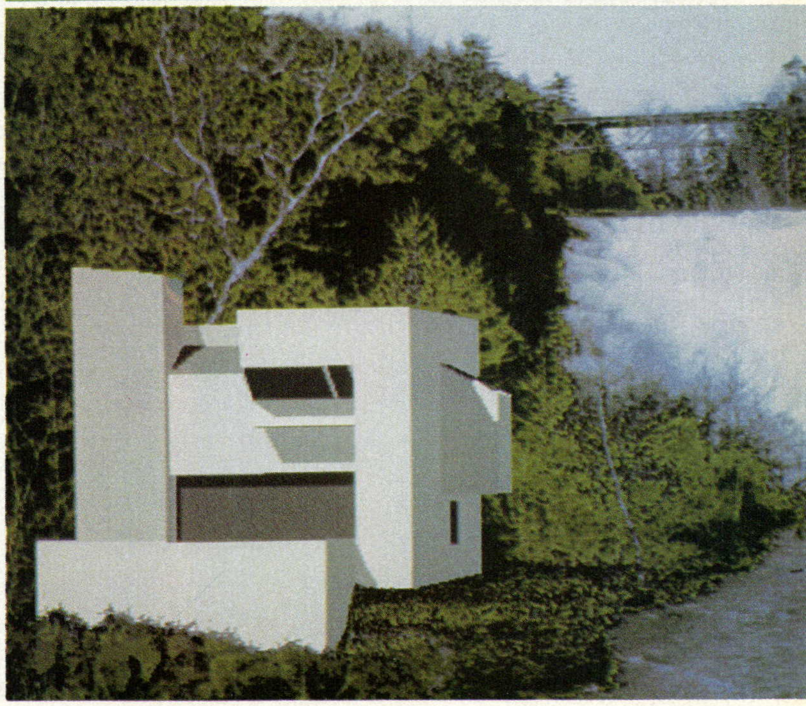
He decided from the start to develop a set of input techniques that would allow the user to define any type of spatial information. Also, mindful that people make a lot of mistakes, he

An "extruded" house can be "rendered" in color and nestled in a photographic setting







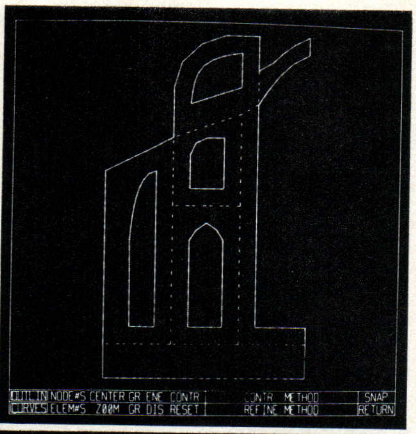


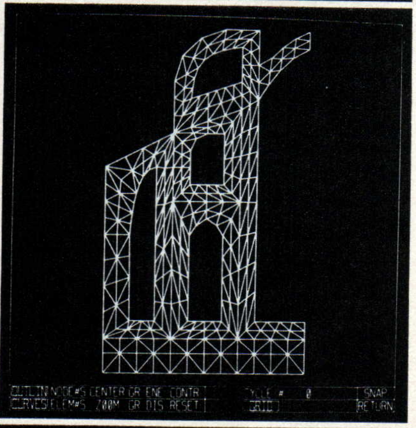
The power and versatility of display techniques is shown in this sequence. A house by architect Robert Whitton (RECORD, mid-May 1974) was drawn into the computer using the EXTRUSION program. Next, a color image was created on a television screen using the hidden surface display routines. All of the surfaces not normally seen have been mathematically erased from the image. The addition of shadows enhances the depth perception of the image. For greater realism, the building can be positioned on top of an optically-scanned, computer-generated background. This is accomplished by photographing a real environment; then the photograph is scanned to convert the picture into numerical coding, so the computer can display the picture on the television screen. Not only can static pictures be created, but also films or videotapes simulating movement through a hypothetical environment. Foliage can be drawn or "painted" on the display after the image has been created.

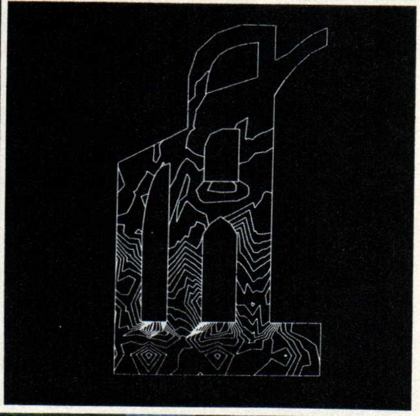
Gravity stresses at Chartres cathedral take shape in contours and in colors

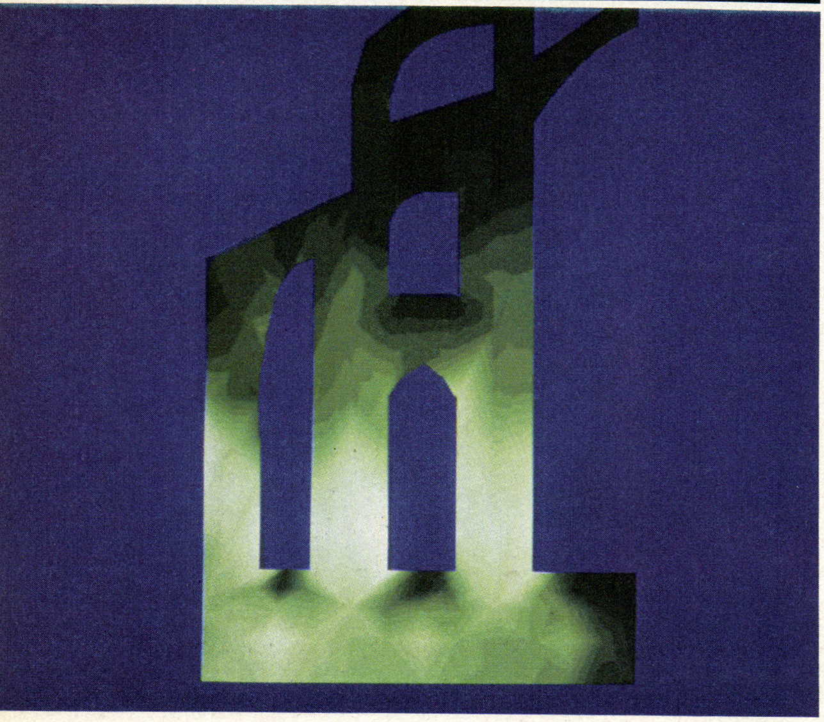
Structural response of complex structures subjected to any load condition can be determined using the finite element method of analysis. The structure is subdivided into a grid of simply shaped elements, and equations are automatically derived representing the contribution of each element to the total system. By combining the individual components, the total structural behavior can be accurately predicted. In this program, the outline of Chartres Cathedral is drawn by the analyst. The finite element mesh next is automatically generated by the computer. Results can be displayed in the form of stress or energy contours, or stress levels can be displayed in color. (FINITE ELEMENT program by Bob Haber and Mark Shephard)

Analytical routines and picture-tube display can show via "pseudo-color" how portal frames and domes behave with various loads (across page). In dome design, routines allow varying materials, member sizes and loads. Also members can be added or removed. Routines are available for iteratively redesigning structures until all members are equally stressed. (Programs by John Gross, Bob Haber and Tom Mutryn)

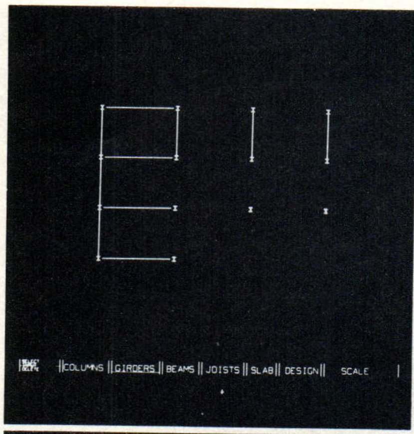


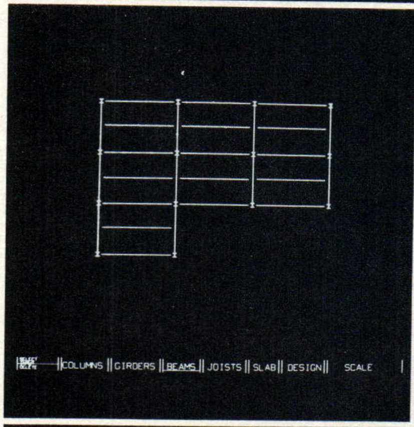


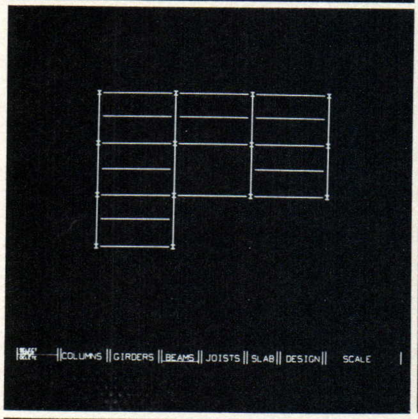




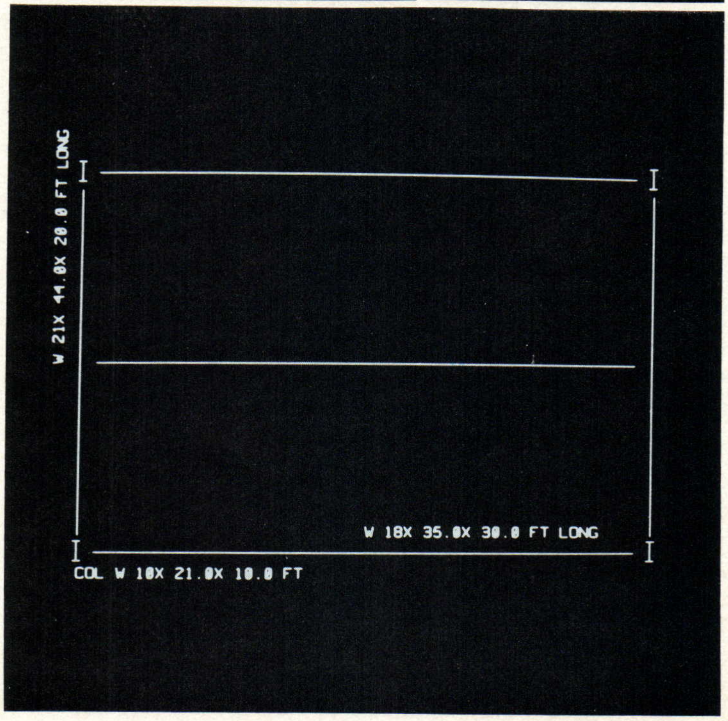
Sizes, weights and shapes of steel members are easily determined for any framing plan







The preliminary structural framing of a building can be "drawn" using interactive graphic routines. First, column locations are identified, and a beam and girder system is specified. When the plan is complete, the live and dead loads are defined; then the computer calculates the sizes and weights of members. The beam design routines check for bending, shears and deflections, and select the most economical sizes from the steel tables stored in the computer. Columns are automatically designed using AISC specifications. Joist and beam directions can be reversed, and the "least weight" solution of 20 framing alternatives can be determined within a couple of seconds. (STEEL FRAMING program by Tom Wooge)



wanted techniques that would let users erase and edit results without having to start fresh. Finally, he wanted communication with the computer to be very simple.

He had two choices: 1) a light pen that communicates by drawing on the face of a picture tube, or 2) a digitizing tablet—an electronic drawing device with a grid of wires embedded in it that can detect the position of a stylus. Both devices are wired to the computer that causes the picture to be displayed on the tube. Greenberg chose the digitizing tablet because drawings can be traced on it, and it leaves the TV screen unobscured.

With the digitizing tablet, drawings can be made very quickly. The operator doesn't even have to draw straight lines, since the computer automatically straightens them out through a routine called "rubber banding." Commands can be entered to ensure that lines are parallel and perpendicular. If one wants continuously curved lines, however, these most be drawn fully on the digitizing tablet. Architects can lay a sketch on the digitizing tablet, quickly trace its outline, and the drawing will be straight and square. A transparent digitizing tablet allows tracing of rear projected images. The computer can be programmed to ignore lines or planes that the observer cannot see—the "hidden surface" routine. It can color the object, shade it, and duplicate the way it reflects light. It can display shadows in true perspective from any angle.

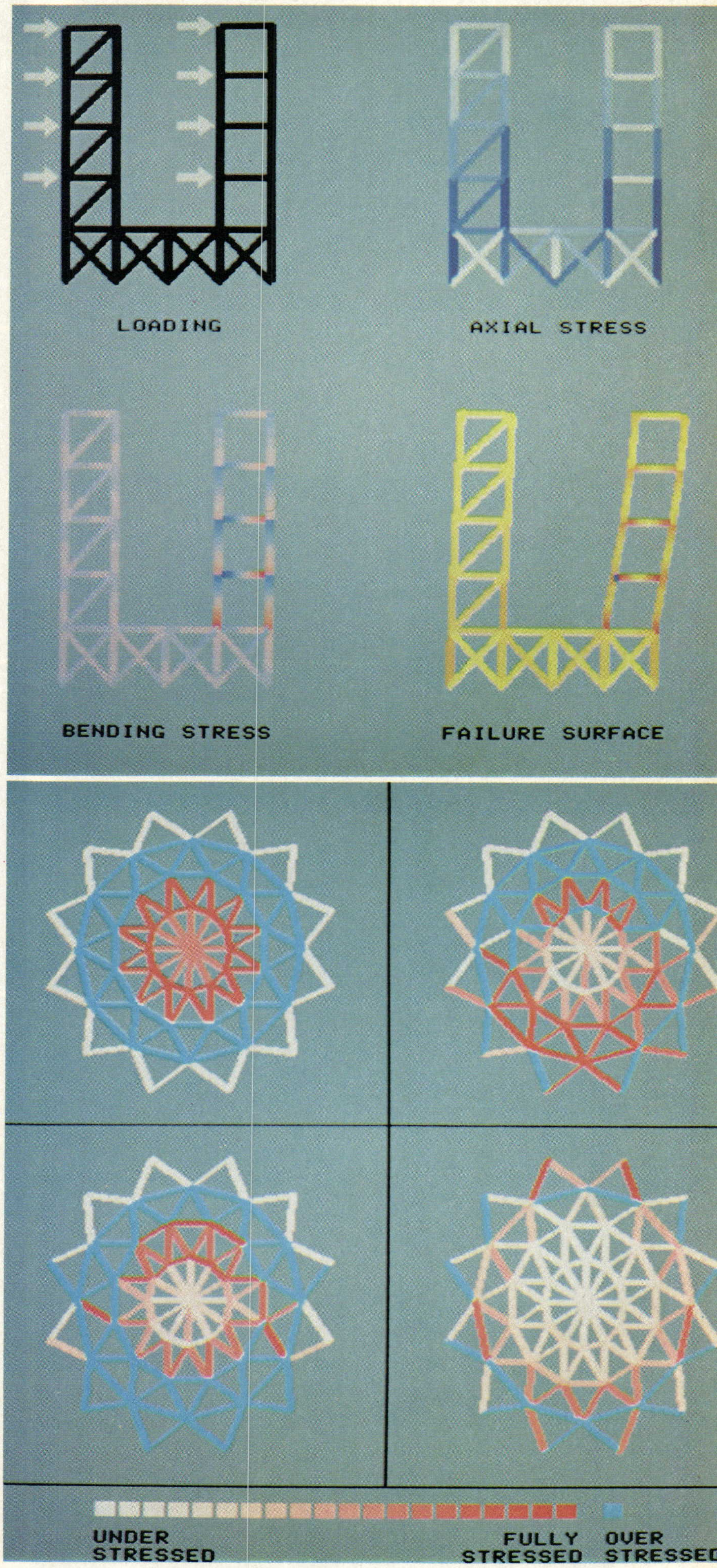
The laboratory of the Computer Graphics Program now has four input routines, and the staff is working on a fifth. Their first project involved numerically describing "primitive" volumes (prisms, cylinders, or any shape one wants) and inputting these geometries. Literally hundreds of these primitives, which are like children's building blocks, can be stored. These primitives can be distorted—*i.e.*, made longer or shorter, fatter or thinner—and they can be multiplied many times. The operator can "build" a structure from an array of different primitive solids.

The second input method, called "serial sections," is for freeform objects. The operator puts into the machine a whole series of sections (*i.e.*, contours) of whatever object he wants to define. An example is the construction of a topographic model. The contours are simply traced on a digitizing tablet. The only numerical input needed is the elevation of each contour and its scale.

The third input method is a reverse of creating a perspective drawing. It determines the location of points in space from a set of photos which are, of course, two-dimensional. Two photos taken from different, but known, locations are placed on the digitizing tablet. By touching the stylus on the same detail in each photo, the detail can be located in three-dimensional space. With this process, one can determine the dimensions of components of a building for which no drawings exist. The dimensions of amorphous shapes such as coal piles can also be determined.

The fourth technique, called "extrusion," is specifically related to architecture. The architects first draw a plan on the digitizing tablet. The plan is displayed on the screen, and

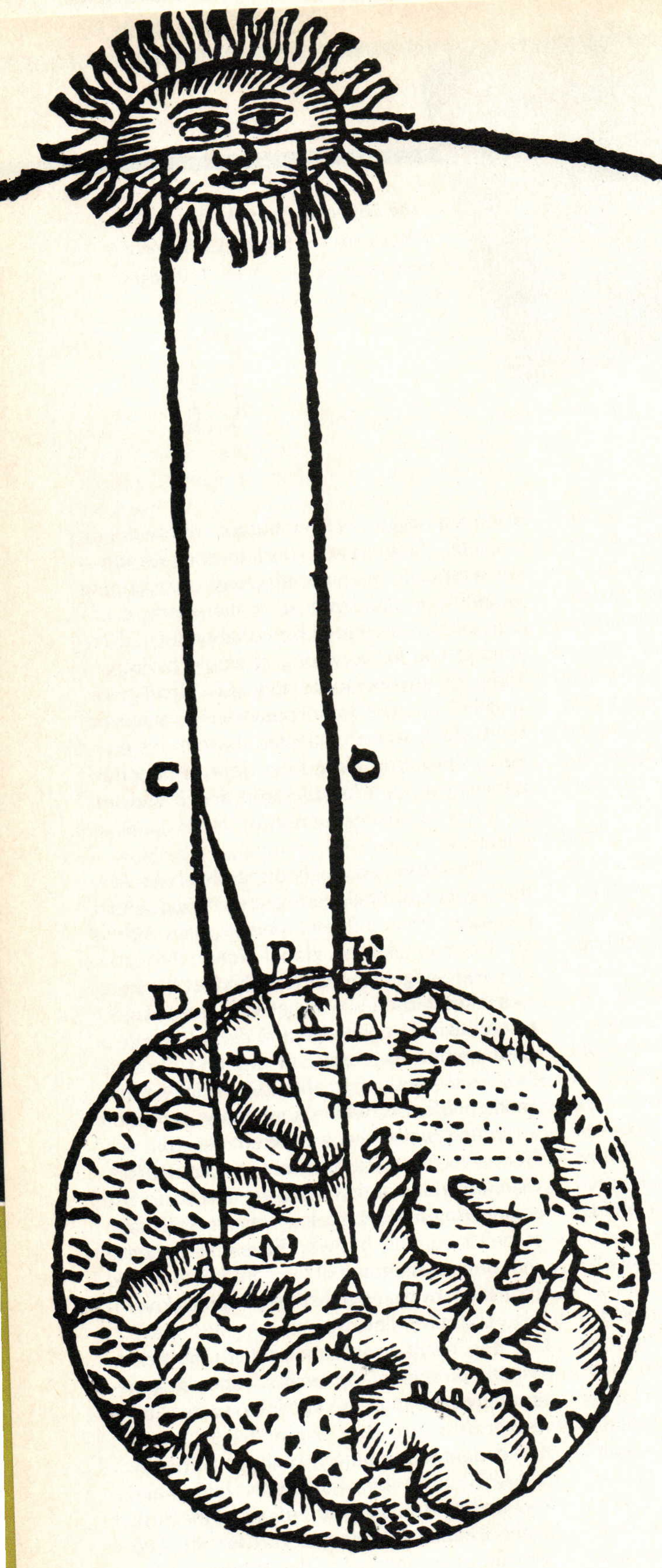
Colors shows stresses in portal frames and in eccentrically loaded domes



or & Associates, contributed "The Engineer's Education" to our issue of mid-August 1974.

capturing and conveying the curious and contradictory mixture of Kahn's greatness, capacity

and helps her complete her movement gracefully rather than fall on her face.



Notes from the field: how architects, and their consultants, approach solar design

by Margaret F. Gaskie

Colorado, as its boosters tirelessly affirm, basks year round in what less favored regions might consider more than its fair share of sunshine.

It has, as a result, harbored over the years a fair share of effort to harness that abundant energy, culminating recently in the location near Denver of the much-coveted Solar Energy Research Institute—a prize whose acquisition moved Governor Richard Lamm to proclaim Colorado on the spot "the solar energy capital of the world."

Well, maybe.

Certainly, the coincidence of climate and that aggregation of current events known as the energy crisis has lately spawned in the Denver area a comparatively high concentration of buildings utilizing solar energy, while raising to a high level the solar consciousness of its architectural community.

Designers' attitudes, explorations and experiences, as revealed in conversations with a small but thoughtful sampling of architects and mechanical engineers, presently engaged in solar projects, perhaps foreshadow those awaiting design professionals whose confrontation with the solar alternative has been postponed—until tomorrow.

"When we learned we couldn't get enough gas, we looked at every possibility we could think of—including capturing heat from the Platte River—before we went to solar."—Charles S. Sink, Charles S. Sink & Associates

Lest Denver's design community be credited with uncommon willingness to innovate—or charged with uncommon alacrity in experimenting at their clients' expense—be it said that the current boomlet in solar building is pragmatically based.

Natural gas, still the fuel of choice in the Denver area, is in short and uncertain supply—often not obtainable for new construction in the amount required or the time frame desired, and sometimes not obtainable at all.

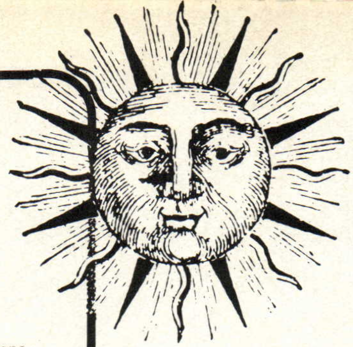
Alternative energy sources, notably electricity, have not skyrocketed in costs as they have in many parts of the country, but prices are rising steeply. Thus, given the region's highly favorable insolation rate, solar energy is seen by many here as a viable option despite comparatively favorable current fuel rates.

(The irony of recent studies predicting that solar energy for heating will compete economically with conventional fuels in such unlikely places as Maine and Minnesota before the same is true in Colorado is not lost on local architects. "We can collect a lot more Btus," muses John Anderson of John B. Anderson and Associates. "But theirs are worth a lot more.")

Attempts to generalize abou[t] the long-range economics of sola[r] energy on a national or even re[-]gional scale lead quickly into [a] morass of "ifs" and "buts." Suc[h] attempts are also, practitioner[s] agree, unhelpful.

The feasibility, economic an[d] otherwise, of solar energy applica[-]tions can only be explored validl[y] on a project-by-project basis, the[y] argue, and even then there ar[e] quite enough variables to chal[-]lenge the computers often em[-]ployed to sort them out. But how[-]ever formidable in execution[,] feasibility determinations devolv[e] as a basically simple process o[f] weighing the proportion of tota[l] heating (and/or cooling) load tha[t] the solar system can be expecte[d] to meet, and the resulting saving[s] in alternate sources of energy ove[r] time, against the cost of the syste[m] itself. Presto: the magic numbe[r] "years-to-payout."

What constitutes a reasonabl[e] payout period, of course, depend[s] largely on who is doing the pay[-]ing. "If you show a developer [a] balance sheet that says he's goin[g] to be lucky to save enough on hi[s] utility bills to cover the interest o[f] the money he had to borrow to pu[t] in the solar system in the fir[st] place," notes architect John Ro[...]



ers of RNL, Inc., "that man is not going to be too enthusiastic."

In many instances, however, clients—particularly public or institutional clients—who will themselves accrue the operating savings over an anticipated building-life of up to 50 years, can readily justify the payout periods of ten to fifteen years (in some cases, less) which are now well within reach.

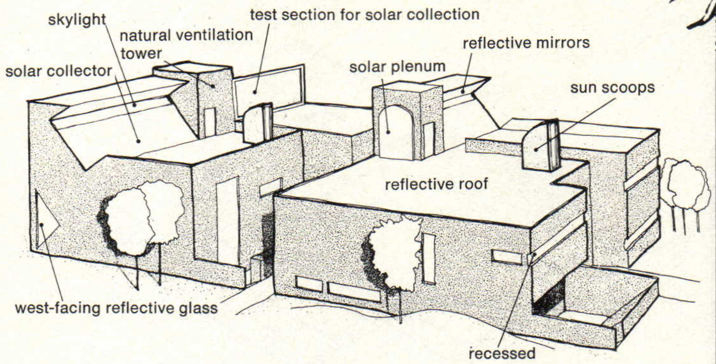
Then, too, there is a strong current of opinion among the public as well as professionals which holds that dollars and cents should not be the only or even the most compelling motive for the use of solar energy.

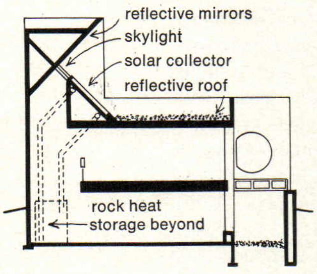
Richard Crowther of Crowther/Solar Group minces no words: "To me it is irrelevant whether solar energy can be made to show a profit at this moment—or shortly. The real question is whether we can afford to continue pulling all our resources out of the earth and burning them up, when the sun's energy is there and when we have so many higher priority uses for fossil fuels. Not to use the sun is immoral, unethical—and ultimately uneconomical."

John Anderson, whose views are similar, adds that he finds clients disinclined to argue the proposition that at some point over the life of a building there may simply be *no* acceptable alternative to solar energy for building heating. "They can see that if you spend a little more money now, whether or not it ever pays off in terms of today's dollars, it certainly will turn out to be an economical step to have taken when somewhere down the road everyone's scrambling to retrofit at a much greater cost because there's no longer any real choice."

In addition, several architects cited solar projects undertaken for reasons of social consciousness, or prestige, or customer goodwill. And others suggest a number of factors—government incentives (or fiats); shifts to life-cycle costing; limits, by the market or by taxation, on building owners' ability to pass through operating costs—that could change the economic picture over time. Meanwhile, though, most agree that premium first costs for solar energy undeniably—and from the buyer's point of view quite logically—inhibit its application in commercial and industrial buildings.

Paired office buildings display a compendium of passive solar devices





Although the small collector area produces less than 20 per cent of total heating required, energy conserving techniques—ranging from wood foundations through controlled reflectances to induced ventilation—bring combined energy savings close to 80 per cent. Cherry Creek Office Buildings, Denver, Colorado. Architects and engineers: Architects Group, affiliated with Crowther/Solar group.

"Let's face facts," says mechanical engineer Frank Bridgers, whose experience with solar systems dates back to 1956, when Bridgers and Paxton designed and built a solar-heated office building for their firm's own use. "An awful lot of solar applications we're seeing today are Federally funded or state funded or municipally funded, so the people's tax money is subsidizing them one way or another—through grants, or appropriations, or low-interest rates, or what have you. I'm not saying this isn't a good thing, just that it's a little different situation for the guy who's borrowing money at 10 per cent."

Or maybe not so very different. "I don't think people should get so hung up on costs," says Donald More of More Combs Burch. "I can remember when the only air-conditioned building in town was the movie. Then suddenly air conditioning became a necessity—but there's still no way to justify it in terms of cost. Solar's a real necessity, and people are going to wake up to that."

"On almost every project these days, the client wants to discuss the implications of solar energy." —William C. Muchow, Muchow Associates

Whether inspired by soaring fuel bills, a record cold winter, or the recent media barrage of information and misinformation about solar energy, clients increasingly are taking the lead in probing the possibilities of solar systems—an initiative design professionals greet with mixed feelings.

"We've come to feel that if we don't encourage clients to consider solar energy, we're shirking our professional responsibility," asserts John Anderson. "So we're delighted when they raise the question."

Other architects, like John Rogers, are less sanguine about the public interest in solar energy: "Sure, people want to talk about it because they think it's exotic and exciting, but they don't want to talk about the price. You've got to be reasonable about giving the client alternatives: solar energy is just one more tool. I think energy conservation and passive systems are going to have a bigger impact faster."

James D. McFall of the mechanical engineering firm McFall and Konkel, Inc., expresses a similar concern that eventual full acceptance of solar technology may be retarded by "too much being promised that can't be delivered."

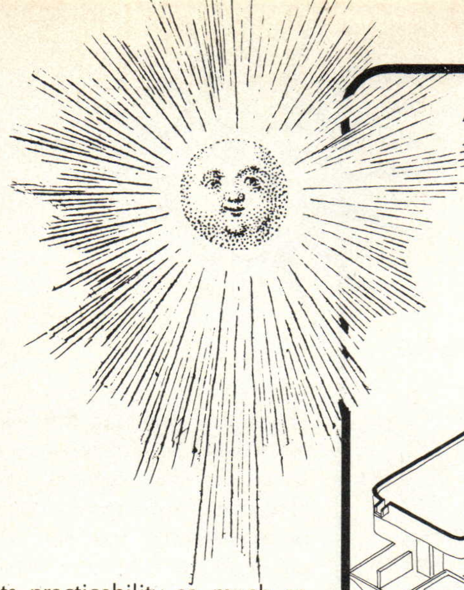
"Those people who are willing to say that their deep-rooted concern is to 'witness' for a technology we truly need are probably more comfortable with solar energy than those who try to rationalize it on the basis of payback. So we're cautious about making sure our clients recognize that solar energy is still largely a demonstration effort."

Frank Bridgers, too, believes there is a danger of solar energy being oversold, especially in residential applications. "It's not free energy as people would like to believe," he cautions, "and it's got some shortcomings people will have to learn to live with. If they expect to just plug in a solar system like they would a furnace and walk away while it coins them money, consumers are going to be disappointed. It's more complicated than that."

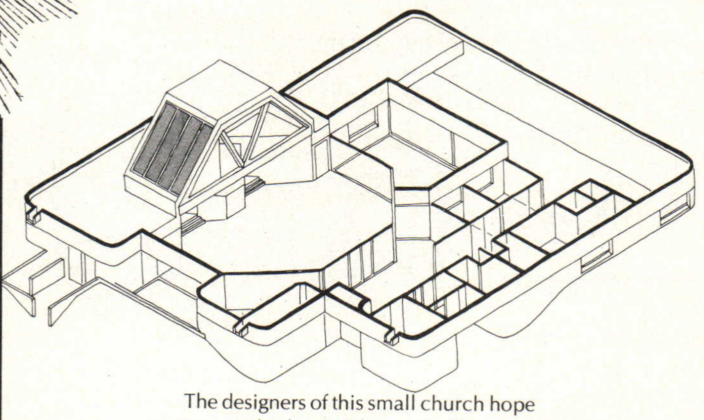
"Solar energy has been looked on by the public, and architects too, as an essentially experimental technology limited to small-scale applications. This is a myth. The existing technology is immediately applicable, and we've been able to convince clients that it's just as feasible for large projects as for smaller ones." —John Anderson, John B. Anderson and Associates

Anderson's views are perhaps colored by his experiences in planning the mini-megastructure that will house the North Campus of the Community College of Denver, which at 300,000 sq ft is the largest solar application in the Denver area. (page 113).

But most practitioners agree that while scale is a significant factor in determining the feasibility of solar energy for a particular project, it is not size in itself that



A small church will store energy for heating at Sunday's services



The designers of this small church hope to provide about 80 per cent of heating, despite low use six days of the week, by maintaining all but a few occupied areas at "preheat" levels through the week, but storing enough energy to bring them up to comfortable temperatures on Sunday. First Church of Christ Scientist, Pueblo, Colorado. Architects: John D. Anderson and Associates, Mechanical engineers: Bridgers and Paxton.

affects practicability so much as the concomitants of size: configuration, use and occupancy.

Larger buildings, for example, are likely to have a comparatively high ratio of interior space to perimeter. And that space is likely to be to some extent self-heating, courtesy of lighting, machinery, equipment and people.

With this head start, the collection and storage area needed to supply a given percentage of the building's total heating requirement may be reduced—or a solar system of given size may be able to satisfy a greater proportion of the over-all demand.

The same factors also have a clear impact on cost, much of which is fixed. As buildings get smaller (assuming an increase in perimeter ratio), the ratio of collector area to building area needed to supply the same percentage of energy demand goes up. So does system cost in relation to total project cost. And so do unit costs for the system, which tend also to vary inversely with collector area.

But building use is an equally critical consideration in solar applications. "If you use a lot of energy," says Frank Bridgers, "you have a better chance of saving a lot with a solar system. And the more energy you save, the more money you can afford to spend to do it."

To illustrate, he posits as a near-ideal user of solar energy a hospital. "That's about the most energy-intensive operation you can get. They've got a lot of load; they need a lot of outside air, which has to be heated; they operate 24 hours a day, seven days a week, 365 days a year."

At the other end of the spectrum? A church. (Though the Anderson-Bridgers team expects to meet even that challenge in the case of the proposed First Church of Christ Scientist in Pueblo, Colorado, by taking advantage of a long collection week, with relatively little heating demand except in carefully zoned areas, to store energy for Sunday's peak use.)

"In terms of its impact on architecture, I think solar energy has to be looked at as only one means of addressing the larger issue, which is energy conservation."—Richard Crowther, Crowther/Solar Group

In discussing the myriad design considerations surrounding the effective use of solar energy, architects regard a thermally efficient building envelope as the *sine qua non* of an effective solar installation.

"You can't even start talking about solar heating until you've buttoned up the building as tight as you can. But by the time you've run the gamut of passive measures—proper orientation, good insulation, weatherproofing, double glazing and the rest—that next step to an active solar system can look pretty small," says John Anderson.

John Rogers emphasizes, in addition to "a good envelope," intelligent operation and load management, and "a reasonable attitude to what you really need" in terms of, for example, inside temperature tolerances or outdoor air supply.

"Any real energy savings have to start with energy efficiency," he asserts. "Without it, solar will never work."

Richard Crowther goes a step further. The most promising path to fruitful use of solar energy, he believes, lies not in active systems but in enlarging the concept of energy conservation to include what might be called the active use of passive solar energy.

"By making the building itself—the site, the structure, the people, the equipment—a solar collector, and by using various kinds of applied passive systems, you get the most results with the least expense" says Crowther. "A collector gives you better control of solar energy—but it comes last."

It is perhaps worth noting that much of Crowther's work in solar design has been on small-scale projects—principally residences, for which the solar premium is often particularly high in relation to total building cost. By following his own dictum of first exploiting available natural energies, however, he is able to aim for a seven-year payback period on active systems—which he does not recommend at all if estimated payback is more than ten years.

The design foundation fo solar applications, Crowther main tains, is basically no different fron that which should be employed i the design of any building. "It is matter of orchestrating all th building elements—placement shape, form, materials, fenestra tion, location of entries—to con trol and integrate internal and ex ternal energies so that there is rea correspondence between th building and its climate."

The point is echoed by othe architects who express concer that as solar technologies becom more feasible, they may be seize on as a renewed license to bottl building environments, rather tha as an extended means of workin with natural forces to control climate.

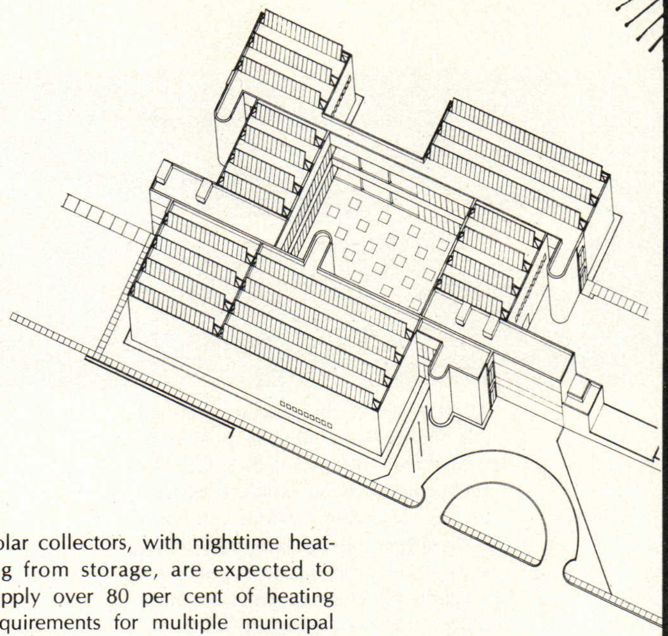
And some feel that while energy conservation is a clearl necessary goal, whether or not i entails the use of solar energy, a misunderstanding of its implications may invite solutions too simplistic, or too single-minded.

The designer's arsenal includes both defensive and offensive modes of achieving energy conservation, and both are needed to achieve a right balance between economic and human values.

"If you design strictly from the standpoint of not wasting heat—bury the building underground, do away with windows, and so on—you can create a wonderful situation for a solar collector," says William Muchow, "but I'm not sure how efficient you're being in human terms."

Muchow goes on to cite as a contrasting approach the creative work being done in school design some 25 years ago, in the Dark Ages before school programs were written with one eye on security and the other on air conditioning. Architects at that time, he recalls, were exhibiting considerable ingenuity in manipulating building orientation, configuration and fenestration to provide effective classroom lighting and cooling by natural means—surely no less valid a form of energy conserva-

Solar-assisted heat pump system for suburban city hall



Solar collectors, with nighttime heating from storage, are expected to supply over 80 per cent of heating requirements for multiple municipal functions, including 24-hour police and computer operations. Municipal Center, Littleton, Colorado. Architects: Muchow Associates. Mechanical engineers: Bridgers & Paxton.

tion than the later impulse to make schools virtually indistinguishable from bunkers to lighten the burden on their mechanical systems.

The recollection is of an approach to energy saving design that many architects find both sympathetic and familiar. "If you go back," says Cabell Childress of Childress/Livaudais, "conservation in the sense of being sensitive to and working with the natural environment is what we were all trained for."

"Remember good old ventilation?" echoes John Anderson. "Most of us learned what we need to know to use solar energy passively long ago, and then just put it in the closet when we thought we had an endless supply of cheap energy. What we've got to do now is pull it out and dust it off and use it."

Richard Crowther, however, believes this may be more difficult than it sounds for architects whose practical experience has been acquired within a framework of throwaway energy. Most designers, he says, can deal handily with passive and active solar systems in an additive, linear sense, but few are trained in the "holistic" approach he believes necessary to exploit natural energies fully. The best solutions, in his admittedly somewhat evangelical view, emerge when designers "look at the building itself, with the things around and in it, as a total, unified energy system."

"We're just on the threshold of learning how to design for solar. It's anybody's guess what future buildings will look like, but it's certain they won't look the same once energy conservation gets a really high priority."—Donald C. More, More Combs Burch

Most architects have the idea that once they pass the hurdle of designing for energy efficiency, the addition of active solar systems will have comparatively little impact on building design.

Where they differ sharply is in the degree to which they perceive "energy efficiency" as including the deliberate exploitation of solar and other natural energies, apart from the essentially defensive mode of thermal conservation that John Anderson refers to as "buttoning up the building."

The several designers whose solar projects to date have been virtually retrofit, in the sense that design was well along before the decision was made to employ solar energy, would clearly have preferred a better opportunity to integrate the systems.

Yet, by and large, the last-hour addition of a roof-full of collectors is greeted as equably as would be, say, the addition of a roof-top cooling tower.

Charles Sink, for example, says of the belated solar installation on his recently completed garage-maintenance facility for Denver's Regional Transportation District, "We were glad we had that huge flat roof to make it feasible."

Similarly, in the case of the solar-heated municipal building now under construction in the Denver suburb of Littleton, William Muchow notes, "We discussed the possibilities of solar heating in the early stages, so the building was designed from the start to accept the system if the client decided to go ahead. But I wouldn't say the architecture changed much as a result."

In solar-conscious Denver, such briefs are increasingly common from clients who, while reluctant to commit themselves to a solar system at the outset, are nonetheless anxious that the building be designed to accommodate it later.

Some architects, indeed, routinely urge such provision on their clients, at least in mechanical system design, believing it shortsighted at best to plan present-day buildings without reference to solar energy.

Certainly "just-in-case" design can guarantee a neater job of solar retrofit, both mechanically and architecturally. But it rarely inspires the extra effort required for the seamless weaving of active and passive solar elements into the building fabric.

For that reason, a few designers take exception to "advance retrofit," believing it reinforces what they see as an already present tendency of architects and clients alike to think of solar energy as additive rather than integral to the building design.

The approach of Denver architects to planning for solar energy is perhaps typified by William Muchow's description of the Littleton project as an attempt to design "a good energy conscious building that would work well with or without solar energy"—understanding "solar energy" to mean only the active system.

With a few notable exceptions, architects appear to have given little thought to what one writer has called "the conscious articulation of the sun by architecture."

As a result, solar design is viewed primarily as a practical matter of making optimum use of and added energy source—the active system—within the context of basically conventional (however thermally efficient) building configurations.

"Integrating" the system, in the sense of a tidy and pleasing disposition of the collectors that are its most conspicuous component, is recognized as a design desideratum but rejected as a design determinant.

The intelligent planning of the project as a whole is still the overriding consideration, the reasoning goes. If that dictates that collectors be arrayed on the roof, or up a wall, or over a parking lot—or down the block—so be it.

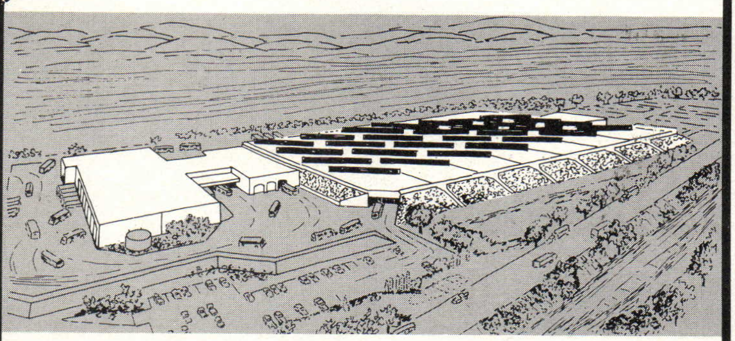
Which is not to say that architects are not acutely aware of the difficulties often encountered in handling the sheer bulk of collectors in large systems. On the Littleton City Hall, for example, William Muchow initially hoped the collectors could form a trellis over the building courtyard, doubling as a sun shield. "But we couldn't get enough surface," he says.

As Donald More points out, "Architects have to work solar into present-day budgets, methods, and technologies," and few are inclined to let the solar tail wag the architectural dog.

At the same time, designers reveal an underlying acceptance that the use of solar energy, in its broad ramifications, is ultimately not compatible with "building as usual."

Richard Crowther perhaps sums up the position by observing that an energy-short society can

Collectors "by the acre" provide heat for bus storage and maintenance building



At 40,000 sq ft, the collector array for this transportation facility is said to be the largest yet installed. Assisted by such energy-saving building features as the surrounding berms, and low (40F) temperature requirements in the storage area, the system supplies the 50 per cent of heating needs the feasibility study showed to be most cost effective. Regional Transportation District Platte Bus Terminal, Denver, Colorado. Architects: Charles S. Sink & Associates. Mechanical engineers: Swanson-Rink & Associates.

no longer afford many otherwise esthetically valid architectural approaches. "The architect has to accept a more limited palette, which means that he will have to be more ingenious in using it." (Bach, he adds, worked with a limited palette, too.)

"Present-day technology is certainly adequate, but I'm sure we'll eventually develop more sophisticated ways of capturing solar heat. Much of the equipment is still pretty crude."—Charles Sink, Charles S. Sink & Associates

As mechanical engineer James McFall asserts, flat-plate technology (which for all practical purposes is synonymous with "available" technology) is very old, very simple—and produces energy of very low quality. Nevertheless, the verdict of the design community is that such systems are the Model-Ts of solar energy—efficient enough and reliable enough for immediate application with relatively few butterflies about performance.

Because the most efficient panels are already nearing the upper reaches of their theoretical potential, given the limiting factor of the sun as a diffuse, low-level energy source, most professionals agree with John Anderson that "future increments of improvement are likely to be very small. You can't catch what isn't there."

Moreover, for space and hot water heating, there is no particular advantage to be gained from painfully boosting attainable temperatures much above the present range.

As a result, dramatic technological advances are not expected to suddenly confront today's buyer with an obsolete system, as some fear. "I don't think that's a danger," says Frank Bridgers. "As long as you're talking about low-temperature heating applications, today's flat plate will still be good twenty years from now."

At the same time, practitioners are following closely such emerging technologies as high-performance collection, which is anticipated as a potential key to increasing the feasibility of solar cooling as well as the flexibility and efficiency of solar heating systems.

Concentrating collectors in particular hold promise of producing the high energy levels needed for absorption cooling. To do so, however, most must directly face the sun, and must therefore be equipped with tracking mechanisms. As Frank Bridgers says mildly, such systems "need more work." Practical applications, he believes, are still a number of years off, and will probably be feasible first in regions like the South and Southwest, where heating requirements are very small compared to cooling, and where solar systems best suited to heating have been slow to gain a foothold.

Denver architects await with equal interest further improvements—and cost reductions—in absorption cooling units designed to operate efficiently at relatively low temperatures, thus making it more feasible to cool as well as heat with a flat-plate collector system.

Second to cooling in the balloting for technology most-needed comes better storage capability, at least partly in the hope that breakthroughs in storage may ultimately make possible self-sufficient solar systems.

(Solar energy advocates' ambivalence toward the need for back-up systems is reflected in the use of the term itself: it is more usually the solar systems, which at present supply only a greater or lesser percentage of total energy demand, that back up 100 per cent mechanical systems.)

Stand-alone systems can be designed now. (And, in fact, as Frank Bridgers notes, the solar-assisted heat pump system he designed 20 years ago for his own firm's offices was originally installed without heating back-up.)

But under most conditions, the size of the system required—collector area as well as storage—increases so drastically that self-sufficiency remains more a theoretical than a practical possibility.

Since, as James McFall says, the quality of collected energy is diluted at the instant of storage, with existing technology it is both difficult and costly to maintain stored heat at the desired temperatures for efficient operation for more than a day or two.

More efficient, cost-effective solar heating-cooling systems could reduce the *use* of back-up systems, but not the *need* for them, so long as there are nights and cloudy days when the sun declines to make itself available for collection.

Thus most designers believe that any real possibility of dispensing with dual systems will wait—probably for a long time—on the development of storage technologies efficient enough to bridge the gaps between collection periods without an inordinate increase in size and cost.

Short of that perhaps impossible dream, however, many designers note that improved storage capability could greatly increase the options in system design, and contribute to more effective—and cost-effective—solutions.

Meanwhile, Frank Bridgers suggests, storage capacities verging on the stand-alone may come to be required simply to reduce the back-up demand on utilities.

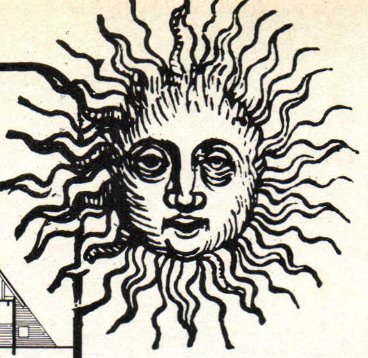
"Most solar systems now use the utilities only when they're in trouble," he says, which results for utilities in an increase in their demand loads, and corresponding need for increased production capacity without consistent offsetting revenue. In response, they are rapidly turning to rate structures that exact heavy penalties from users—like solar installations—whose peak loads are high in relation to their base loads.

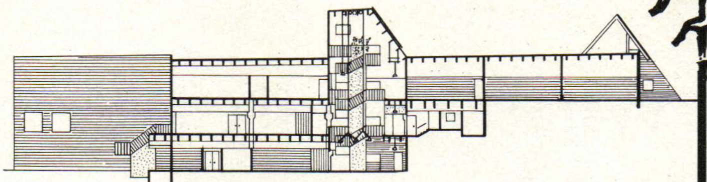
The obvious defense for solar users is to use their back-up systems when rates are most favorable to store heat against the need to run them when rates are highest. Such strategies can reduce over-all energy use as well as utility costs, but, according to Frank Bridgers, "it's going to take a lot of storage."

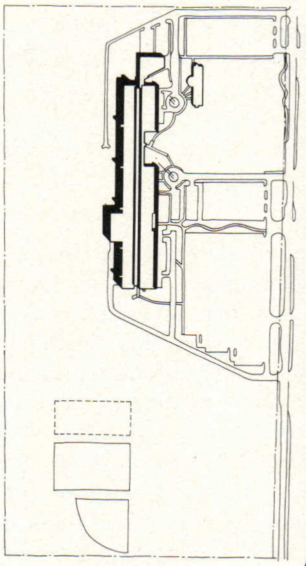
"We've seen changes take place just in the short time between design work on the community college and the projects we're doing now." —John Anderson, John D. Anderson and Associates

One barometer of the solar industry's evolution from an art of high uncertainty to something approaching building industry norms

Solar system will meet 80 per cent of community college's heating needs







In the 300,000 sq ft structure designed for Denver's community college, the potential disadvantage of extensive perimeter, dictated by program demands for outside access, is offset by substantial internal heat gains from relatively high levels of occupancy and such heat-producing areas as vocational shops. The solar-assisted heat pump system is expected to meet about 80 per cent of heating needs, augmented by ambient heat. Community College of Denver/North Campus, Denver, Colorado. Architects: John D. Anderson and Associates. Mechanical engineers: Bridgers and Paxton.

is the level of caution designers find necessary in specification and bidding procedures.

On his first solar project, for example, John Anderson backed performance specifications with performance testing of the systems submitted as meeting them—which was just as well, as the low-bid system proved not to meet the specifications. On two recent school projects, by contrast, "We knew pretty well what we could expect from various systems, so we could specify on an 'or equal' basis among those we considered acceptable."

Despite agreement that both the products and the information supplied by manufacturers have become much more reliable in recent years, few architects are yet prepared to specify on a product basis. The common practice is to issue performance specifications requiring certified tests.

Moreover, design professionals uniformly assert that changes for the better in collector performance and reliability are by no means matched by improvements in the composite systems of which they are a part.

Most would support James McFall's contention that solar energy now is in an interface stage between development and application that is new to the building industry, in that the two are being pursued simultaneously rather than sequentially. The attempt, he believes, is both slowing development and multiplying "debugging" problems in the field.

"We feel that solar energy is now basically in the first generation of application experience," he says.

The cautionary tales circulating among Denver's design community focus on (1) the assembly of individual panels into the collector array, (2) the attachment of the collector units to building surfaces, and (3) the integration of the solar collection and storage system with the back-up mechanical system.

Some pages from Frank Bridger's notebook illustrate:

Underscoring Charles Sink's description of solar systems as a "plumber's paradise," Bridgers notes that plumbing is a larger component of installed system cost than the collectors. An efficient piping design, therefore, is crucial. At the Community College of Denver, he says, a 10 per cent reduction in the number of field connections, with allied system revisions, contributed to a cut in mechanical-electrical cost of almost $400,000 under first estimates.

In similar vein, Bridgers recalls an instance in which the low-bid collectors required side coupling and could not be installed flush together as planned. Result: a reduction in the number of collectors that could be accommodated in the "billboard space" provided by the supports.

And again: if the back of a roof-mounted, side-to-side collector array is exposed, wind can produce a strong sail effect which must be accommodated in the design of the supports and attachments, and possibly also in the structural design requirements for negative wind load.

Such details, some obvious and some not, no doubt explain the unanimous advice of Denver architects to others considering the plunge into solar design: "Get a good mechanical engineer."

Cabell Childress, whose experience with solar projects so far comprises a near-miss and a maybe, finds this piece of advice a bit hollow.

Five years ago, he recounts, "We had a client who knew the energy crisis was about to break, and wanted to make a 'statement.' So we called mechanical engineers from Chicago to California, but we couldn't get technical support for a solar design. The building was too big, the equipment wasn't available. . . . One actually gave us a collector area of something like five acres for 20,000 sq ft of building.

"The client would pay," he says. "But we couldn't make sense of it."

On a more recent project (the maybe), the chilling factor was an additional cost for a solar system estimated at almost 20 per cent of total project cost—compounded by a doubled fee for mechanical engineering.

Not surprisingly, Childress's present view is that while solar energy may be "no big deal technically," the difficulties of encompassing it within the norms of practice are daunting.

"Solar," he concludes, "has just got to be easier."

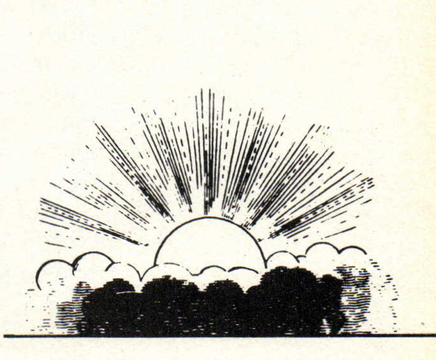
Easy it is not. A few Denver architects have apparently been able to confine their involvement in the nitty-gritty of solar projects to following their own advice on the hiring of able technical help. But the majority have felt constrained to undertake an arduous program of self-education, on top of the extra investment in design time.

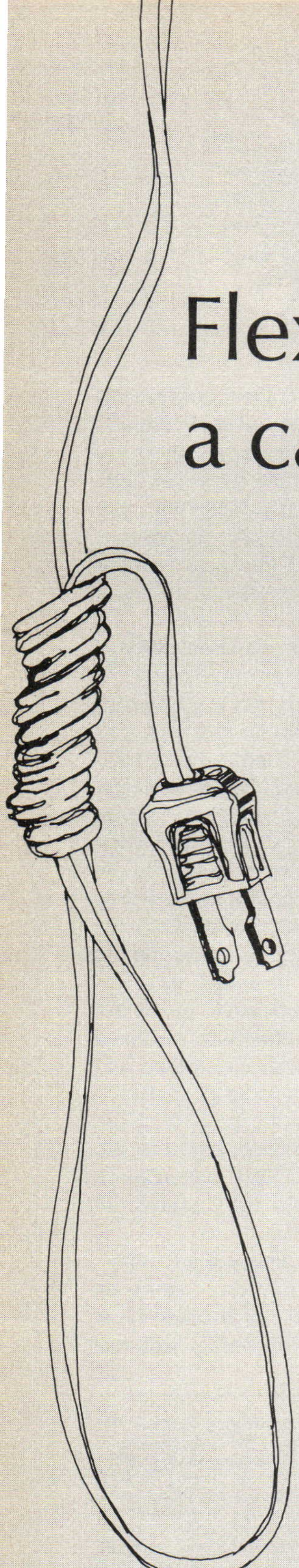
Nor is the situation different for mechanical engineers. As Frank Bridgers says, "Unfortunately, there are no real short cuts to becoming competent in solar design. You can't become competent just by studying; you have to get out and see first-hand what works and what doesn't. People doing solar work for the first time are going to make mistakes."

James McFall, whose firm is among those regarding solar design as premium work, points out that usual fee structures assume a conversancy with the systems and the supporting industry that cannot obtain in the case of a developing technology like solar energy, adding, "We haven't—on any solar job—fully recovered costs."

"There's pressure in today's economic situation," sums up John Anderson, "to pull stuff out of a drawer. With solar, you just can't do it."

* The 17th-century drawing on page 108, taken from a book by the German scientist Athanasius Kircher, illustrates sunlight and its distribution over the earth. Although he erred in having the sun revolve around the earth, Kircher, using geometry, determined accurately which parts of the globe would be dark at a given time of the year. (From the book *Weather*, Life Science Library, 1965.)





Flexible wiring systems: a catalog of current technology

The spectrum of systems and devices depicted on these pages suggests the wide range of choice that architects and their engineers have in providing flexibility for power, light and communications. Flexibility has long been a requirement of office building and school clients, but the advent of open planning, followed now by energy conservation, with its implications of more and more task lighting, have encouraged many of the developments you see here.

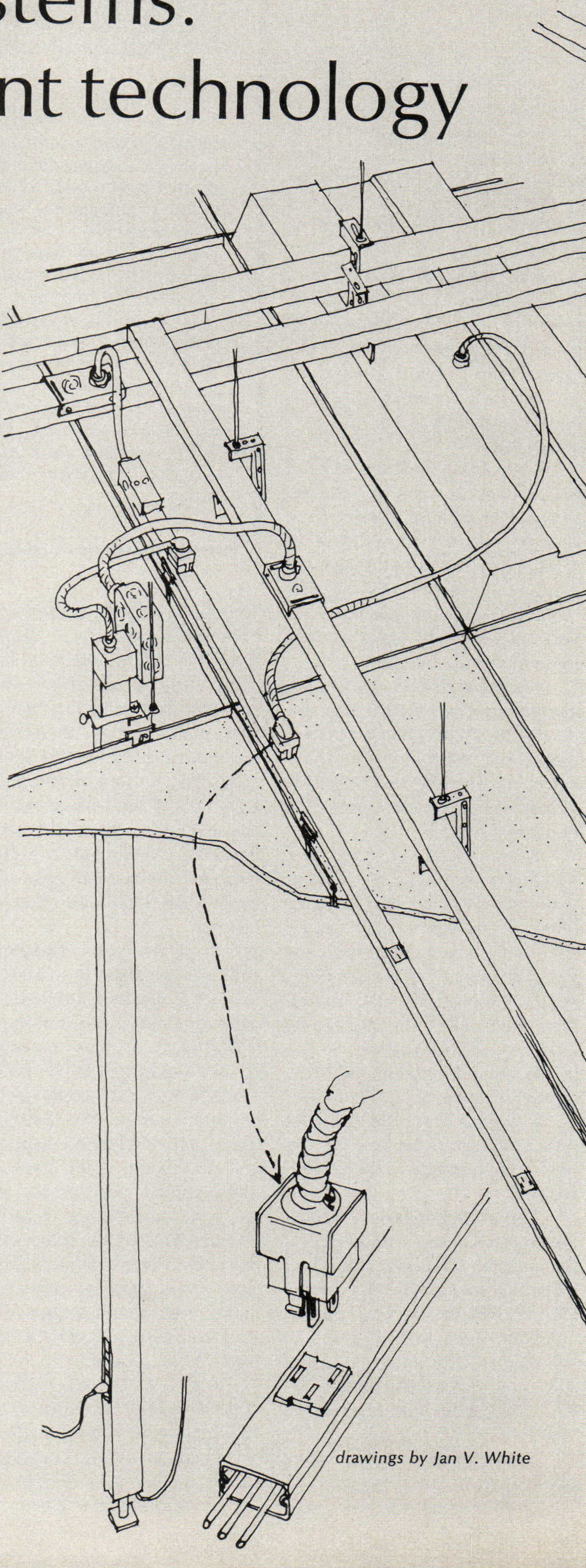
The grandaddy of flexible wiring systems, is, of course, the underfloor duct in which raceways are embedded in concrete fill. This was followed by cellular floor systems in which the cells are integral with the structural metal deck. Cellular floors have gone through a number of permutations, including the use of large-type cells for air distribution. More recently, attention has been paid to cosmetics of the outlets, some of which can be fully concealed by carpet.

When the floor construction is concrete instead of steel decking, then the alternative system to poke-through (which requires coring slabs and using rated fittings) is an overhead raceway with associated power/telephone poles. Code allows these raceways in air-handling ceilings so long as the ceiling is accessible. Originally, power poles were hard-wired to raceways, but then power plugs and raceway receptacles were developed that made the power poles much more flexible.

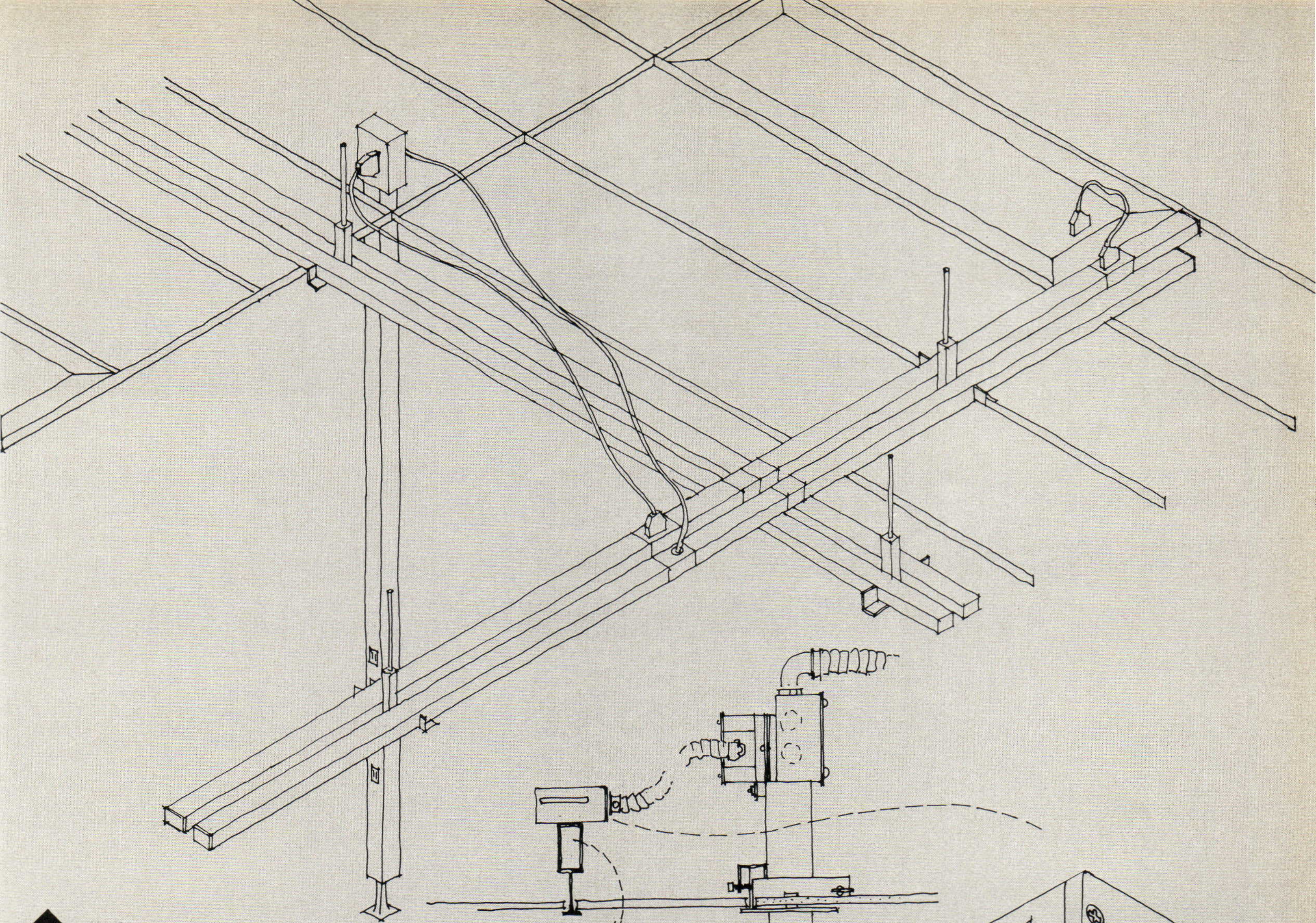
If lighting flexibility alone is sought, then cable sets either with or without overhead raceways may be used.

Youngest of all in the family of flexible wiring systems is the use of access flooring for power and communications distribution. From the aspect of flexibility, the advantages are obvious. Insurance companies and banks have been early users, partly because of their growing dependence upon computer terminals, video displays, and other electronic and communication equipment.

Light track is an exposed raceway that architects have grown fond of because flexibility is limited only by track locations.



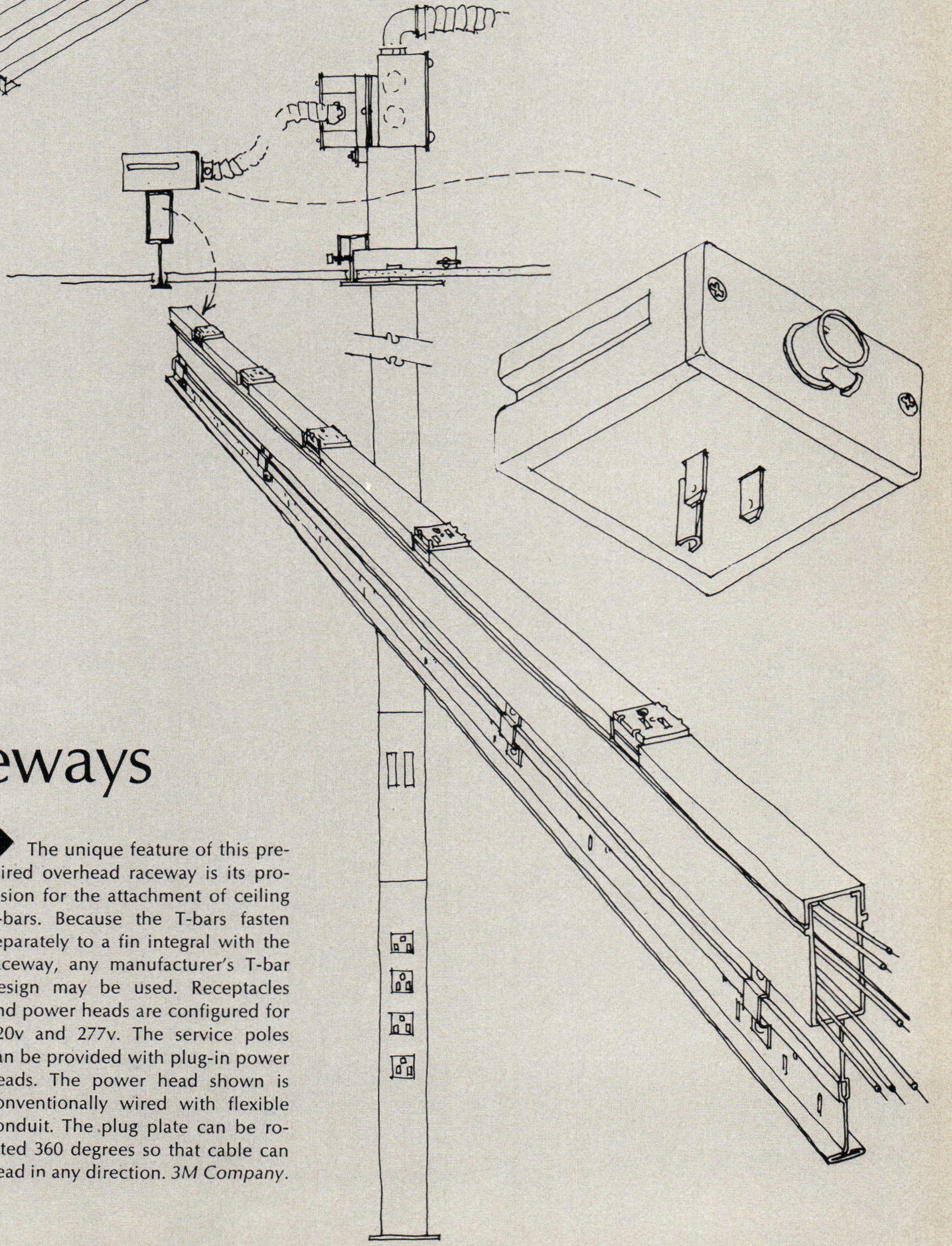
drawings by Jan V. White



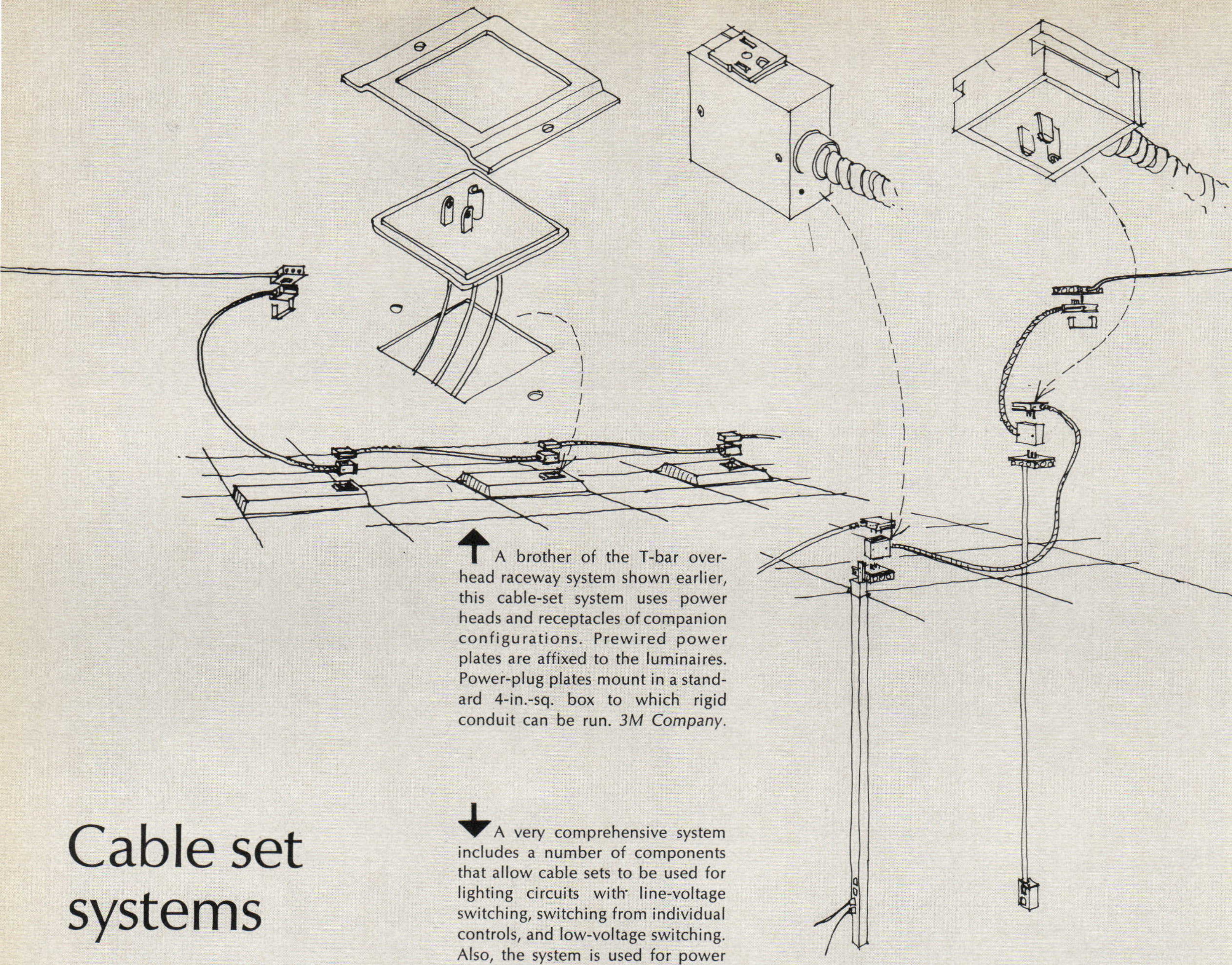
Preassembled cable sets for 277v lighting, 120v lighting and 120v power interlock with corresponding receptacles installed in raceways and at power/telephone poles. Electricians lay the raceway wiring in the field. Two types of raceway cover plates are provided: one to accept power receptacles, and the other flexible conduit for telephone wiring. Wiring from power poles can feed receptacles and surface mounted raceways built into open-plan work stations. *Walker Parkersburg Division of Textron, Inc.*

Overhead raceways

This system achieves speed in installation by means of a factory-wired harness of receptacles that is laid in the bottom half of the raceway during field installation. The receptacles, which in this drawing are alternately 120v for poles and 277v for luminaires, match precut holes in the cover of the raceway. Plug-in luminaires are another time-saver. Depending upon local conditions, the luminaire's 6-ft-long flexible metal cable and plug may be hard-wired to luminaires in the shop or on-site. *The Wiremold Company.*



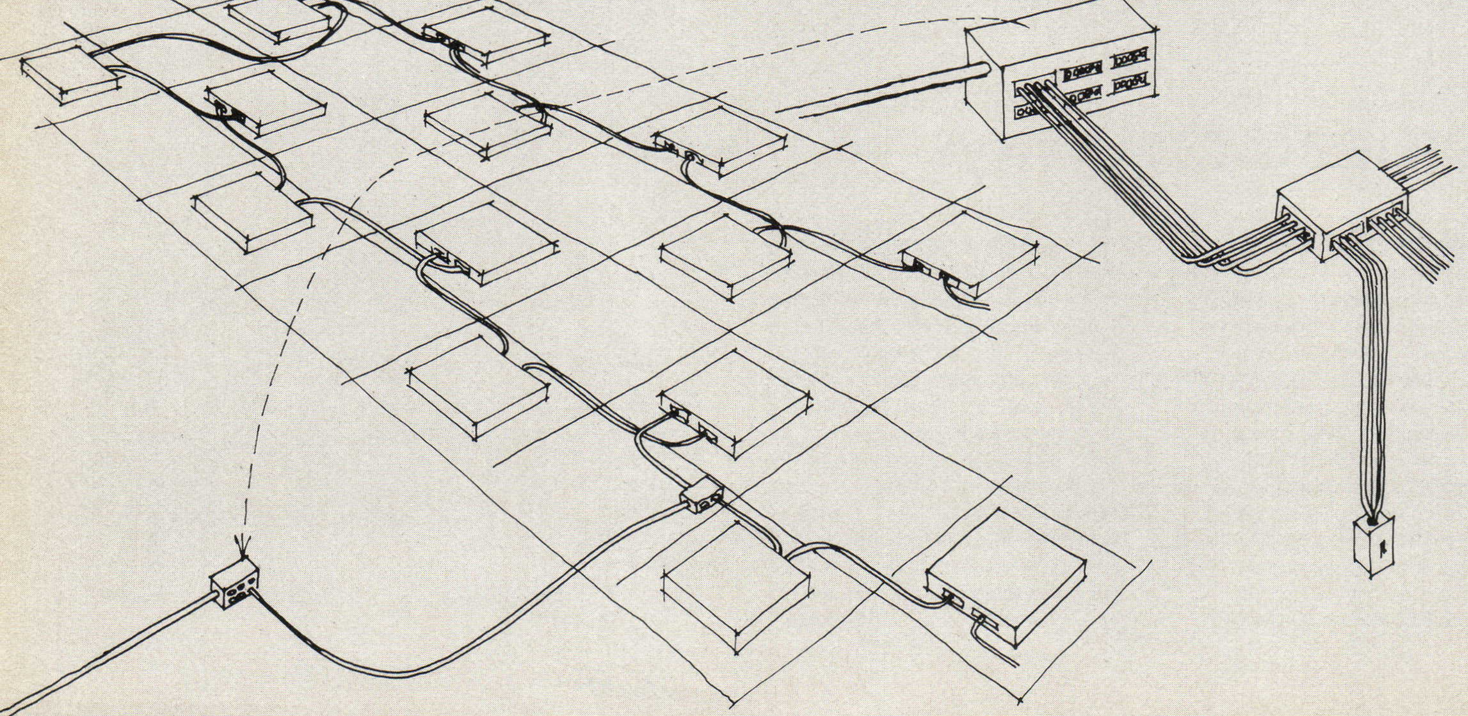
The unique feature of this prewired overhead raceway is its provision for the attachment of ceiling T-bars. Because the T-bars fasten separately to a fin integral with the raceway, any manufacturer's T-bar design may be used. Receptacles and power heads are configured for 120v and 277v. The service poles can be provided with plug-in power heads. The power head shown is conventionally wired with flexible conduit. The plug plate can be rotated 360 degrees so that cable can head in any direction. *3M Company.*



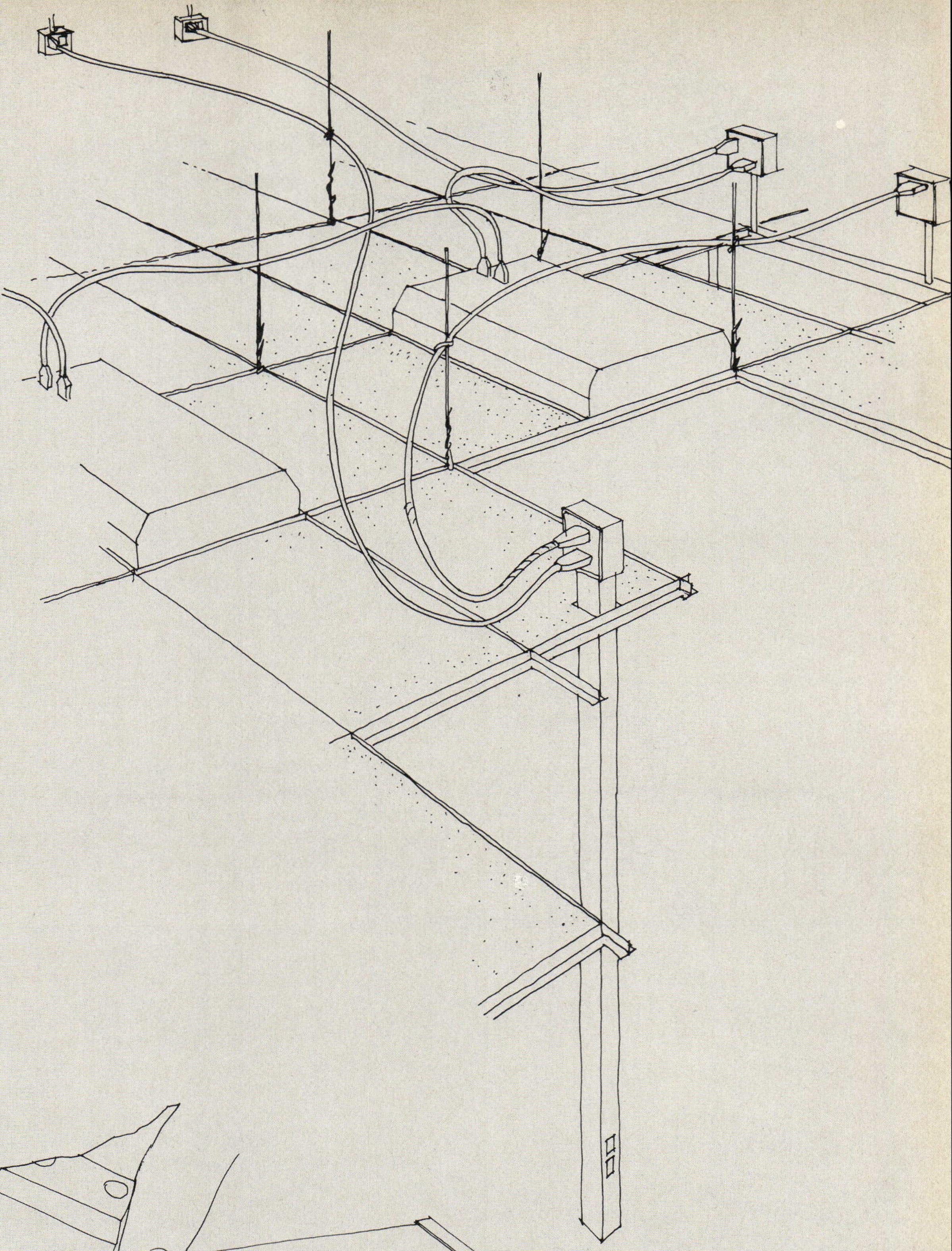
A brother of the T-bar overhead raceway system shown earlier, this cable-set system uses power heads and receptacles of companion configurations. Prewired power plates are affixed to the luminaires. Power-plug plates mount in a standard 4-in.-sq. box to which rigid conduit can be run. *3M Company.*

Cable set systems

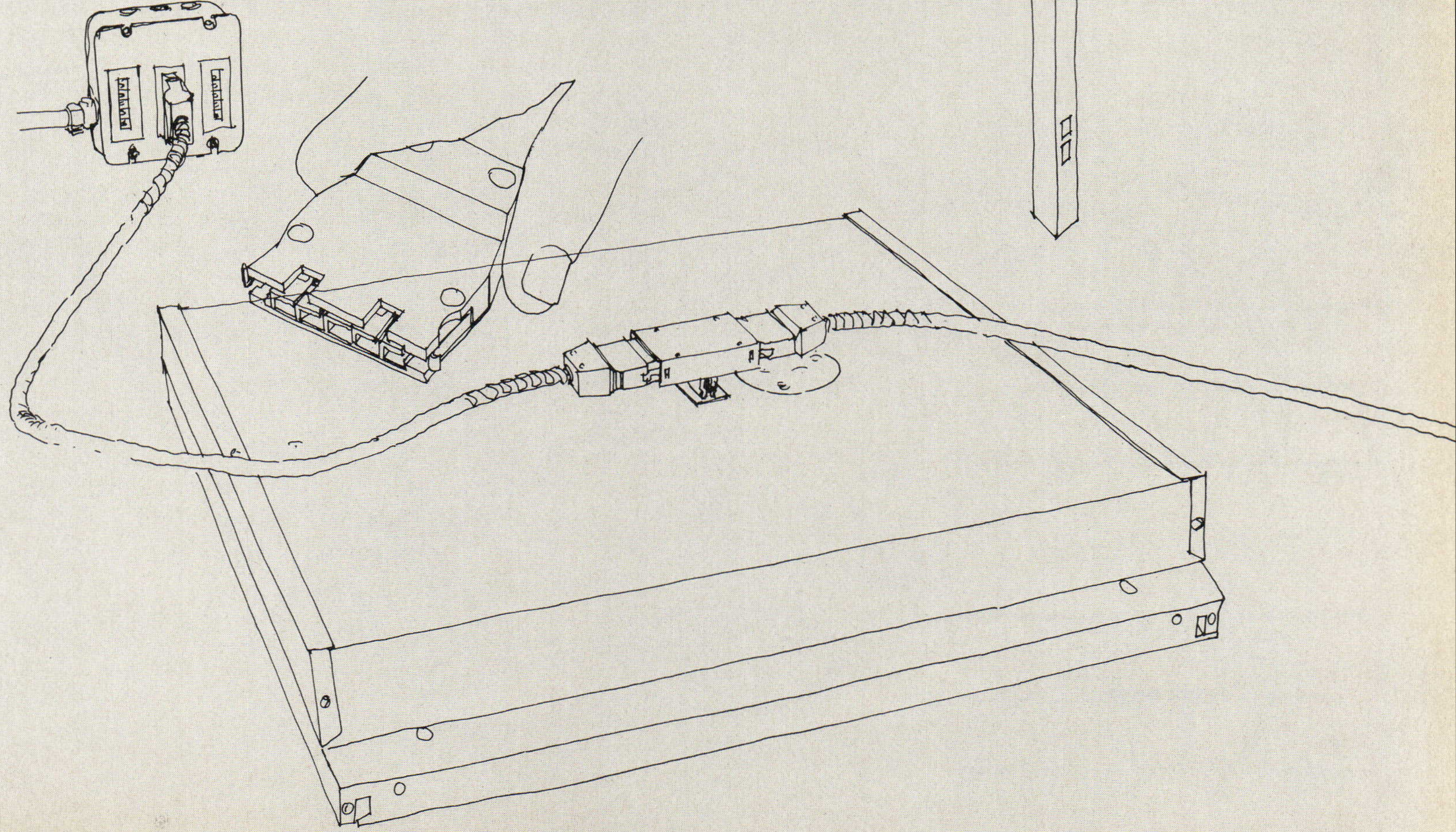
A very comprehensive system includes a number of components that allow cable sets to be used for lighting circuits with line-voltage switching, switching from individual controls, and low-voltage switching. Also, the system is used for power circuits, communication circuits and clock/signal circuits. Principal components are distribution boxes (connected to load centers), tap boxes (prewired components with a through-feed feature), and adapter assemblies (devices to adapt devices to the system). *Electro/Connect Division, Emerson Electric Co.*



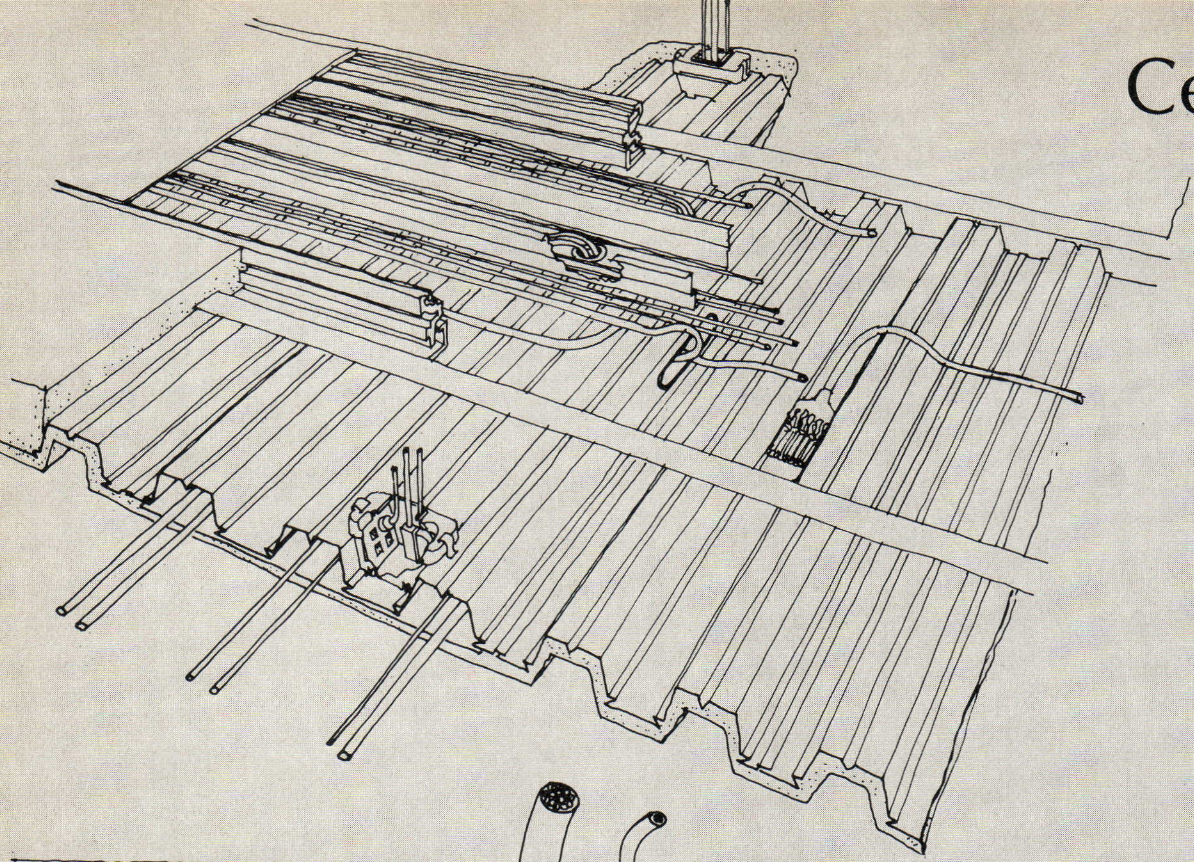
Three basic devices compose this simple, though versatile, system: 1) cable set, 2) distribution/junction units and 3) wiring adapters. The distribution/junction unit connects to power from the panelboard, and provides receptacles for cable sets to feed lighting and power poles. Wiring adapters are installed in luminaires and at the tops of power poles. The adapters also are used with clocks, speakers and communication panels. A positive mechanical interlock prevents accidental disconnection of plugs from receptacles. *Architectural Power Systems.*



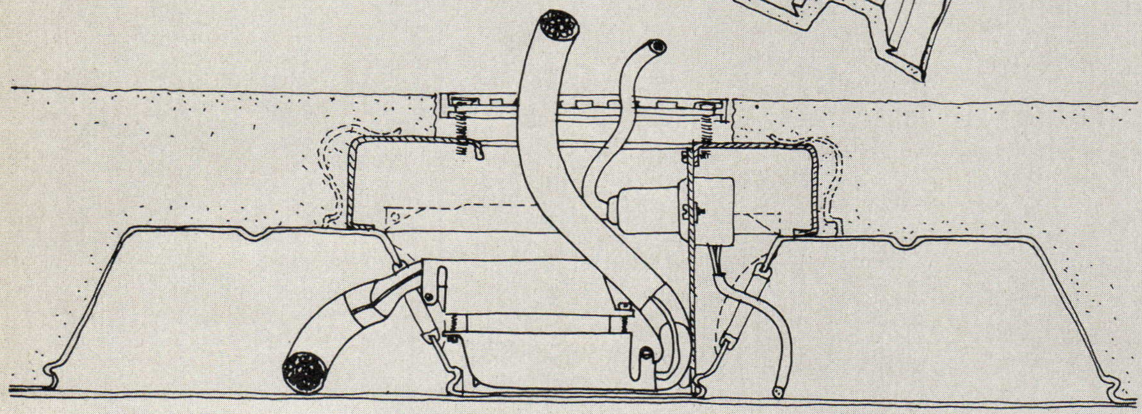
Key to the simplicity of this system is a device called a Selector Module that gets plugged into the receptacle mounted in the top of each luminaire. The number of ballasts to be electrified is determined by choice of module. Because power is fed through the Selector Module, rather than the fixture, one fixture can be unplugged without affecting others on the circuit. The other two components of the system are a Conversion Module that has provisions for three lighting circuits, and the cable sets that have a power-in head and a power-out head. *Relocatable Wiring Systems, Inc.*



Cellular floors

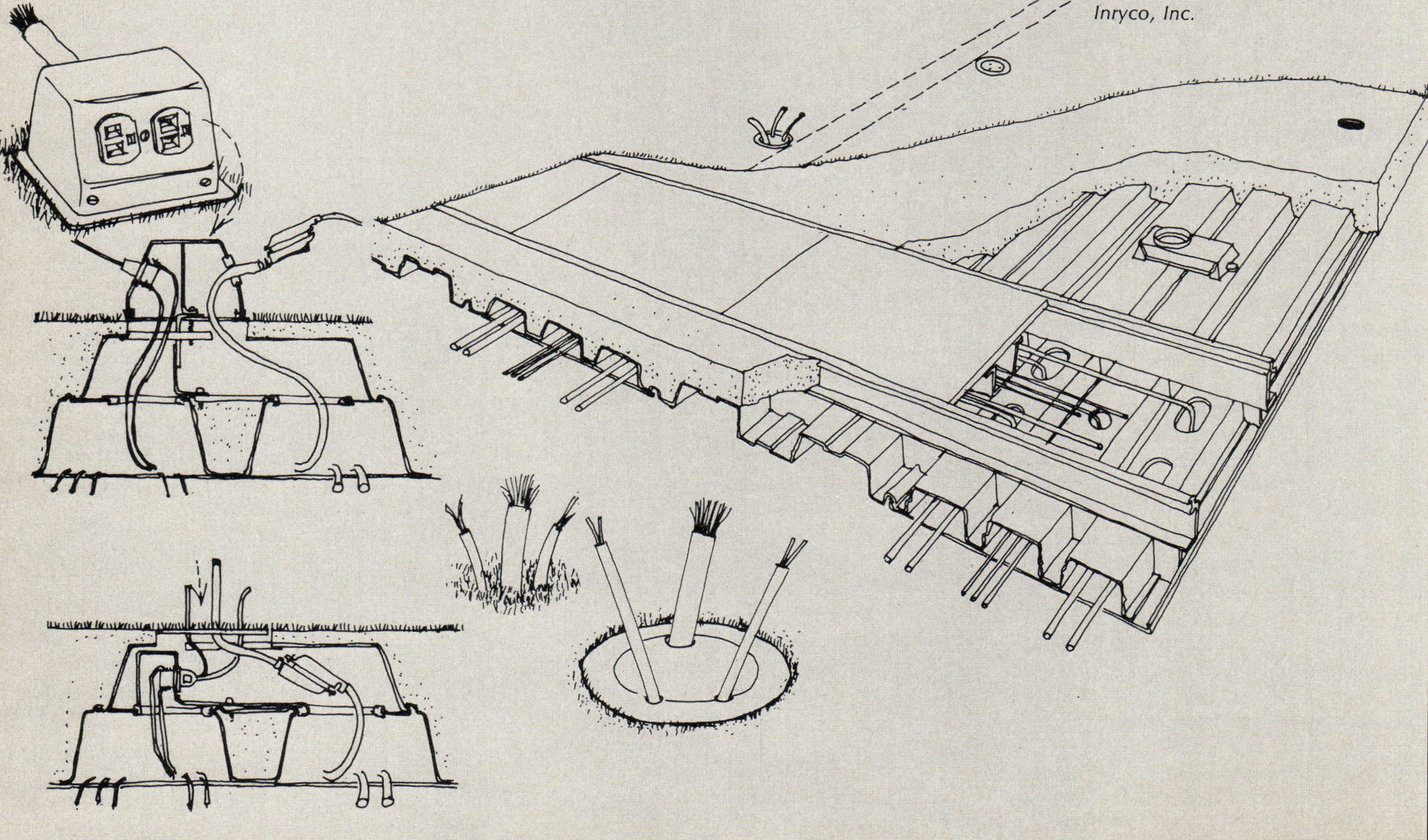


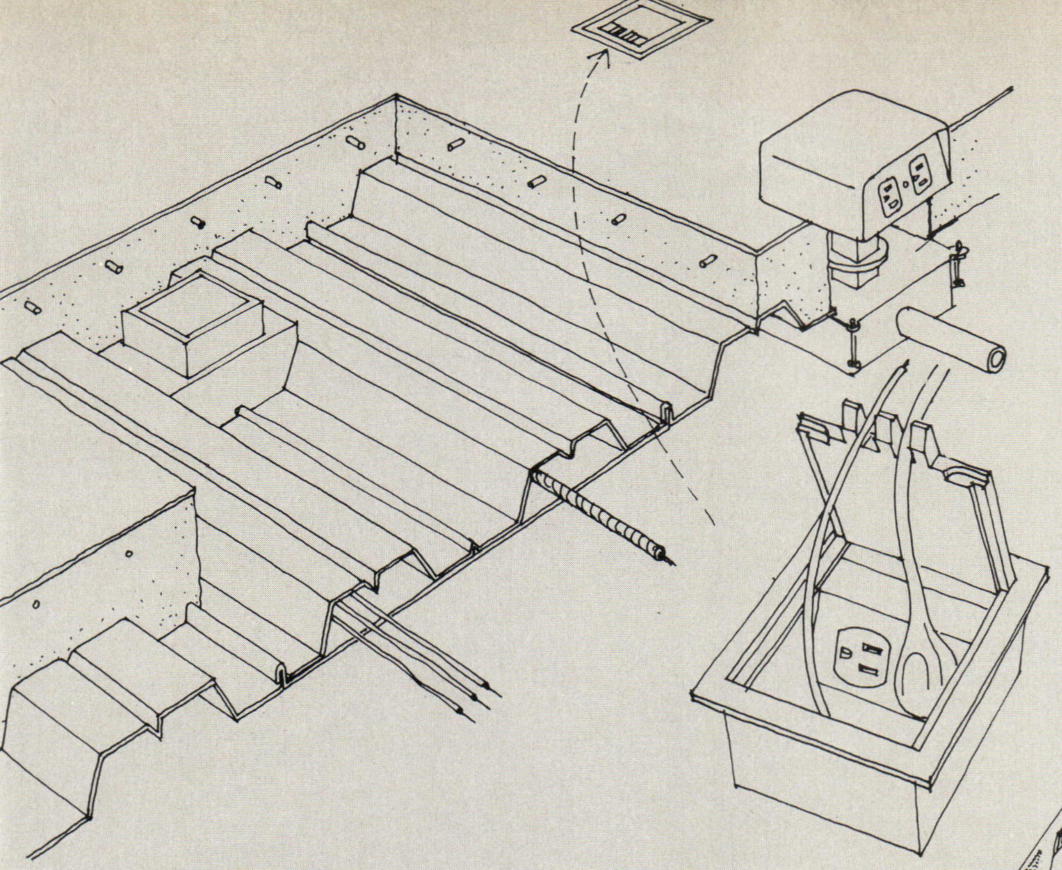
← In the most recent version of this manufacturer's cellular floor system, preset flush outlets allow power cords and telephone wires to penetrate carpet unobstrusively. Power wiring for receptacles is reached through prepunched holes in power cells that are grommeted when the cell is activated. Access to telephone wires is achieved the same way. A two-piece plastic cover is drilled for the wires; carpet is slit in an H to form flaps the size of the cover, and is also slit for the wires. A flange ring, leveled by screws, places the plate even with the floor. *H. H. Robertson Company.*



→ Both preset and afterset inserts are shown with this manufacturer's floor. Also shown is a flush service fitting with a flip-up lid for access to power and telephone. In reality, the afterset insert shown is a poke-through fitting because it has been installed by means of coring the concrete from below, which requires a special fire-rated device (see poke-through detail). *Roll Form Products, Inc.*

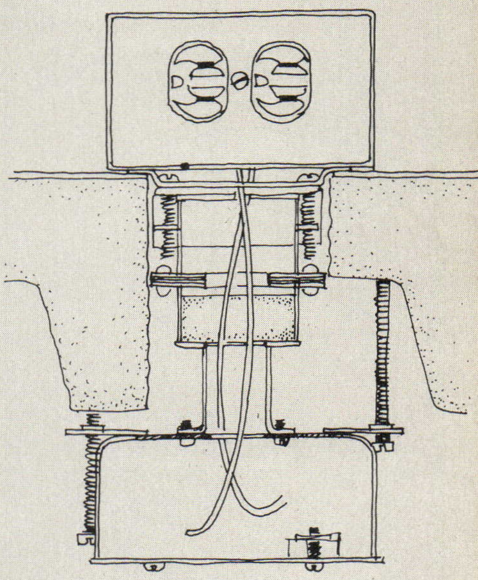
↓ The preset inserts of this design can be turned 180 degrees so that they are staggered and serve both sides of a partition. Three different access techniques are shown: surface fitting, flush fitting (which has a solid plate), and a carpet-covered fitting (which has a "split" plate with holes in the center for wires). *Inryco, Inc.*

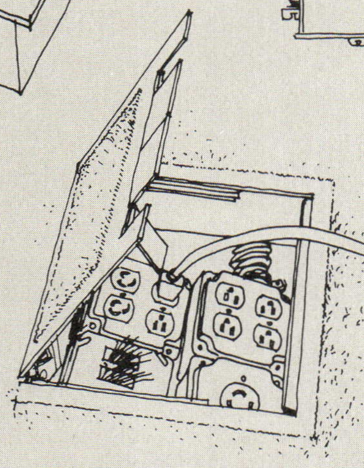




Poke-through fitting

To maintain the fire rating of the floor, this poke-through fitting has a coating in the fire-panel assembly that swells to fill opening in case of fire. *Raceway Components, Inc.*



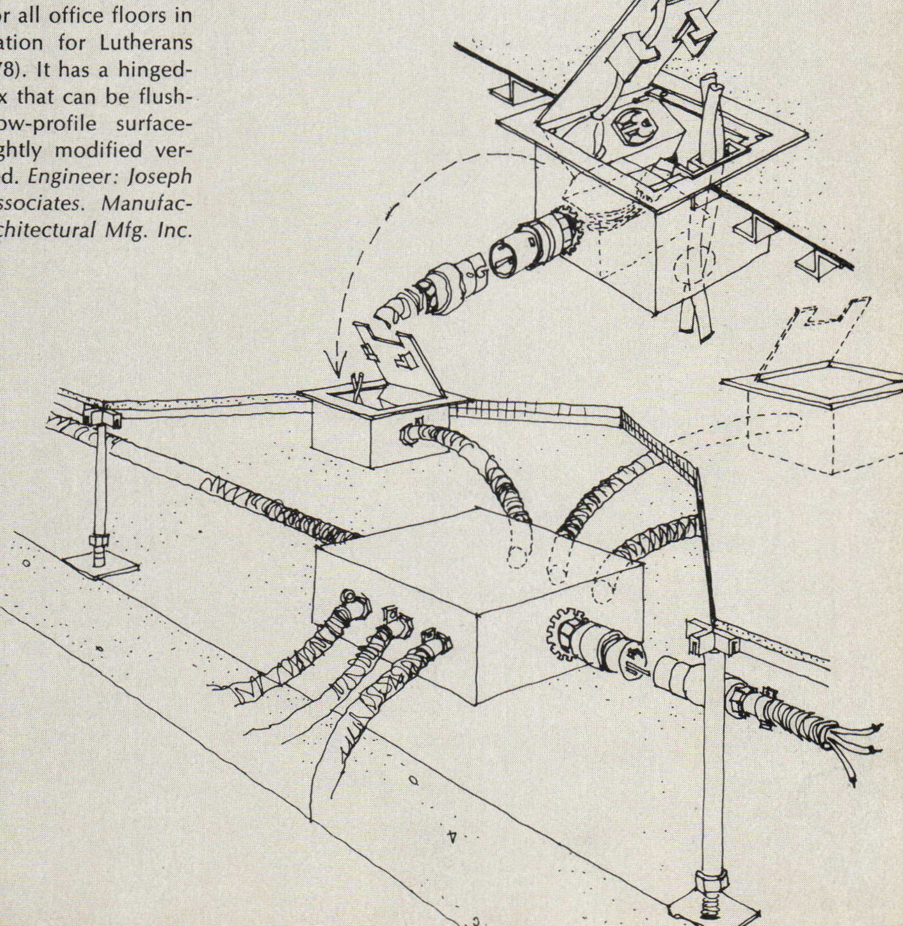


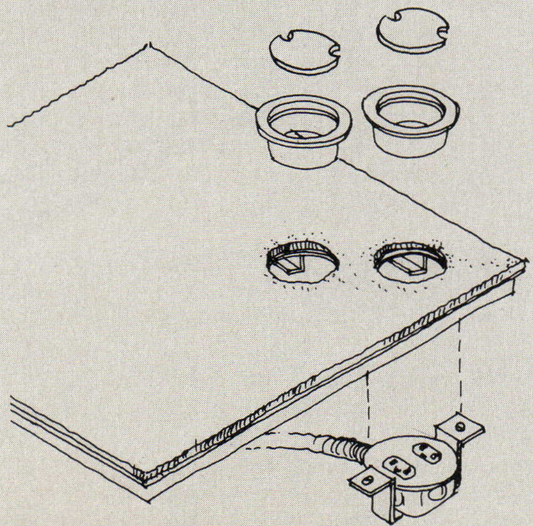
→ Large hinged cover conceals source of a large number of electrical and communication services within the access floor used for offices of a New York City bank. The services include power for typewriters and CRT displays, communication wiring, and a twist-lock 208v receptacle for a minicomputer. *Donn Access Floors, Inc.*

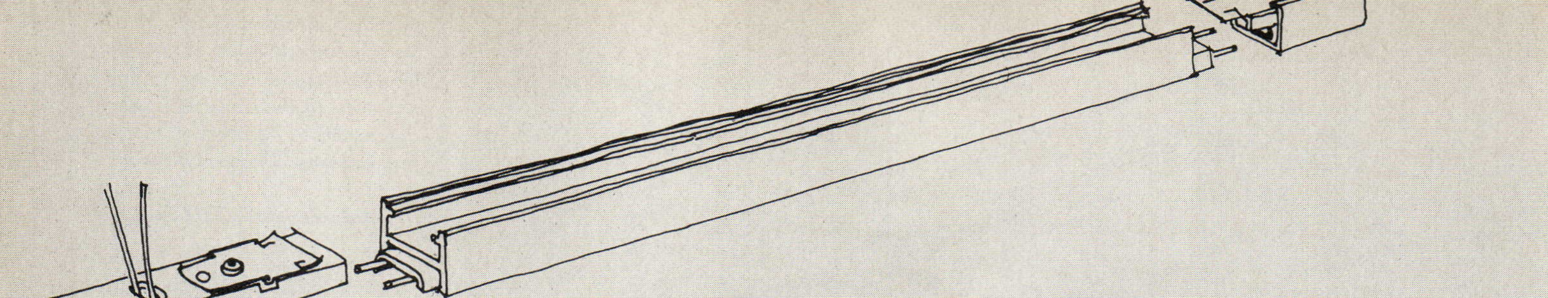
Access floors

↓ Electrified access floor panel below has one 4-in. cutout for power and another for telephone. The holes are grommeted with molded plastic shoulder bushings and have notched, snap-in covers with one or two holes. Flexible conduit from a junction box is connected to a conventional octagonal electrical box. This type of panel was used in the Federal Home Loan Bank Board Building (page 66). *Tate Architectural Products.*

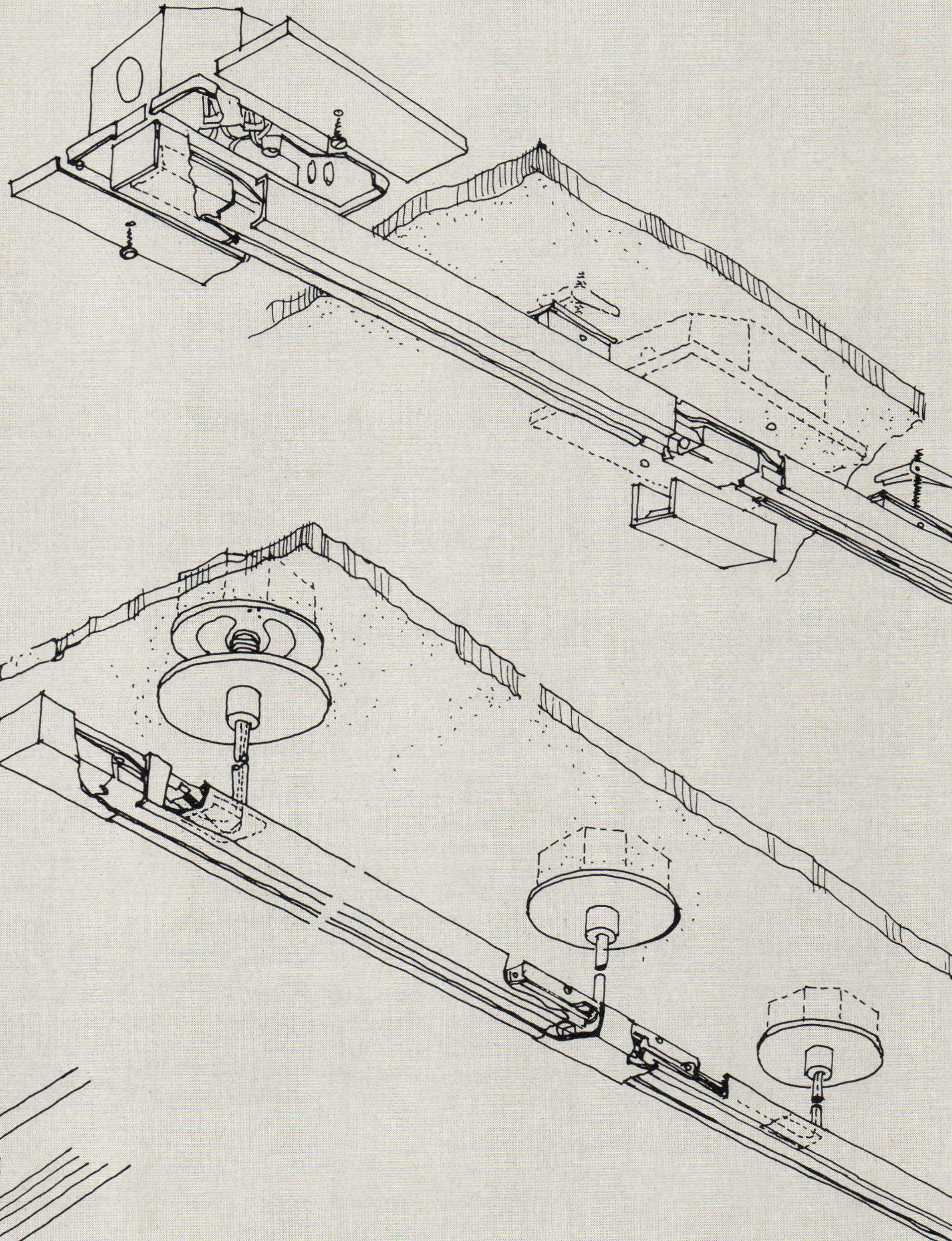
→ This is the engineer's concept drawing for an access floor system that was used for all office floors in the Aid Association for Lutherans building (page 78). It has a hinged-lid electrical box that can be flush-mounted or low-profile surface-mounted. A slightly modified version was installed. *Engineer: Joseph R. Loring & Associates. Manufacturer: Liskey Architectural Mfg. Inc.*



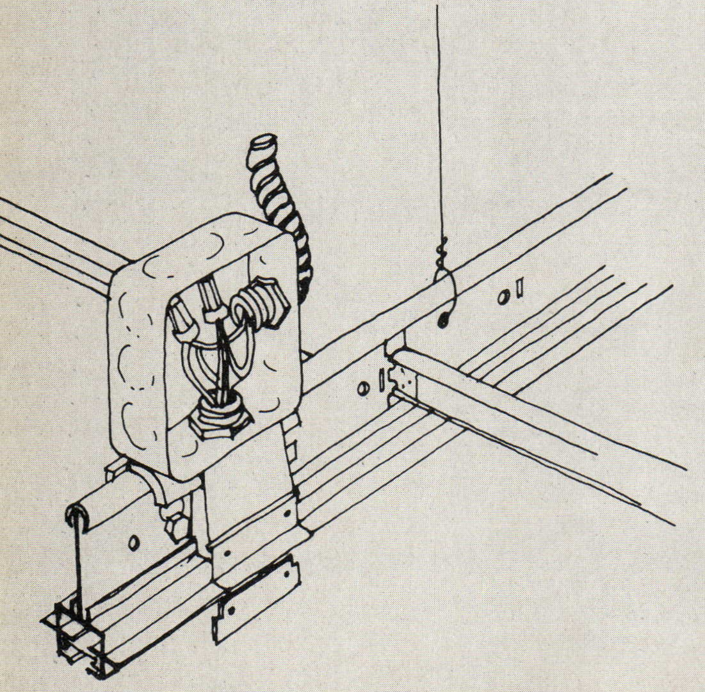




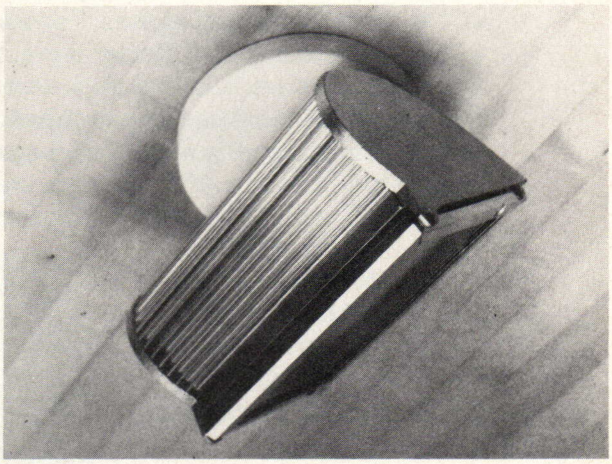
Light track



Light track has long been a favorite of architects for stores and other commercial spaces, museums, galleries, schools, houses—almost anywhere that flexible, adjustable lighting has top priority. It can be used many ways architecturally, as can be seen at right and below: surface-mounted, stem-mounted, or concealed. The track comes in modular lengths for individual track units, and 8-ft lengths can be coupled for continuous runs. The system shown below provides a complete ceiling system using extruded aluminum runners that can be electrified or not, and that support 1- by 4-ft acoustical ceiling tiles or 2- by 4-ft regressed-edge lay-in panels. Concealed splines support the acoustical tiles which cover the flanges of the runners. The notched 2- by 4-ft panels lie on top of the runner flanges, forming a continuous reveal about the perimeter of the panels. With the lay-in panels, access to the plenum can be obtained at any point. Incandescent accent fixtures, fluorescent luminaires, and recessed incandescent or H.I.D. downlights can be used with the system. *Lightolier.*



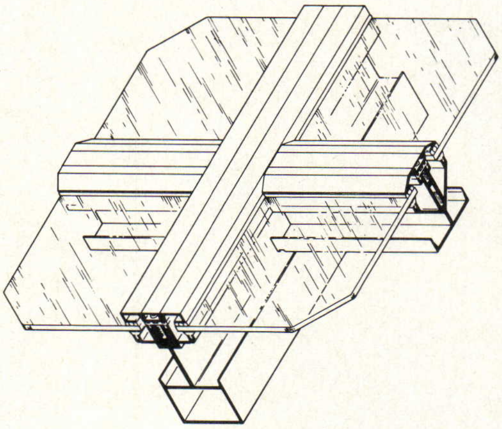
For information, circle item numbers on Reader-Service Inquiry card, pages 179-180.



Ceiling and wall washing luminaire introduced

Designed by Sylvan R. Shemitz & Associates, this asymmetric distribution, sharp cut-off luminaire is available with canopy or stem mounting, useing tungsten halogen lamps from 100 to 200 watts. Both models measure 6½ in. in length for the 100- and 150-watt units, and 9½ in. for the 200-watt luminaire. All are 3½ in. deep. Stems are 18 in. long and canopies are 5 in. in diameter, in egg-shell white. Even lighting is claimed with a patented reflector that directs approximately 13 times the candlepower at 65 degrees as at 0 degrees. Heavy extruded aluminum construction is featured. The installation shown is the Crowley Maritime Corporation, designed by Robinson and Mills, Architecture and Planning (see RECORD, February 1977, pages 131-136). ■ Elliptipar, Inc., West Haven, Conn.

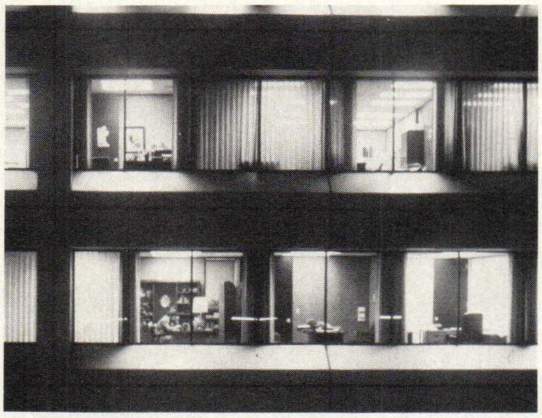
Circle 300 on inquiry card

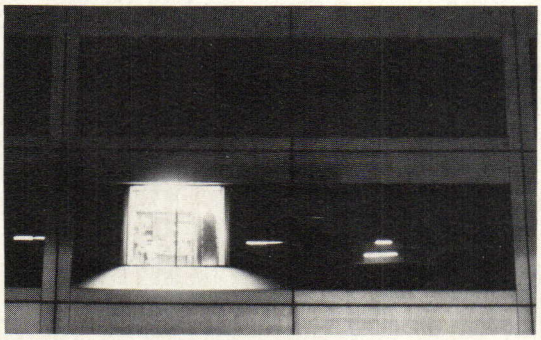


Thermal curtain wall developed for sloped glazing

The "1600 S.G." sloped glazing system features purlins joined to rafters without the use of shear blocks and screws. The joint is accomplished with one fastener to allow quick erection, according to the company. Drainage gutters located in the glazing pockets, and behind the glass carry away condensation or rain water that may enter the wall. The overlapping design allows water to drain from the purlin gutters into the rafter gutters, and to be carried down to the exterior through a continuous weeped sill member. Double glazing and thermal barrier are part of the system. ■ Kawneer Architectural Products, Niles, Mich.

Circle 301 on inquiry card





Automatic low-voltage switching reduces light energy

Designed to reduce the amount of energy used in lighting, this low-voltage switching permits automatic and local control of lighting in each work area. Remote control relays are installed on each lighting circuit, and low-voltage control lines connect them to local switches. An automatic timer switches off the lights at the end of the day, yet late-working employees can override the system with the individual switches. In one application, the equipment was used to reduce the lighting level to one-third between shifts and during lunch breaks. ■ Touch-Plate Electro Systems, Inc., Paramount, Calif.

Circle 302 on inquiry card

more products on page 129

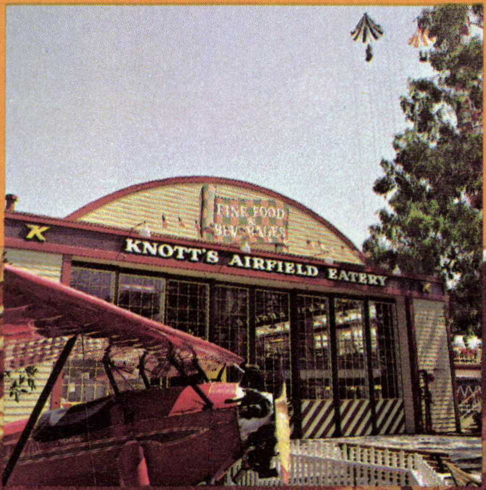
The Airfield Eatery: making history comes easy to Trus Joist.

The place: Knott's Berry Farm Airfield Eatery. The assignment: recreate a 1920's hangar . . . and with it, all the fun and excitement of that most flamboyant of eras. For assistance with the restaurant's spectacular barrel arch roof, architects called on Trus Joist engineering.

Our advanced engineering technology accomplished easily what other systems couldn't. MICRO=LAM® chords were brought to a taut 35′ radius curvature through an arch of 90° in a 50′ span. Our lightweight, rapidly-installed wood-and-steel trusses are tough enough to handle the load, yet open enough to keep the old hangar aura.

Our technical representatives and engineers are experts and innovators in structural systems. We'll back you up from computer design and layout assistance to delivery coordination and jobsite inspection. So whether you're recreating the 20's or planning for the 80's, you can count on Trus Joist to make your place in history secure.

Architect: Ronald D. McMahon & Associates
Engineer: Ruthroff & Englekirk
Contractor: C. I. Construction Co., Inc.



Specify Trus Joist. We've got our system down to a science.

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TRUS JOIST CORPORATION
P.O. Box 60, Boise, Idaho 83707

or information, circle item numbers on ̛eader-Service Inquiry card, pages 179-180.

AFETY DECKING / Fact sheet describes steel safety lecking with open-ribbed construction and wear-esistant finish. Deck's interlocking sections fit to-;ether to form mezzanines, decks and catwalks; ailing, stairs and supports are also available. Safety leck capacity limits are shown on a table. ■ Inter-ake, Inc., Chicago, Ill.

Circle 400 on inquiry card

;EWAGE TREATMENT PRODUCTS / Brochure de-;cribes a variety of construction products for waste reatment plants, including weir plates and scum baffles; cast iron, steel, aluminum and FRP control ;ates; pipe; metal buildings; and drains. ■ Armco Steel Corp., Metal Products Div., Middletown, Ohio.

Circle 401 on inquiry card

;ELF-DRILLING FASTENERS / Booklet describes how and where to use this manufacturer's line of engineered, special purpose, self-drilling and tapping fasteners, all said to lower costs by eliminating hole-making in a variety of construction applications. Available head, thread and point styles are shown; also discussed are several types of power screwdrivers suitable for driving the fasteners shown. ■ Elco Industries, Inc., Rockford, Ill.

Circle 402 on inquiry card

ROOF FLASHING / How *Nervastral 600* elastic roof lashing can be stretched and shaped to form water-ight flashing around any roof contour is detailed in a product bulletin. *Nervastral 600* is said to flex freely without cracking and to resist weather and aging. It can also form field-fabricated expansion joints. ■ Rubber & Plastics Compound Co., Inc., Long sland City, N.Y.

Circle 403 on inquiry card

BUILDING PANELS / Exterior and interior applica-ions, available colors, thicknesses and surface con-igurations for a line of mineral fiber reinforced architectural panels are given in a 24-page booklet. These lightweight masonry panels are used as ex-erior and interior walls, fascias, soffits, etc. Featured n the brochure is the *Struct-O-Wall* dry wall system utilizing lightweight structural steel studs and tracks with a facing of architectural panels. Also outlined are fastener and joint sealant reccommendations, average physical properties, and warranty and cer-ification information. ■ Johns-Manville, Building Systems Div., Denver, Colo.

Circle 404 on inquiry card

METAL COATINGS / Bulletin describes a nickel-chromium, molybdenum, aluminum composite powder, which is flame sprayed directly onto low-carbon steel for a grind-finish "stainless-type" protective coating. Mechanical preparation of the substrate, such as grit blasting or rough threading, is eliminated; no separate bond coat is needed. ■ Metco Inc., Westbury, N.Y.

Circle 405 on inquiry card

INSULATION ADHESIVES / Eight adhesive products for bonding fibrous glass and other insulation materials to sheet metal are described in table format. Included are end uses, features, application methods, color, solids content, consistency, coverage and bonding range. Featured is "Adhesive 4230," a new product with non-flammable and fast drying characteristics. UL tunnel test results for flame spread, smoke development and fuel contribution are given. ■ Adhesives, Coatings and Sealers Div., 3M Co., St. Paul, Minn.

Circle 406 on inquiry card

GARAGE DOORS / Product literature explains how the use of isocyanurate and polystyrene insulation materials in steel and wood flush commercial overhead-type doors improves insulating values and lowers flammability. Flame spread on all models is rated at under 25; doors meet FS HH1524. All insulation is protected by an overlay panel of steel or hardboard, depending on door selection. ■ Raynor Mfg. Co., Dixon, Ill.

Circle 407 on inquiry card

THREE-DIMENSIONAL GRAPHICS DISPLAY / *Primob* (Projected Image Mobile) visual display screens combine free-swinging panels and a projected image in an audio-visual construction said to be easily adaptable to many settings: corporate headquarters, waiting areas, expositions and trade shows, etc. Product data sheet explains how balanced panels are set in motion by a small fan; panels themselves can be constructed in almost any shape. Any slide or film projector can be used to produce images on *Primob*. ■ John J. Karamon, Stamford, Conn.

Circle 408 on inquiry card

PLUMBING FIXTURE SUPPORTS / A brochure presents *Hi-Set* supports for mounting fixtures used by the physically handicapped. Supports need no alteration or special installation. ■ Jay R. Smith Mfg. Co., Piscataway, N.J.

Circle 409 on inquiry card

STORAGE EQUIPMENT / A storage and shop equipment catalog includes prefabricated crossover bridges, catwalks, walkways with protective railings, mezzanines and platforms, as well as shelving systems, storage drawers, and racks. Cabinets, lockers, bins and mobile stock trucks are also shown. ■ Equipto, Aurora, Ill.

Circle 410 on inquiry card

HEAT RECLAIM UNIT / Designed especially for commercial restaurant exhaust, this heat reclaim unit salvages waste heat generated by cooking equipment and uses it to temper make-up air. An illustrated folder presents on-site photos and typical schematic drawings of the "HRU" liquid-vapor-liquid rooftop package, which combines exhaust and supply fans into one unit. ■ Gaylord Industries, Inc., Lake Oswego, Ore.

Circle 411 on inquiry card

CONSTRUCTION PRODUCTS DIRECTORY / Booklet lists manufacturers of such steel building construction products as: decks; doors; fireplaces; floor joists; kitchen cabinets; residential siding; agricultural, commercial and industrial roofing and siding; studs; and wall panel systems. ■ American Iron and Steel Institute, Washington, D.C.

Circle 412 on inquiry card

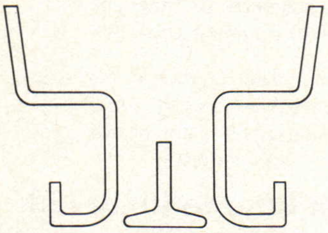
SOIL-RESISTANT CEILING PANELS / Ceiling board with a film facing is said to prevent chipping and flaking of paint, reduce corner and edge damage during installation, and discourage dust build-up on the installed suspended grid ceiling. White boards come in four decorative patterns and a range of sizes; they have an NRC rating of up to .80. Film-faced boards will not warp, buckle or sag, even in humid environments of new construction. Boards are UL-listed and are designated Class 25; the illustrated brochure gives physical properties and test results. ■ Owens-Corning Fiberglas Corp., Commercial Ceilings Div., Toledo, Ohio.

Circle 413 on inquiry card

Two views of the new Motorola corporate headquarters building in Schaumberg, Illinois.

The Carrier Moduline VAV System lets this office change its layout quickly and at low cost.

When Motorola wanted an air conditioning system that would be flexible enough to let them change floor plans in their new building easily, architects Graham, Anderson, Probst & White of Chicago gave them a Carrier Moduline® VAV System.



DIFFUSER DETAIL
MOTOROLA INSTALLATION

Moduline® supply, dummy and return air units are all conveniently integrated into the ceiling. With the slender line diffuser shown in cross section (inset) the partitions can be set in a wide variety of patterns. They can even be placed directly below the center of the diffuser, sending air to both sides of the partitions.

During the one-year moving-in period, Motorola has used the full flexibility of the modular ceiling and air system in their office layouts. Furthermore, as partitions are moved in future years, Moduline® control zones can easily be changed accordingly, without duct changes and usually without moving any air terminals. With custom ceilings or standard, no other variable volume system gives individual comfort at such low cost... or does it more unobtrusively.

Almost three-quarters of a million Moduline® units have been installed in offices and other structures to date. Write for the Moduline Systems brochure or contact your nearest (in major cities) Carrier sales representative.

Carrier Machinery and Systems Division, Carrier Parkway, Syracuse, New York 13201.

Number One
Air Conditioning
Maker

Carrier®

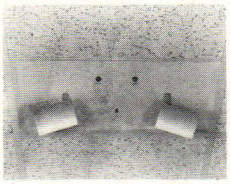
Division of Carrier Corporation

For more data, circle 43 on inquiry card

SOLAR HOT WATER HEATING / Available as a packaged system with matched components for easy installation, the *Solarcraft* hot water heating unit is said to provide from 55 to 85 per cent of year-round hot-water needs for residences, apartments, motels, and small commercial buildings. As a heat-transfer medium circulating through the system from solar panels to water heater and back, the *Solarcraft* system uses a polydimethylsiloxane (silicone) fluid. An advantage of the silicone fluid over other heat transfer mediums is said to be a low vapor pressure, which eliminates need for venting and liquid replacement; only a small air-cushioned expansion tank is required to absorb the thermal expansion of the medium. Also, the silicone does not attack building materials, is ionically pure, extremely inert, and low in viscosity and readily pumped. The 3½- by 8½-ft collector panels shown in the photo consist of a fiberglass-reinforced plastic tray containing a layer of high-temperature-resistant thermal insulation, a black-finished *Rollbond* absorber panel containing the fluid, and a two-layer plastic cover. *Solarcraft* water heaters have an auxiliary 4 kW immersion heater. ■ State Industries, Ashland City, Tenn.

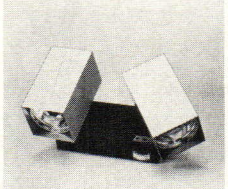
Circle 303 on inquiry card

EMERGENCY LIGHTING / Intended for easy installation in dropped panel ceilings, the "C-Ling Lite" emergency fixture has twin multi-directional white cylinders to provide direct lighting to stairways, doors, down hallways, etc. The self-contained unit is powered by nickel cadmium or sealed lead calcium batteries, and is said to supply fail-proof reliability with no maintenance. ■ Chloride Systems, Inc., North Haven, Conn.



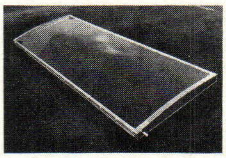
Circle 304 on inquiry card

EMERGENCY FIXTURES / These calcium-lead or nickel-cadmium battery-powered emergency lights incorporate an automatic solid-state charger and transfer circuit. Square and cylinder style fixtures 4¾-in.-long are offered; both swivel over a 45-degree arc. High-intensity quartz halogen lamps are equipped with recessed reflectors which distribute light in a wide field. ■ Yorklite Electronics, Inc., York, Pa.

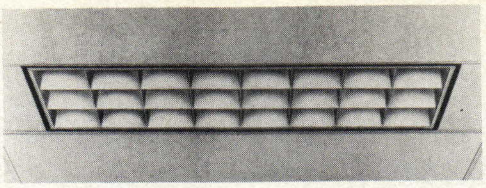


Circle 305 on inquiry card

SOLAR COLLECTOR / This panel uses a clear acrylic curved lens as a cover for the insulated copper heat-absorption plate. Soldered copper tubing contains the circulating water in the system. Panels have aluminum housing and end plates, with copper manifolds, and are provided with all hardware, including pump and valves. Control unit options include automatic thermostatic control for shut-down in freezing or overheating conditions; manual control with audio alarm; or manual system with drain. ■ TechniTrek Corp., San Leandro, Calif.



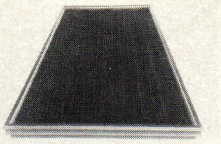
Circle 306 on inquiry card



FLUORESCENT FIXTURES / This line of parabolic recessed fluorescent lighting fixtures is available in both static and air-handling versions. The low-brightness fixture is said to virtually eliminate glare; vertical reflecting surfaces provide no dirt-collecting areas, and the acrylic enamel finish resists dust-attracting static charges. Parabolic fixtures are offered in a variety of sizes and louver cell configurations, as well as with static, air supply, heat exchange, or a combination air supply/heat exchange capability. ■ Westinghouse Electric Corp., Pittsburgh, Pa.

Circle 307 on inquiry card

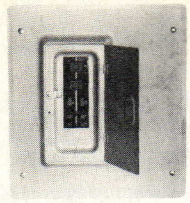
INDUSTRIAL SOLAR COLLECTOR / Designed for commercial and industrial space and water heating, this line of all-metal solar collector panels features ½-in. I.D. copper water passageways and extruded aluminum frames and absorbers. The "Model 200G" high-temperature panel (shown) has a double-glazed, 3/16-in. tempered glass cover, and fiberglass insulation on both back and sides. Suggested applications include radiant baseboard heating and air conditioning, where output temperatures are in the 150F to 200F range. Two other models provide lower output temperatures for space and water pre-heating. All panels are guaranteed for two years on parts and labor, and 10 years against leaks. ■ Alten Corp., Mountain View, Calif.



Circle 308 on inquiry card

more products on page 131

CIRCUIT PROTECTION / The *Pushmatic* riser panels are designed for indoor applications in medium- and high-rise residences; they are suitable for use as service equipment with a maximum of six main disconnect means. Circuit breakers feature push-button operation and bolt-on connections; panels have extra-wide gutters for risers and conduit, and will accommodate up to 40 branch circuits (with *Duplex* breakers). Riser panels are available in either 125- or 200-ampere models; six choices of panel interiors; and shallow or deep recessed enclosures. ▪ Gould/I-T-E Electrical Products, Spring House, Pa.

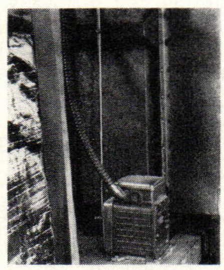


Circle 309 on inquiry card

REFLECTIVE INSULATING GLASS / *Solarban 490 Twindow* insulating glass incorporates a metallic gold coating to reflect the sun's heat and brightness, providing the highest energy-saving potential of any of this manufacturer's architectural glass products. The glazing consists of two panels of clear glass separated by a dry air space, with the entire unit hermetically sealed. The metallic reflective coating is applied to the inner surface of the outdoor glass panel. Transmitted light is a soft bluish-gray. ▪ PPG Industries, Inc., Pittsburgh, Pa.

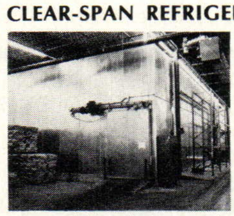
Circle 310 on inquiry card

THERMAL ENERGY RECOVERY / Said to significantly contribute to the optimum performance of heat reclaiming coil installations is the "tilt" actuator unit shown here. The heat transfer device (a closed evaporator-condenser system) is automatically tilted plus or minus one inch from the horizontal plane to obtain optimum heat recovery within its range, as sensed by the control system in response to the combination of indoor, exhaust air and outside air temperatures. ▪ Penn Div., Johnson Controls, Inc., Oak Brook, Ill.



Circle 311 on inquiry card

CLEAR-SPAN REFRIGERATED SPACE / Large refrigerated storage or processing spaces with a totally obstruction-free interior can be obtained by suspending prefab urethane-insulated ceiling panels from the roof supports of the sheltering building. The 4-in.-thick aluminum or galvanized steel-clad panels weigh at most 3½-lbs/sq ft, said to be well within the safety load factor of most industrial roof systems. Construction of the refrigerated room starts with the insertion of hangers between ceiling panels as they are assembled. An angle iron is bolted to these, and steel rods or straps connect the panel to the building roof. The prefabricated freezer shown is 40- by 60- by 18-ft, with a clear-span interior needing no structural steel. Air movement within the room is maximized, reducing refrigeration load. ▪ Bally Case & Cooler, Inc., Bally, Pa.



Circle 312 on inquiry card

more products on page 132

SAVE MONEY ON YOUR NEXT BUILDING. HAVE IT BUILT BY HAND.

Handmade masonry buildings do cost less. But how?

The mechanics of creating walls with mortar and brick, or block, or stone have changed little over the centuries. But technology in the production of masonry products has improved radically. So has on-site automation of materials handling. And so has masonry craftsman efficiency.

The exactness and flexibility of masonry construction avoids the expensive on-site refitting necessary with some materials. The mason can adapt to on-site construction variables. So he can save time. And money.

With prefabricated masonry panels, a building goes up even faster. Yet, the integrity of materials and the advantages of handmade quality and beauty are not forfeited.

Some modern masonry systems, such as engineered loadbearing masonry, are proving to be among the most economical building systems ever developed. They boast low initial costs which allow any project budgeter to rest easy.

Of course, initial cost savings are only part of masonry's economy story. Operating costs are nearly *always* significantly less for a masonry building. Once built, masonry construction savings build and build.

It all adds up to less—less initial cost, less operating cost.

Have your next building built by hand. By bricklayers. And save.

For more information about a masonry system that will lower your building costs, write to IMI.

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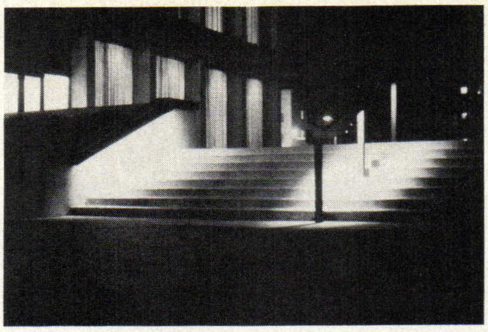
The Mason Contractors and Bricklayers Union of the USA & Canada.

For more data, circle 51 on inquiry card



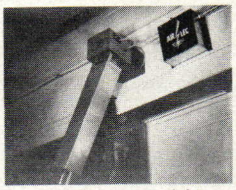
ILLUMINATED HANDRAILS / Fluorescent, incandescent, or cold cathode lamps are used in these lighted handrails to provide uniform low-level illumination for pedestrians. The *Rail-Lite*, constructed of extruded aluminum in sections up to 16-ft long, can be freestanding or wall-mounted; it can be mitered to change direction and go around corners. Railings meet OSHA requirements, and are also available non-illuminated to provide continuity of design. ■ Sterner Lighting Systems Inc., Winsted, Minn.

Circle 320 on inquiry card

ELECTRONIC SECURITY / *Terminus* is a programmable, variable-sensitivity security system available in two models: one for large department stores, warehouses, factories, and another for smaller retail firms and light industrial plants. The high-frequency perimeter sensors (shown being installed in photo) can distinguish between "soft" and "hard" shock pulses indicating an intrusion. An initial "hard" shock alerts the sensor to its preprogrammed instructions. An audible alarm will sound to alert guards; a perimeter sound alarm may be used to frighten would-be intruders, etc. A 1.5AH 12 VDC sealed back-up battery, continuously charged, is standard equipment. ■ Poly-Scientific, Div. of Litton Systems, Inc., Blacksburg, Va.

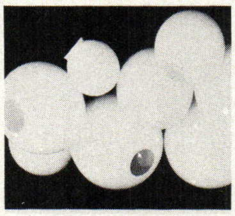
Circle 321 on inquiry card

AUTOMATIC DOOR CONTROLS / This line of automatic door closers has been redesigned to centralize all controls within one aluminum cabinet. This is said to facilitate installation and reduce maintenance requirements. The control kit comes complete with tubing and electrical wiring suitable for all normal installations. ■ Air-Lec Industries, Inc., Madison, Wis.



Circle 322 on inquiry card

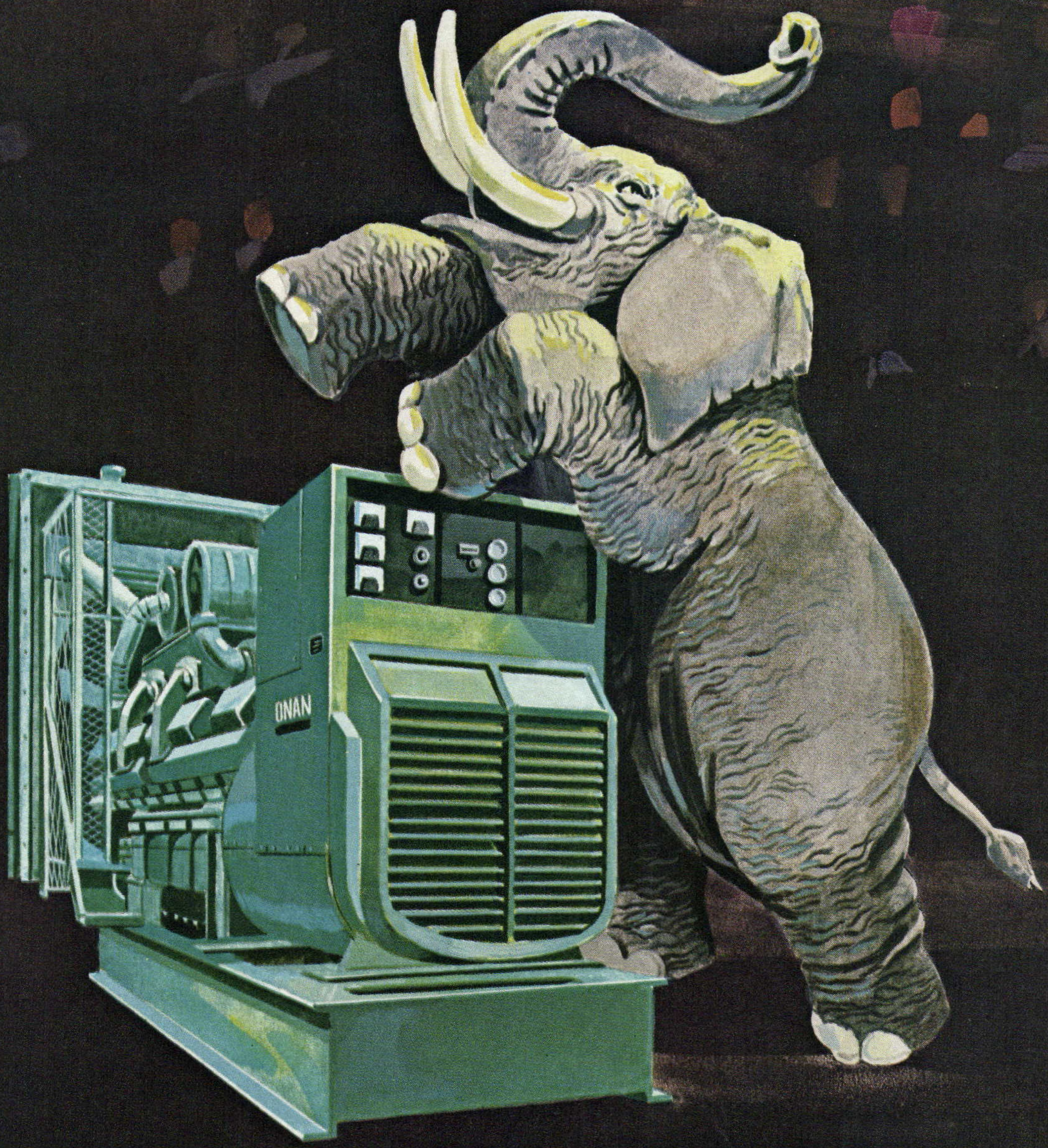
VANDAL-RESISTANT GLOBES / Manufactured in polyethylene and vandal-resistant *Lexan* polycarbonate, these lighting globes are available as spheres, cubes, acorns, saturns, trixoids and ellipsoid shapes in sizes ranging from 8- to 24-in. in diameter. Intended as replacement units, globes can be cut with the exact opening needed to fit an existing holder, or holders may be ordered with the globes. Where tamper-proof installation is required, the *Kam-Loc* cast aluminum holder may be ordered. ■ Trimblehouse Corp., Norcross, Ga.



Circle 323 on inquiry card

Here's big power you won't forget!

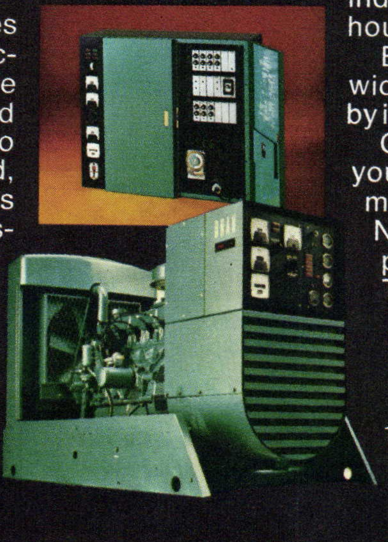
(Up to 750 KW)



Over the years and around the world, Onan electric power systems have been turning in memorable performances in all kinds of applications – from hospitals to civil defense installations to office buildings to circuses – wherever reliable standby or prime power has been in demand.

Today, Onan is one of the first names people think of when the subject of electric generating equipment comes up. We make more than 45 different sizes and hundreds of different models – from 1 to 750 KW, gas/gasoline or diesel-powered, air-cooled or radiator-cooled. There's even a 500 KW unit powered by a gas-turbine engine.

Our large capacity sets, like all our smaller models, are designed, manufactured and tested with meticulous care. Once we've engineered a system that we figure is as reliable as any other on the market, we go several steps further.



Our hard-nosed testing people spend countless hours putting Onan systems through grueling trial runs, using our multi-million-dollar test facilities.

Then we back up each *system* (engine, generator, automatic transfer switch) with a commercial/industrial warranty for 5 years or 1500 hours. (Details available upon request.)

Beyond that, we also maintain a world-wide parts and service network, standing by in case your customers ever need help.

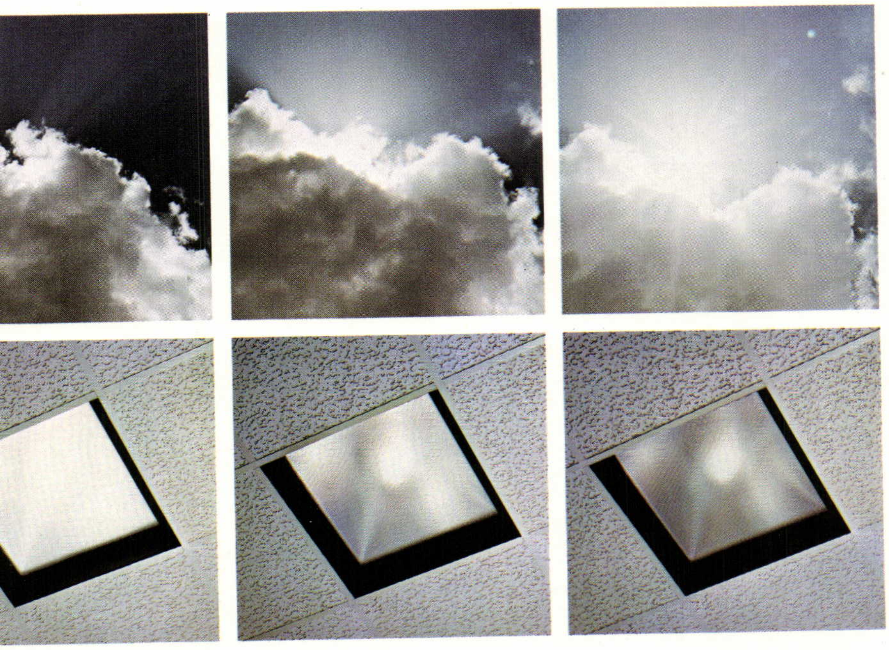
Onan. The name to remember when you specify big power. For more information, contact: Onan, 1400 73rd Ave. N.E., Minneapolis, MN 55432 Telephone: 612/574-5000. TELEX: 29-0476, TWX: 910-576-2833.

Onan®

The systems approach to power . . . worldwide.

For more data, circle 54 on inquiry card

HERE COMES THE SUN. THERE GO THE LIGHTS.



If sunlight supplements artificial lighting, lamp power is reduced.

Control can be by programmed timers, by computer interface, or by manual override.

AEC compensates automatically for initial system "over-design" and anything else that effects illumination levels.

And never do you pay for more energy than what's necessary to maintain optimum illumination.

Taken one step further, AEC even allows you the flexibility of designing your own wattage lamps. Because by setting the footcandle level where you want it, you also get precisely the wattage you need to fit any given application.

AEC FROM WIDE-LITE LETS YOU TAKE ADVANTAGE OF SUNLIGHT, AND CONSTANTLY ALLOWS FOR OTHER LIGHTING FACTORS. AUTOMATICALLY.

Finally, lighting has come out of the dark ages. Thanks to AEC (Automatic Energy Control) exclusively from Wide-Lite, a Dimming system that does a whole lot more.

Like in Alexander City, Alabama, where it's currently dimming HID lamps both automatically and manually. Compensating for sunlight, lamp depreciation, work requirements and other factors in Russell Corporation's vast new textile facility. And shaving an estimated $7,000 per year off the utility bills in the bargain.

THE DAWN OF THE "LUMEN-STAT."

Wide-Lite's AEC controls the level of illumination in much the same way as a thermostat controls the level of heat. How? By starting with our advanced dimming capability and then going one better—adding ceiling-mounted photocell sensors. These "read" the level of illumination and operate the dimming controls quietly by solidstate circuitry.

All you do is set the system at the desired footcandle level. As room or outdoor area illumination levels fall from lamp and dirt depreciation effects, lamp power is automatically increased.

IT'S SO AUTOMATIC, IT EVEN *PAYS* FOR ITSELF.

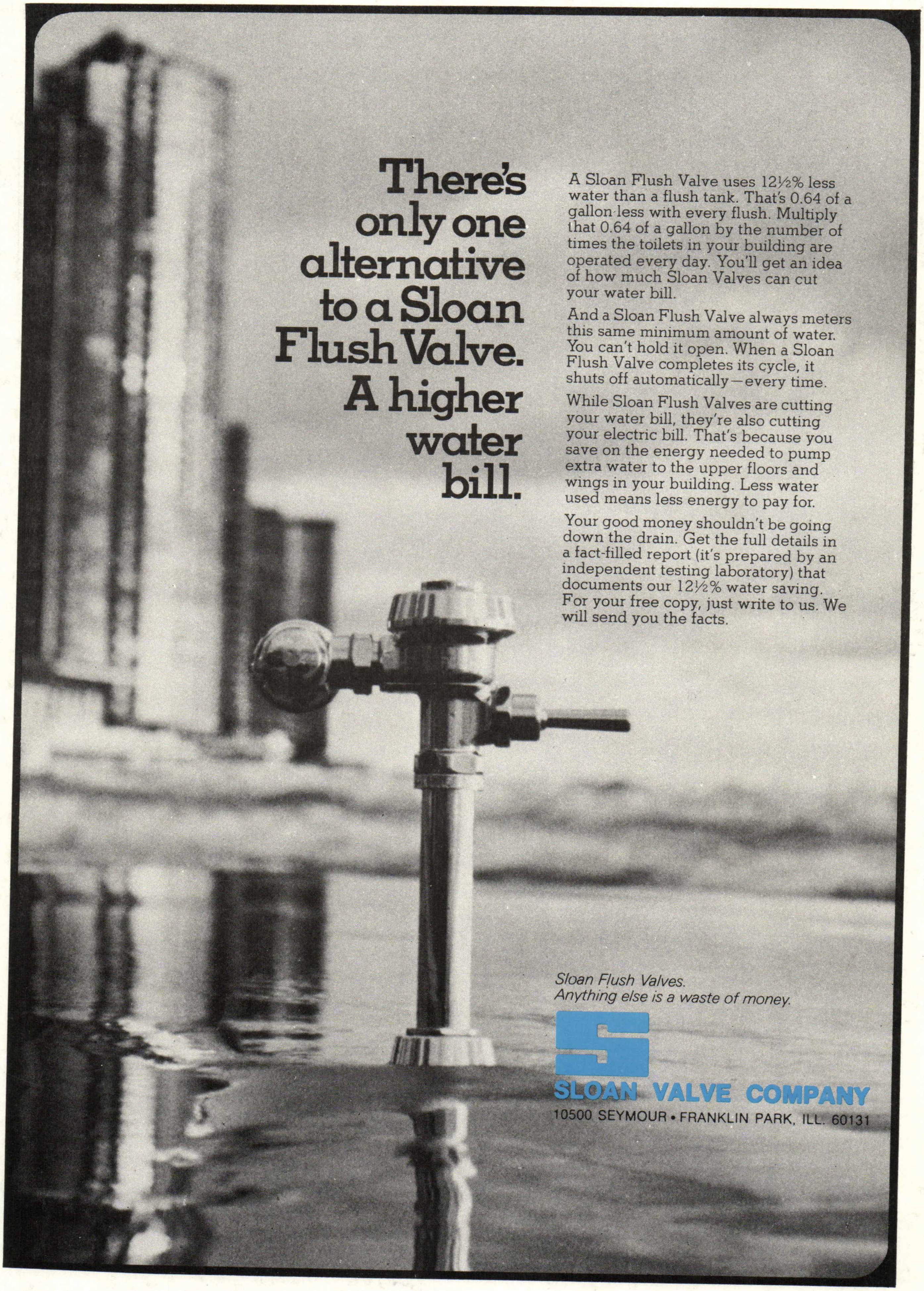
As if that weren't enough, Wide-Lite's AEC gives you another bonus after two to three years of use. Because at current electricity rates, that's when the AEC Dimming System typically finishes paying for itself by saving up to 25% in power costs. Of course, the higher the rates, the greater the return on your investment.

And only Wide-Lite offers the range of dimming, the automatic operation, and the kind of equipment that extends lamp life and improves lumen depreciation. All Wide-Lite equipment is covered by our published three-year limited warranty, too.

Next time the sun goes down, AEC will be improving lighting efficiency somewhere. Indoors or out. Commercial or industrial. Haven't power costs increased enough to make you start looking for ways to save?

WideLite

P. O. Box 606, San Marcos, Texas 78666
Wide-Lite® products also manufactured in Australia, Belgium (for Europe), Canada, Mexico, Great Britain, Venezuela and South Africa.
A company of the Esquire Lighting Group



For more data, circle 75 on inquiry card