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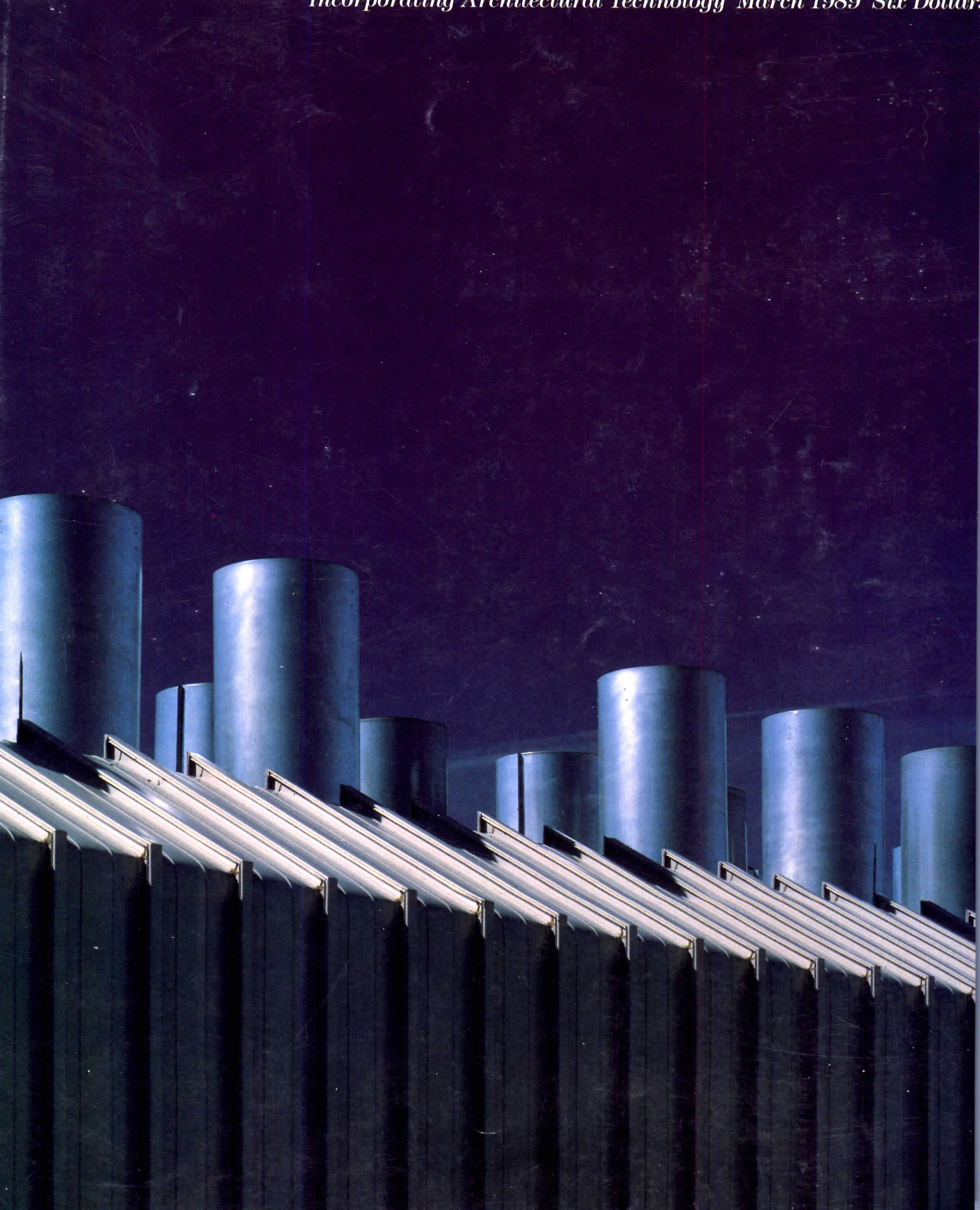

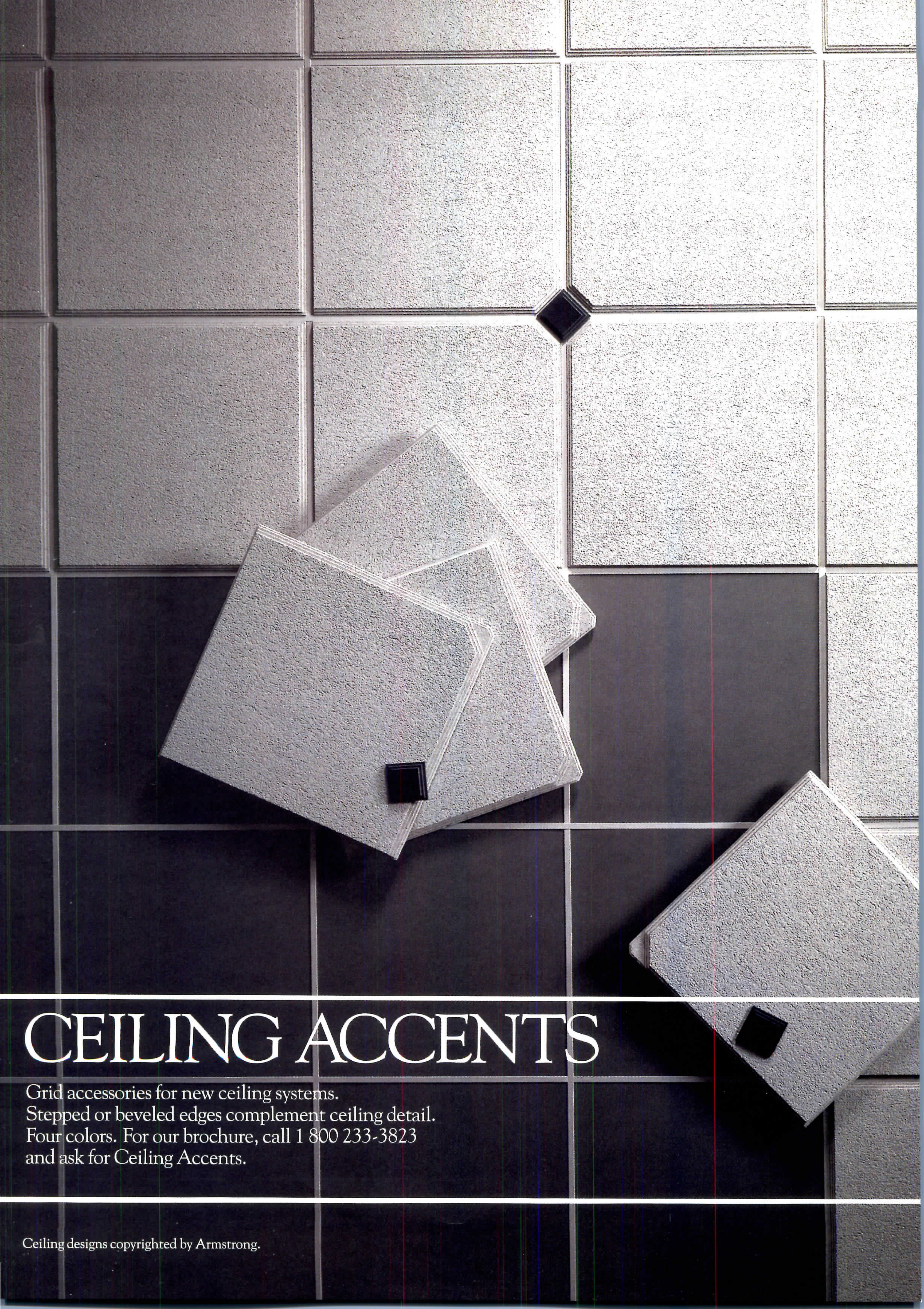
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EVENTS

April 4-6: Training Program on Marketing and Promoting Downtowns, Hilo, Hawaii. Contact: Vicki Onderdonk, National Trust for Historic Preservation, 1785 Massachusetts Ave. N.W., Washington, D.C. 20036.
April 4-6: Restaurant and Hotel International Design Exposition and Conference, Los Angeles. Contact: National Expositions Co., 15 W. 39th St., New York, N.Y. 10018.
April 6-8: AIA Housing Committee meeting on "Affordable Housing," Washington, D.C. Contact: Joanna Bache at Institute headquarters, (202) 626-7361.
April 7-9: "IMAGE(S)": Monterey Design Conference, Monterey, Calif. Contact: Brook Ostrom, California Council/AIA, 1303 J St., Suite 200, Sacramento, Calif. 95814.
April 8-9: Conference entitled "Thinking the Present: The Last Twelve Years of American Architecture," Cambridge, Mass. Contact: Beth McKinney, Harvard University Graduate School of Design, 48 Quincy St., Cambridge, Mass. 02138.
April 8-10: AIA Committee on Design conference, "Synthesis: Architecture, Craftsmanship, and Design," Washington, D.C. Contact: Joanna Bache at Institute headquarters, (202) 626-7361.
April 10-12: Course on Designing Electrical Systems for Hazardous Locations, Madison, Wis. Contact: E.K. Greenwald, Dept. of Engineering Professional Development, University of Wisconsin-Madison, 432 N. Lake St., Madison, Wis. 53706.
April 13-14: Symposium entitled "Time and Place in Architecture," College Station, Tex. Contact: Norma Teetes, Texas A&M University, College of Architecture, College Station, Tex. 77843.
April 16-18: International Ceramic Tile Exposition, Dallas. Contact: Marvin Park & Associates Inc., 600 Talcott Rd., Park Ridge, Ill. 60068.
April 17-19: International Colloquium on Stability of Metal Structures, New York City. Contact: Structural Stability Research Council, Fritz Engineering Laboratory 13, Lehigh University, Bethlehem, Pa. 18015.
April 17-20: National Computer Graphics Association Annual Conference and Exposition, Philadelphia. Contact: Sharon Sutton, NCGA, 2722 Merrilee Dr., Suite 200, Fairfax, Va. 22031.
April 17-20: "Electrical Systems Design for the Non-Electrical Engineer," short course, Madison, Wis. Contact: E.K. Greenwald, Dept. of Engineering Professional Development, University of Wisconsin-Madison, 432 N. Lake St., Madison, Wis. 53706.
April 20-22: Symposium on "Louis Sullivan and the Architecture of Democracy," Grinnell, Iowa. Contact: William Deminoff, Grinnell College, Grinnell, Iowa 50112.
April 20-23: Annual California Preservation Conference, Los Angeles. Contact: Eric Stoltz, CPC, 433 South Spring Street, Suite 1024, Los Angeles, Calif. 90013.
April 27-28: Seminar on Project Management for Engineering and Construction, Chicago. Contact: Association of Energy Engineers, 4025 Pleasantdale Rd., Suite 420, Atlanta, Ga. 30340.
April 27-28: AIA Interiors Committee meeting cosponsored by the Washington Design Center, on "Trends that Affect Interior Design," Washington, D.C. Contact: Christopher Gribbs at Institute headquarters, (202) 626-7589.
May 5-8: AIA Annual Convention, St. Louis. Contact: Ketchie Brassel at Institute headquarters, (202) 626-7396.

LETTERS

Rudolph at Yale: An incorrect statement appears in the subhead and introduction to Michael J. Crosbie's interview with Paul Rudolph on the Art & Architecture building at Yale [see Nov. '88, page 100]. Your interview was not the first time since the completion of the building that the architect discussed the A&A building for publication. When I was preparing an article on this building several years after it had opened (after the *favella* but before the fire), Paul Rudolph spent more than an hour with me in his office. I had previously interviewed many other people and spent three solid days in the building (sleeping in the top-floor guest room, talking to dozens of students and faculty and staff, and studying the building in all its grandeur and failure). Although I did not present his views in question-answer format, his views were reflected throughout the article, along with the views of many others.

Paul Rudolph hated my article, which appeared in *The Architectural Forum* (July/August 1967), and resented Editor Peter Blake for publishing it. He did not permit Peter Blake to publish anything else of his for some years at least. The article was both loved and hated by readers.

We all survived that difficult time. I can understand why certain things are inadvertently dropped from memory or intentionally forgotten in a subsequent interview.

Ellen Perry Berkeley
Shaftsbury, Vt.

Clients in Cleveland: I was delighted to read the excellent article on the urban rebirth that Cleveland has been experiencing in the last decade [see Dec. '88, page 88]. Jonathan Barnett indeed focused on the most relevant issues and reviewed the most prominent architectural urban planning projects recently completed, proposed, or designed, including our recent Galleria at Erieview. However, I am sorry he missed pointing out an important factor in this urban redevelopment. In addition to the planning, design, and sound economic considerations, mention should be given to one of the prime developers behind several of the major projects mentioned. After all, architects and planners would not be given the stage to perform if the clients who hired them were not recognized for their visions as well.

One such participant in the process in Cleveland is Richard Jacobs, who has clearly provided or is providing a leadership role in the development for three of the major projects mentioned in the article (the Galleria, Society Center, and Ameritrust headquarters) and who should be credited for carrying a great deal of the responsibility to see that these projects are executed with all of the significance of sound design, economics, urbanity, vitality, etc.

Richard Jacobs and his brother David Jacobs of Jacobs, Visconsi & Jacobs are longtime Cleveland-area residents and are also premier developers in Ohio and the Midwest as well as being the new owners of the Cleveland Indians. Having worked closely with them in the execution of the Galleria, we know first-hand of their personal commitment to the renaissance of this city, like many others in mid-America requiring a major emotional and financial commitment. I suspect that Philip Johnson, Cesar Pelli, and Kohn Pedersen Fox, all of whom are working with the Jacobs brothers in Cleveland, would share some of our respect and admiration for their commitment to quality as well as participation in seeing their vision of the new Cleveland become a reality in their lifetime. We all hope for visionary clients such as them, and we should give them more recognition for their performance as well as for allowing us to participate in the process.

Anthony Belluschi, AIA
Anthony Belluschi Architects
Chicago

Solutions for Cities: Andrea Oppenheimer Dean's "The State of the Cities" article [Dec. '88, page 71] should be read by anyone involved, interested, or living in a city. We intend to make it required reading at San Diego's City Hall. I would like to make one correction, however. She writes that "San Diego voters approved a 'Quality of Life' initiative limiting residential development to 8,000 units. . . . " This was one of two ballot measures in the city, which were complemented by two ballot measures in the County of San Diego. All four measures were rejected by the voters.

While the issue of growth must be dealt with—preservation of neighborhoods, protection of open space and sensitive lands, and public facility adequacy, including transportation—the election campaign in San Diego progressively focused on a residential building permit limitation as a solution and perhaps as a way of avoiding the real problems. Since the failure of the ballot measures, elected officials and interested citizens have embarked on a more realistic course of action, focusing on the problems and do-able solutions.

Michael Stepner, AIA, AICP
City Architect, San Diego

The Institute

ACSA/AIA Honor Charles Moore For Excellence in Education

Charles W. Moore, FAIA, has been designated as recipient of the 14th annual Topaz medallion for excellence in architectural education. In one sense, this 1989 award, given by AIA and the Association of Collegiate Schools of Architecture, brings the program full circle. Moore studied under the first Topaz award recipient, the late Jean Labatut, as a graduate student at Princeton in the mid-1950s.

Unlike Labatut, however, Moore has not become identified with a single institution, nor predominantly with teaching and administration. While active as an educator almost continuously since 1950, teaching in at least 10 different schools, he has been in practice for an even longer period. After working in several other architectural and engineering offices between 1947 and 1962, Moore founded or co-founded no fewer than seven architectural firms, and maintains an association with four of them at present. Additionally, he has co-authored at least seven books, and his penchant for travel is almost legendary. A witty and engaging speaker and juror, Moore is in constant demand for lectures, conferences, competitions, and other events around the globe, and finds it hard to say no, particularly since his own architecture draws heavily on vernacular sources and traveling is the best way to discover them.

Several of the previous winners of the award have established reputations as distinguished practitioners as well as educators, but Moore's accomplishment in that area is remarkable. His individual and collaborative designs earned 32 major design awards through 1988, including five national AIA honor awards, with three of those latter coming in just the last four years. He is widely regarded, along with Robert Venturi, FAIA, as a seminal force in developing alternatives to standard modernist architecture. Moore wryly notes that he has been "called a grandfather of postmodernism. I object to that because it's like having a grandson who grows up to be a kleptomaniac." But however one defines and judges the postmodern revolution and its products, the phenomenon has been a significant factor in education and practice for at least 20 years.

Moore was born in Michigan on Oct. 31, 1925. The Halloween date seems significant, since his work and teaching are filled with gentle mischief and his buildings abound with tricks and treats. His contributions to both pedagogy and the building art consist of a quiet undermining of the predictability and self-importance that modern design and theory had assumed until a generation ago, and the introduction of genteel hedonism into a rather puritanical architectural mainstream. While Venturi was developing irony and restoring high-pedigree classical sources to the architectural dialogue, Moore was cultivating whimsy and finding inspiration in more ordinary buildings of many cultures.

Moore's pedagogy was strongly influenced by an architect of very different design inclinations, Louis I. Kahn. The younger man never formally studied with the older, but he made a point to sit in on many of his studios. There, he saw a master teacher subordinate his own inclinations to those of the students. "With Kahn, the student's project always took center stage. When I'm being a good studio critic, I'm similarly being interested in the work that the students are doing, rather than in my own preoccupations. Part of the pleasure of being a teacher is loosening people up and making them more inclined to do interesting things. Not putting a special stamp on them, but spreading a set of attitudes and ways of working."

Somewhat paradoxically, one result of this student-centered technique is the development of disciples. Moore says that his early work grew out of Kahn's and in retrospect that influence seems clear. Likewise, for all his self-effacement in the studio, Moore has attracted legions of stylistic followers.

Much of this is a function of personality. Until recently, he made it a point to work with entering (rather than advanced) students in order "to open them up, make them confident about their abilities. Like clients, students have a lot to offer, and they need to be reinforced, not beaten down."

Moore quite consciously assumes the role of uncle to his students, or lately, he notes jokingly, the role of grandfather. This means building their confidence, entertaining them with soft-spoken charm and subtle wit, and suggesting possibilities rather than laying down rules. The technique is undeniably effective—"he's like the Pied Piper" says Franklin Israel, a teaching colleague at UCLA.

Moore has a knack for involving a multiplicity of people in his various projects, be they teaching, writing, or carrying on a practice. He encourages collaboration, saying that "working by yourself is not the way the world is." He also blurs the line between teaching and practice. Most of his partners and many of his staff have

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Below, Charles Moore in a recent studio at the University of Texas.

Dana Norman—U.T. Austin school of architecture


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The Institute *from page 23*
been former students, and he was an extraordinary early supporter of the Urban Innovations Group, UCLA's student-staffed practice arm.

His current design studio at the University of Texas at Austin involves a combination of individual and group efforts, and he likes to teach in teams, since it is "faster and more interesting" than solo efforts. Given his schedule, which frequently resembles Brownian motion on a planetary scale, it is also the only way to participate in a conventionally structured educational system. At times his hydra-headed life stretches institutional flexibility to its limits, but his colleagues have high regard for his value to their institutions. Harvey Perloff, the late dean of the school of architecture and urban planning at UCLA, once declared that "an hour with Charles Moore is worth as much to a student as a month with a junior faculty member." And the University of Texas, his other teaching post, wooed him as seriously as it pursues linebackers and business professors. Moore began teaching there in 1986 because "they allowed me to write my own ticket."

While his current academic allegiances are to the Sunbelt, Moore is best known for teaching work north of the 37th parallel. He has taught at U.C. Berkeley, Princeton, Harvard, and Yale, where he taught from 1965 to 1980 and was also dean of the school of architecture for the first five years of his stint. This Yale period was probably his finest as an educator; it has so far accounted for over half of the entries on his roster of distinguished students, marked his longest tenure and greatest administrative involvement with any institution, and coincided with a highly inventive and exploratory period in his own design work.

The early Yale years were also marked by strong social consciousness. While the architectural world will never forget a famous Ivy-League design studio field trip to Las Vegas, it needs to be reminded that Moore took his Yalies to Appalachia to provide community design and construction assistance. During that New Haven period, his architectural office also produced designs for local public housing. Perhaps ironically, the social ferment of the '60s was a factor in Moore's withdrawal from a strong academic leadership role. "I once liked administering, but I finally came to think that I'd done my stint," he recalls. "After 1968, chairmen had less to say about the intellectual life of the school."

Since those years, Moore also has tended to have overlapping involvements with schools such as Yale, UCLA, Cal Poly Pomona, the University of Houston, and now the University of Texas. "I have a very hard time leaving places, but don't have a hard time starting at a new one. I don't have a life plan, but every 10 years or so I'm itching to go somewhere else."

Today, at 63, he expects to continue at Texas for another seven years until the mandatory retirement age, and thereby complete his last 10-year cycle in architectural education. After that, the itch will probably take him back to his Sea Ranch condominium, the place that, among all his residences, he most considers home. By then he will have spent just under half a century in architecture schools as a student and as a teacher.

There can be little doubt about the importance of those five decades. In the words of one of his former students, USC Architecture Dean Robert Harris, "Charles Moore is simply the most intelligent, most generous, and most inspiring teacher of our generation." That this educational record has been combined with a full, innovative and highly regarded design career makes the accomplishment that much more remarkable.—John Pastier

Institute Honors Seven for 'Distinguished Achievement'

AIA has announced seven winners of 1989 Institute honors recognizing "distinguished achievements that enhance or influence the environment and the architectural profession." The honors will be conferred in May at AIA's annual convention in St. Louis.

Hugh Hardy, FAIA, chaired the jury on Institute honors. Other jurors were Glenn Garrison, AIA, of New York City; Frank Gehry, FAIA, of Santa Monica, Calif.; Charles Guggenheim of Washington, D.C.; Bill Lacy, FAIA, of New York City; Lydia Tan of Oakland, Calif.; and student member Douglas Bailey of Bozeman, Mont.

The winners are:

- V'Soske Inc., a leader in carpet design and manufacturing, cited for the "ability to energize others in the exploration of materials, texture, decoration, and form." Sixty years ago Stanislav V'Soske founded the company that bears his name. He rev-

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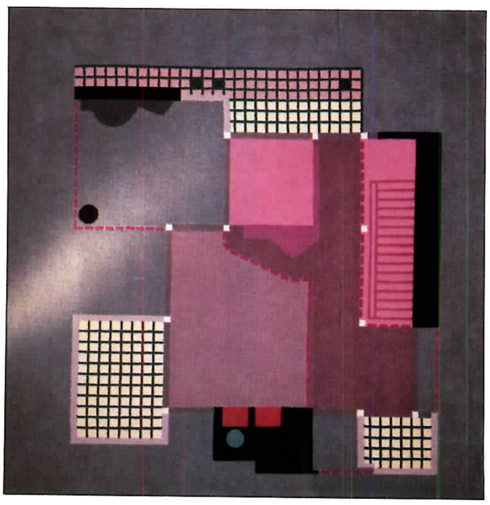
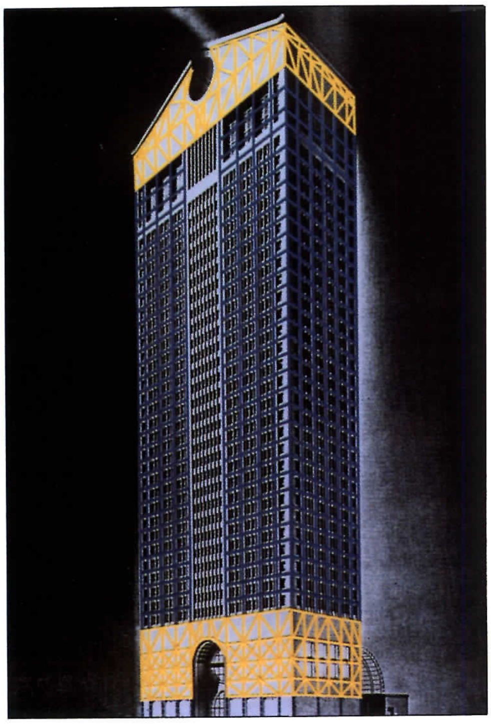
Below, colorful Rug #1, designed by Richard Meier and produced by V'Soske.



The Institute *from page 26*
olutionized the carpet industry when he invented the hand-tufted wool rug. In 1979 V'Soske initiated a program of collaboration on a collection of rugs by outstanding architects and designers, including Michael Graves, FAIA, Charles Gwathmey, FAIA, Richard Meier, FAIA, and Arquitectonica.

• Leslie Robertson of New York City, an engineer cited for his contributions to "his and our profession in terms of the understanding of the impact of natural forces on high-rise buildings and resultant structural and architectural solutions." A native of Los Angeles, Robertson graduated from University of California, Berkeley, in 1952. He was named a partner at the Seattle engineering firm Worthington & Skilling and moved to New York City to open a branch office. Known for his innovative designs and contributions to the technology of super-tall buildings, Robertson also has collaborated on the Portland Museum of Art, the AT&T building, and the World Trade Center.



Above, Engineer Leslie Robertson's towering steel structural system of the Johnson/Burgee AT&T Building.

• Eduard Sekler, architect, historian, and professor at Harvard's graduate school of design. A native of Vienna, Sekler studied at Technische Universitaet and London University before coming to the United States in 1953 as a Fulbright fellow. He was the first director of the Carpenter Center for the Visual Arts and served as its chairman of visual and environmental studies. His numerous books and publications include *Josef Hoffman: The Architectural Works*. "Professor Sekler combines, in a unique way, the insight of the theoretician and historian with the architect's view and understanding of his total environment," said the jury. *continued on page 33*

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• David S. Haviland, dean of the school of architecture at Rensselaer Polytechnic Institute in Troy, N.Y. For more than 20 years, Haviland has influenced the evolution of architecture as business through his writings on practice and project management issues. He is a contributing editor and co-author of the 1988 *Architect's Handbook of Professional Practice.* Citing his dedication and consistently high-quality contributions to the practice of architecture, his nominators wrote, "We are, all of us, more insightful, and better prepared to undertake practice issues that impact all architects."

• The American Academy in Rome, a center for independent study and advanced research in the fine arts, humanities, and classical studies. Founded in 1894 by architect Charles Follen McKim, the academy continues to be an intellectual and artistic haven for architects, scholars, and artists.

Each year the academy awards the Rome prize to approximately 30 promising Americans, providing stipends and studios for them to pursue independent work for six months to two years. Since its founding, the academy has awarded more than 850 Rome prize fellowships. In addition, six to eight distinguished scholars, architects, and artists are invited to Rome for several months' residency each year.

In citing the academy, the jury wrote: "It continues to provide commodious quarters for its select enclave of postgraduate fellows and guests and afford them a perspective of history and culture that is unique to Rome. Louis Kahn, Charles Moore, George Nelson, and Robert Venturi, to name but a few, are among those architects whose work has been enriched and directly influenced by a sojourn at the academy."

• Battery Park City, a public and private development on the southern tip of Manhattan. The 92-acre tract, leased by the Battery Park City Authority to private developers, was cited as "a unique and special place to work and live."

Rather than create an isolated community, the master plan by Alexander Cooper and Stanton Eckstut extends the existing street grid and view corridors into the project and forges a strong relationship between new buildings and the existing World Trade Center complex and the city's transporation system. The commerical center includes 8 million square feet of office space in four towers, designed by Cesar Pelli & Associates, ranging in height from 33 to 50 stories. Two lower, domed structures mark the main entrance at Liberty Street. The Winter Garden, an indoor public space of telescoping glass vaults, connects the offices and opens onto a three-acre plaza.

Rector Place, the first residential component of the 1979 master plan, provides 2,217 apartment units in 11 buildings. The

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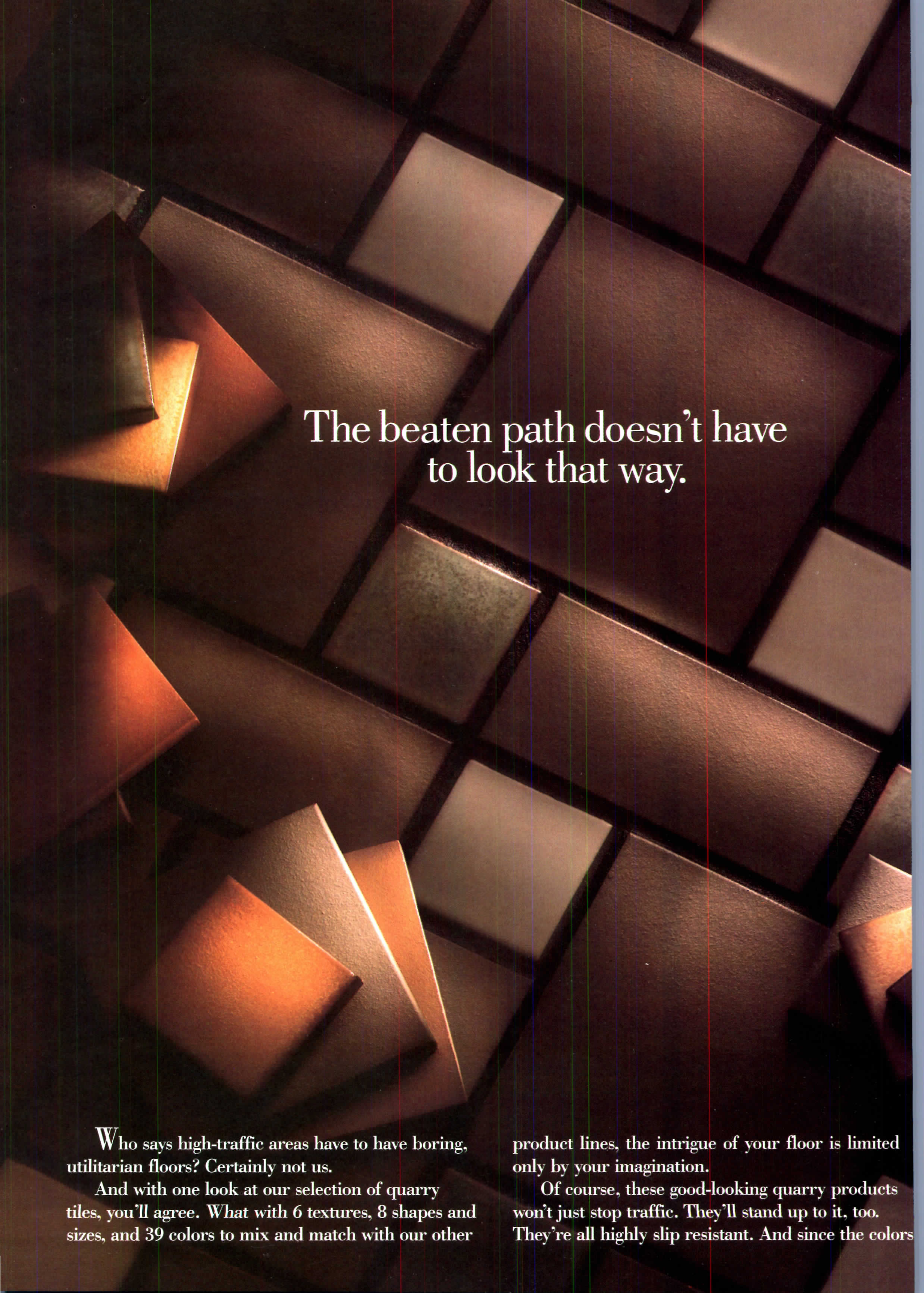

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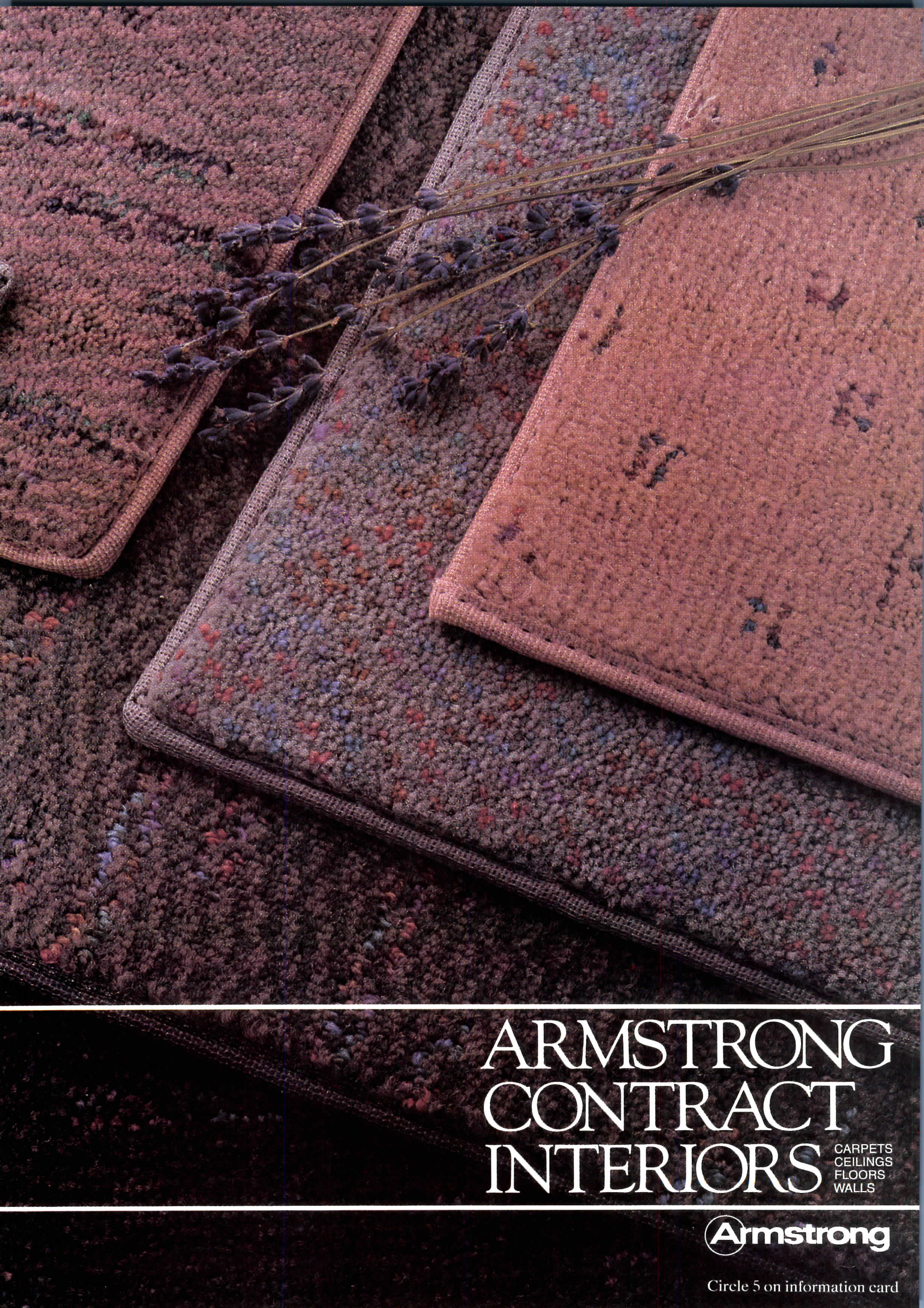

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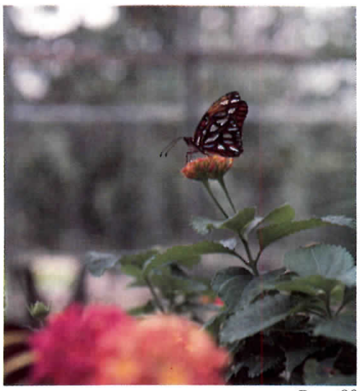
Right, Day Butterfly Center resident in Callaway Gardens, Ga.



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Below, right: Lovins residence greenhouse. Left, service aisle in a new MIT lab.

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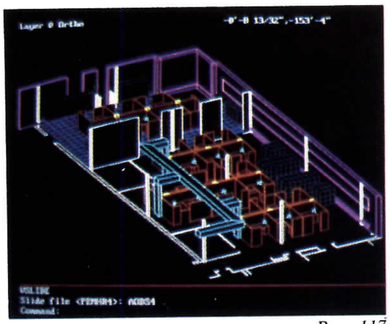

Johnson Control's new HVAC and partition system for open office.

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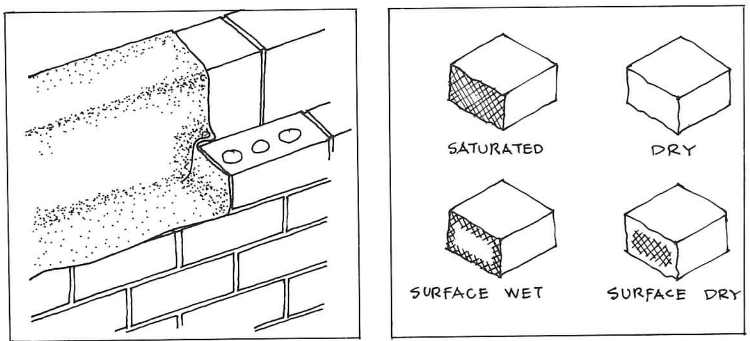

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Waterproof brick walls require end dams (left) and drying (right).

Cover
Miles Laboratories Inc. pharmaceutical research center in Westhaven, Conn., by Haines Lundberg Waehler (see page 94). Photograph by Fred George.

Fay Schroeder had a problem. She needed a quality office system for the loan operations area at First Commerce Corporation's lead bank in New Orleans. But aesthetics were going head to head with economics.

"We needed a comfortable and productive working environment," she says. "We certainly wanted it to look nice. But since it's a back office area, we didn't want to spend a lot of dollars on it."

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riverfront park system links a series of individual parks totaling approximately 50 acres. "Against all odds," wrote the jury, "the public and private sector as well as the art and business community have come together to create, over time, a quality, humanistic environment."

• Niels Diffrient, a furniture designer and author from Ridgefield, Conn. The jury called him "the prominent industrial designer of our time." Born in Star, Miss., Diffrient moved to Detroit as a child and studied art at Cass Technical High School. He attended Wayne State University and Cranbrook Academy, where he received a Bachelor of Fine Arts in design and architecture. Diffrient worked for five years with Eero Saarinen, assisting with the design of two Knoll chairs. After receiving a Fulbright fellowship in 1954, Diffrient worked for 25 years with Henry Dreyfuss. In 1981 he left the Dreyfuss firm to pursue special projects in furniture design, including chair lines for Knoll and Sunar Hauserman. Diffrient is the author of *Humanscale,* a three-volume publication from MIT Press that addresses human factors in design.

Eleven Foreign Architects Named AIA Honorary Fellows

Eleven architects have been named honorary fellows of the American Institute of Architects for their notable contributions to architecture and design. The honor is conferred on architects of "esteemed character and distinguished achievements" who are not U.S. citizens. The new honorary fellows will be invested at AIA's national convention this May in St. Louis.

The eleven architects are:

• Louis Gerard Arretche, Paris architect and educator, who has been chief architect for several major public buildings and restoration projects for the French government. His atelier in Paris has been the training ground for many of France's important practicing architects.

• Sir Philip Manning Dowson, a founding partner of Arup Associates and a member of the Royal Fine Arts Commission. He was knighted in 1980 for services to architecture and was awarded the RIBA gold medal in 1981. His major works include residential colleges and laboratories at Oxford and Cambridge and the concert hall at Snape Maltings. He now is working on the master plan for Paternoster, an area adjacent to St. Paul's Cathedral in London.

• Lorenzo Aldana Echeverria of Guadalajara, Mexico, former president of the College of Architects of Mexico and the Society of Mexican Architects. His major projects include the tourist expansion of Palenque, Chiapas, the monumental Plaza of Garibaldi, and the Church of San Bartolome in Mexico City.

• Sverre Fehn of Oslo, Norway, the 1986 Saarinen visiting professor at Yale's school of architecture and now a professor at the Architectural School of Oslo. In 1982 he was awarded the Prince Eugene medal for outstanding artistic achievement by the King of Sweden. Fehn's major works are the Museum at Hamar, the municipal library at Trondheim, and the Nordic Pavilion for the Venice Biennale.

• Josef Paul Kleihues of West Berlin, the 1987 Saarinen visiting professor at Yale. He designed the International Building Exposition in West Berlin, the Youth Hostel and Educational Center in Wolfen, and the Neukolln Hospital in West Berlin.

• Toshio Nakamura, Tokyo architect and writer. He was one of three founders and is now editor in chief of *A+U* magazine.

• Shin'ichi Okada of Tokyo, architect responsible for the Japanese Supreme Court in Tokyo, the Nippon Dental College campus in Niigata, the Tsukuba University Central Library, and the Okayama Municipal Museum of Oriental Antiquities.

• Juhani Pallasmaa of Helsinki, director of the Finnish Architecture Museum from 1968 to 1983. His major works include the Finnish Embassy in Beijing, restoration of Old Harbor Market in Helsinki, and the Finnish Cultural Institute in Paris.

• Johan Richter of Aarhus, Denmark, the country's Royal Building Inspector. Among his projects are concert halls in Aarhus and in Bjorneborg, Finland, and several London Docklands projects.

• Alfred C.W. Roberts, Toronto architect and specialist in cost control and management in architectural projects. He played a major role in the construction of such projects as the New Brunswick Hospital program, the University of Alberta Heath Services Center, and the Ottawa Civic Hospital.

• Aldo Rossi, of Milan, who now teaches at the Harvard graduate school of design.

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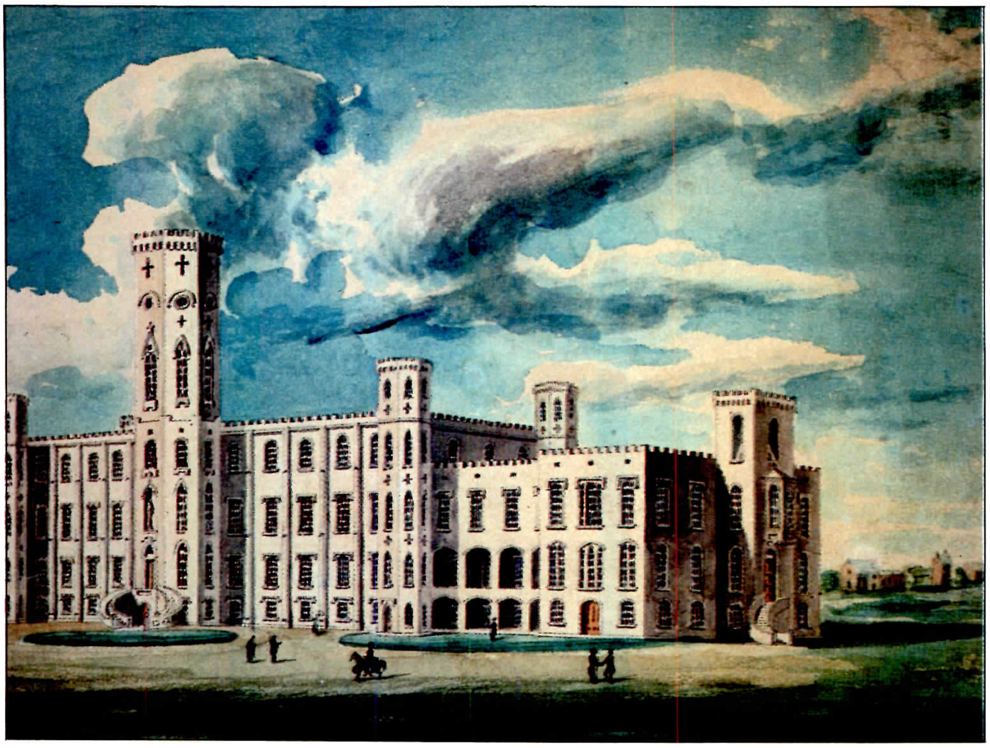

Courtesy of Smithsonian Institution Archives

The first major exhibition of the work of Robert Mills is on view through April 2 at the Octagon Museum in Washington, D.C. Organized by the American Architectural Foundation, the exhibition entitled "Robert Mills: Designs for Democracy" features original drawings, watercolors, books, and photographs of his work spanning half a century from 1802-1852. Supported by a grant from the Otis Elevator Co., the exhibition will travel and will open next in Columbia, S.C.

A protégé of Thomas Jefferson, Mills apprenticed in the office of Benjamin Henry Latrobe, and he considered himself to be the first native-born American to train in this country for a career in architecture. The exhibition attempts to document not only the development of Mills's career but the importance of architecture in the realization of the goals of the expanding American government. Organized thematically and chronologically, the exhibition shows the development of building types necessary for the implementation of democracy: capitols, courthouses, government building, universities, hospitals, jails, and monuments. Mills adapted and reinterpreted classical architecture and established his version of Greek revival as the style most expressive of the new American political system.

Although many of Mills's works are well known (the Washington Monument, U.S. Treasury Building, U.S. Patent Office), he has never been the focus of a major exhibition. The pen and ink and watercolor drawing shown above is Mills's unrealized proposal for the Smithsonian Institution. A controversial competition in 1846 selected a design by James Renwick; Mills was named supervising architect.—Lynn Nesmith

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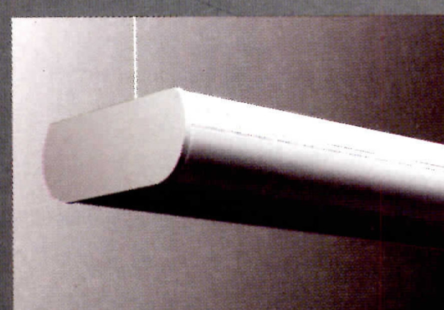

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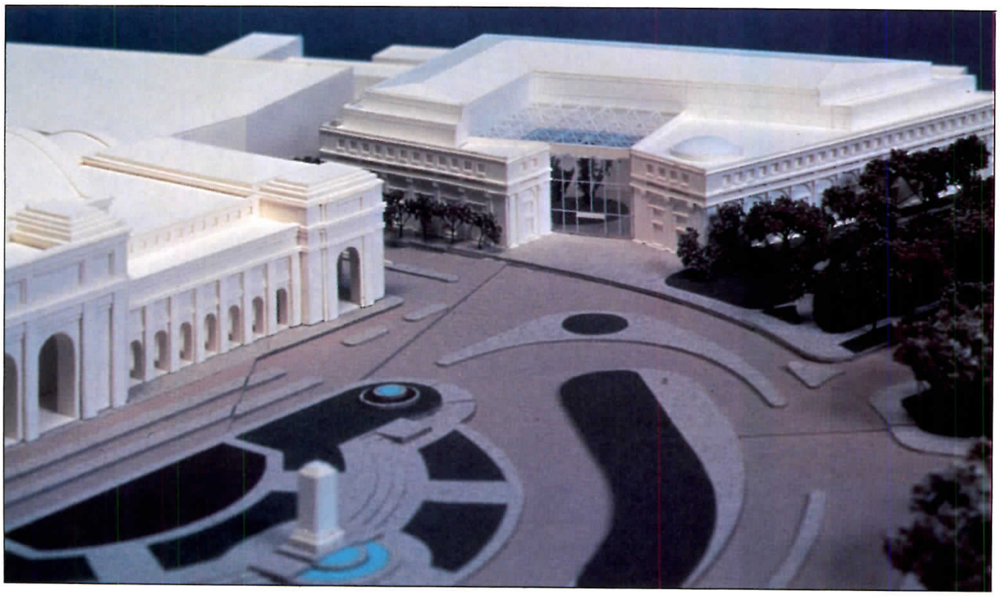
Barnes Wins Design Competition For Federal Judiciary Building



Edward Larrabee Barnes/John M. Y. Lee & Partners has been selected the winner of an "architectural/financial" competition for a new judiciary office building to be located adjacent to Daniel Burnham's recently restored Union Station in Washington, D.C.

In a city where politics overshadows architecture, the restrained and respectful scheme by Barnes can be viewed as an architectural equivalent to President Bush's aspiration for the country: Barnes's building incorporates forms and a scale sympathetic to Burnham ("kinder"), while a large glazed entranceway and skylit, landscaped atrium literally opens the building up to the public ("gentler").

The concept of a government building on this prominent parcel of land is not new. The site fell under the jurisdiction of the 1901 McMillan Commission that provided plans for the Mall and Capitol grounds. In the 1970s the government was still trying to determine the most appropriate use for the land. In 1985 Congress authorized a competition that would provide a preliminary design for a new headquarters for the judiciary branch and also would give the government alternatives to the "old-fashioned" process of financing new buildings with federal tax dollars.

A major factor in the selection of the winning team was the developer's financial package. The program called for an unconventional financing approach where a developer pays for the construction, leases the building to the government, and in no more than 30 years turns the building over to the government.

Architect of the Capitol George M. White, FAIA, (whose office will oversee the building's construction) solicited proposals from approximately 50 development firms, and, from a field of 19 who responded, invited five developer/architect teams in March of 1985 to submit full-scale design and development proposals. The announcement of the 10-member jury's selection of Barnes, in association with developer Morton Zuckerman's firm Boston Properties, was made at a Senate subcommittee hearing led by Sen. Daniel Patrick Moynihan (D-N.Y.), a longtime supporter of quality architecture in the capital, as well as a major force in the revitalization of Pennsylvania Avenue.

Barnes's winning scheme was cited as an "elegant solution continuing in the mainstream of modernist architectural philosophy . . . that succeeds in making a meaningful architectural statement without competing with Union Station for visual prominence." The principal facades of the building will be clad in the same white granite as the station, while the building's basic configuration will be a large trapezoid with an off-center skylit atrium.

The proposal by the other four finalists ranged from an almost direct classical revival design by Kohn Pedersen Fox to a somewhat contextual modernist scheme by Henry Cobb, FAIA, of I.M. Pei & Partners.

Skidmore, Owings & Merrill (credited to both the New York City and the Washington offices) proposed an abstracted classical scheme recalling both Union Station and Burnham's Old Main Post Office to its west, as well as SOM/Washington's own recent work that has drawn from the city's rich collection of Beaux-Arts buildings. Kevin Roche's scheme echoes its classical neighbors but anchors the main entrance with a bold archway flanked by columns topped with sculpted eagles.

The competition process was unusually slow, but Moynihan was enthusiastic about its results, saying he had "never seen an architectural competition which produced such eminent entries."—LYNN NESMITH

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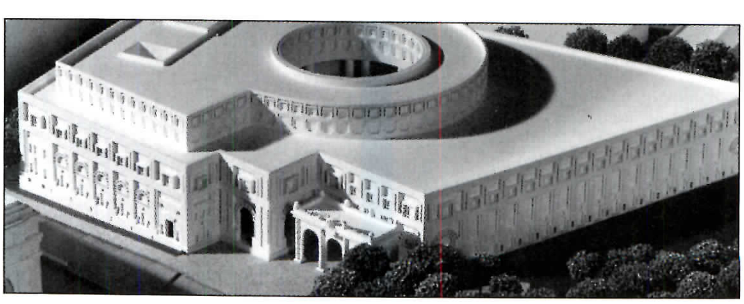
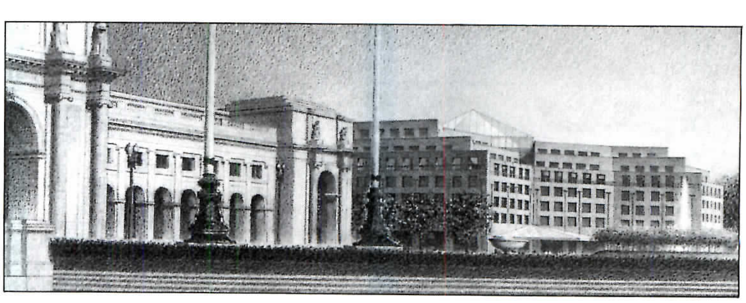
Above, Barnes's winning scheme. Below, clockwise from top right: SOM; I.M. Pei; Kohn Pedersen Fox; and Kevin Roche.



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Solving the problem.

Street & Lundgren, an Aberdeen, Washington architectural firm, was hired to design a fire station for a nearby town. The project was completed, there was a grand opening celebration, and Street & Lundgren received the "keys to the city."

Almost six years later, the town filed a suit against Street & Lundgren. There was water leakage into the fire house and some hairline cracking of exterior masonry. The town was afraid the building might not be structurally sound.

Roy Lundgren called Dale Currie, DPIC's regional claims manager in San Francisco, and described the situation. The leakage appeared to be due to the town's failure to waterproof the structure on a regular basis. The cracking was almost certainly cosmetic, due to expansion during freezing.

Dale believed the problem was solvable.

He made two trips to Washington during the next few months; first, to meet with the town and hear its grievances and second, to conduct a roundtable discussion to mediate the dispute. It was a delicate situation. The town's building inspector was convinced the structure had serious problems. Street & Lundgren and the project's structural engineer were confident the building had been well-designed.

Dale managed to keep the dialogue open. Ultimately, the town hired a consulting structural engineer to assess the situation. This engineer's opinion fully supported Street & Lundgren, and convinced the town its fire station *was* structurally sound. Now, all that was left to be done was help the town resolve the existing problems. In the conciliatory environment established by Dale, Street & Lundgren provided maintenance guidelines for the fire station as well as advice on how to repair the cracked masonry.

Dale continued to work with the town's attorney. A year and a half after the initial action, the town agreed to a *dismissal with prejudice*, meaning it was satisfied no further litigation was necessary.

R. Dale Currie

Richard Dale Currie is an assistant vice president and manager of DPIC's regional claims office in San Francisco. He is a graduate of the University of California at Berkeley and the John F. Kennedy University School of Law and a member of the California bar. He has over a dozen years of experience in construction-related claims management.

Claims happen. It's what you do when they happen that shows the stuff you're made of.

"I liked Dale Currie immediately for his grasp of the situation, his concern about our welfare, his willingness to come up promptly and talk the situation over.

Dale was very skillful in seeking a solution to the city's doubts about the building—a difficult job based on the evidence that had been presented by their home-grown people, whom they know and trust. He showed a willingness to understand their problems, and to come to a resolution that satisfied them. He showed his concern for them in a way that made them very comfortable. And they responded very positively to him.

The idea of the roundtable was his. And he mediated and orchestrated it. He suggested what we should do to allay the fears of the city and we did it. And everything worked.

In essence, what Dale Currie and DPIC did was put out a fire before it really got started.

And you realize, from a business standpoint, all this cost us was our time."

Roy E. Lundgren

Roy Lundgren is a principal in the firm of Street, Lundgren & Foster, a 39-year-old architectural firm based in Aberdeen, Washington. He is a past director of the Southwest Washington chapter of the AIA and former building code commissioner for the city of Aberdeen. We value our relationship with his firm and thank him for his generosity in talking about an important subject for design professionals.

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Study Assesses Thermal Comfort In Existing Office Environments

The Center for Environmental Design Research at the University of California, Berkeley, recently released results of the first phase of "A Field Study of Thermal Environments and Comfort in Office Buildings." The study, sponsored by the American Society of Heating, Refrigerating, and Airconditioning Engineers (ASHRAE), developed procedures for assessing thermal environments and occupant comfort in existing office buildings.

Principal investigators Gail Schiller, Edward Arens, Charles Benton, and Fred Bauman conducted the study of 10 office buildings in the San Francisco Bay area, comprising 2,342 visits and 304 volunteer participants. The buildings ranged in size from 54,000 to 2 million square feet.

A primary goal of the study was to test whether comfort standards developed by ASHRAE through laboratory studies in which sedentary people are exposed to constant, uniform thermal conditions are suitable for real buildings. The researchers maintain that the occupants' physical and mental activities, as well as numerous functional and esthetic conditions in a real office, may influence their thermal response, which therefore cannot be measured adequately under laboratory conditions.

The first phase of data collection—geared to the needs of ASHRAE as sponsor and its engineering and research communities—is complete, and analysis is still being done. The researchers suggest that their initial analyses indicate that:

- Optimum thermal acceptability is lower than levels assumed by current ASHRAE Standard 55-81.
- Workers prefer conditions slightly cooler than those established by the current standards.
- There may be particular problems with low air movement in buildings.
- Satisfaction with thermal conditions is lower than with nonthermal aspects of the work environment.
- Satisfaction with work-area temperature is higher when the degree of individual control increases.

The study consisted of two broad types of measurement. A qualitative thermal assessment survey, completed several times by the volunteers during a week-long investigation, yielded 53 fields of data on thermal sensation, thermal preference, comfort, mood, clothing, and activity. (A background survey, including demographic data, health characteristics, and work and job satisfaction, was compiled for each participant.) After each thermal assessment survey, taken during the performance of normal work, the researchers took quantitative physical measurements at the volunteer's workstation to establish air temperature, dew point, globe temperature, air velocity, plane radiant temperature asymmetry, and illuminance. The measurements were taken at three levels: ankles, torso, and head and neck. For comparative supplementary physical data, stationary environmental measurements were taken at a separate, representative workstation during the week the occupants were surveyed.

One aspect of the study presented in the report reveals that, based on three perceptions of thermal sensation (cool, neutral, or warm), 82 to 84 percent of the participants were comfortable during the monitoring periods. However, in terms of thermal preference, only 52 to 53 percent of the participants said they wanted no change in the environment. Usually, in both winter and summer, they wanted to be cooler. Also interesting is that the building that best satisfied occupants' thermal preferences in both seasons was one with operable windows and no mechanical airconditioning. In terms of correlating the occupants' thermal satisfaction with air movement, "cool and drafty" was perceived as comfortable, while "warm and stuffy" was perceived as an uncomfortable condition.

During both seasons, temperatures cooler than the ASHRAE Standard temperatures—21.8 degrees centigrade (approximately 71 degrees Fahrenheit) in winter and 24.5 degrees centigrade (approximately 76 degrees Fahrenheit) in summer—by 0.5 degree centigrade (about one degree Fahrenheit) were preferred. This held true even though the subjects wore clothing closely resembling what ASHRAE describes as "summer clothing" year-round.

In their preliminary analysis, the researchers concluded that satisfaction with the thermal environments in office buildings was lower than that achieved under laboratory conditions. They also suggested that centralized, autonomous environmental control systems are inherently limited in their effectiveness, and they called for both field and laboratory studies to investigate new methods of providing individual control through operable building envelopes or user-controlled systems such as task ventilation or spot heating and cooling.

The researchers acknowledged the limitations of conducting the study only in the San Francisco Bay area, which enjoys a temperate climate. Their future studies, including tests now going on in Thailand, will compare airconditioned offices with naturally ventilated offices. They hope this comparison also will yield some indications of cultural differences in thermal perceptions. The researchers also plan to extend the existing data base by repeating the San Francisco study in other climate zones in the United States.

Copies of the preliminary report are available from the Center for Environmental Design Research. Contact CEDR, 373 Wurster Hall, University of California, Berkeley, Calif. 94720, or call (415) 642-2896.—M. Stephanie Stubbs

Two Buildings Recognized in Energy Design Awards Program

The Georgia Association/AIA and Georgia Power Co. recently announced the Carter Presidential Center and the Scarborough Building at Emory University as the winners of the 1988 Georgia Energy Design Awards program.

The Carter Presidential Center, (shown below) designed by Jova Daniels Busby in a joint venture with Lawton, Ememura & Yamamoto, houses a research center, two museum theaters, a town meeting hall, and a full-scale replica of the Oval Office within its 130,000 square feet. Its energy-efficient features include below-grade construction to minimize building heating and cooling loads, overhang/window designs to maximize shading, and efficient envelope and HVAC design.

© Gabriel Benzur, Inc.

The Scarborough Building, designed by Tippett & Associates/Architects Inc., comprises a 150,000-square-foot renovation and a 50,000-square-foot addition to a clinical medical facility at Atlanta's Emory University. To boost energy efficiency, the building includes combination of separate cooling plants, insulated glazing with minimal glass in the east and south facades of its insulated envelope, an energy-efficient lighting system, and upgraded electric service.

The awards program, which is in its sixth year, promotes professional and public recognition of architecture in Georgia through acknowledgement of the effective blending of energy-conscious design features and architectural quality.

News continued on page 47

Deaths

Hans Blumenfeld: Architect, Author, Philosopher, Planner

Hans Blumenfeld wrote an autobiography, *Life Begins at 65* (Harvest House Ltd., 1987), when he was well into his 90s. It is a surprising story, more like a movie script than an architect-planner's life. Here we perceive the ingredients that help make up the whole man: the unlikely young soldier, the unsuccessful architect, and the mellowing, patient, and understanding philosopher-planner. His zest for travel, conversation, and inquiry informs his thinking in the book, which should be seen as an essential part of the curriculum for the education of the seasoned designer of cities.

Blumenfeld was born in Osnabrück (West Germany) in 1892. From 1924 to 1927 he worked in architecture offices in New York City, Baltimore, and Los Angeles. After a stay in the Soviet Union, he returned to the United States in the late '30s, working for General Motors on the elaborate model "city of the future" for the 1939 New York World's Fair.

In 1941 he became research director of the Philadelphia Housing Association, and from 1945 to 1952 worked with that city's planning commission, whose division of planning analysis he headed beginning in 1948. In the late '40s and early '50s, he concurrently advised the United States government on the reconstruction of Germany.

Blumenfeld was deputy director of the newly founded Metropolitan Toronto Planning Board beginning in 1955. During the '60s he lectured at the University of Toronto and was a board member of the Canadian Institute of Planners and a consultant to the Montreal City Planning Department.

Those who knew him were impressed by the quality of Blumenfeld's thinking and conversation on a range of subjects, especially urban problems. Although he held impressive professional credentials, his approach to complex questions such as metropolitan growth and transportation may have seemed naive. But despite his gentle manners and mild demeanor, he never missed an all-too-frequent opportunity to point out when the emperor-commissioners were not wearing any clothes. He was always ready with suggestions for appropriate urban garments, which, he ruefully noted in his autobiography, were rarely adopted. He believed in the potential of architecture as a civilizing influence and saw modernism as a humanistic response.

Blumenfeld, 97, who had become a Canadian citizen, died late last year in Toronto after his first serious illness, a stroke.—Simon Breines, FAIA

Mr. Breines, a longtime friend of Hans Blumenfeld, is a principal of Pomerance & Breines in New York City.

Raymond S. Thompson, AIA, was cofounding president of the Indianapolis Chapter/AIA. Since 1983 he had been a member of the Indiana State Board of Registration for Architects, serving as chairman in 1988. Except for his college years at the University of Illinois, where he earned a Bachelor of Science in architecture, and subsequent military service, Thompson was a lifelong resident of Indianapolis, working for 35 years with James Architects & Engineers. Most recently, Thompson was principal in charge for the design of the new Indianapolis Zoo He died last October at the age of 60.

David J. Platt of Staten Island, N.Y., an architect with Olympia & York and a member of its management team for the renovation of Canary Wharf in London, was among the passengers on Pan Am Flight 103 out of London, which exploded with a terrorist's bomb in December. He was a graduate of the New York Institute of Technology. He was 33.

Harwood Taylor, FAIA, was most recently with the Houston firm Taylor/Lundy/HKS. He also was cofounder and chairman of the board of Neuhaus + Taylor Architects and principal in charge of design in its successor firm 3D/International. He earned a Bachelor of Architecture from the University of Texas and attended Virginia Military Institute, Stanford University, the Sorbonne, and the University of Houston. He died in December. □

Varied Perspectives on the Evolution of Technology

Imagining Tomorrow: History, Technology, and the American Future. Edited by Joseph J. Corn. (MIT Press, $17.50.)

This book is a retrospective look at technological development, taken under the premise of gaining a prospective view of the efforts of present technology. *Imagining Tomorrow: History, Technology, and the American Future* is recommended to those in the design disciplines and should be required reading for all students of architecture.

The book contains 10 essays from a variety of authors, most of them contemporary scholars, and an epilogue by Joseph J. Corn. Several the chapters are case studies of predictions once made about "new" technologies. The essays present a critical review of the explosive development of new machines and design ideas introduced between the end of the 19th century and the 1960s. During this period, it was common to think of machines and even such things as new urban plans and futuristic housing designs as ushering in a better tomorrow, possibly even utopia. Corn refers to the essays as a history of "the future that used to be."

One author, Jeffrey L. Meikle, describes the development of streamlined design during the Depression, and how plastic became the "material of the future." According to Meikle, streamlined design and the use of materials such as plastic, which made streamlined design possible, were society's attempt to escape from the harsh economic restraints of the period.

Architects will especially like Brian Horrigan's chapter on the changing appearance and meaning of the "home of tomorrow." Horrigan's primary contribution is his documentation of the efforts of architects, engineers, and inventors to bring housing into the mainstream of American technological development. Individuals such as R. Buckminster Fuller, Le Corbusier, and Richard Neutra tried to redefine the house in the 1920s and '30s, in response, according to Horrigan, to the social and economic movements of the period.

Architects and urban designers will appreciate also Carol Willis's chapter on the utopian cities of the future. As the United States became more urban during the 1920s and '30s, the skyscraper evolved into an important image of the utopian city. High-speed transportation and many other inventions of the era were envisioned as the technological supports for blocks of skyscrapers proposed by urban futurists.

Historian Carolyn Marvin provides an interesting history of a seemingly simple invention—the electric light. Around the turn of the century, the uses proposed for the electric light far exceeded its basic function as an illuminating device. These included projecting messages on the moon, signaling schemes to strike up wireless communication with extraterrestrials, and advertising on clouds.

In his epilogue, Corn observes that the writers make three important points concerning the past visions of the future. First, many of the predictions were erroneously exaggerated or wildly utopian. Second, the utopian predictions and imagined uses of technological developments were widely accepted by scientists, popular science fiction writers, big business, and society in general. Third, the reader, given his or her own range of experience, is made to imagine what the consequences of such beliefs and projections have been to date, and what they may be in the future.

Identifying these three themes and projecting their impact on the future, however, are two aspects of the book that deserve criticism. The themes may be difficult for the beginning student of technological assessment to comprehend. Some mention of them in the introduction would alert the reader to consider them as the technological developments are reviewed. Second, the reader must imagine what the actual effects of the previous technological developments have been on current history and on the future. The authors obviously are experts on their subjects, so it would be interesting to know what they think the future of these technological developments will be.

The book is well written and makes for interesting reading. The chapters are well illustrated and contain excellent lists of references for further study. *Imagining Tomorrow* will make the contemporary designer pause to consider how previous technological developments have affected the present, and what they may hold for the future.—Charles W. Graham, AIA

Mr. Graham is associate director of housing research at the center for urban affairs at Texas A&M University.

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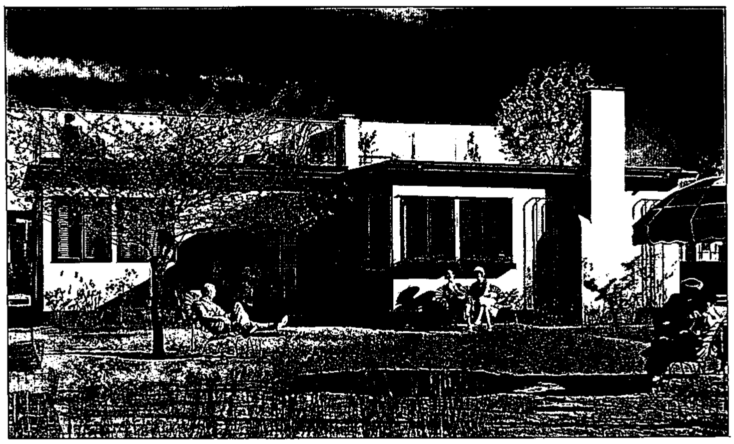
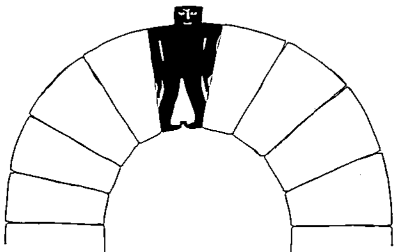


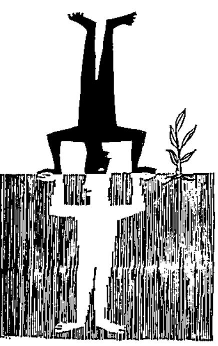
Top, Prototype mass-produced house by architect Howard Fisher for the 1933 Chicago fair. Bottom, LOF Co.'s 1945 'Kitchen of Tomorrow.'

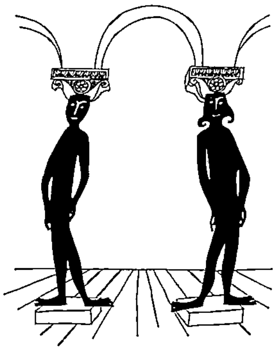


What it Feels Like to Be a Building. Forrest Wilson. (Preservation Press, $14.95).

Whoever has taught children knows that their best frame of reference is their own bodies. In a stroke of genius, Forrest Wilson, master teacher and architect, has used this well-known fact to explain architectural structures to "seven-year-olds and older" by imagining buildings as living beings and asking them how *they* feel. The buildings have answered his questions by means of exciting and clever pictures and one-line explanations that allow us "children," whether seven or 70 years old, to feel in our own bodies how buildings work.

It would be tempting for this reviewer to comment on the subtle graphic and verbal means by which Wilson effortlessly achieves his goal, but this would spoil the fun for both children and adults. Yet, how can an engineering teacher, who has labored for the best part of his life to explain buckling to architecture students, ignore the eye-opening figure labeled "long thin columns tend to bend," which makes elementarily obvious the concept—first explained mathematically by Euler more than 200 years ago—in two human columns (one masculine and one feminine) graciously bent at the hips? Or the clarification of Newton's principle "action equals reaction" by means of an upside-down black man supported by his white mirror image, conveying graphically the inevitability of the law and its mystery? Or the need of a thrust to balance the tension in the cable of a suspension bridge, expressed by two people pulling each other by outstretched arms and leaning backward?





Drawings by Forrest Wilson

"Teaching structures by mathematics," I was once told by a famous European structuralist, "is easy: you put a few numbers in a computer, push a few keys, and read the answer. But to teach by words alone, you really have to know what it's all about." I would add that to teach by graphics alone you must know structures even better, and I would conclude that Forrest Wilson is indeed a master structuralist. This book, kept in hiding for so many years, is now available again and is a joy to peruse. I advise all parents of future architects to get it, and, if by chance they happen to be architects, who knows, they may even learn structures themselves—this time painlessly smiling.

—Mario Salvadori

A noted structural engineer, Mr. Salvadori has taught structures at Columbia University and has written several books on the subject.

Energy Design for Architects. American Architectural Foundation; Alexander Shaw, editor. (Fairmont Press, $54.).

Remember the flood of energy research materials developed through AIA's Energy Professional Development Program (EPDP) almost 10 years ago? There was *Energy in Architecture* (the "silver bullet"), the EPDP workshop looseleaf binders (the "black notebooks"), and the *Energy Monograph Series* (the skinny little books with gray or brown covers, depending on whether they were design- or practice-oriented.) This was good stuff, I know, because I was part of the AIA Research Corp. team that put these materials together. If you also are familiar with these documents, you know that their major flaw is not the material presented, but that the organization and linkages among topics were not as cogent as they might have been.

Energy Design for Architects, edited by Alexander Shaw for the American Architectural Foundation (which absorbed the remainder of the AIA Research Corp.), sweeps away these problems in a clearly organized 350-page format. It distills the best information (text and graphics) from the EPDP materials into an easy-to-use handbook broken down into four major categories: the design process, fundamentals, design elements, and design analysis.

However, it is the portions of the book supplementary to the main text that make the major tie-ins that are essential to a useful handbook: for example, a detailed, cross-referenced index, a list of figures with titles explaining what they show, and an extensive glossary punctuated with illustrations. With respect to *how* architects need to use research information, it is a great idea to have two tables of contents, one topical and one with great detail. It is obvious that editor Alexander Shaw and technical consultant/editor Earle Kennett, both major participants in the original EPDP efforts and both with architecture backgrounds, thought extensively about and took great pains to refine the presentation and usefulness of the information.

Energy Design also presents some new and some updated information that may prove valuable in the way energy design is incorporated into the practice of architecture today. For instance, a chapter on codes and standards explains the Model Energy Code and its three primary paths to achieve compliance: systems analysis, component performance, and acceptable practice ("going by the book"). It also contains a list of major standards organizations and the specific building energy issues that their standards cover, as well as manufacturers' associations that have developed their own standards for components.

Another chapter of new information, entitled "Construction and Commissioning Process," posits that the effort for energy design can be wasted unless the building is "finished right," and it offers the architect tips on project planning and overseeing the construction process. Specific topics include developing good project documentation, preparing operation and maintenance manuals, and construction specifications for contractor requirements prior to occupancy. Additionally, the "Building Types" chapter comprises an interesting collection of building-specific energy design considerations, condensed and referenced to magazine articles that cover these subjects in detail. Sections on the building types presented (offices, educational facilities, retail stores, apartments, hotels/motels, and health facilities) include information on overall energy-conscious design strategies, form and space organization, lighting systems, and appropriate HVAC design. Finally, "Energy Management and Controls," an area that has seen many changes over the past decade, has been brought up to date.

Energy Design is a laudable evolution and expansion of the original EPDP effort, a process we (among ourselves) called "meatball research," stealing from Hawkeye Pierce's analogy of "MASH as meatball surgery." That EPDP process was posthaste to the best of everyone's ability—after all, there was an energy crisis going on. The new *Energy Design* has all the right refinements of a next phase, sort of like taking schematics into design development. The U.S. Department of Energy, which funded the effort, chose the right editors. If you don't have the original materials, this is the book you want as a first reference. If you do have them, save them as "deep pocket references" to *Energy Design for Architects.*—M. Stephanie Stubbs

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The Rajput Palaces: The Development of an Architectural Style. G.H.R. Tillotson. (Yale University Press, $45.)

Borrowing has been a part of the architectural tradition for centuries. Indian craftsmen responded no differently when faced with the Moslem conquest of their borders and readily assimilated Islamic influences. The existing architectural conditions of the time have become shrouded in the mystery of the architecture itself and have remained largely unexamined by scholars.

The Rajput Palaces goes beyond the view of borrowed Islamic imagery and invention to uncover the deeply entrenched Hindu foundation that underlies Rajput palace development. This exploration separates and distills Rajput architecture from a primary reading of an architecture of foreign imposition. Rather, the author demonstrates with vast research and articulately described examples that Rajput architecture is a rich, indigenous style altered by Islamic characteristics, which deserves an independent place in the history of Hindu architecture.

The Rajputs were dynastic clans prolific in the construction of rather magical palace complexes in western and central India. These palaces have numerous repetitive architectural and programmatic elements, spaces, and features that enable the tracing of their transformation and disposition over time. In an introduction, the author presents the context, climate, and general history, which are critical to an understanding of the architecture. This is followed by chapters based on an analysis of stylistic evolution, culminating in what the author terms "Rajput mannerism." Within this history is woven the constant recognition of the essence of these structures as an inherited Hindu architectural tradition of intention.

The Hindu world is less ordered and rigid than the Islamic and concerns itself with organic growth and natural harmony. The palace architecture, in mirroring complex attitudes, was generally accretionary in nature and not formalized. Monumental stone-walled complexes were composed of numerous indoor and outdoor spaces, sometimes not distinguished from the wall itself.

Distinctive architectural attributes included deep eaves, or *chajjas,* and projecting balaconies assisted by intriciate brackets, aedicular *chattris,* or umbrellalike stone screens. An important Mughal influence was the glorification of the Islamic tradition of vaulting, domes, and arches. This arcuation became highly integrated with the elaborate corbelling and crafted columns of the Hindu system of trabeation. It added enrichment on many levels, such as the development of the cusped arch so frequently associated with the architecture of India. The lightening of load and the reduction of mass encouraged by arcuation made the palaces appear more ethereal.

Although the book is loaded with photographic illustration, more conceptual and analytical drawings are needed to extract the ideas and essences of the images. The photographs are, at times, too rich to make the point as succinctly as the prose does.

G.H.R. Tillotson's book fills a long-standing void. A collection of remarkable buildings has been given a more fitting place in history and in our working vocabulary and sensibility of place.

—Claudia Russell

Ms. Russell is a practicing architect in Cambridge, Mass.

Design in Familiar Places: What Makes Home Environments Look Good. Sidney Brower. (Praeger, $39.95.)

"All this talk about architecture . . . is very dangerous: it brings the ears so far forward that they act as blinkers to the eyes," Edwin Lutyens once cautioned. According to Sir Clough Williams-Ellis, who recounted the incident, it was impossible to engage the famous architect in any serious conversation about his work; like many gifted designers (Mies van der Rohe comes to mind), Lutyens distrusted intellectualizing what he considered to be primarily a visual profession.

Talking, or rather writing, about architecture is what Sidney Brower, an architect and planner, does in *Design in Familiar Places,* and his short book offers some interesting insights for practitioners and students who are willing to risk a slight case of blinkering. Brower is concerned with the way people perceive their surroundings and how these perceptions affect their behavior. It is his thesis, supported by the research of others and by his own observations in the field (he was chief of

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design analysis in the Baltimore city department of planning), that there is a pronounced difference in perception of a neighborhood between two types of observers: residents and outsiders. An outsider admires a picturesque street, while a resident sees a neglected row of old buildings. An outsider interprets a group of friendly men in the park as a sign of community conviviality; the locals recognize the local winos. What residents "see" is tempered by their knowledge and experience of the place and can differ significantly from the impressions gained by the outsider.

The idea that we perceive the physical environment in distinctly different ways is not new. More than 10 years ago Donald Appleyard advanced the notion that there exist three common modes of perception: the sensory (the building as an esthetic object), the operational (the building as a setting for personal actions and behavior), and the inferential (the building as a medium of social communication). According to Appleyard, people shift among the three modes of perception; Brower goes further, however, and suggests that in particular circumstances one mode of perception is predominant. The outsider in a strange neighborhood looks for landmarks, and his experience is guided by practical necessity; hence, he perceives mainly in an operational mode. The tourist, a special sort of outsider, enjoys the sensory experience of the sights. The resident, on the other hand, is much more likely to be sensitive to the social implications of the environment—not "the quaint neo-Victorian house on the corner" but "my pal Joe's home."

It is Brower's contention, and the main theme of this book, that "designers look at the environment in a special way, and they see it more like outsiders than like residents." Is this true? Brower offers some evidence (not enough, in my opinion) to support his thesis, but common sense suggests that he is correct. Architects are often called upon to design buildings the workings of which are unfamiliar to them; and, even if they have an intimate and specialized knowledge of the building type, their peripatetic careers often make them outsiders to the communities for which they build. Even when this is not the case, the view of the designer—which Brower calls the artistic view—is necessarily superficial.

The discontinuity between the perception of the designer and that of the user is likely to be greatest in residential environments. The second part of this book is devoted to case studies that the author carried out over a period of 13 years in Harlem Park, an inner-city Baltimore neighborhood, and describes the author's research and involvement in attempts to ameliorate public parks and make them more responsive to local needs.

These case studies are at once the strength and weakness of *Design in Familiar Places*. The duration of the project—we learn not only about the preliminary research but also about the implementation and subsequent use—and the author's candor make for fascinating and sometimes heartrending reading. Brower's research led to a number of municipal interventions, some successful and some not. Attempts at user participation demonstrated that, when it comes to design, residents can be just as shortsighted as outsiders. Harlem Park is a predominantly black, low-income neighborhood, evidencing all the social stresses that typify American city life today. That and the fact that the author, who teaches community planning at the University of Maryland, carefully avoids generalizing from his particular experience, will limit the impact of the author's message for many readers.

That would be a shame. "Looking at the environment from a resident's point of view," which is Brower's deceptively simple prescription for more responsive design, has broad implications for the designer of *any* building—office, museum, or hotel—not only social architecture. We need more of this kind of research, but on a much broader scale. Our profession is certainly blinkered, but it is from too little thought, not from too much.

—Witold Rybczynski

Mr. Rybczynski teaches architecture at McGill University in Montreal and has written several books on housing design.

ARCHITECTURE

This annual technology issue deals with perhaps the most basic function of building—mediation between indoor and outdoor environments. What of the external environment is to be excluded from the indoors, what is admitted, and how must it be modified? What goes into creation of a nurturing interior environment? What can turn it pathological?

The issue begins with three articles about fundamental concerns: the building skin as it affects temperature, light, and energy use; the creation of a satisfactory acoustic environment; the air we breathe indoors.

Then follow three buildings designed to create special environmental conditions; a look at laboratory design, which almost always involves stringent environmental demands, and a look back at the performance of some prominent energy-saving buildings from the energy-conscious 1970s.

Finally there is a triad of articles on threats to a healthy indoor environment: an update on the rising consciousness of the causes and effects of indoor pollution, and reports on the specific hazards of radon and CFCs. Editors in charge of the issue were M. Stephanie Stubbs and Douglas E. Gordon.

Turning to the future, we hereby announce that October will be a "discovery" issue presenting built works of architects and firms never before published in major magazines. Note that it is the architects and firms, not just the buildings, that must not have been previously published. However, an architect working for a firm that has been published can submit work done on his or her own time if he or she has not previously been published individually.

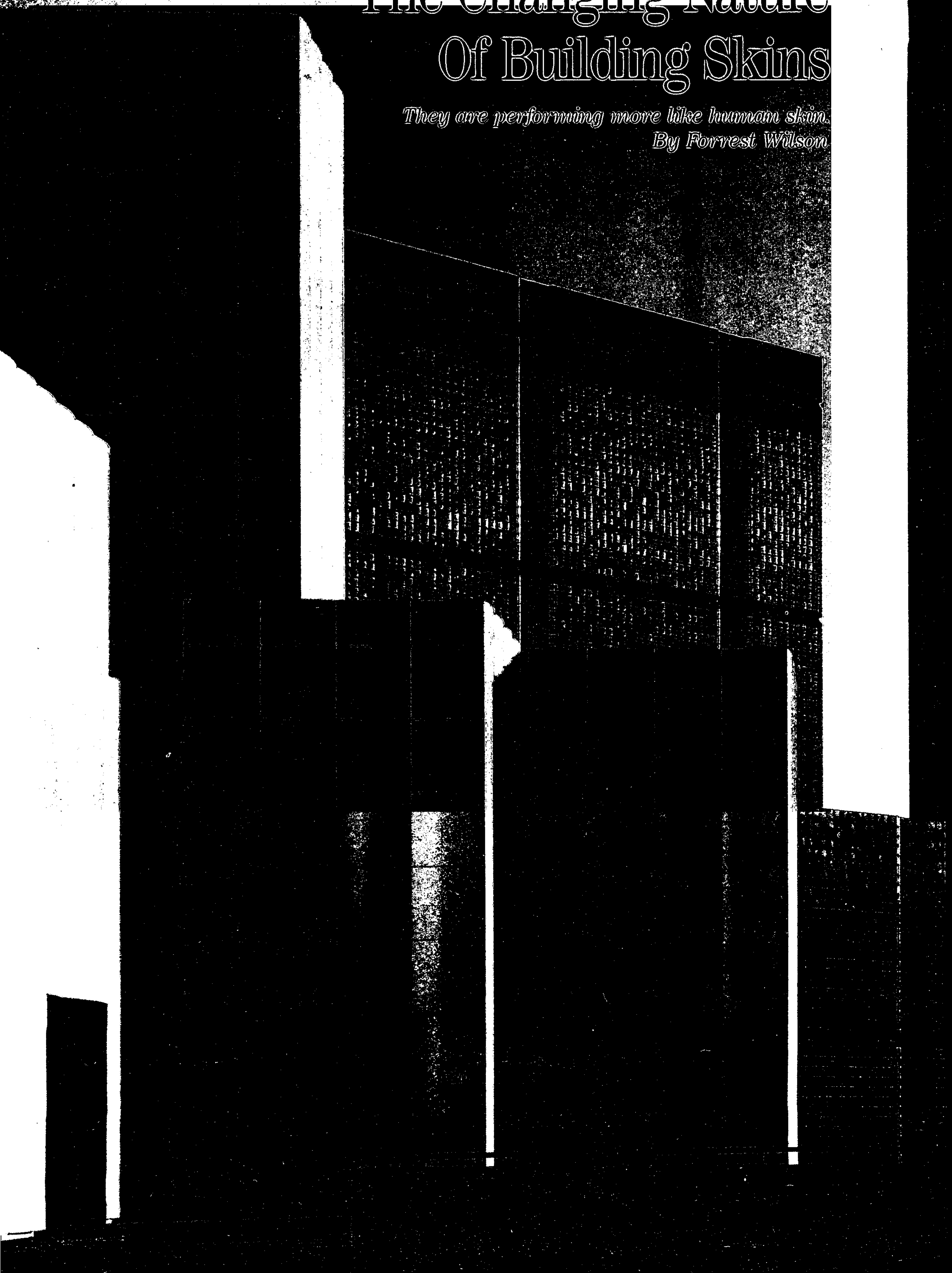
A few definitions: By "major magazines" we mean this one, *Architectural Record, Progressive Architecture,* and the late *Architectural Forum* and *Architecture Plus.*

What constitutes publication? Multi-illustration presentation of completed buildings. Single pictures don't disqualify, nor do presentations of unbuilt projects.

Submissions are due June 15 and should include a brief description of each project, plans and any other drawings that help communicate the design, and photographs. At this stage the photos don't have to be of publishable quality. They just need to be descriptive. They can be slides, transparencies or prints, color or black and white.—*D.C.*

The Changing Nature Of Building Skins

They are performing more like human skin.
By Forrest Wilson



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By the end of this century curtain walls will display hot and cold flashes and elude radar. Architectural historians will add a chapter or two describing the esthetics of blushing and the textures of goose-pimpled building skins. What follows is a brief update on the high-tech expectations and practical developments in building skin design since the energy crisis of the 1970s.

On the eve of the oil embargo, it was cheaper to burn lights continuously in glass buildings, day and night, than to install light switches. "In those days," says Alan Kaplan, partner and director of engineering with Haines Lundberg Waehler, "you could not afford thermopane or insulation."

Today the cheapest electricity is 6 cents a kilowatt-hour, oil is a dollar a gallon, and, says Myron Schloss, senior associate and HLW's chief electrical engineer, "owners will spend money to save energy. There are at least 10 times as many types of lamps as there were 20 years ago, and ballast technology has greatly improved."

The response to the energy crisis has resulted in dramatic redesign of building skins. The building sector is the single largest consumer of energy in the United States. Seventy-five percent of the nation's $150 billion electric bill is consumed in buildings and it is in building design, particularly building enclosure, that major changes were and are being made.

Since the oil shocks of the early 1970s, Americans have enjoyed a 35 percent rise in the gross national product without increasing their energy consumption, according to Arthur Rosenfeld and David Hafemeister, writing in *Scientific American* last April. The services energy generates are provided more efficiently, and energy is saved by improved building skins.

Eight years ago the AIA Journal (Oct. '81) surveyed the development of curtain wall technology since the energy crisis and reported the following:

National Aeronautics and Space Administration (NASA) research was inspiring investigations of surface control of reradiation of heat from absorbing surfaces and reflective mirror films for glazing, insulation, fire-resistant materials, and photovoltaics for buildings. Aerospace technology had given us Mylar (the aluminized plastic film sold commercially as "space blankets"), coatings, and home and commercial wall coverings and drapery liners. Heat-shield coatings for re-entry vehicles and sound insulation compounds were adapted for fire insulation in buildings. Teflon-coated fabric structures were researched.

Hardy Holzman Pfeiffer Associates' Los Angeles County Museum of Art, opposite page, uses gently fluted, sandblasted stone for its low walls. The glass block on the high walls is UV-filtered. Above, insulated stainless steel panels, tinted vision glass, and glass spandrel panels cover the Industrial Technology Center in Ann Arbor, Mich., by William Kessler & Associates.

Dynamic-membrane building skins had been investigated in the mid-1970s to explore the idea of a membrane responsive to changing solar conditions. Air-controlled systems to regulate the flow of sunlight into or out of a building were developed experimentally. Five years earlier, a "solar cell" system of three membranes was included in a study for the General Services Administration.

The Department of Energy was sponsoring research to develop new materials and systems for lightweight thermal storage, phase-change and radiative cooling materials, water walls, reflective transparent glazing, and insulating movable curtain walls.

Steve Selkowitz of Lawrence Berkeley Laboratories predicted that in five to 10 years advanced coatings for glass and plastics would change automatically. The overall design of metal sandwich panels was re-examined to improve energy performance and reduce weight.

The glass industry, hardest hit by the energy crisis, has had the clearest research agenda and the greatest array of new products under development and on the market. The glass buzzword for the '70s was shading coefficient; for the '80s, it was emissivity.

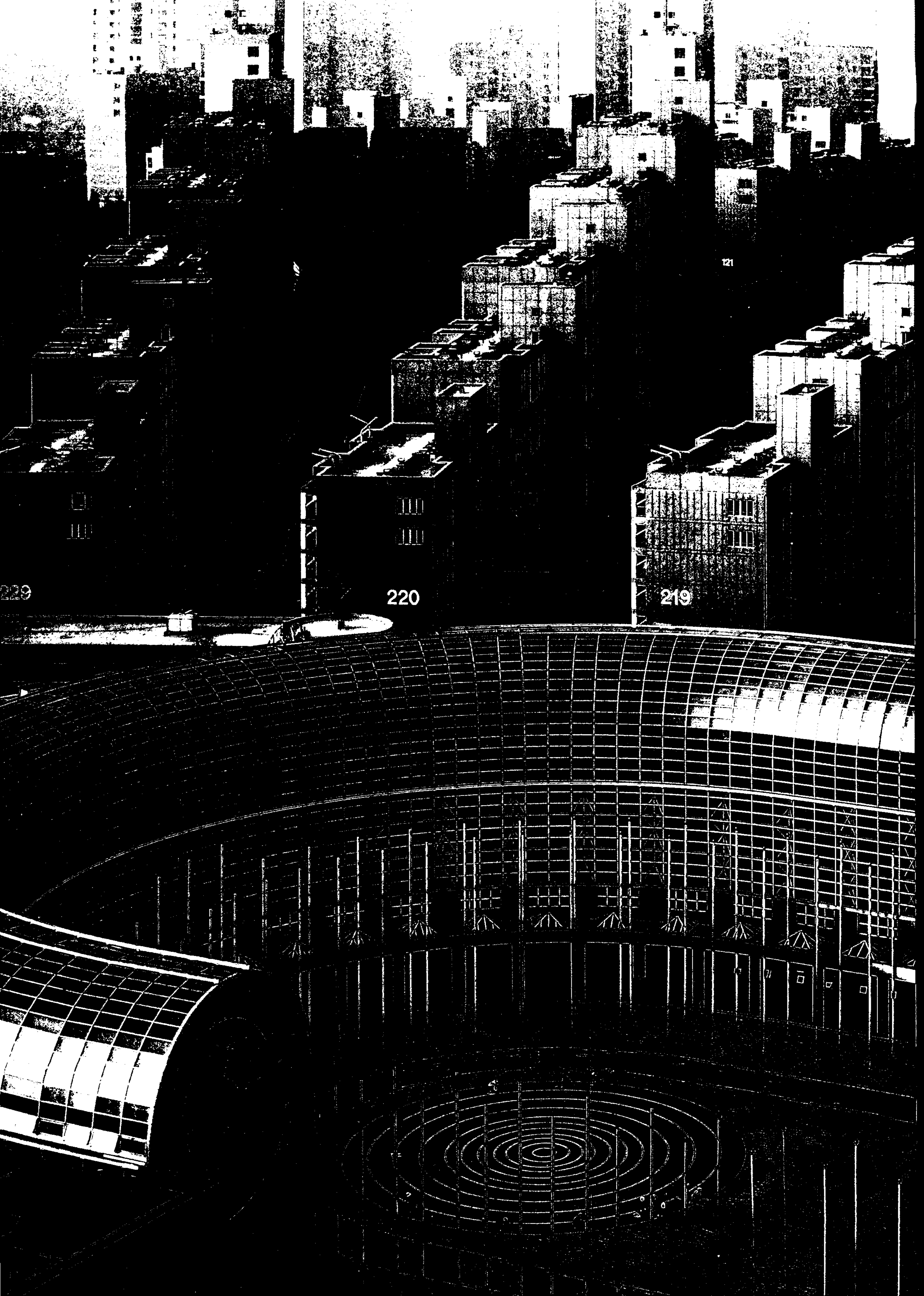
Films for window products were entering the market, and substantial research continued. The films increase the insulation capacity of windows and reduce penetration of ultraviolet light, without compromising solar gain. Efforts were being made to incorporate solar-control devices into windows, as was common in Europe. The industry introduced controlled air-flow window assemblies, in which the air space in the window becomes an extension of the mechanical system. Use of glass spandrels with built-in thermal controls was anticipated.

There were other solutions. The architects of IKOY in Winnipeg, Manitoba, saw the skin as a "thermodynamic barrier" perforated at will. The skin alternated as an opaque or transparent membrane, changing the skin's opacity or transparency according to the uses of the interior space.

A design concept called a "control grid" permits random skin perforation, says Ron Keenberg, IKOY principal. The grid establishes a dominating design pattern. The elements are random within a strong symmetry and do not compromise the barrier's harmony.

The dream: Can a coating help the building skin perform like the human skin? David Pellish, AIA, director of the Department of Energy's solar building division, believes it may do the next best thing, which is to act as a controllable membrane. When Corning incorporated a new chemical structure in glass, to manufacture photochromic eyeglasses, it was a breakthrough, he says.

A building in the northernmost part of our country gets at least four times as much energy for heating as it can possibly need. Ratios increase, of course, as you move south. It is not only the heat of the sun but also the diffuse radiation around the building that must be taken into consideration. "Look at the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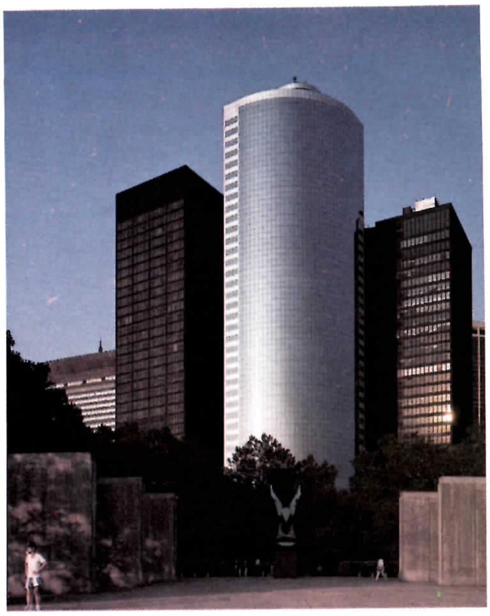

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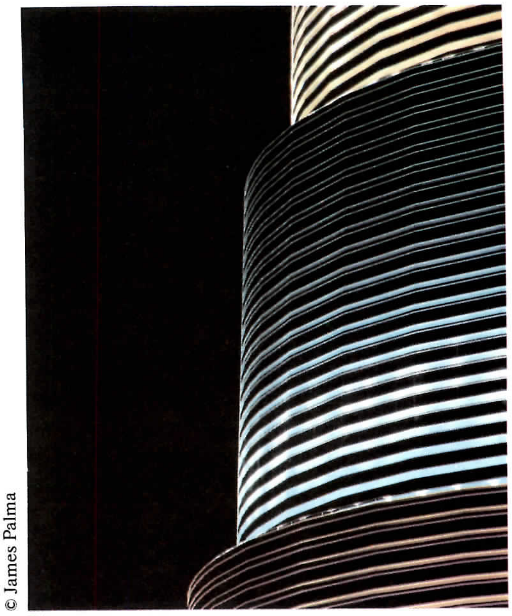

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whole building envelope and capture that energy and use it for the occupants' benefit, using advanced scientific materials," says Pellish.

Electro-chemical-scientists are experimenting with coatings that allow the building occupant to control the passage of heat during summer and winter, day and night (see Aug. '88, page 98). This is a revolutionary step compared with the traditional way of thinking of the building enclosure as a thermal overcoat.

"The Lawrence Berkeley Laboratories have seen their research accelerate change in the real world of building," says Selkowitz. "Low-e window technology has been tremendously successful even though much of the window industry was skeptical that the R and D in the 1970s would prove successful."

A team at the EIC Laboratories that includes David Rauh, Stuart Cogan, and Ronald Goldner has received recognition for its advanced work on electrochromic "smart windows," and the United States has been interested in applying that technology to the canopies of fighter planes.

"The goal is the control of radiated energy while permitting light transmission rather than modulating the narrow band of visible light. The spectrum includes both visible wave lengths and infrared and we are trying to control transmission through both wavelengths," Pellish says.

"But we are talking about the whole building, the entire enclosure," Pellish continues. "The window is at most 25 percent of the building surface—the rest is opaque. There are other ways of capturing energy on opaque surfaces."

At the beginning of the energy crisis glass was thought to be the enemy, but that was wrong, says Pellish. "It can be made to react like the human skin." Energy must be captured and transported, but the "smart window" is not enough.

Mechanical systems that deliver heat by air or water are not very efficient. Radiation is four times as effective. The Romans understood radiant heating with masonry, as evidenced in the Baths of Caracalla. That technology can be improved. The brick may know what it wants to be, as Kahn said, but it does not know what temperature to discharge after storing heat.

Phase-change materials can do what the brick does with far more finesse and can be controlled. Phase-change materials can store great quantities of heat with the change from solid to liquid. The change can be formulated to take place around 70 degrees Fahrenheit, to prevent overheating. When the temperature falls below the low 70s, the materials give the heat back.

Research for encapsulating phase-change materials in wallboard is being conducted by a manufacturer and is being considered for production. The challenges remaining include retaining wallboard's traditional fireproof virtues, painting, and the like but these are not insurmountable, according to Pellish.

Until recently, environmental control systems responded only to interior environments. Variations of external conditions were largely ignored. As "intelligent envelope" systems approach the marketplace, more attention is being paid to exterior climatic conditions, with technologies tending to stimulate dynamic rather than static building response to weather variation.

Opposite page, the 1988 Seoul Olympic Athletes' and Reporters' Village by Williams & Woo has a curved glass arcade for its memorial plaza. The concrete-clad housing units step up to 24 stories. Above left, Chicago's Northwestern Atrium Center by Murphy/Jahn houses 1.6 million square feet with a scalloped curtain wall skin of blue and silver reflective glass and black vision glass. Curved stopless glazing forms the "window" of 17 State St., center, a 42-story office tower in New York City by Emery Roth & Sons. Above right, Miami's Centrust Tower, by I.M. Pei & Partners, has each of its 36 stories articulated by two bands of glass and two bands of metal. The skin is lighted with changing sequences of color.

Research on motorized window openings, sunshading devices, and daylight guiding systems activated by sensors coordinated by microprocessors has reached the stage where these are almost marketable. They will be activated by instruments sensitive to external climate, air temperature, solar radiation, and wind speed and direction. Research in this area is presently conducted at the University of Sheffield in England.

It is planned that the building be linked to local weather stations. While the long-range prediction of weather remains a chaotic art, short-term predictions are often reliable. These will allow the building time to adjust its internal systems and external skin to changes in weather.

How can sunlight be redirected indoors to replace electricity? Electric light fixtures make heat, which must be cooled. How can sunlight be programmed? "If a clerk in a supermarket can place a can of Campbell soup on a holographic device that will read it at any angle, programming sunlight is possible," says Pellish.

Demonstration models of holographic panels developed by the Advanced Research Group in Maine now successfully transfer daylight from the exterior deep into interior building spaces. Elizabeth King, one of the group, has predicted that by this spring there will be embossed panels for full-size mock-ups. The problems of mass manufacture then will be analyzed.

The building skin has revolutionized our thinking. Skins can combine all kinds of materials and control the transmission of energy through them. A hollow opaque skin panel with suspended particles can capture energy from the heated exterior surface; the energy can be transferred to wherever it is needed in the building, in an elegant interpretation of the brick's radiation.

"We know that the surface of the stealth bomber must transform the electric magnetic rays of radar," says Pellish. He reasoned that the scientists working on coatings to control electric magnetic waves were working on another part of the electromag-

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© San Francisco Light Works

Left, The Fine Arts Center of Arizona State University at Tempe, by Antoine Predock, Architect, presents a skin collage of concrete, masonry covered with stucco, and brick. Above, the Lowes Ventana Canyon Resort Hotel in Tucson, by Frizzell Hill Moorehouse Architects, uses split-faced custom block made locally to capture the color and texture of its desert landscape. Opposite page, the Centerway Parking Facility in Corning, N.Y., by Arthur Cotton Moore & Associates, demonstrates the use of a highly articulated brick veneer coupled with a metal roof.

netic spectrum, but it involved the same phenomena as the building skin. "They are dealing with coatings on airplanes—why not coatings on buildings?" Pellish says. When he approached the scientists with this question they said they had been doing this for 12 years. "Then give me your throwaways," he pleaded.

These developments have been going on for the past decade, but how close are they to realization?

The reality: What drives building enclosure design today? "Payback, and the time frame is almost zero," answers Mike Flynn, building skin designer with I.M. Pei & Partners. The skin is allocated a percentage of the budget; if more money is added it must be taken from another part of the budget.

The cost of reflective glass is paid for in the reduction of mechanical plant cost. But payback can be less tangible. Insulating glass sells space, and so the owner pays for the advantage. Facade finishes give an immediate payback. Clear or hard coated aluminum requires more expensive alloys than painted aluminum. A good painted coating saves aluminum cost.

The aluminum curtain wall of the '50s and '60s is the result of the aluminum industry's decision to enter the building market after World War II. Architects were not running around saying "give me aluminum," says Flynn. Rather, the aluminum manufacturers decided to sell to architects. Aluminum companies created a need and invested tremendous amounts of time and money into making aluminum into a building material. They were helped by the strong hold the "Miesian ethic" had on U.S. architecture, says Flynn.

"If Mies had not been born, Kawneer would have had to invent him," remarks historian Arch Farch.

The steel industry was less interested, continues Flynn. There is a standing monument to the competition between the two industries at Roosevelt Field on Long Island. It is a full-size model of a portion of the curtain wall of the Chase Manhattan Bank. Half is stainless steel and the other half is aluminum.

After Chase, Flynn says, facades were aluminum. Marketing strategies aside, aluminum is a workable material with a wonderful touch, and it has marvelous alloys. The aluminum industry had a capacity to produce, a will to popularize, and, like the Italian stone industry, established a design reference.

The silicone industry created a demand, as the superabrasives industry is doing today. That was a difficult task, for at the time silicones entered the market two-part polysulfides were performing reasonably well, says Flynn. No one wanted to be "the first guy on the block." But silicone manufacturers had the money and the grit to wait for their time to come, and now they can't sell enough of it, and so we have solid glass skins with no visible means of support.

The glass industry made a major commitment to developing new products for buildings. It had begun research before the energy crisis and was forced into drastic action to survive the initial reaction to the window as energy villain. In 1954, SOM's Lever House in New York City had demonstrated that glass has the quality of opacity as well as transparency; before this, glass was associated only with "window." The glass spandrel introduced glass as a cladding material, but the idea was accepted slowly. "For years some architects refused to design a glass spandrel because glass was associated with transparency," Flynn recalls.

Market share has inducted major players into the skin trade. Italian stone manufacturers decided after World War II to invest in new stone fabricating equipment, which now slices granite to 25 millimeters (one inch). Coincidentally, investment builders decided that a conservative, stable banker's image was marketable, and stone has this image, says Flynn, so "Italian technology merged with a market attitude."

The facades of commercial buildings have been and will remain "straightforward," predicts Flynn, because of the payback. However, this will change quickly if "lively facades" become popular in the irrational marketplace. "Who could predict the popularity of hula hoops or thin stone veneers?" Flynn asks.

A major tactical building problem to be overcome, Flynn continues, is the integration of wall systems. Although a heating system through a curtain wall might save five inches of floor space per running foot, such a system is seldom done. Facades are designed in layers, and the less coordination between them, the faster the building is designed and built. Layers are planned so that the building envelope can be designed and built by various specialties doing structure, skin, mechanical, and plumbing without getting in each other's way. "Everyone gets along best without bumping into each other," says Flynn. "All they have to know now is floor-to-floor height and column spacing, and sometimes column spacing makes no difference."

The coordination of the various designers and multitudinous trades involved in assembling a smart skin seems trivial compared with the effort required to market aluminum, tinted glass, silicone, and thin stone over the past two decades. The technology is there. The right questions are being asked; all that is lacking is a marketing decision to convince the world that living-skin buildings are the best thing since sliced bread. Then favorable payback may give us colorful buildings that turn red with hot flashes, blue with cold, and elude radar defenses. □

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Letting Fresh Air Back into Buildings

The evolving state of the art of natural ventilation. By Benjamin Evans, FAIA

Going into a nonairconditioned building during hot weather is like going from the frying pan into the oven, where the air is hot and stagnant. This is a waste because, at a surprising number of places and times, the interior would be a lot more comfortable if a breeze could get inside. Our buildings tend to hold heat when we least want it; for some reason we design them so that the outside air can't get inside to cool us or the building.

It doesn't have to be that way. Before airconditioning there were all sorts of techniques used to beat the heat, including taking advantage of natural air currents. The Greeks provided porticos around their temples for shade and breeze. The Arabs put scoops on their roofs to funnel air through their homes. The frontier Americans built dogtrots and porches so they could sit in their rocking chairs and enjoy the cool breeze.

These techniques are not lost to us. We just quit using them because we've become fat and sassy with our airconditioning and cheap energy. Of course there are times and places when natural airflow isn't appropriate or won't help us much. If your nose is stuffy from an allergy and the air outside is hot and humid, you'll want cool, filtered air instead of an outdoor breeze. Still, almost everywhere, there are times of the day and year when a natural breeze in the shade is all you need for comfort.

Breezes act according to the laws of nature, and one must understand certain scientific principles before one can guess with accuracy how to control air movement. Until recently, people remained relatively ignorant about air movement simply because air is something you can feel but not see. For thousands of years, people managed to capitalize on air movement in building design based largely on intuition alone. It wasn't until the middle of the 18th century that people began to experiment with air and to try to explain what it is and how it works.

An early theory was that air pressure had something to do with electricity (which people didn't understand either). Some thought that the clouds were held up by electricity and that electricity caused smoke to rise. In 1783, a French couple tried to catch smoke (and electricity) in a paper bag and accidentally invented the hot-air balloon. Around the turn of the century, a French physicist substituted helium for hot air in a balloon and discovered the principle of air pressure, which is fundamental to our understanding of air movement: a body of higher-pressure air will move (expand) toward a body of lower-pressure air. To put it simply, as the pressure of air (or gas) increases it expands and becomes lighter, thereby tending to rise, or move, until it finds a place in the atmosphere where the surrounding pressure is the same (Figure 1).

Global air pressure differences are caused principally by the sun warming some parts of the earth and that earth, in turn, warming the air, while other parts of the earth and air are not warmed as much (polar ice caps, forests, etc.; Figure 2). The result is that the warmed air (higher pressure) tries to move toward the cooler air (lower pressure).

The rotating motion of the earth also has an influence on geographic air movements. As the earth spins, it pulls the air around with it, but the air doesn't entirely keep up. There is slippage. It was at about this point that we realized that air has mass and therefore is affected by gravity, and that it follows the law of inertia—mass once set in motion tends to continue straight until its direction and speed are changed by some outside force.

Some of the outside forces at the global scale are mountains, forests, land masses, ice caps, and all sorts of geographic formations. Geographic features affect the origins and movement of the wind because the wind moving over the ground and other objects causes friction, slowing some parts of the air.

All of these phenomena—pressure difference, inertia, and friction—tend to produce turbulence so that air doesn't often move smoothly along a straight path. It takes short darts here and there, speeds up, and slows down. When two currents of air are traveling in opposite directions, they always will be separated by a series of eddies because adjacent particles of air always move in the same direction. Laboratory studies have shown that these eddies range from the very large through a series of adjacent eddies to the microscopic, which cannot be seen with the naked eye (Figure 3). But at the scale of a single building, for ease of calculation in building design, we allow that air moves in a fairly well-defined path.

Another important set of air movement phenomena is explained by the Bernoulli theorem of fluid behavior (which considers air a fluid). Defined by the 18th-century Swiss mathematician, the Bernoulli theorem includes the observation that fluid pressure decreases as the rate of fluid movement increases. For example, an airfoil, which is what allows powered aircraft

Figure 1

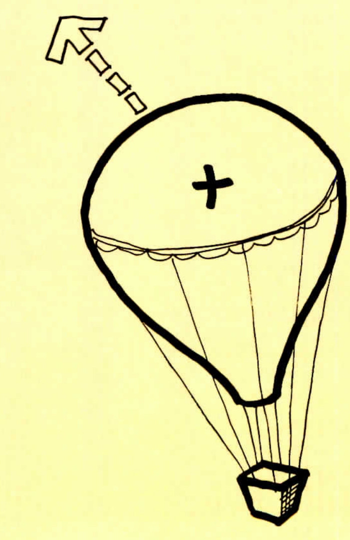


Figure 2

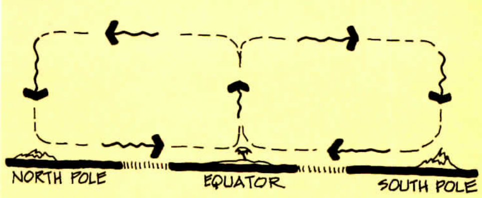


Figure 3

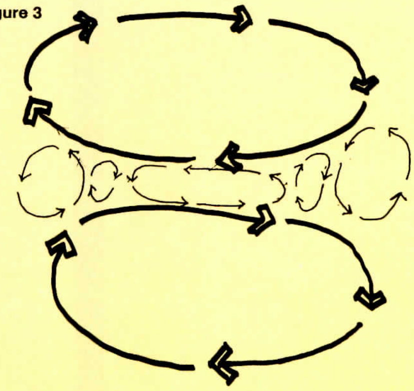
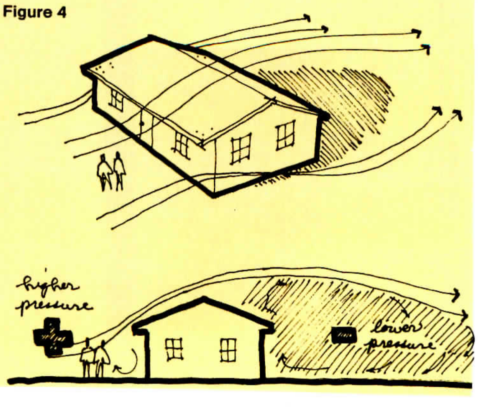


Figure 4



Mr. Evans is a professor of architecture at Virginia Polytechnic Institute and State University.

to fly, is flat on the bottom and humped on the top. The hump makes air flow faster over the top of the wing, which means—as we know from Bernoulli—air pressure over the wings goes down and the airplane goes up.

Another fluid property of air is that, when flow is temporarily constricted, as when the air enters an hourglass-shaped funnel, its speed increases inside the constriction (accompanied by the now-familiar pressure decrease). The phenomenon was observed and recorded by Giovanni Venturi, the 19th-century Italian physicist for whom the effect is named. To see how the Venturi effect occurs at the building scale, envision the windward (high-pressure) wall as a flat funnel and a windward inlet, such as an open window or door, as the constriction. As long as an outlet is sufficiently sized, air flowing through the inlet will move faster than the outside breeze.

Let's assume that we have a nice gentle breeze blowing along the earth's surface, coming from a high-pressure air mass over in the next county to a lower-pressure air mass somewhere down the road. On striking a solid object—a simple cube-shaped building, for instance—air movement is interrupted. As the air piles up in front (upwind) of the object, its pressure increases until it is forced over and around the solid object, creating a lower-pressure area behind the object (downwind). Air in this lower-pressure area on the downwind side is eddying and moving slowly back upwind toward the solid object. This protected area is sometimes called the "wind shadow" (Figure 4).

The greatest pressure differential around a building occurs when the wind strikes it perpendicularly. This creates the largest wind shadow and, thus, the lowest downwind pressure. If we could move the building around until its smallest dimension faced into the wind, we would see that this would produce the smallest wind shadow and least pressure downwind.

If we put a number of buildings together on a site, we will get a variety of wind shadows and patterns, and each building will get hit by less wind than if it were all by itself. Each building affects the others. Often, we will be looking for patterns that will allow the maximum amount of wind to hit each building.

Since air moves from higher pressure to lower pressure, it makes sense to put a building's breeze inlets adjacent to the higher-pressure areas and breeze outlets adjacent to the lower-pressure areas. To determine the best places for inlets and outlets, therefore, we need to have some idea of where the high and low pressures will occur on the building surfaces. On a simple cube shape, we see that the windward face of the cube is under positive pressure, relative to ambient air pressure, and that the top, back, and sides of the cube are under negative pressure. It is easy to visualize from this that an inlet on the windward face and an outlet on any of the other surfaces will produce cross ventilation.

If the wind approaches the cube from a 45-degree angle, we get a variety of pressures on the surfaces. Pressure areas are less distinct, making it more difficult for us to find the best high-pressure area for the inlet (Figure 5).

Figure 6 shows the relative air speeds above a simple block-shaped building. The contour line marked 1.0 represents wind movement at the prevailing wind speed, or 100 percent. The .4 line represents the area of speed that is 40 percent of that of the prevailing breeze. If we look at these wind pressures in terms of the building structure, we see that the roof and the downwind walls are all in negative pressure areas and tend to be pulled away by the wind.

Everyone knows that hot air rises. This is not a contradiction to the statement that air is moved by pressure differences. As the temperature of a body of air rises, the air pressure differences cause it to flow toward a lower-pressure area, usually higher up. These "stack effect" currents are useful in exhausting unwanted air, such as the air that might collect under a skylight or next to the ceiling, but they are of little benefit in directly cooling people through evaporation, simply because the currents are not moving fast enough and usually do not pass through the living zone (the areas where people are). Stack-effect currents are particularly effective at night when the cooler night air can be brought in to carry to the outside the heat that has been absorbed by building materials during the day.

What isn't commonly known about stack-effect ventilation is that prevailing breezes almost always overcome or offset the effects of air movement caused by thermal differences. Even in areas where considerable process heat is emitted in the interior, mild cross ventilation will overcome the stack effect and carry the heat out via the breeze. So, a stack effect can work in conjunction with cross ventilation.

Figure 5

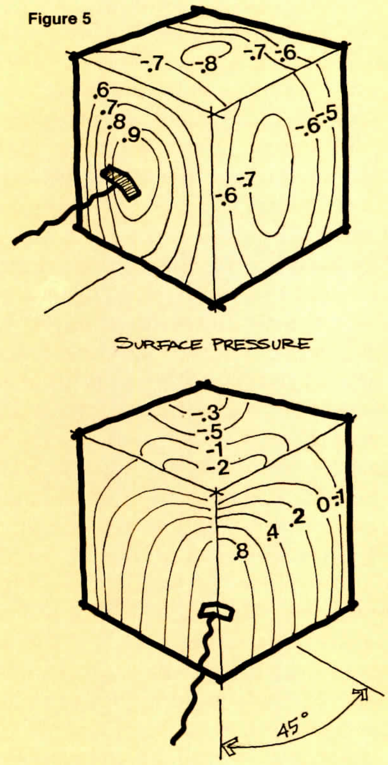


Figure 6

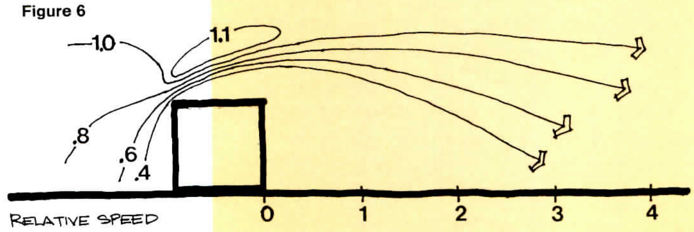
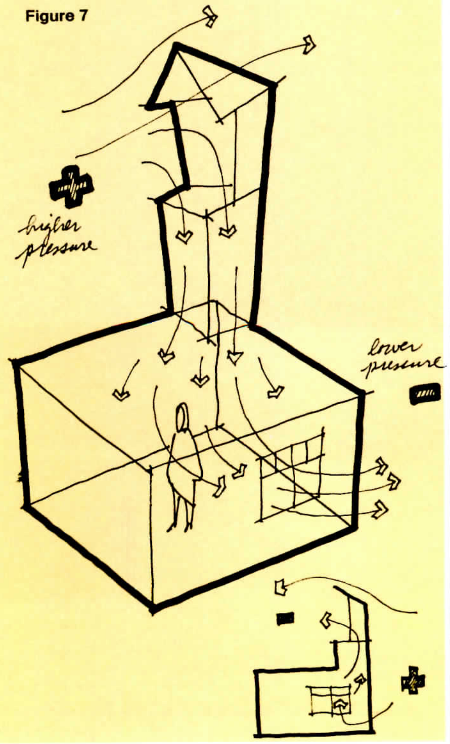


Figure 7



In some Middle East countries, "windscoops" have been used for hundreds of years to induce natural interior ventilation (Figure 7). These windscoops rise above the roofs of houses to create pressure areas that pull the air into downstairs rooms, either down the scoop when the wind blows from one direction, or into windows and out of the windscoop when the prevailing wind is from the opposite direction. Notice that the windscoops do not push or force the air down the tower. Acting as Bernoulli's theorem dictates, the air movement into the interior is created by pressure differences caused by wind blowing over the windscoops and the building.

Another similar type of construction used in the Middle East to induce natural airflow is the "venting tower" (Figure 8). Here, the tower rises above the building roof to interrupt the wind and create a low-pressure area, regardless of the direction of the prevailing winds. The low pressure over this venting tower pulls air into the building from higher pressures below. This system requires manual opening of windows toward a high-pressure area.

The same principle is in effect in the Pantheon of Rome (Figure 9). The round opening at the crown of the dome allows the low pressure created above the dome by prevailing breezes, regardless of direction, to draw fresh air into the interior through the doors on the exterior.

Figure 8

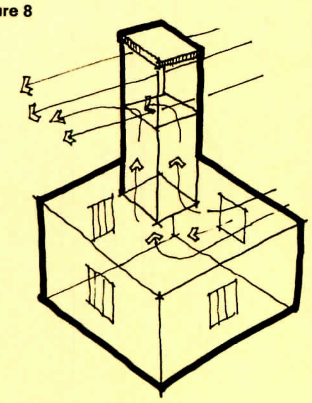
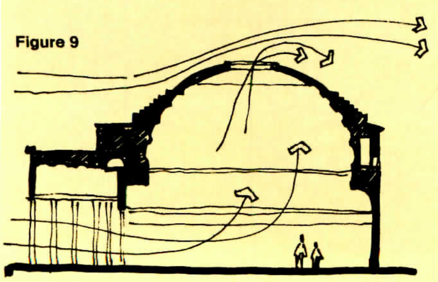


Figure 9



However it is achieved, cross ventilation is not a matter of filling a building with air as much as it is one of moving air through the building. You can't put water into a bottle that is already full of water unless you pour out the old or put a hole in the other end so that the bottle can empty itself while you're pouring the fresh water in. The same thing is true of buildings and wind. For cross ventilation, air needs a way in and a way out. That means judicious use of outlets as well as inlets.

Figure 10

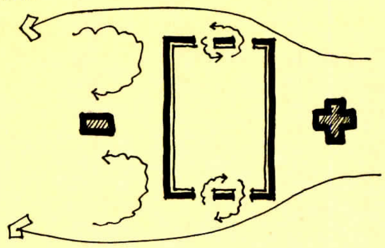
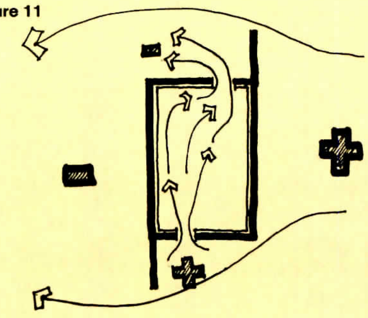


Figure 11



If we punch a hole through the building from the windward side to the downwind side, it is easy to see that some of the air would move through this hole from the high pressure upwind to the lower pressure downwind rather than going all the way around the building. This is what we used to call "cross ventilation." It is the fundamental process by which air is moved through the inside of a building.

The principle that air flows from high pressure to low pressure helps us analyze airflow patterns and create new ones. In Figure 10, we have a building oriented so that the wind approaches from a blind side (one with no windward inlets). Obviously, there will not be much air movement inside the building even when the windows on the ends of the building are wide open. There will be high pressure on the upwind side, low pressure on the downwind side, and low-pressure areas at both ends.

To get the air to move through the windows from one end of the building to the other, we need to create a new high-pressure area on one end (the inlet) and a lower-pressure area on the other end (the outlet). The solution is to attach a windbreak (Figure 11) that will create a high-pressure area immediately in front of the windbreak (at one end of the building). Another windbreak on the opposite end of the building toward the downwind side will tend to further reduce the low-pressure area there and so draw the air from one end of the building to the other, or crossways to the the prevailing breeze. This solution will probably not create an ideal interior environment, but it will be better than it was before.

Next, let's look at windscreens. Did you ever wonder why we call them windscreens instead of windbreaks, when obviously in both cases we are looking to block the wind? It's because screens work better than nonpermeable barriers. A solid fence doesn't provide as much protection as a screen or fence that has some holes in it (Figure 12). Wind speed in the wind shadow is slower behind a screen with the perforations than behind a solid fence. (Here the wind speed is expressed as a percent of the uninterrupted wind speed.)

Trees and shrubs also can be used as windscreens, and they are full of "holes," but they can also be used to direct the air so that people can take advantage of the cool breeze in otherwise protected areas. We have to consider whether we want breezes for cooling or whether we need protection and be careful to put the trees where they can cause the desired result (Figure 13).

Now, what happens to the breeze once it gets into the building? We said before that air has mass and inertia. Like a big steel ball bearing, once it starts rolling it will keep rolling straight until it hits something or eventually slows down and stops due to friction with the ground. Once the breeze is directed by the inlet into the building, it will tend to keep going straight until it hits something. It's easy to see how walls and doors will force the air in one direction and then another. It's important to note, too, that a breeze does not move directly from the inlet to the outlet, except in special cases. So the pattern of an incoming breeze is not affected by the location of the outlet.

The size of the outlet does have an effect, though. As was mentioned in the discussion of the Venturi effect, in a simple building, if the inlet-to-outlet ratio is exaggerated, the result will be a very fast movement of air through the inlet (the speed of the air at the inlet may exceed the exterior air speed considerably). The effect also occurs *around* buildings, such as when the bulk of a building is raised above the lower level (open plaza) or when two buildings are placed close together.

Figure 12

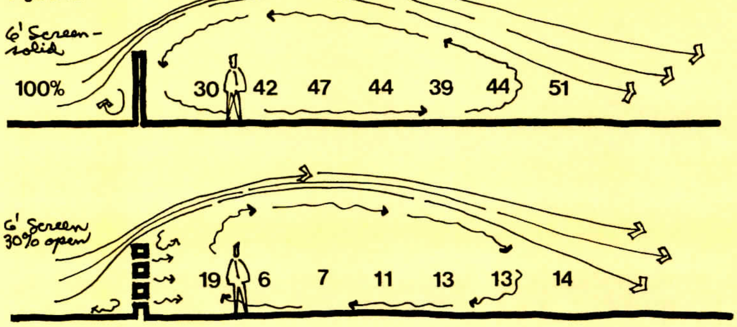


Figure 13

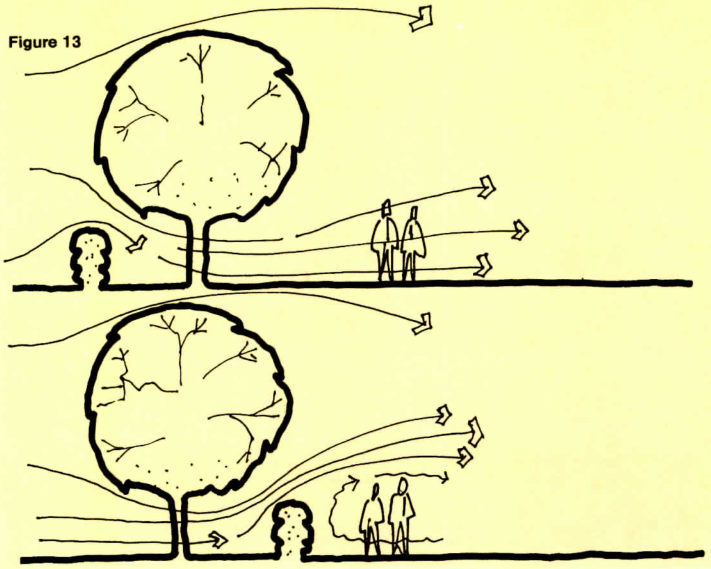


Figure 14

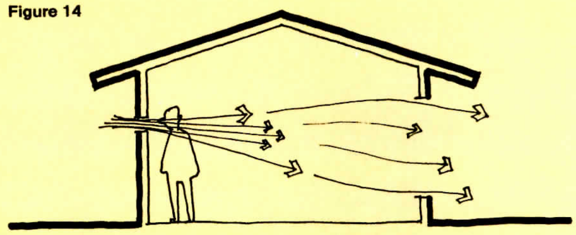


Figure 15

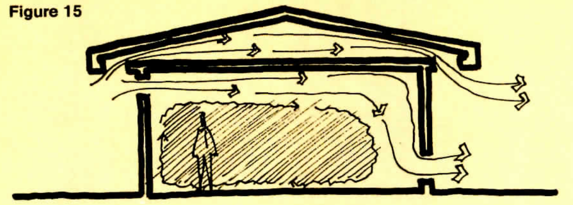
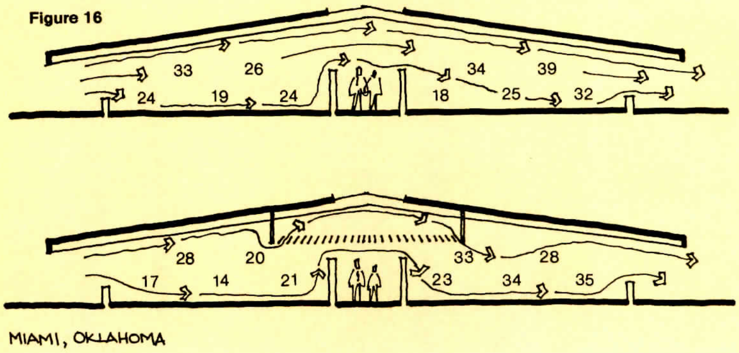


Figure 16



Air speed is important in cooling people. The faster the air moves, the more moisture and heat it will take away from our bodies by evaporation. We can get maximum air speed just inside an inlet by having a small inlet and a very large opposite outlet (Figure 14). (So the old idea of placing windows to face the breeze doesn't work best.) The ratio of the inlet to outlet determines the speed of the airflow. If we have a small inlet opening, say 12 inches square, and a large outlet, say 12 feet square, we could generate a pretty fast breeze. And if we put our rocking chair up next to that 12-inch hole, we would get a good cooling breeze right on our nose. Of course, back in the rear of the building, near the outlet, the breeze would be pretty slow and we wouldn't want to put our rocking chair there. The best compromise for good air speed throughout the interior is to have the outlet about 10 percent larger than the size of the inlet.

Air speed may also be important in cooling the building itself when the outside air is cooler than the inside surfaces of the building. By convection, the moving air picks up the heat from the walls, floors, ceilings, furniture, etc., and carries it on to the outside (Figure 15). If we let the cool night air into our usually hot buildings, that cool air will reduce the heat stored in the building materials and leave that space much cooler for the next day when the sun comes up and the air gets hot. But, while air speed is important, the *quantity* of air moved through the interior (air changes) is the most important factor, and that is accomplished with inlets and outlets about the same size. We shouldn't confuse air speed for cooling people with air changes for cooling buildings.

Obviously, for cooling people, we must get the breeze to them. If a breeze doesn't blow where we are (through the living zone), then it can't be very helpful in cooling us by evaporation. Likewise, if the moving air doesn't get to all the building surfaces, it won't cool them either.

For example, in a school in Miami, Okla., the architect designed big windows and openings over the corridor for a through breeze (Figure 16). Early studies in the Texas Engineering Experiment Station wind tunnel showed a shadow in the leeward classroom, so the architect added louvers in the plenum over the corridor. The louvers not only direct the breeze down into the living zone of the classroom but also shield the brightness of the skylights from direct view below.

Another factor that may be used to control the path the breeze takes when it moves through a building is the location of the inlet in the face of the building surface (windward face). In a rectangular building with the inlet in the center of the windward fenestration, the air will tend to move straight through the opening. If the inlet is off center, the breeze will tend to enter the opening and move off to one side. This happens because the air pressure on the exterior fenestration will be greater over the larger wall surface and smaller over the smaller wall surface, relative to the location of the opening.

The pressure differences on exterior fenestration cause what might be called "surface vectors," or currents that move along the surface of the building, seeking a way around or through. Projections on the fenestration—overhangs, louvers, vertical columns, etc.—can further alter these pressure differences and change the way the breeze is forced into the inlet.

As the breeze starts to flow into the inlet, the way the inlet is designed will also affect the pattern the air takes. Think of the inlet as the nozzle of a garden hose.

Figure 17

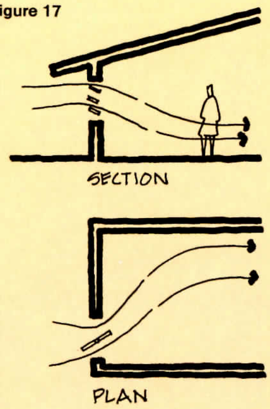


Figure 19

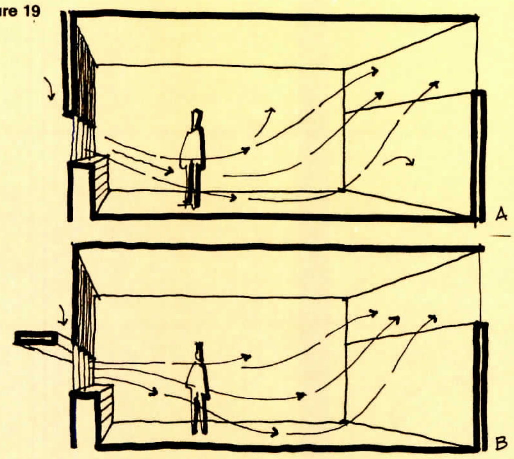


Figure 18

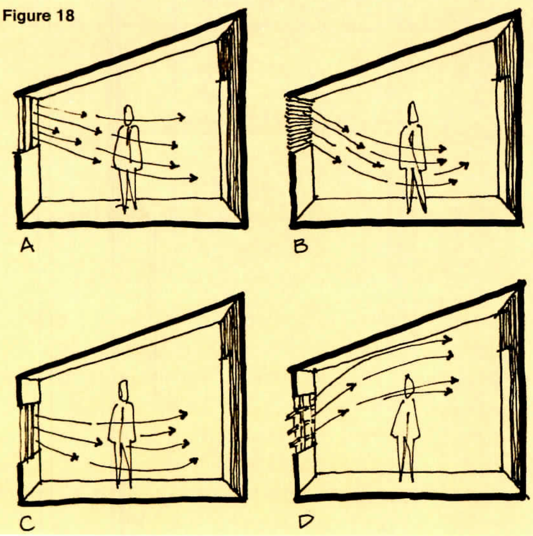
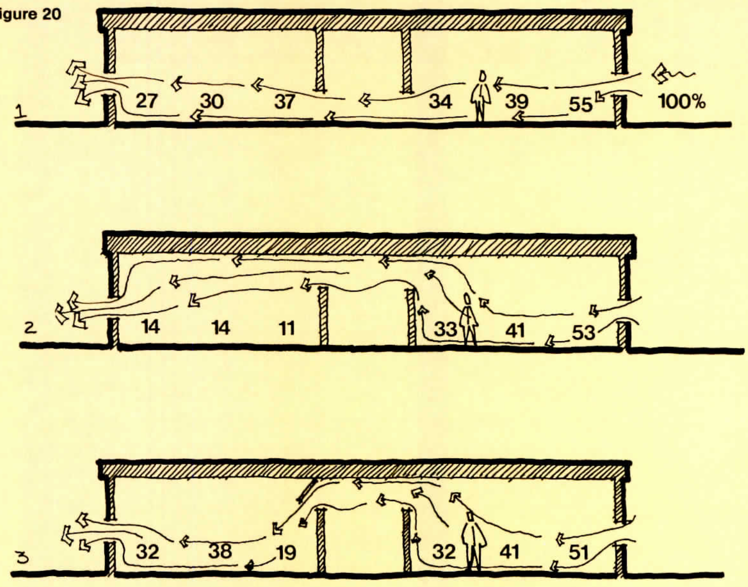


Figure 20



The high-pressure water in the hose will squirt where the nozzle is pointed.

Most conventional windows provide some control of breeze. This is the simple opening that lets air come in but doesn't give it direction. With a simple opening, the direction of the incoming breeze, as we have seen, is determined by the location of the inlet (window) in the windward fenestration.

With a horizontal vane window, the air will follow the direction of the window vane—up or down. The sideways direction of the breeze is still a function of the location of the inlet in the windward wall. With a vertical vane window, the air can be directed right or left. Again, the up or down pattern will be determined by the location of the inlet in the windward wall. To get the incoming breeze to go where we want, we have to select the type of inlet opening that will do what we want it to do (Figure 17).

The following case studies of air patterns around typical groups of buildings illustrate the application of air-movement principles to ventilation problems.

Window selection and placement. In this design for a bedroom in Texas (Figure 18), the casement windows (A) direct the incoming breeze into the room near the ceiling.

Venetian blinds (B) direct the breeze down into the living zone of the room. Locating the casement windows nearer the floor (C) would also allow the breeze to flow through the living zone. But, if awning windows (D) had been used instead of the casements, they would have thrown the air up to the ceiling and over the living zone. Selecting the proper location for the window, as well as the proper window type, is important to produce the desired airflow.

A sunshade. In this particular classroom design (Figure 19), the breeze comes in downward and through the living zone where it can cool the students (A). But, when the sunshade was added to the windows, it caused the windward surface pressure patterns to change and the breeze coming in through the windows to be directed upward, over the living zone. A simple slot in the sunshade (B) allowed the surface pressure difference to return to normal and the breeze to be directed down into the living zone again.

Controlling the flow. Here are some airflow patterns and speeds for a double-loaded corridor building, showing ways to get the breeze into the living zone and indicating some relative air speeds while the inlets and outlets remain constant in size. (Figure 20; interior air speeds are given as a percent of the outdoor uninterrupted wind speed.)

In the top diagram, the windows are simple openings and the corridor walls are pierced with large openings near the floor. The scheme provides a flow of air throughout the living zone of the cross section.

In the second diagram, high corridor openings provide little breeze in the downwind living zone. The third diagram suggests one way to redirect the downwind breeze. A low opening in the downwind corridor wall is another way. Notice in Figure 21 that, with a two-foot inlet and four- or six-foot corridor opening, the incoming breeze is faster than the prevailing outside wind.

Interior windbreak. The site for this school in Elk City, Okla. (Figure 22), by CRS Architects, and its programming requirements dictated that the long dimension of the building be parallel to prevailing breezes. There wasn't much opportunity to get breezes into the building except through the narrow end and into the wide corridor, which was to double as a gathering place or commons. Since this was in the days before airconditioned schools, natural airflow was considered an important issue.

(A) The first wind tunnel tests at the Texas Engineering Experiment Station showed that breezes that came into the building were funneled down the corridor and out the windows of the furthermost classrooms.

(B) A little creative study in the wind tunnel indicated that, if some sort of solid object were placed in the corridor, or commons, and if its location were judiciously selected, it would cause the incoming air to build up pressure and flow more or less uniformly out the windows of all classrooms. The need for some extra office space suggested that this "solid object" could be a small office.

(C) In the first schemes, open classroom doors provided the principal inlets for the breeze, but finally the designers opted to put "slot ventilators" along the corridor walls and provide opportunity for the incoming breeze to spread throughout the classroom areas.

Cooling through the core. A school in Laredo, Tex. (Figure 23), designed by CRS, also was built before airconditioned schools became common. Although the summers in Laredo are quite hot and dry, for most of the school year the weather is moderately warm.

The basic concept of the school called for a central core between the back-to-back classrooms, which would provide some mechanical, electrical, and plumbing services to the classroom areas and provide through-ventilation for cooling by natural breezes. The breeze moves into the upwind classroom and is directed into the living zone. It then moves into the central core chamber and hence down into the downwind classroom through a grill in the wall, and finally out the downwind windows. Wind tunnel tests in the Texas Engineering Experiment Station laboratories proved that the scheme was feasible. The building is oriented to catch the prevailing breeze, when there is one, and the school certainly works better than most of the nonairconditioned buildings in that climate.

The architect designing a breeze-dominated facility can be guided by the principles outlined here, and, for fairly simple shapes and relationships, these principles will suffice. However, when more complex building forms are developed, the resulting pressure differences and airflow patterns will be difficult if not impossible to predict. The solution is to test the proposed design with a scale model introduced into a steady wind stream and analyzed with smoke. It is possible, but very difficult, to do this outdoors. Best results will be achieved in a boundary-layer, steady-flow wind tunnel such as may be available at a number of universities throughout the country.

The college of architecture and urban studies at Virginia Tech operates such a wind tunnel specifically designed for scale model studies of buildings. These facilities are used for research and student teaching and are also available for designers in search of a sophisticated airflow analysis of a proposed facility design. □

Figure 21

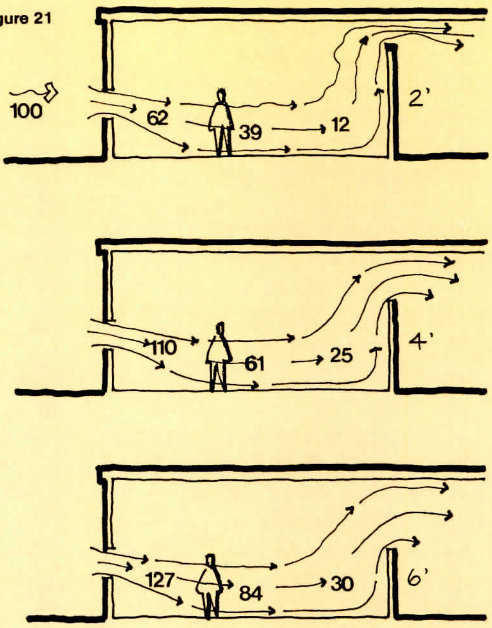


Figure 22

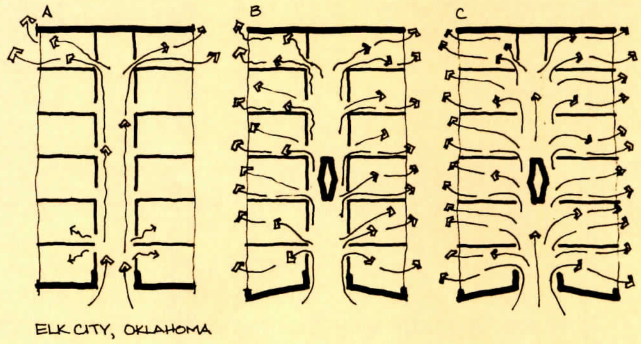
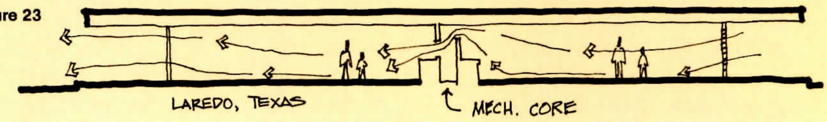


Figure 23



Blocking the Bombardment of Noise

Keeping the interior acoustical environment comfortable. By Carl J. Rosenberg, AIA

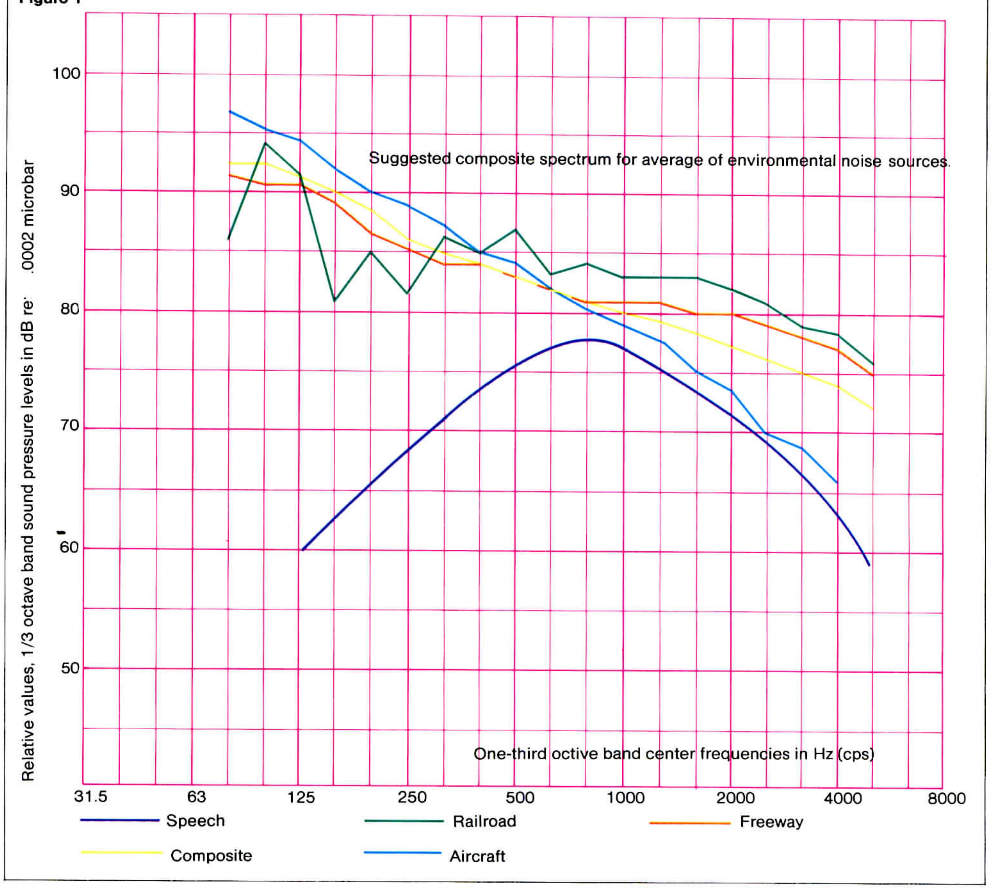
In our modern industrialized society, we constantly are bombarded by a wide range of noise from the environment, such as from airplanes, cars, trucks, buses, cooling towers, lawn mowers, airconditioners, etc. In a school, high levels of noise from nearby roads will discourage learning. In houses near an airport, the deafening sound of aircraft awakens people, disrupts their telephone conversations, and interferes with their television viewing. At a hospital, the noise from a helicopter landing pad can be stressful to patients. At offices, intrusive noise can reduce productivity.

The buildings we build, where we locate them, and how we design them affect how these noise sources impact our lives. This article introduces some tools of environmental noise control analysis, with emphasis on techniques of noise reduction provided by buildings.

To wage the battle against these pervasive sounds, we need a measure of their magnitude. Our measurement tools describe the spectrum (noise signature of pitch and frequency), the level (loudness), and the duration (time patterns) of environmental noise.

Spectrum. Each noise source has its own unique sonic characteristics, which let us distinguish a truck from a motorcycle, or one type of automobile engine from another. Nevertheless, recent studies have shown enough similarity among all these spectra to suggest a standard spectrum that represents in a reasonable manner the average of freeway, aircraft, and railroad noise sources. This average spectrum allows us to model the noise in the environment for a number of sound reduction studies (see Figure 1). The salient aspect of this average spectrum is that most of the energy is low-frequency, around 250 Hz and below.

Figure 1



Level. The loudness of a sound is measured in decibels (dB) for each frequency range. Because the spectra of environmental noise sources are so similar, we can simplify our analysis, combine all the frequencies using the commonly accepted A-weighted filter of a sound-level meter, which measures the sound level in units called dBA (decibels on the A-weighted scale). This filter adjusts and combines the sound in the same manner as the human ear, which discriminates against low frequencies. This means that, for equal levels of acoustic energy, we are less sensitive to low, rumbling sounds than to high-pitched sounds. Without this filter, the low-frequency sound of diesel engines (which is similar to the spectrum in Figure 1) would be deafening. The manner in which the A-weighted filter adjusts the sound is shown in Figure 2. A-weighted noise levels in the environment can range from 30 dBA (very quiet) to over 100 dBA (painful).

Duration. The noise from modes of transportation (airplanes, cars, trucks, trains, helicopters, subways) fluctuates over time. The fluctuations may occur over just a minute or two (as a truck goes by), or over an hour (when there is a pile driving or demolition at a construction site), or over a full day (noise levels from highway traffic vary as road traffic patterns change), or over a year (varying levels around an airports due to seasonal wind patterns).

To resolve this dilemma, acoustic engineers have developed a measure called the "equivalent noise level," or LEQ, which represents with a single number, for any given time period, the equivalent or average noise energy from fluctuating sources. The decibel scale is a logarithmic scale, so the energy average is not an arithmetic average. For example, imagine a 20-minute interval when for half the time the noise level is 70 dBA and for the other half the sound is quieter, at 50 dBA. The LEQ, or energy average, for the 20 minutes, is 67 dBA, not 60 dBA, as shown in Figure 3.

LEQ values typically are measured for an hour and can range from LEQ 40 (perhaps during a quiet nighttime hour in a rural setting) to LEQ 90 or more (perhaps near a construction site during excavation).

For workplace locations, the daytime LEQ values are an accurate description of how loud the noise is. For residential areas, it is necessary to account for the fact that, because of normal sleep patterns, we are more sensitive to noise late in the evening and early in the morning. This is done by the "day-night equivalent noise level," or LDN, which averages 24 LEQ values over a full day, but first penalizes or increases the nighttime values (10 p.m. to 7 a.m.) by 10 decibels. The LEQ and LDN values are the most commonly used metrics for comparing and evaluating environmental noise. LDN values range from LDN 45 (a very quiet enclave) to LDN 80 or more (close to an airport; see Figure 4).

The actual LEQ or LDN noise exposure level at a site can be measured with proper acoustical gear, or it can be estimated with adequate data on the noise source patterns,

Mr. Rosenberg is a supervisory consultant in architectural acoustics with Acentech, Inc., of Cambridge, Mass., a new Bolt Beranek and Newman company for acoustical and environmental technologies.

Figure 2

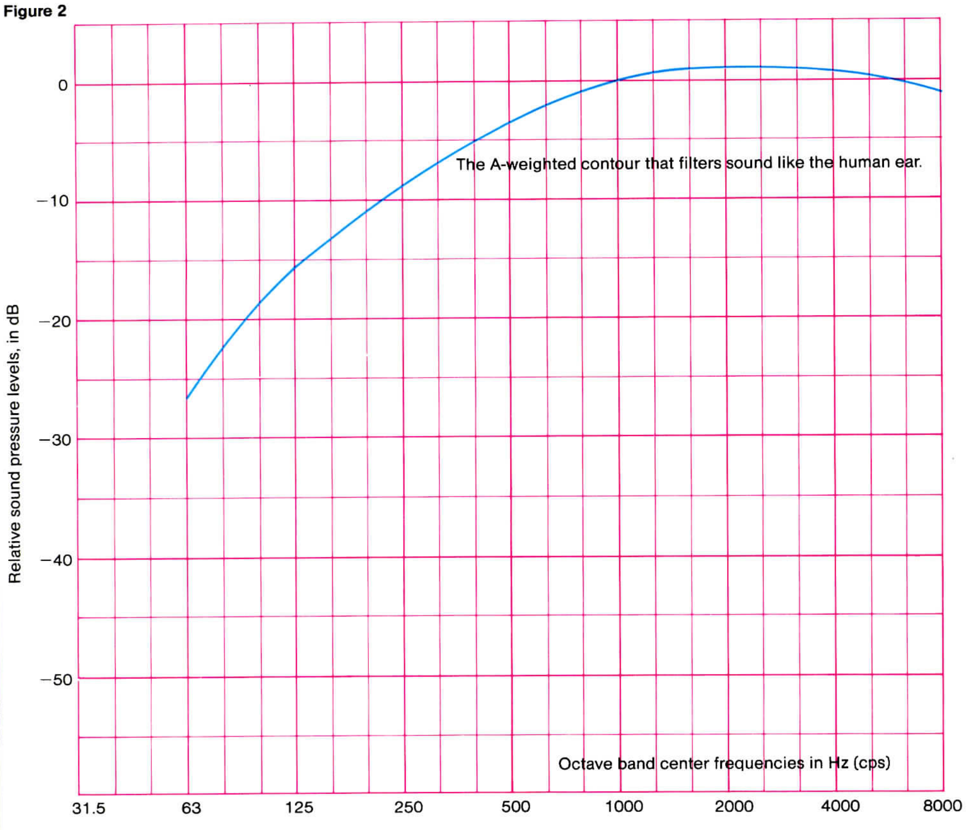
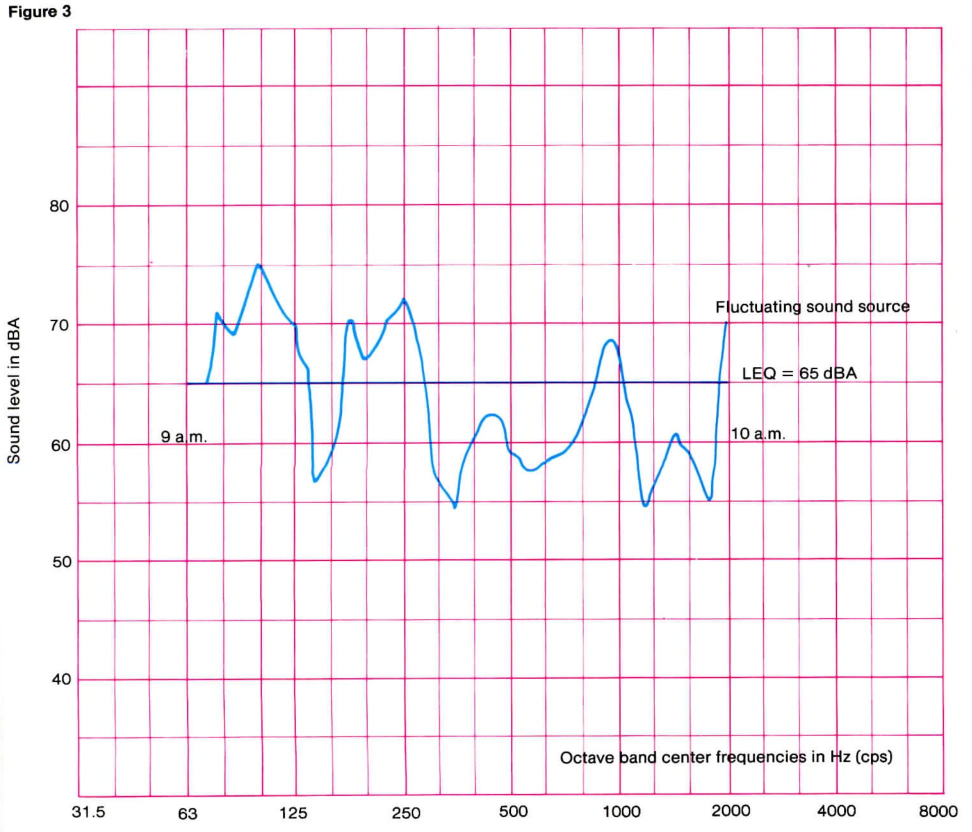


Figure 3



such as traffic counts, train operations, or whatever. Also, airports are required to document the noise exposure to the community with LDN contours updated for current runway utilization. The LEQ or LDN for every site level does exist and can be determined.

Noise exposure criteria. Studies in the early 1970s by the Environmental Protection Agency suggested that a reasonable threshold of annoyance for environmental noise in residential areas for most people in a normal population is around LDN 65. When environmental noise exceeds LDN 65, many people find it objectionable. This value has been promulgated by the U.S. Department of Housing and Urban Development and many state housing agencies to be a limit for "acceptable" conditions.

This acceptability is based on the assumption that typical residential constructions provide about 20 decibels of sound attenuation and that a suitable interior exposure should not exceed LDN 45. When *exterior* environmental noise levels exceed LDN 65, HUD and others require additional sound reduction measures to protect the *interior* environment.

Of course, everyone seems to respond to sound differently, depending on the level of the sound, one's association with it, one's life style, and the message of the sound. At one site near a railroad track, planners were perplexed at the low incidence of complaints in spite of high noise levels; then they found that most of the residents used to work on the railroad and found the noise comforting.

There are other environmental noise metrics and criteria one may encounter, such as speech interference levels (SIL), the noise level exceeded 10 percent of the time (L10), the community noise equivalent level (CNEL), and others, which are similar to the basic LDN concept but different in particulars and are beyond the scope of this article.

The LDN 65 criterion relates only to environmental noise sources. Other noise codes address concerns about steady-state sources such as industrial activity or your neighbor's airconditioner; these community noise codes may be more stringent, perhaps allowing only 50 dBA or so at the property line.

Also, our sense of annoyance may be quite unrelated to actual noise levels. For example, in the town where I live, the community basketball court mistakenly was located near some houses; the activity was annoying because of the content of the sound (the thump, thump of the basketball and associated expletives), and

Figure 4

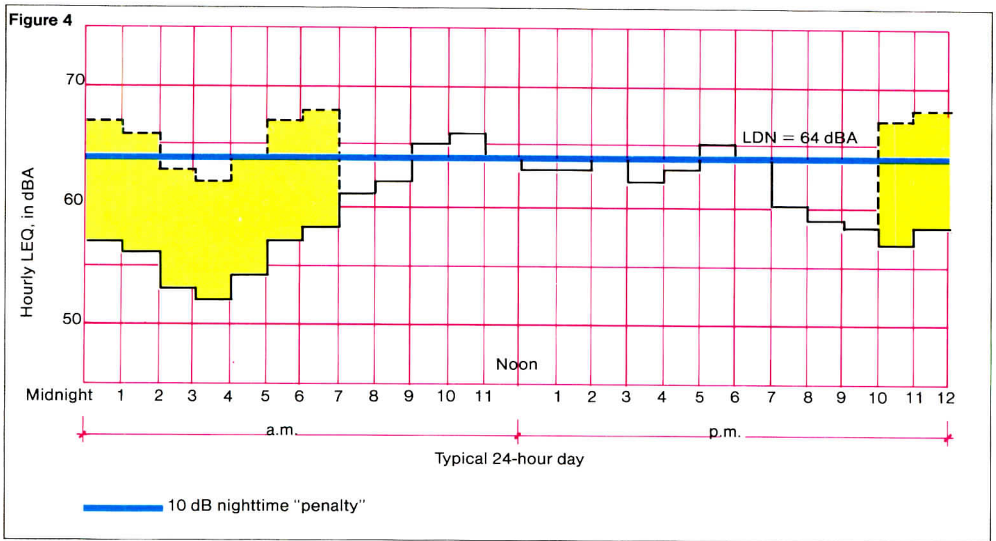
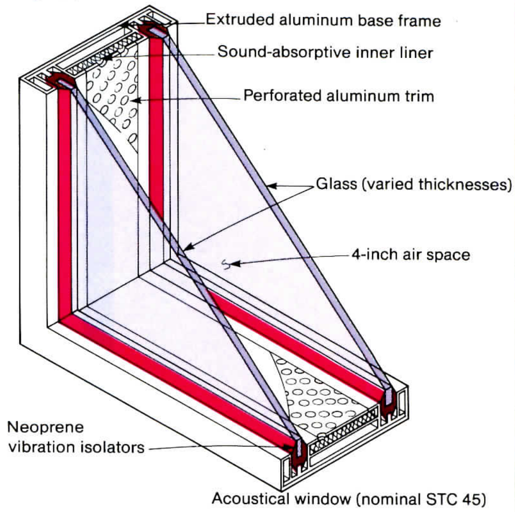


Figure 5



Acoustical window (nominal STC 45)

the court had to be removed. Research has shown—in case anyone does not already recognize this—that the single most annoying noise source in residential communities is barking dogs.

The best noise control treatment is to quiet the source. For example, there are codes, albeit poorly enforced, for noise from diesel exhausts. Cooling towers can be run at reduced speed during the night to quiet the noise; with multicell towers, two fans at half speed are quieter than one fan at full speed, and they deliver the same amount of cooling. Construction noise can be limited to certain hours of operation. FAA regulations are phasing in quieter aircraft engines. Highways often are bordered by berms or barriers to contain the noise. (Trees and plantings that hide noise sources have absolutely no acoustic benefit, but they can reduce our sense of annoyance by removing the offending source from view.) When we are limited in the amount of noise control we can introduce at the source, we look to buildings to protect us from noise.

Soundproofing strategies. Most of us accept reasonable levels of environmental noise inside our residences and places of work. However, in environments where the noise is unduly loud—that is, where exterior levels typically are LDN 65 and above, or where people are particularly sensitive—improvements must be made to the noise reduction of the building envelope. As with all acoustical problems, this means treating the weakest path first. In addition to tackling the problem at its weakest point, there is a hierarchy of "lines of defense" that suggests strategies.

The Sound Transmission Class (STC) rating is the accepted nomenclature for the ability of materials or construction systems to block sound (see Nov. '87, page 85). The advantage of this single number terminology is its universal acceptance by architects and engineers and the availability of performance data (although many exterior wall and roof constructions have not been adequately tested). The disadvantage is that the STC rating is designed to rate the noise reduction performance of materials for typical office or speech sources, not for environmental noise (as is the standard spectrum described above and shown in Figure 1), which has much more low-frequency content than speech. We can still use STC ratings, but keep in mind that they usually overstate the insulating properties of a construction system by five to 10 dB for environmental noise. That is, a construction with a rating of STC 30 will reduce environmental noise by only about 20 dBA.

The primary path through which sound attacks a building is where there are no barriers at all, that is, the cracks and gaps and leaks around penetrations. These openings have a value of STC 0. Old windows that rattle in their frames or ungasketed doors are significant sound leaks. Sealing these leaks is the same primary concern as when the goal is preventing heat loss during the winter: it does not make sense to insulate the walls until you close the door. When a typical building is sealed in this manner, we usually achieve 20-25 dBA noise reduction.

The next-weakest sound path acoustically is still usually the windows. Single-pane glass has a noise reduction value of about STC 25 to 30 (that is, 15 to 20 dBA of environmental noise reduction). Insulating glass is not much better, because the narrow air space between layers of glass, less than an inch, effectively couples the two layers of glass together, acting like a connector to form a single window unit.

In all fairness, glass really is an exceptional sound barrier material, as it is very dense. For equivalent thickness, it is better at blocking sound than concrete. However, we do not usually see six-inch-thick slabs of glass.

As a second line of defense, the way to provide more protection against higher environmental noise levels is to improve sound isolation of a window system by using two completely separate layers of glass spaced at least two inches apart and preferably four inches apart. This large air space allows the layers to act more independently and improves the STC ratings by 10 to 15 points. More importantly it improves the noise reduction performance at low frequencies, to 250 Hz and below. In residential applications, this can be done with well-fitting, tight storm windows either inside or outside. Nevertheless, the large air space is necessary for sound isolation. There also are special sound-isolating double windows, which have two separate panels connected in one frame, with a proper thermal break (see Figure 5).

Another window treatment is to use acoustic laminated glass, similar to the safety glass on car windshields. The lamination allows the two parts of the window sandwich to move independently and to be damped in their movement. This has a benefit of about five to 10 STC points compared with a similar thickness of regular glass.

Laminated glass comes in thicknesses of ¼, ½, and ¾ inches (STCs 36, 39, and 42 respectively) and can be combined into regular insulating glass configurations or into a double window system (see Figure 6).

In one recent project for an office building near a railroad, the preferred sound isolating system was a double window with a four-inch air space. However, the visual impact of the deep mullion on the facade was unacceptable to the historic preservation review commission. Instead, the overall window thickness was reduced to 1¾ inches, using two layers of laminated glass and a smaller air space, and it still achieved a 35 dBA reduction of train noise (a rating of STC 46).

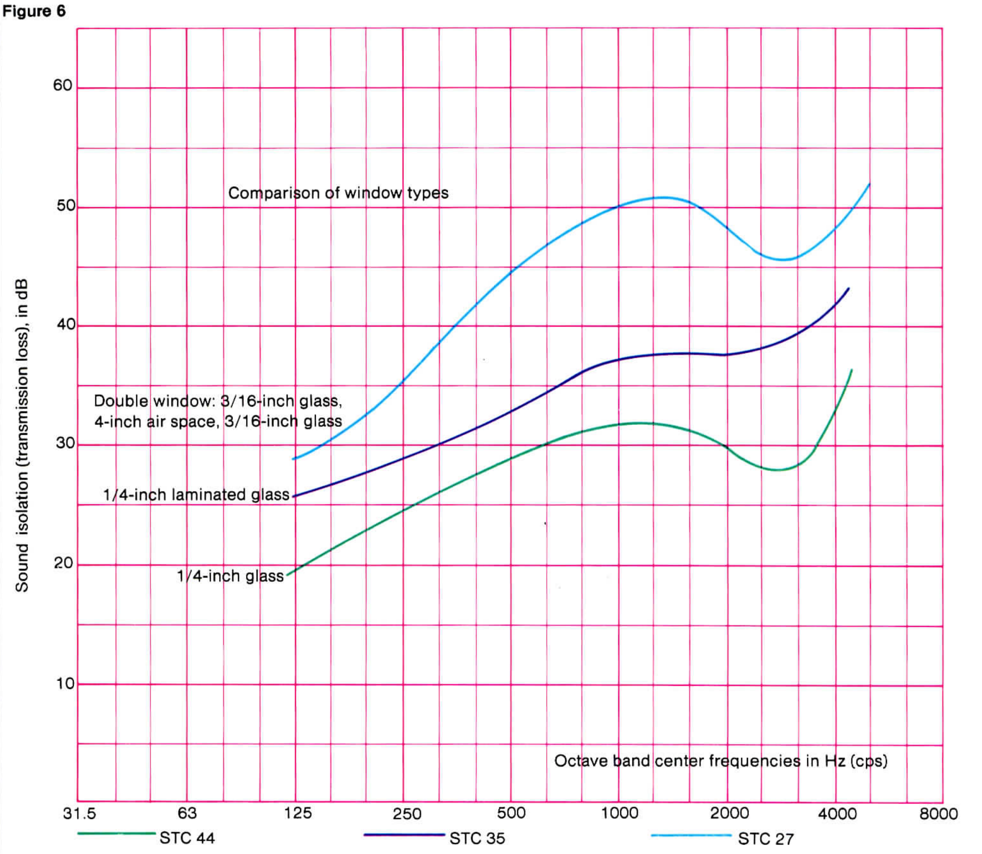
Other penetrations must be considered, too. Residential doors should be solid-core, well-gasketed, or weatherstripped. If possible, there should be a vestibule, if not, a good storm door. Airconditioners are a problem because, when the vent is open to bring in fresh air, the STC of that path is 0, and when the vent is closed there is only a single layer of sheet metal as a barrier; such airconditioners or vents may have to be removed or the ventilation system changed to a central system so that noise control techniques can be added properly. These techniques can provide 30-35 dBA of environmental noise protection, a 10 decibel improvement that will make intrusive sound levels seem half as loud.

In most houses, the noise reduction performance of good windows and storms will approach that of the rest of the envelope. There may not be any remaining single weakest path. What can be done, then, as a third line of defense for additional improvement? In this case, all systems must be upgraded together, most likely with double construction systems that provide a dead air space between inside and outside. This will entail double windows (not just storm windows), double walls (separate inner studs or inner skins on resilient channels), and separate ceiling structures. Attic insulation becomes important. Vestibules are now the mandatory way to treat doors. The inner room becomes a separate room in the building.

This concept of a room-within-a-room is just as suitable for other, more severe noise isolation problems as well. For performance environments (see Oct. '88, p. 93) the criteria for excluding intrusive noise are extremely severe. It may be necessary to develop a full isolation system for walls, windows, doors, roof, and even the floor. St. Peter's Church in the Citicorp Complex in New York City sits entirely on neoprene isolator pads so that the noise and vibrations from the subway below are not audible.

The last defense. There are two ways the conditions within a room can affect annoyance from intrusive noise. One is that absorptive finishes in a room reduce the sound somewhat, but they affect only the sound that has already come through

Figure 6



the walls or windows. A heavily furnished bedroom will sound slightly quieter than an unfurnished bare room; unfortunately, we have found that the amount of sound absorption in typical living spaces does not vary greatly once the room is occupied. The maximum difference might be no more than three to five decibels, and seldom do we see such extremes.

The second manner in which the interior environment can affect annoyance is the degree to which other sounds are present. Part of our annoyance from environmental noise is that it is recognizable and draws our attention. In one office building, where an executive was distracted by the truck traffic outside, the additional window we first proposed was going to be too expensive and awkward to install. Instead, we added a sound masking system that introduced a noise of its own, louder than the highway noise, but not so loud at to be distracting. The constancy of the masking sound covered the fluctuation of the traffic sound. When you are in a hotel near an airport or interstate highway, a fan may be more soothing than the roar of trucks or the whine of a jet engine. This same approach is even more successful outside, as shown in the vest-pocket parks in New York City, where fountains help cover street noise.

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Photographs © Wayne Thom Associates

Borrowing Techniques of Shelter From Desert Trees

Red Mountain Ranch Visitors Center, Arizona.
By Lawrence W. Cheek, Hon. AIA

To an architect willing to watch and learn, both the plants and animals living in the Sonoran Desert of Arizona can imply an architectural language. For the Red Mountain Ranch Visitors Center, Phoenix architect Robert R. Frankeberger, AIA, has stolen a strategy from the spiny cholla cacti and twiggy palo verde trees that surround it.

These plants, Frankeberger observed, "create their own filigree of shade to protect themselves from the sun." Some species of cholla, in particular, sport a jacket of needles so dense that sunlight barely squirms through. If a building were to do likewise, he reasoned, not only would it make environmental sense but the patterning of light and shadow also could provide ornamentation.

Red Mountain Ranch is an 830-acre housing development in the sprawling Phoenix suburb of Mesa. Many prospective buyers are newcomers to Arizona. With that in mind, Mobil Land, the developer, asked Frankeberger to design a visitors center that could help sell the idea of living on the desert even on those days when it seems as hospitable as a pizza oven. Frankeberger also thought he saw an opportunity to inspire buyers who were going to be building their houses at Red Mountain. "You can always refrigerate a building, but that isn't an architectural solution," he says. "I was hoping this would stretch some imaginations." So far, no luck: the development is sprinkled with the strictly conventional Spanish Colonial Revival Revival houses that are the rage around Phoenix.

The enclosed space of the Visitors Center itself is conventional: a 4,500-square-foot wood frame and plaster box. The finish is a wan green that Frankeberger chose because it resembles the color of desert vegetation seen in the distance. Some visitors may find it bilious. There is a roof garden used for community parties and promotional gatherings.

The distinctive element, of course, and the feature that makes the roof garden habitable, is the swooping lath that teases the building with ribbons of shade. It isn't just a utilitarian screen; it exudes personality. Marcus Whiffen, editor of a regional architectural journal entitled *Triglyph*, has written that it suggests a desert bird of prey, its wings half-spread. Others see it in motherly terms, as an immense hawk sheltering her brood from the scorching sun. In fact, the delight of the lath is its duality: it seems both monstrous and delicate, predatory and protective, mysterious and congenial. Looking out through it, one enjoys the contradiction of being a part of the desert yet sheltered from it.

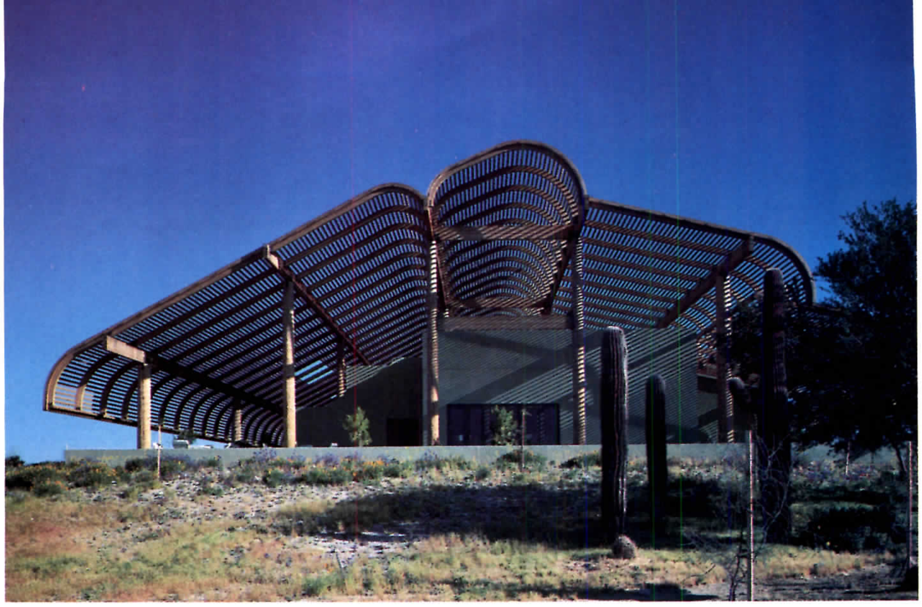
The tight weave of light and shadow is also a desert experience. It abstracts the sensation of walking in an arroyo in the mottled shade of tiny-leafed mesquite and ironwood trees. Frank Lloyd Wright understood this. In 1940 he wrote that "the dotted line is the line for the desert, not the hard line nor the knife edge." The "dotted line" scatters the light and welcomes architecture into the stark but lovely world around it.

The lath is made of rough-sawn Douglas fir 2x3s spaced three inches apart; it's supported by cylindrical fir columns. There's no finish to protect the wood—Frankeberger insists it's unnecessary. "Using wood in the desert seems impractical, but it's not," he says. "It's not going to mildew or dry rot. It is going to chap, but if it's rough-sawn, that's disguised."

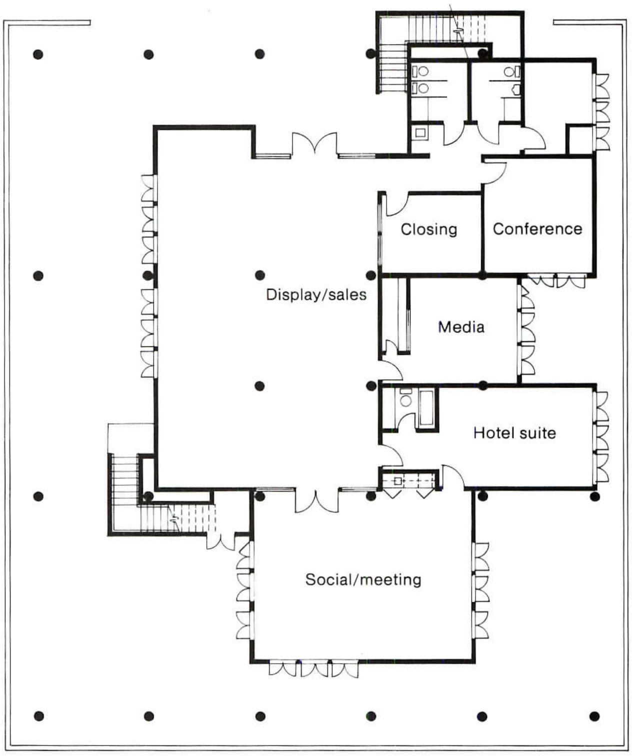
No one has studied the lath's effect on airconditioning load, but that isn't its reason for existing. It's simply a marketing tool. There is a perception of a kinder, gentler climate under it, and that may help close deals.

There's one problem. More community buildings are rising around the visitors center, and Frankeberger's lattices are multiplying. Mini-laths, looking like fragmentary offspring of the mother, now loom over patios at the country club, the tennis courts, and even a mailbox cluster. Employed sparingly, this thematic reiteration would be charming. It is past seeming sparing. It is becoming a cliché. Frankeberger pleads that he's now a leaf in a whirlwind. "This is what happens," he says, "when you start out with a marketing device and it becomes a signature for the development."

Swooping lath roof gives the center its mother-hawk look, seen from the southwest, opposite, and from the northwest, above.



View above shows the center cradled under its sunshade; below is the west garden. Opposite page shows 'dotted lines' of sun and shade in the roof garden. □



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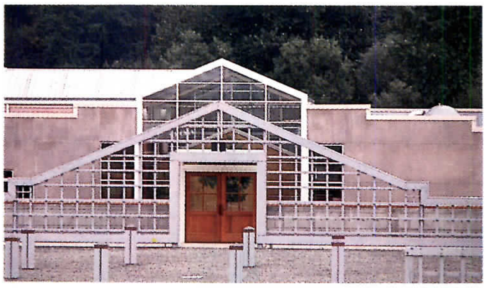


Photographs © Linda M. Feltner

Controlled Environment for Plants

Douglas Research Conservatory, University of Washington. By Timothy B. McDonald

The Douglas Research Conservatory addition to the Center for Urban Horticulture on the campus of the University of Washington in Seattle expands the capabilities of the first major facility in this country dedicated to research and study of plants in urban environments. The new conservatory allows controlled studies of plants from various parts of the world in individually designed and controlled environments, including varied levels of air pollution or root oxygen deficiencies. "Urban environments are not the best place for plants, and the conservatory in essence is a factory for dealing with environmental conditions," says Johnpaul Jones, AIA, partner in charge and principal of Jones & Jones, the architect for the project.

The firm's skill in the integration of architecture and landscape architecture has brought into its office not only building projects but also gardens, aquariums, and a considerable number of planning projects. One such project was the master plan for the Union Bay Teaching/Research Arboretum, completed in 1976. On the same 115-acre site, the firm later designed and supervised construction of the Center for Urban Horticulture and then the Douglas Conservatory.

Long association with the site made Jones & Jones aware of its complexities and quirks. Bordering Lake Washington, the site was a marsh and peat bog, but starting in 1926 its central portion was used as a landfill. In 1966, the refuse was capped with fill material. Unfortunately, the naturally high water table had saturated the peat and refuse and accelerated its decomposition. This decomposition generated gases and subsidence that have made large portions of the site undesirable for building. In fact, the original design sited the conservatory south of its present position, but the escaping gases and soil's poor bearing conditions caused the building to be relocated to the north and east, on an axis with the horticultural center.

The surrounding residential community carefully scrutinized the conservatory design. Wary of university expansion, residents were concerned that a large-scale building would bring problems to their neighborhood and obstruct their view to the lake. "To answer their concerns, we designed all of the buildings low, sunk half into the ground. Everything above the ground is limited to one story and looks very residential in character," says Jones.

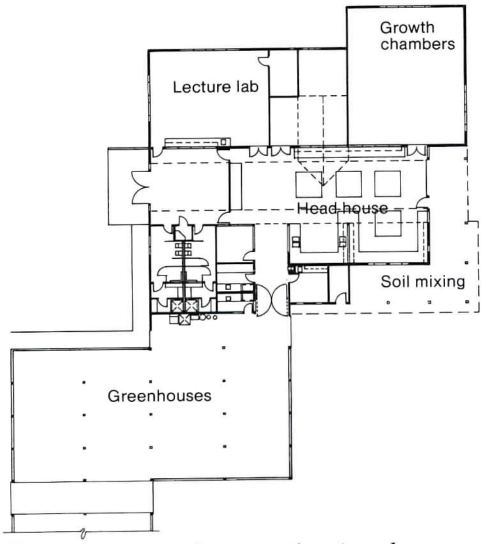
The first phase of the design, which was funded privately, includes the head house containing the growth chambers, laboratories, classrooms, workshops, storage, and environmental controls, as well as the first of several greenhouses. As state funds become available, additional greenhouses will be added.

The greenhouse system, manufactured in the Netherlands, was selected by the client and shipped to the site for assembly.

"Our firm ended up providing the slab and working with the Dutch engineers on the mechanical and structural systems," says Jones. The overseas coordination required some special attention. For instance, the motors for the mechanical units, all supplied by the Dutch firm, were not UL listed and had to be replaced. And while the glass walls of the greenhouse are double glazed, the roof is only single glazed. Although the single glazing permits maximum light penetration, it didn't meet the city's energy code. Happily, given the special nature of the buildings, the city agreed to waive the local code requirements for the greenhouse. To integrate the project, Jones & Jones incorporated some basic elements of the Dutch greenhouse system, such as the pitched glazed roofs, exposed steel structure, and large natural finished doors into the head house.

The existing greenhouse (as well as all future greenhouses) has separate mechanical, shading, and lighting systems controlled by a central computer in the head house. The client specifically requested these discrete mechanical packages for ease of control and increased environmental sensitivity within each greenhouse unit. Additionally, glass partitions divide the greenhouse into three separate bays, creating smaller and more controllable environments. The greenhouse has two gas-fired boilers, the second as a backup should the first fail.

An evaporative cooling system, located in the greenhouse north wall, cools and humidifies the bays. Also controlled by the central computer, the cooling system uses chlorinated reservoir water that is pumped up and allowed to drip down through corrugated cardboard material. Any water that does not evaporate



Facing page, main entry (top) and pitched roofs give the conservatory its community-approved residential scale. This page, clockwise from upper left: entry court, head house, and greenhouse.

Photographs © Linda M. Feltner

is recycled. "It's a simple system, a good deal like a radiator. A float in the reservoir signals when the water is low," says Chapin Krafft, the project architect. The cooled air is then pulled through the greenhouse by fans located in the south wall.

Additional cooling as well as insulation for the greenhouse is provided by the automated shading system. The manufacturer supplied each greenhouse with shade blankets, one for each bay. The architect likens them to covers for swimming pools. Mounted on stiff quarter cables at nine to 10 feet above the floor, the blankets' positions are adjusted by the computer, to provide the amount of shade or sunlight required by any experiment. The blankets also provide insulation at night, and can be put in place to prevent excessive heat gain.

Designing the greenhouse slab was not as simple an exercise as one might guess. Jones explains that the wide expanses of slab often used in a greenhouse make it difficult to control cracking. "While this normally isn't a problem, we and the client were concerned that chemicals or contaminates used in experiments could be washed into the cracks and eventually escape into the surrounding soils," he says. "Working with the local concrete institute, we found the best solution was to score the concrete. The initial cuts, made while the concrete was still green, were 1/8 inch wide and 1½ inches deep. We made a second cut, 3/8 inch wide and one inch deep, over the first cut after the concrete cured. The cuts, filled with a flexible epoxy grout, act as control joints."

The head house portion of the project also demonstrates the architect's environmental concerns. The central core of the head house is a simple steel post and beam system with a translucent plastic roof. The structure in rooms off the central core is exposed, except in the lecture room where a gypboard ceiling has been hung "just to spiffy it up." The exterior finish is stucco on lath over metal studs, and the interior finishes also were kept simple and inexpensive. For instance, plywood panels were fastened to the structure and finished with marine spar varnish, and all fasteners were left exposed. "We tried to keep everything industrial and simple, using materials that normally wouldn't be exposed and finished," says Jones.

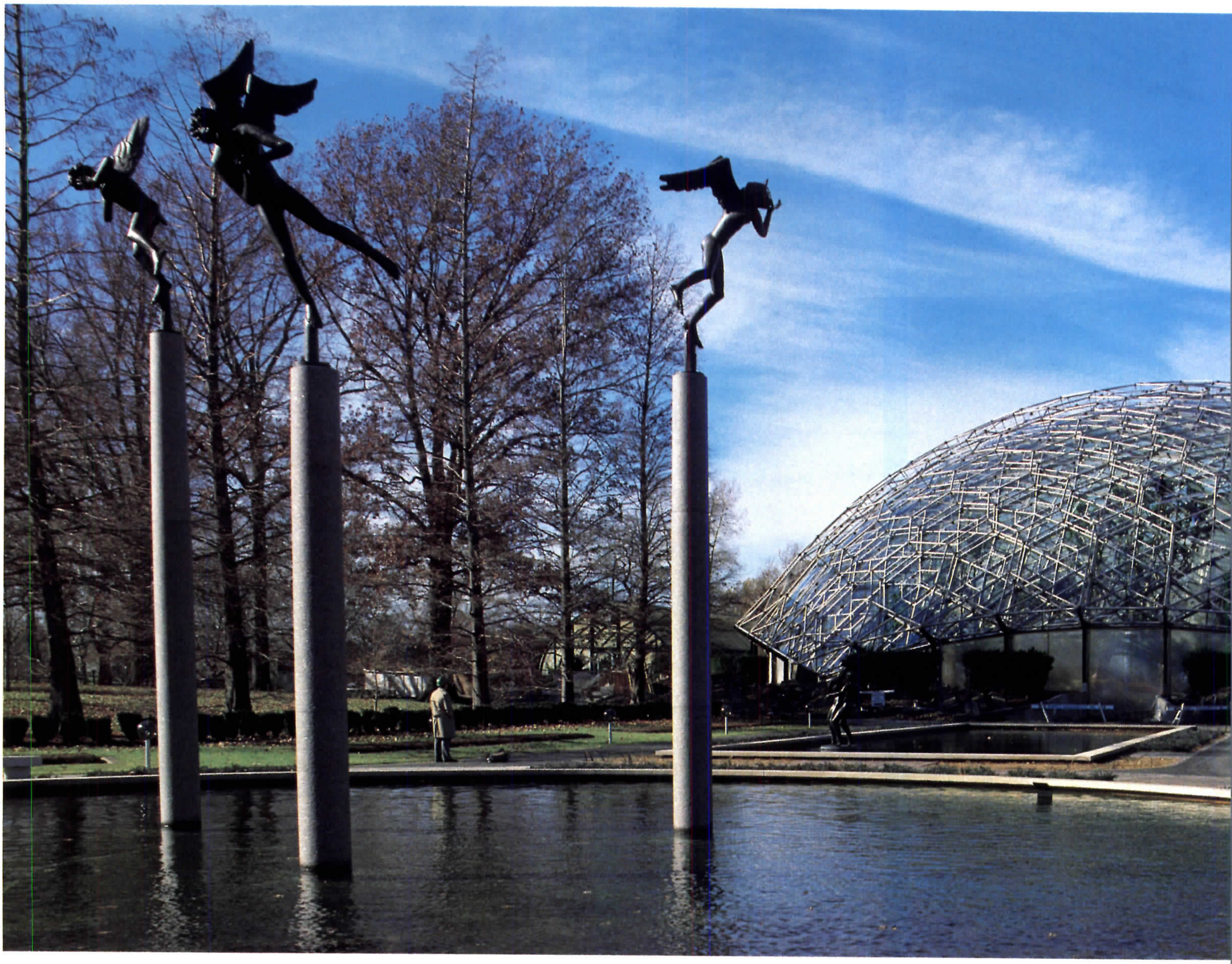
The head house core, which often is cooler than surrounding spaces, is zoned separately from the classroom, growth chamber, labs, offices, and rest rooms. A gas-fired radiant heater suspended from the ceiling joists heats the core, while two small boilers provide radiant hot water heating for the other rooms. For cooling, a continuous band of clerestory windows runs the length of the head house's central core, and every seventh window is operated by a pneumatic opener controlled by a remote heat-sensing unit linked to the computer. When it is too hot, the windows open and through-wall fans exhaust air.

Directly off the central core is the growth chamber room, housing 12 units that the architect describes as looking like "giant freezer units." Although an off-the-shelf item, each stainless steel unit is a contained environment in which specialized research can be conducted. Computer-controlled, each unit provides carefully regulated periods of light and amounts of water and nutrients. At present three units are in place, and others will be added as the research load requires. As more units are put into place, a cooling tower may have to be added as planned.

The two labs, one for brewing pesticides and the other for making and mixing fertilizers, are quite small. Both are positively sealed and equipped with fume hoods as well as standard lab equipment, including purified water and compressed air.

Both the head house and greenhouse are equipped with three water systems: potable water for domestic use, nonpotable water, and purified water for experiments. A reverse-osmosis system with de-ionizers provides the purified water. To avoid the contamination that normal plumbing may cause, the purified water is distributed throughout the complex in plastic pipes connected by plastic couplings.

In addition to the usual university classes and research projects, the horticulture center and the new conservatory offer continuing education courses and information to landscape and architecture professionals. With its unique emphasis on urban horticulture, this plant "factory" is and will be an important resource for the Seattle community and for other urban communities as well. □



Allen Freeman

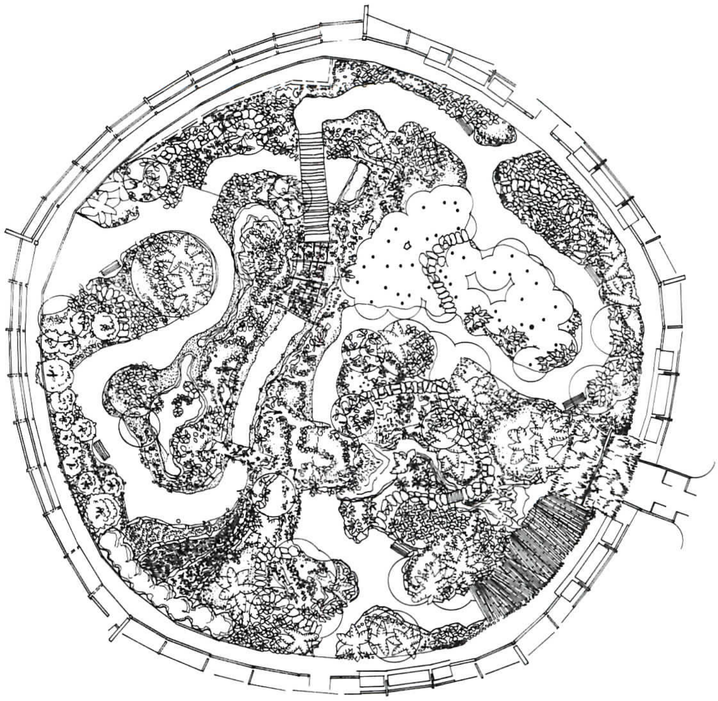
Reglazing a Celebrated Dome Greenhouse

The Climatron, Missouri Botanical Garden, St. Louis. By Allen Freeman

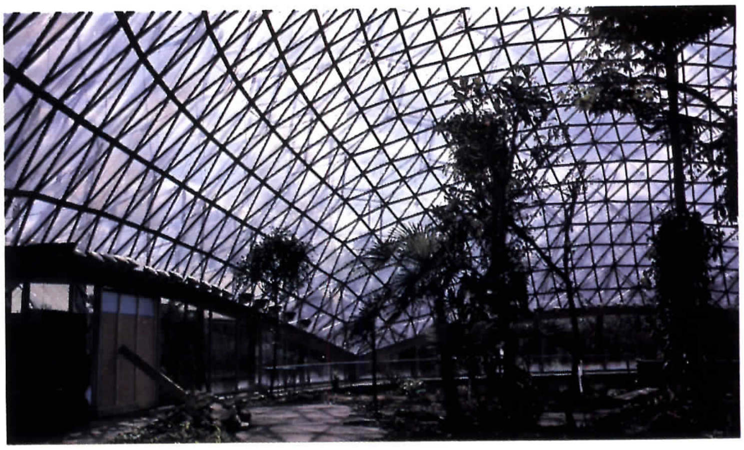
The Climatron is justifiably treasured in St. Louis. The architect, Eugene J. Mackey Jr., employed Bucky Fuller's geodesic dome with economy and clarity as a free-span greenhouse covering three-quarters of an acre in the Missouri Botanical Garden. The structure was entirely aluminum (Murphy & Mackey won the R.S. Reynolds award for it in 1961), and the skin was Plexiglas, a material that enabled the architects to design an enclosure strong and light enough to meet the local building requirements at the time.

Murphy & Mackey predicated the Climatron's structure on—and tailored its skin supports to—the flexibility and light weight of Plexiglas. A double layered pipe structure of hexagons rose above five perimeter "lunes" that arced down to five piers. From the dome structure were suspended by aircraft cable 3,625 triangular Plexiglas pieces. The glazing material's life span under these conditions was then unknown; one estimate was five years. The system actually lasted 28 years, although there were leaks from the beginning, no doubt caused by the movement of the flexible system, and through the years the skin became abraded and developed little internal fractures, giving the once clear Climatron a hazy appearance and reducing transmission of sunlight by about 50 percent.

Now almost complete is a project of skin removal and reglazing that is restoring the dome to transparency. Today the aluminum structure stands as it has since 1960, except that glazing no longer hangs from it. The new enclosure is a freestanding dome (allowed under the BOCA code now used in St. Louis) anchored at the five piers. It employs a rigid low-e glass manufactured as a laminated sandwich with a reinforcing plastic interlayer. The glass is cut into larger pieces than was the Plexiglas,



Allan Freeman



and the glazing pattern, instead of triangles playing against the hexagonal structure as before, is now hexagonal and identical in size to the structure's pattern. "We reduced the number of glass pieces and thus glazing bars and the resulting amount of shading," says Jim Morgan, architect for the reglazing project. The elastomeric glazing sealant is a thermoplastic rubber.

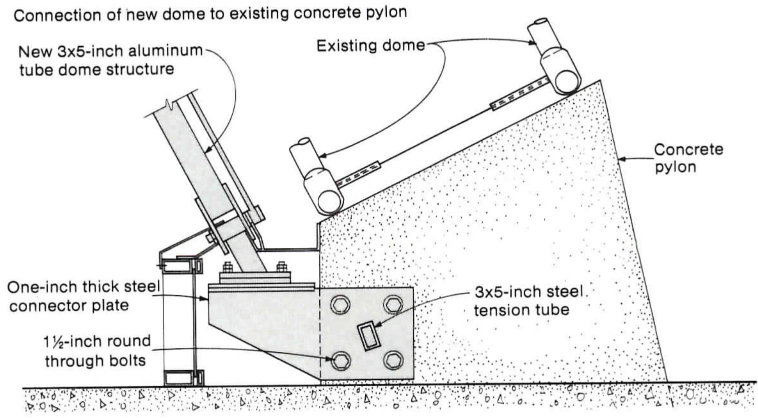
Construction of the glass dome was intricate and complicated, says Morgan, because of concern about excessive point loading on the geodesic structure, which is designed for uniform loads resulting from wind, snow, and the like. Construction crews were prohibited from bearing on the aluminum frame for hoisting glass. A crane raised the glass from the outside, while workers who clambered atop the structure worked with others on scissors lifts inside to position and secure the pieces. The project, begun last May with removal of the old panels, was a race against weather to re-enclose the structure and protect the botanical specimens, some of which are more than 200 years old and came from a display at the St. Louis World's Fair in 1904. The last piece was placed Oct. 26, and the plants were protected from freezing. Since then, workers have been installing cap pieces to permanently anchor the glass, using a wet seal.

HVAC modifications include introduction of heating ducts around the entire perimeter and a "cannon fan" aimed upward in the center of the dome to eliminate air stratification.

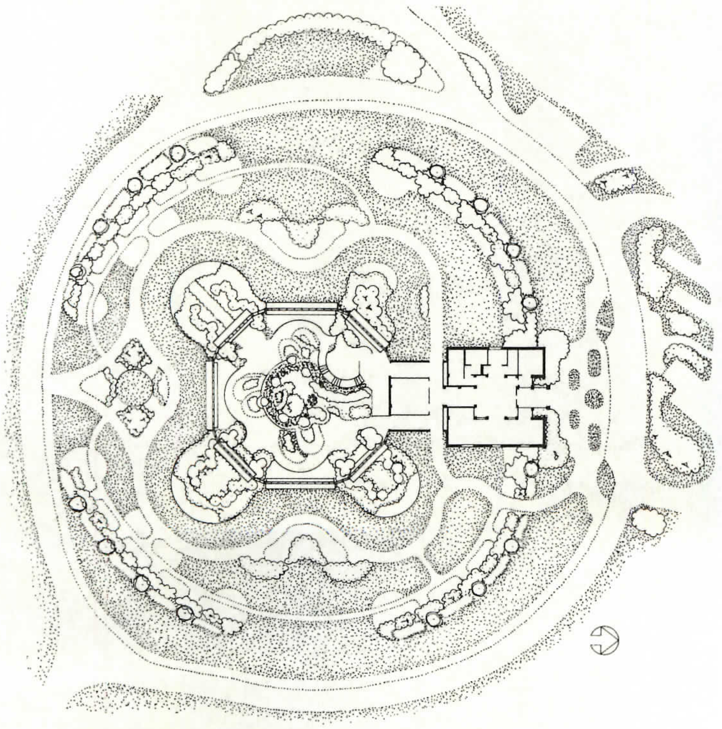
Still to come is relandscaping by Environmental Planning & Design and completion of a new annex greenhouse called the Temperate House, designed by the Christner Partnership. □

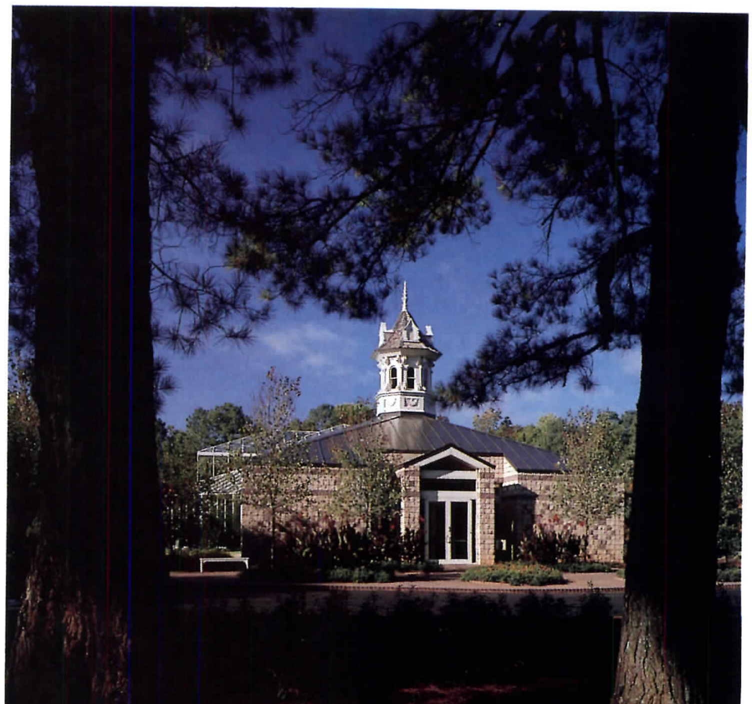
Top right, new landscaping plan is by Environmental Planning & Design. Right photos, new dome (above) and 'before' view.

Connection of new dome to existing concrete pylon



Photographs © Paul G. Beswick





Top, the octagonal conservatory was intended to evoke Victorian greenhouses. The entry pavilion, above and right, is clad in split-faced concrete block. Its top-knot is from a demolished building in a nearby town.

Special Center for Fragile and Demanding Creatures

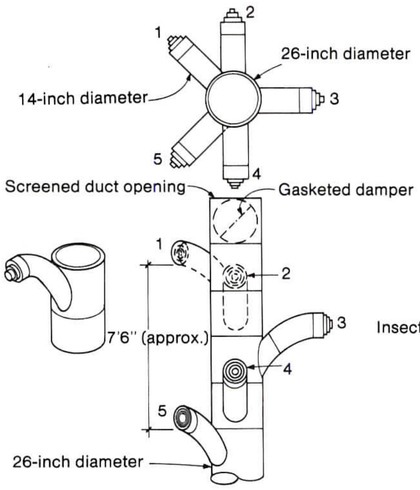
Butterfly Center, Callaway Gardens, Georgia.
By Allen Freeman

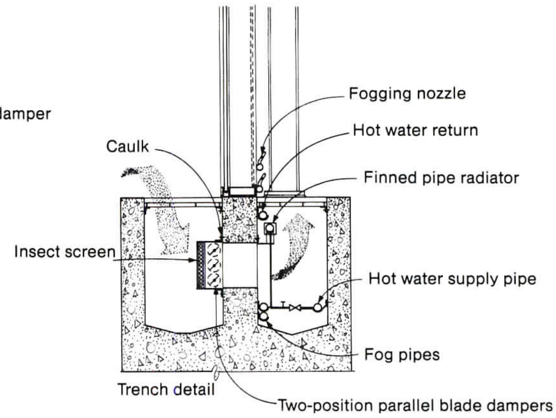
Here is a house for butterflies, flowers, birds, and people. The butterflies dine on the flowers; the birds—hummingbirds, doves, ducks, and partridges—dine on butterfly predators; and people come to see the butterflies. The client, Callaway Gardens in rural western Georgia, calls it the largest free-flight, glass-enclosed conservatory in North America for the display of butterflies. Named for the founder of a motel chain whose widow provided funds, the Cecil B. Day Butterfly Center is a companion to the John A. Sibley Horticultural Center shown on these pages in December 1984; both lie within the 2,500-acre botanical preserve.

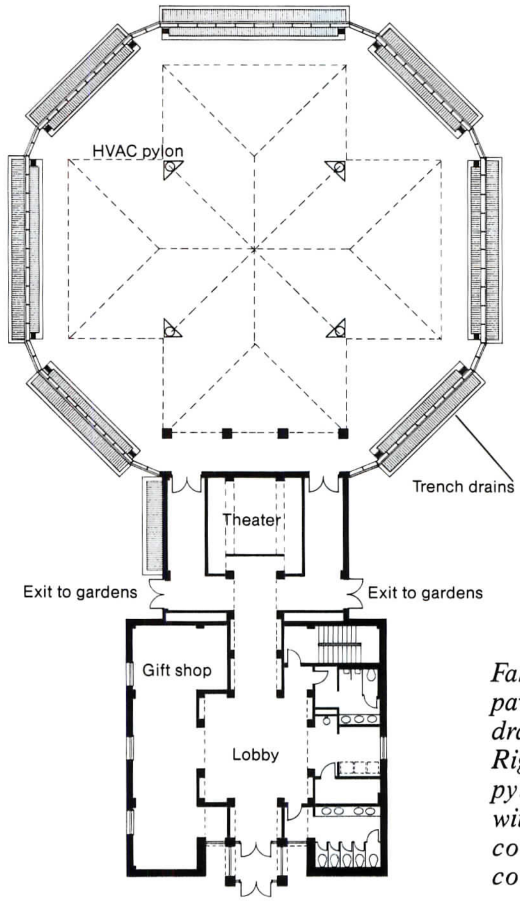
Because caterpillars are ravenous and would denude the tropical plants in the butterfly house, they live behind the scenes at Callaway Gardens, in humdrum greenhouses befitting their wormy character. Only after they spin their cocoons are they put on display, in a glass-front incubator the size of a small refrigerator within the butterfly house, where they are lined up like so many tiny mummies. There locally produced pupae are joined by exotic specimens shipped in from around the world. When the winged adults emerge, they are released into the conservatory.

Butterflies thrive best in a constant 78 degrees Fahrenheit with humidity between 60 and 80 percent, and they need sun to charge up the tiny solar collectors in their wings and launch themselves into flight. Architect Jova Daniels Busby, consulting engineer Nottingham, Brook & Pennington, and landscape architect Robert E. Marvin & Associates found little precedent for the Day Center—mostly modified greenhouses in England and Australia. Henri Jova, FAIA, says, "I didn't know a damn thing about butterflies until this came up. Now I know more about them than I know about my own family." With consultant horticulturist Bill Barrick, lepidopterist Frank Elia, and biologist Jane Brook, they created a safe environment for up to 1,000 live lepidopterans and a nearly ideal place for people to appreciate them.

The butterfly house occupies a small glade edged by a circular drive. You approach the clearing from the southeast; the glass structure rises amid flower gardens and lawn bordering curvilinear paths. These plantings are intended to attract indigenous butterflies. Cars and tour buses circle the clearing and then turn off into shadowed obscurity under trees on the glade's northern and western edges. The building comprises two dissimilar abutting structures that relate to each other a little like Laurel and Hardy: a taut and deadpan entry pavilion with a funny hat as Stanley set against a white, puffed-up octagonal glass conserva-







Photographs © Paul G. Beswick

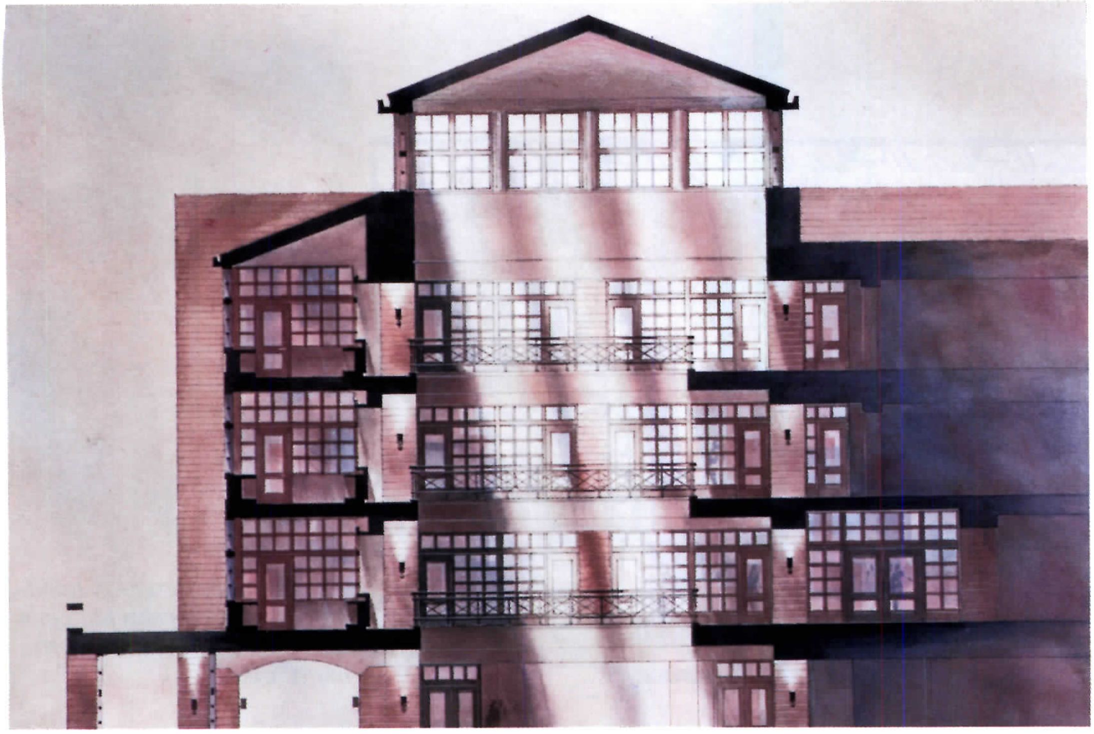
Far left, the entry pavilion has cathedral ceiling, Right, HVAC pylon sprouts within a structural column in the conservatory.

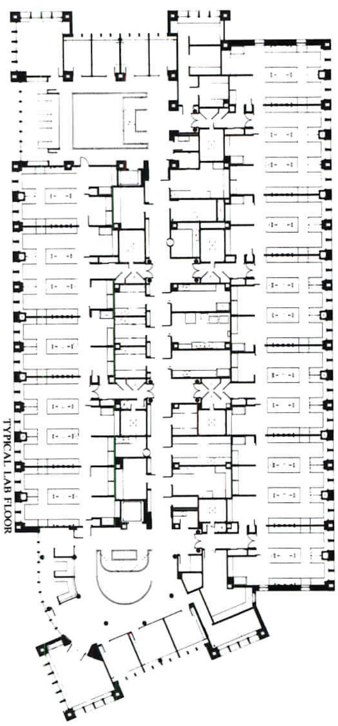
tory as Oliver. (The hat is an architectural relic from a house in LaGrange, Ga., and it seems about a size too large.)

You can buy a souvenir, see a video about butterflies, and generally cool off in the entrance pavilion, but you can't buy snacks because human food attracts ants and cockroaches, enemies of the butterfly. From there you enter the warm and humid conservatory, where butterflies flit among the tropical plants and a waterfall and, perhaps attracted to your bright jacket, land on your shoulder. A curved brick walk swings out near the edge of the glass enclosure and completes a circuit back to the entrance; if you stand in certain spots you may get drops on your head from overhead foggers. Four steel column clusters support the glass and steel enclosure, each column composed of three structural Vs and braced with zigzag members. Within each cluster is a creamy white HVAC pylon with vents sprouting like sawed-off limbs. The enclosing structure, also painted white, is somewhat beefier and more complicated than one might desire, apparently a trade-off in favor of a more interesting two-tiered, octagonal building form. Netting is strung inside the enclosure both to protect butterflies from hard surfaces and to satisfy an Environmental Protection Agency requirement of a double enclosure. (EPA is fearful of a butterfly equivalent of the Japanese beetle invasion.) The netting precluded use of filtered glass because winter light levels would be unacceptably low.

Their fragility means that butterflies are demanding creatures. Consulting engineer Arthur Brook did extensive computer modeling to test proposed building orientation, extent and type of glass, and light emission. His goal was to promote butterfly flight and plant growth during winter without frying the conservatory contents in summer. In addition to passive solar heat, the customized system uses gravity ventilation when outside temperature and humidity meet interior needs; powered ventilation for summer with concealed perimeter "trench" intakes housing a pressurized fogging system for evaporative cooling; high recirculation fans to minimize stratification and conserve heat; an air handling system with economizer and humidifier for winter conditioning; a supplemental cooling coil in the air handling unit (for social functions in the conservatory); a high-level fogging system for winter humidification and summer cooling; and a computerized system to control all functions automatically.

An important measure of the Day Center is the grace with which it conceals its environmental sophistication. □





Rutgers University lab design shows intent to incorporate both daylight and casual meeting places.

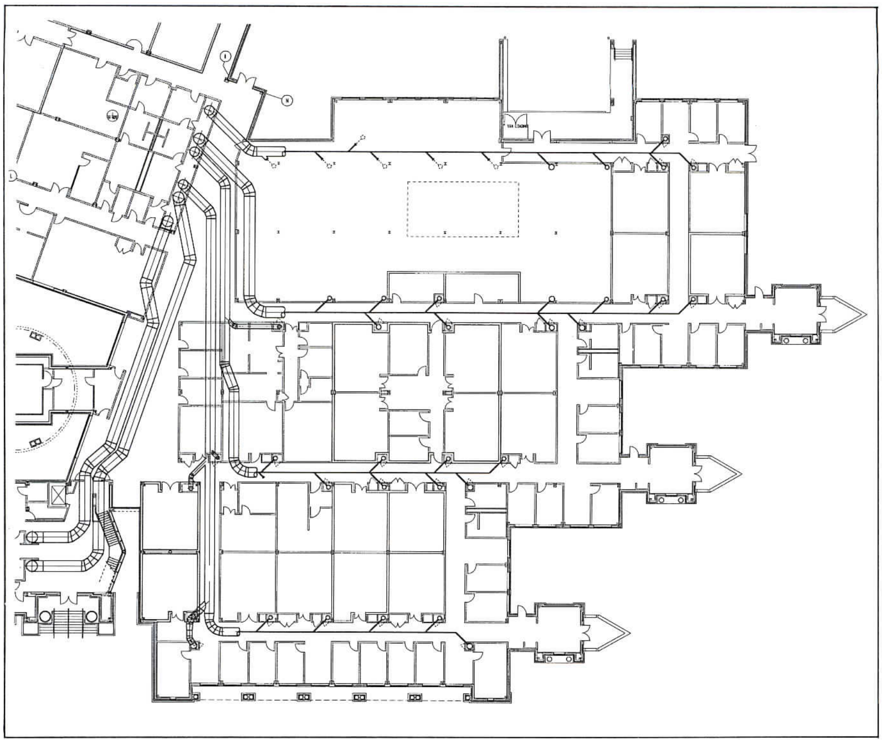
ever need in every one of those modules. Utilities usually were brought up in shafts. If you made a large lab out of a series of small modules, the modules would always be interrupted by a shaft wall and they became a physical impediment to lab layout. The approach we've been following recently is to create large, uninhibited laboratory space—a loft type of space—and collect the services in one end or opposite ends of the building." In HLW's design for the Miles pharmaceutical research center in West Haven, Conn., shaft spaces are located at the ends of the L-shaped building, with additional shafts toward the plan's bend. From the shafts, air ducts and plumbing are distributed through six-foot-deep hung ceilings to labs located at the building's periphery. Lab support areas and storage are placed in the plan's spine.

Kiil adds that, in general, mechanical systems tend to share spaces in labs, adding to flexibility. "Very often we provide spaces for systems, but we don't build in all of the systems. Sometimes its economical not to build everything in, but to provide space for it so that at a later date when you need more complex systems they can easily be added."

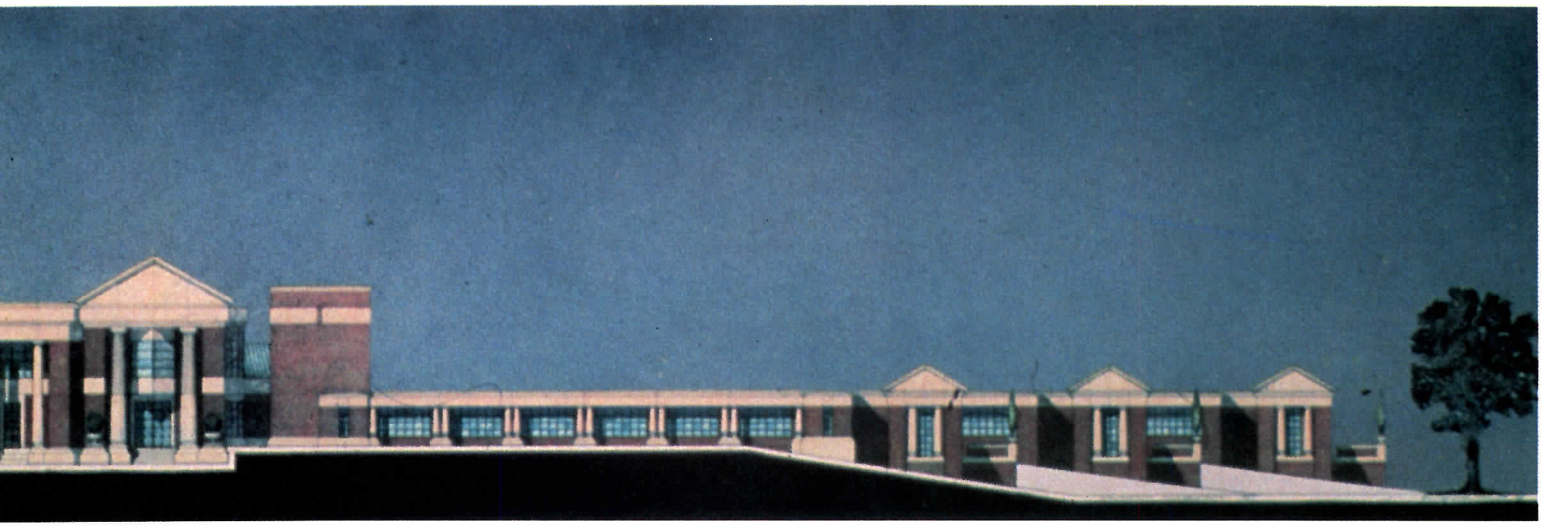
Flexibility in a lab designed for production requires equipment that can be modified without disrupting the manufacturing process. Says Loiacono, "In micro-electronics, a piece of equipment may have a life of only 18 months. You have to have flexibility in terms of space and available utilities so a new piece of equipment can be moved in and connected in the shortest possible time."

Another Symmes Maini & McKee project, Serono Laboratories in Randolph, Mass., had a great number of technical demands to be accommodated in an existing one-story building of 12,000 square feet. The biotechnology lab allows research and development of new therapeutic products through recombinant DNA technology to be tested before being put into large-scale commercial production. Thus the lab had to be flexible enough to respond to the changing direction of biotech research. "Probably the biggest challenge was to provide for the use of gaseous materials and the removal of liquid waste by gravity within this single-story warehouse," says James Polando, Symmes Maini & McKee's chief process engineer. The mechanical room for this kind of lab, normally housed in a two-story space, had to work in a one-story space.

Maintaining mechanical systems and the facility itself is essential for research that requires an environment where conditions must be consistent over long periods of time for experimentation. For production of pharmaceuticals and biological matter, FDA approval rests on the repeatability of the manufacturing process. Every step—and the environmental conditions in which

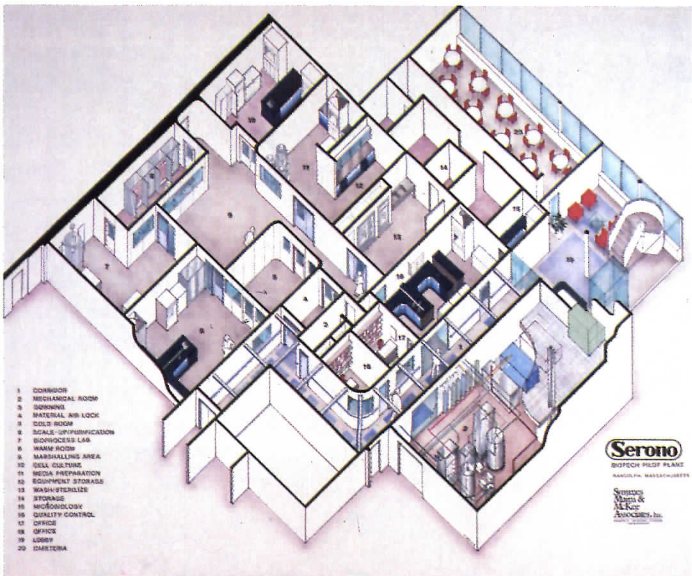


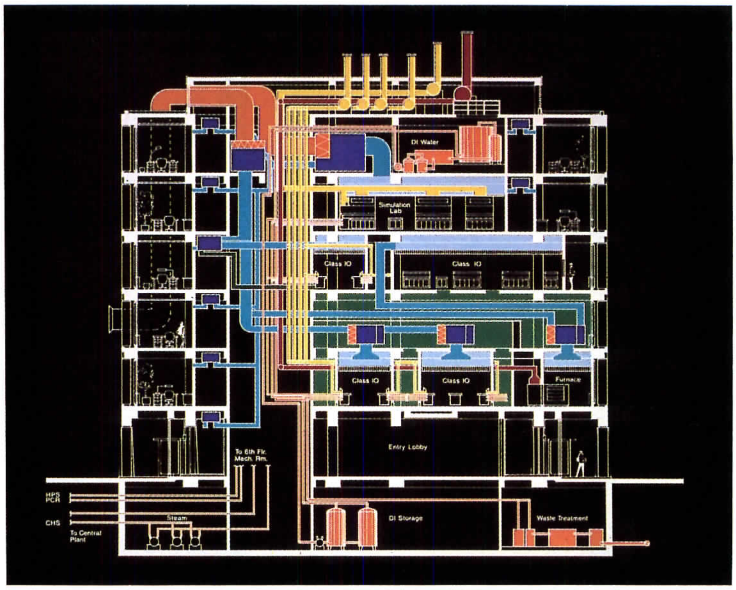
NCPA building, right and below, isolates mechanicals in a separate building (left) from lab spaces.

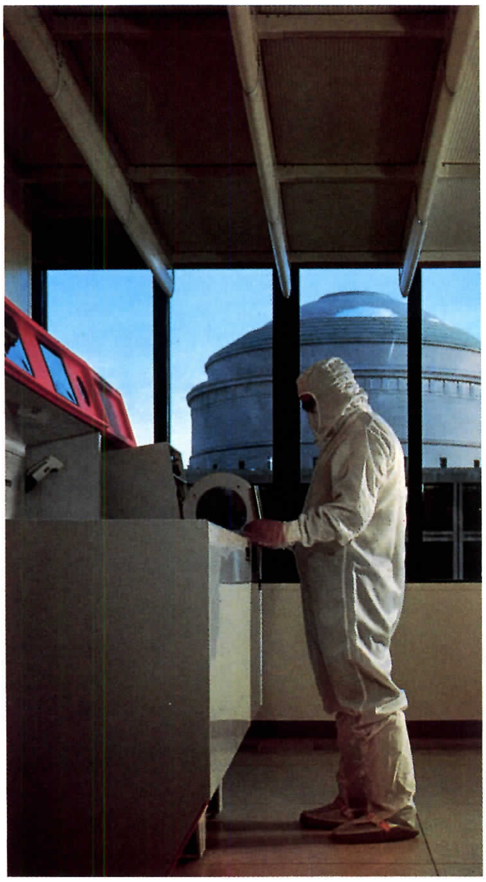


Below, flexible HVAC system of the Serono DNA lab allows a wide variety of lab types. Note observation corridor.

Wayne Soverns







Above and top, MIT's microsystems technology lab is an adapted building housing clean rooms up to Class 10.

it is carried out—has to be identical to assure the product's safety. Says David Rowan of Payette: "I think maintenance is a big problem. Very few institutions have knowledgeable maintenance departments that really know how to adequately maintain the equipment. You try to keep things as simple as possible."

Loiacono observes that, with the increasing complexity of laboratories, "there's a trend toward more sophisticated maintenance staff. You can't design a system that's maintenance free, but the systems should be simple. If the systems are overly complicated, they'll be shied away from by the maintenance staff. It's a combination of simplicity in design and good-quality monitoring systems that will encourage their maintenance."

The lab spaces themselves have to be designed for durability and cleaning. "You have to consider a lab in the same way you'd consider a commercial kitchen," says James Polando. "You want to maintain it in sparkling condition. Biotech labs often have to be steam-cleaned daily, so you choose finishes and construction techniques that allow you to scrub down a room."

Emphasis on a lab's mechanical and technical performance needs to be matched with concern for the lab's inhabitants—their physical and mental comfort and settings for the casual exchange of information. Intensely controlled lab spaces need a counterbalance in soft, quiet, daylighted retreats where technicians and scientists can refresh their energies and discuss their work. "We've been trying to merge the productive and reflective spaces in a lab by creating a third environment where you can have great interaction," says Payette's Burke. "Interaction is important in labs right now because the boundaries of specialties and disciplines are breaking down—there's a much greater sharing of interdisciplinary knowledge. This sharing can be promoted by sharing services, resources, and facilities."

At Payette's Wellman research building at Massachusetts General Hospital in Boston, which is the world's largest facility committed to laser research, a typical floor of the 12-story building has wide-open laboratories and shared instrument areas. Another Payette project, the Rutgers University Center for Advanced Biotechnology and Medicine, a facility to be used by both commercial and university-based scientists, has large stair atriums on either end that serve as casual gathering spaces. Offices with glazed interior walls are grouped around the atriums to encourage eye contact and interaction. The building will be connected to others on campus, another gesture toward interdisciplinary melding. "Many research buildings are being connected to each other," comments Payette's William Wilson, AIA, "because that's the nature of research." □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Miles pharmaceutical lab distributes services vertically at the ends of the building, then horizontally to peripheral labs.


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The Performance of Some 1970s Energy Savers

By and large it has been a success. By M. Stephanie Stubbs and Douglas E. Gordon

I would speculate that when the energy conservation movement in architecture is seen in historical perspective, it will resemble the eclectic period prior to the modern movement—very early stirrings which were then smothered, and re-emerged. I think when we [architects] *approached the energy issue 10 years ago, a window was opened, and it scared the hell out of people. It means an investment in the future and a realignment of institutional relationships, and it means we have to think really hard.*
—David Bennett, FAIA

By the late 1970s, architects had embraced the tenets of energy conservation for residential architecture and were beginning to explore methods for conserving energy in larger buildings. This article profiles six larger-scale commercial buildings that were pioneers in the use of energy-conservation techniques and presents how they have fared and been adapted over time.

Some of these buildings had energy systems that were dismantled because of technological disgruntlement or drying up of federal funding. One building traded photovoltaics for active solar, while another is considering revamping its active solar system for photovoltaics. Unexpected increases in office computer use blew electric demand projections off their printouts. But it cannot be denied that these advance scouts tested the waters for the rest of the profession. In all cases, the buildings' performances as energy conservers are sound and yield important lessons and their architects are justifiably proud of the fact.

Some of these architects believe that the most important lesson learned is that integration of energy into the design mainstream is the key to success. Mark R. Mendell, AIA, senior vice president and general manager of Cannon in Grand Island, N.Y., says, "In the scramble immediately after the oil embargo, too often we saw people doing anything to save a couple thousand BTUs, including things that were really defiantly antidesign. As a driving force, energy has come to be accepted as part of the routine that designers take into consideration. Those elements of energy-conscious design that reinforce *design,* as opposed to just accomplishing technical objectives—daylighting, attitudes toward the geometry and siting of buildings, using shading—are now more widely appreciated."

Alan M.H. Sloan, director of engineering with Cannon, says a major lesson was that active solar did not work so well. He says, "Quite honestly, the engineers had predicted that, economically, even through life cycle costing, active solar would not be effective. The problem is that those active solar demonstration projects, when pushed to prove that the engineers were wrong, proved instead that the engineers were right. Our firm never has been a proponent of active solar. In fact, we've never done one—we're totally dedicated to passive aspects of building design."

Lovins House/Rocky Mountain Institute Research Center

The home of Amory and Hunter Lovins and the workplace of most of Rocky Mountain Institute's staff of about 30, is a 4,000-square-foot house, office, and greenhouse in Old Snowmass, Colo., completed in 1984. The building, with its advanced energy- and water-saving features, is over 99 percent passive-solar heated and uses less than a 10th the electricity and half the water of buildings of comparable size and use, according to the Lovinses. "Our electric bill for lights and appliances is about $5 a month right now," Amory Lovins says.

Technologies used in the center include air-to-air heat exchangers, automatic (ultrasonic) light switches, door sweeps that raise and lower as the door is closed and opened, air locks for exterior doors, efficient fluorescent lamps with tunable electronic ballasts and light-polarizing lenses (reduced glare cuts light-level requirement), compact fluorescent lights, an on-demand (tankless) modulating-capacity gas water heater to supplement the five-ton stratified storage tank for solar-heated water, argon- and krypton-insulated glazing, below-grade exterior insulation, a solar clothes-drying cabinet, solar-charged electric livestock fence and exterior lights, a cold-fuser photocopier, ultra-low-flush toilets, water-saving taps and shower heads, wood stoves (one soapstone and one cast iron—mostly for appearance), and a high-efficiency refrigerator with a customized exterior passive cooling fin for additional energy savings during cold weather.

At an elevation of 7,100 feet and with 8,700-degree days the superinsulated and semi-underground building gains through the windows and the central greenhouse a third more heat than it needs to keep daytime radiant interior temperatures in the 80s Fahrenheit and air temperatures constantly in the 60s during winter months. Walls are about R-40, and the roof about R-60. Glazing is typically R-5.3, doors are R-2, glass storm doors R-9, and the perimeter skirt around the foundation four to eight feet deep is R-25. Uncontrolled air leakage is less than 0.1 changes per hour. Ventilation is provided through six air-to-air heat exchangers and operable windows. By having more glazing area (200 square feet) for heat gain, more masonry for heat storage, and more vent area than is necessary, the building stays comfortable even during unusual weather, Amory Lovins says. Observed local extremes include minus 47 degrees Fahrenheit and continuous midwinter cloud cover lasting up to 39 days, he says.

Walls are 16 inches thick (two wythes of CMU, plus four inches of Freon-filled polyurethane foam). Adding to the building's mass is more than 150 tons of sandstone used to face the steel-reinforced inner and outer walls. The total heat-storing mass, including the earth beneath the building, is about a million pounds, Amory Lovins explains. In a day of no solar gain in January, he calculates, the building loses about 0.8 degrees Fahrenheit per day.

Window placement within the curving south wall and an overhanging cantilevered arch enclosing the 900-square-foot greenhouse allow light and heat to penetrate to the north side during winter and block excess sun penetration in summer. The windows are insulated with a thin, coated Mylar film between two panes, and are argon-gas-filled (this was the first commercial installation by Southwall of its Heat Mirror assembly, Hunter Lovins says, although, she points out, the experimental facility is not a product development laboratory). "We use the same glazing tech-

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nique, only with two layers of Heat Mirrors, for the R-9 storm doors," she says, predicting R-12 for the next version. "Superinsulated windows allowed us to glaze on the north side. In fact, the snow reflects diffuse winter light through the north-facing windows to the point that they gain more heat than they lose." The greenhouse stays warm enough to grow bananas, avocados, papayas, and tomatoes year-round.

Rocky Mountain Institute operates in a large library, a computer room off the north hallway, and a loft above it, which together provide 20 workplaces in a variety of settings. Two-thirds of the electrical use in the building is for the seven computers, two photocopiers, fax, plotter, and two laser printers, which all contribute surplus heat.

Photovoltaic power to the ceiling fan in the greenhouse means it runs when the sun is shining and air circulation is needed. The reinforced-concrete beam that holds up the greenhouse roof doubles as heat-storage mass. Inside the south-facing surface above the beam is 100 yards of polybutylene pipe that passively preheats water, allowing the active solar collector area to be reduced by more than a third. The white-plastered greenhouse arch also diffuses light through the building, reducing the artificial lighting need to only 0.01 to 0.02 watts per square foot. A waterfall recirculating water to a fishpond provides an acoustic mask for the otherwise silent building.

"We had a pretty good notion of who would do good work and which were reputable manufacturers," Hunter Lovins says of the active system installed during initial construction. "We've had nothing but good performance out of our system." A newer solar addition uses a passive downpumping thermosiphon to heat an outdoor superinsulated hot tub, backed up by a submersible aluminum wood stove.

A harsh climate challenges the Institute's energy-saving ability.

The solar clothes dryer is a dark-walled shaft lighted and warmed by clerestory windows. Clothes take up to 10 times the normal time to dry, but the destratifying fans and the 30-watt air-to-air heat exchanger run 100 times more efficiently than a conventional dryer, netting a saving of 90 percent.

"When we do economic analysis to figure payback rates, we're not counting externalities, such as avoided environmental costs, although we think they are important," Amory Lovins says. "About the worst result is the 10- or 12-year payback on our refrigerator and freezer, because they're handmade prototypes, but that's okay. I thought it was important to try them out. The payback, from diminished energy use, also is better than the 20 to 30 years a utility would get from building the equivalent piece of a power plant to run an inefficient refrigerator. That's the way we should be doing the comparison—not on the very fast paybacks required by consumers but on the very slow paybacks required by utilities. If we do that, I think even our handmade prototype refrigerator is cheaper than not having it. Our building as a whole is tenfold better still."

"The technologies or systems you use depend on what you are trying to achieve," Hunter Lovins says. "If you were building in Florida, you would build differently than if you were building in Alaska. But for a building that will be comfortable in any climate all year long, the basic concepts are usually superinsulation, tight construction, good zone coupling, and passive solar. If you have a 1970s passive building, the way they used to be built, with little attention to tight construction and no more than standard insulation, you get swings in temperature. You tend to overheat in summer and get cold in the winter."

Hunter Lovins is quick with a response when reminded that tight construction and superinsulation have been criticized recently for trapping and concentrating airborne irritants. "The answer to indoor air pollution, including radon, is stopping the poisons' entry, or, failing that, then ensuring a constant supply of fresh air prewarmed through heat exchangers," she says. "It is a myth that old leaky buildings are more healthful than tight superinsulated buildings. Research at the Lawrence Berkeley Laboratory shows that you can get much higher concentrations of radon in leaky buildings than will ever occur in tight buildings with constant, controlled ventilation. With heat exchangers, you get energy-efficient control over the ventilation rates and flow."

The energy-efficient ballasts and fluorescent lights in the Lovins house are manufactured for commercial applications. "We normally wouldn't put them in ordinary houses—we just did it as a demonstration of what is possible," Hunter Lovins says. "But they are both pleasant and effective. If they were in general use, the energy savings would be equivalent to about 60 Chernobyl-sized nuclear power plants. And our compact-fluorescent replacements for incandescent lamps can save another 50 giant power stations."

Demonstration of efficiency and renewable energy sources is a major purpose of the Lovinses' home. " We've had about 12,000 visitors in the past five years," Amory Lovins says. "The more good technology we can expose them to, the better. Other features recently completed or in the works are a 'crittery' (a superinsulated, passive-solar, photovoltaic-lighted piggery and chicken coop in a separate building, from which biogas may be collected one day) and a two-kilowatt photovoltaic array.

"Even though the crittery is built, we went ahead with the photovoltaic system next instead of the biogas technology because Mobil Solar gave us about $10,000 worth of PV equipment," Amory Lovins says. "I would not otherwise have bought a large PV array under our circumstances at this time—although it would be cheaper than grid electricity if we were upwards of about 400 yards from a power line."

The PV system is line-excited, which means that the inverter that changes direct current from the cells to line-voltage alternating current is synchronized with, and gets its synchronization from, the local electrical utility's grid. "Utilities like that sort of system," Hunter Lovins says, "because if the grid fails, the inverter also stops working. That means they can be confident that no power is being fed back into the grid from sources that aren't supposed to be operating, and linemen are safer from getting electrocuted. You can, instead, do the same thing by isolating the system from the grid when the grid crashes. That's attractive to me because it adds the resilience of being able to generate while the utility grid is down."

The utility may have the last word in the matter, however, just as it did when requiring that the Lovinses purchase a $1 million insurance policy before connecting to the grid. "Supposedly, the insurance protects the utility if we damage the grid," Hunter Lovins says. "It actually is much more likely that hash and transients from the line will damage *our* equipment, but then that's our problem.

"The retail price of electricity we avoid with a PV array is about seven cents a kilowatt/hour, but the utility will pay us only a cent and a half for what we sell back. So, since we are about 50 feet from the first of two interconnected buildings owned by Rocky Mountain Institute, we're exploring selling our surplus power next door to the institute rather than back to the grid."

Turning excess electricity into hydrogen is another long-term possibility, but one the Lovinses have yet to calculate in terms of cost-efficiency. Hydrogen produced electrolitically with surplus power would be used to fuel the kitchen stove and the backup water heater, which now burn propane. Another possibility might be to convert the stove to burn biogas from the crittery. "We are not using the biogas yet," Hunter Lovins says. "When we designed the place, we decided to bring technologies on one at a time so we weren't facing too many design issues and construction problems at once. Since the house was built, we have been slowly adding on."

Below left, interior offices of Rocky Mountain Institute, showing the curved sandstone wall. Below right, the Institute's plan calls out its many energy-saving features and devices.

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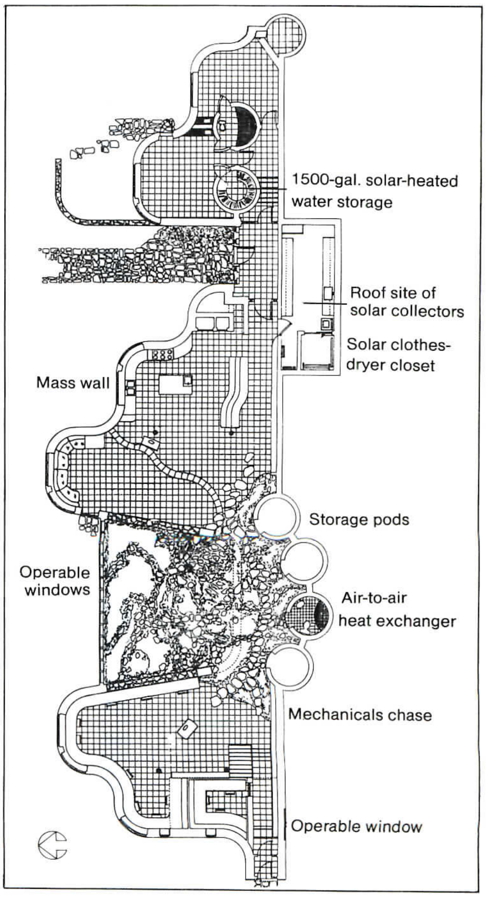
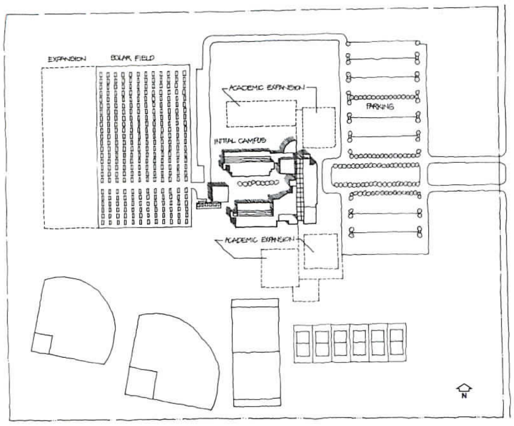
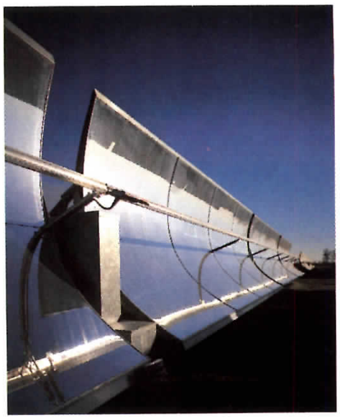




This page, clockwise from left: site plan, PV collectors, vaulted corridor, and front elevation of the Mississippi County Community College.



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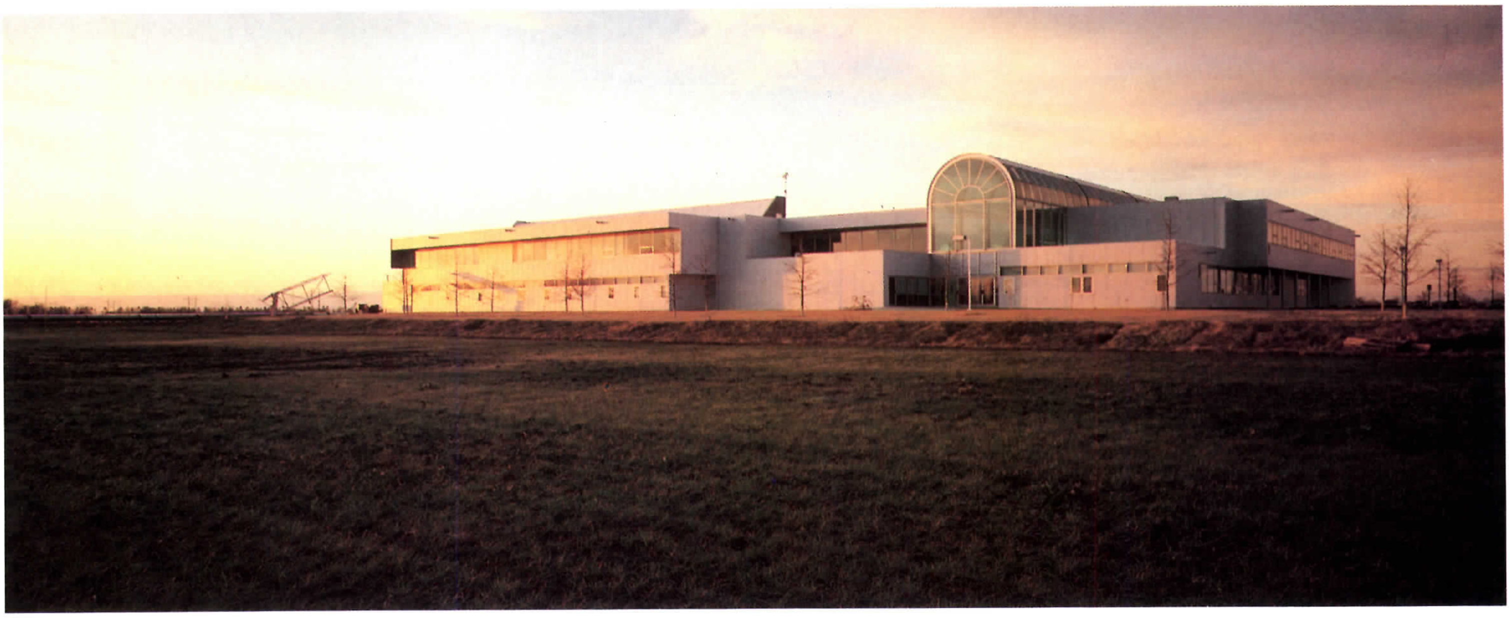

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Mississippi County Community College

The eastern prairie of Arkansas may seem like an odd site for a high-tech solar demonstration showcase. Nonetheless, the Mississippi County Community College in Blytheville, Ark., proposed in the late 1970s and put into operation in 1981, exemplifies the contradictions born of an idealistic era and baptised by technological and economic realities. The architects and college board of the MCCC, under the direction of Harry V. Smith, Ph.D. (president of the college from 1975-1983), took on the exploration of photovoltaics (PVs) as a source of electrical energy for the 54,000-square-foot new building complex, with an unsolicited grant from the U.S. Department of Energy.

"We had the contract to design the school, and were working on it, when the possibility of designing a photovoltaic system, through Dr. Smith's efforts, presented itself," says John J. Truemper, Jr., AIA, of Cromwell Architects Engineers (formerly Cromwell, Neyland, Truemper, Levy & Gatchell) of Little Rock, Ark., architect in charge of the project. "We started completely over—we wanted to make it more high-tech, something more appropriate for use as a PV demonstration showcase. Also, the original design was fairly conservative due to a very tight budget, and the DOE grant put some money into a building design budget for the energy-saving features."

The project, which at the time was the largest photovoltaic building installation in the world, was designed to provide both electrical and thermal energy through a PV array field consisting of 45 rows of six collectors each, with each row having an independent tracking system. The parabolic collectors were horizontally mounted on a north-south orientation, and each collector contained a total of 60,000 wafer-thin (12-millimeters) cells. Each row of collectors was designed to produce approximately 360 volts at 20 amps, or 7.2 kilowatts. In all, the system's designed electrical output was 320 kilowatts, to accommodate the building's peak energy demand of less than 4.75 watts per square foot. The cells were hydraulically cooled with an ethylene glycol solution, with the dissipated heat used to provide all the space heating for the buildings, even during periods of low insolation. The glycol solution flows to a heat exchanger, from which water at 130 degrees Fahrenheit is piped to the building directly or to huge storage tanks.

The site seemed right for photovoltaics. "The utility company for Blytheville supplied both electricity and gas, and at the time there was an extremely bad gas shortage," Truemper says. "The utility company would not extend gas service to any new facilities. Because the college was going to have to be all-electric, which traditionally has been more expensive here than a combination of an electrically cooling/gas heating system, photovoltaics looked particularly attractive at that place and time."

Nevertheless, the experimental nature of PV systems at the time influenced the architects to place the array in a field behind the building rather than integrated with it, but the building itself shows much care given to an energy-conscious design. The 80-acre campus is organized around a central concourse with a glazed barrel-vault roof, which is passively heated by the sun in the winter and, in the summer, is cooled by breezes and natural convection via a ridge vent and operable louvers at each end. Backup fans and shade trees help when needed. West-facing walls are concrete while the rest of the exterior skin is insulated aluminum sandwich panels.

A hierarchy of conditioned spaces was determined by careful attention to the school's energy consumption and programmatic requirements. The occupied spaces, such as classrooms and offices, are fully heated and cooled while the corridor spaces are conditioned primarily by losses from the occupied spaces. Daylighting used for task illumination conserves energy by significantly reducing artificial lighting and airconditioning demands. The entire mechanical system is monitored by a computerized energy-management system.

Description of the building and thermal system in present tense and the PV system in past tense is not, unfortunately, just a sloppy editing job. Despite much testing and adjustment during its two years of operation, the system was never able to exceed 55 percent of the rated electrical output, although design winter thermal output was reached successfully. Some of the problems included distortion of the reflective surfaces and focusing accuracy due to torsional stress in the large-size collectors, and nonuniform illumination of the cells, causing difference in power output, localized overheating, and current bypassing. The production of thermal energy from the plant generally was much less subject to system inefficiencies than was electrical production. The operators reported that, on sunny days with the outdoor air temperature 44 degrees Fahrenheit, the array would maintain the building interiors within normal operating range, that is, above 68 degrees.

"The main problem with the PVs was that the apparatus that focused the arrays was not accurate enough for the photovoltaics," says mechanical engineer William M. Woodsmall Jr. "Unfortunately, there was no more federal money to make the corrections. The building became a real stepchild after it got built. In other words, they got some information out of the installation, but they could have gotten a lot more if they had just put a little bit of money annually to gather information. The school just flat out didn't have the money to do it themselves—they weren't funded to monitor it or to properly maintain it. It's sad, because a lot of money was put into the project initially."

Although it originally was thought that the useful life of the concentrators would be 10 years, after two years of operation, by measuring the accelerating deterioration of the receivers, it was estimated that the system would function for only one or two more years. Therefore, the school and DOE explored options for a conversion package that would allow the school to reduce its dependence on electricity for heating. In mid-1984, DOE accepted a proposal from the college to convert 33 of the original 45 collector rows to all-thermal service.

Work was completed in October 1984. Limited operation of the all-thermal system was conducted from November 1984 to early February 1985, but further operation was suspended pending the repair of damage incurred during a severe winter storm. Very early preliminary estimates suggest that the total thermal output of the new system exceeds that of the old version, although its collector area is 27 percent smaller. This report cites numerous lessons learned during PV/thermal operation that were made available to the solar photovoltaic program for later projects.

The final summary report on the performance of the building, issued by Oak Ridge National Laboratory in 1986, states that large-line focused mirrors (such as those used on the Mississippi County college building) no longer are favored for photovoltaic arrays. "[T]he startup and operating experience accumulated at the MCCC Project provided useful examples to guide the Department of Energy's (DOE's) mainstream solar projects that followed it," said the report.

All in all, however, the building is doing well, and the school is planning to expand according to the architect's original design. "Our job was to design an energy-efficient building, and we've been successful to a great degree. One problem is the all-electric boiler. The idea with the photoelectric system is that we would not have to use it. But because the PV system failed, the school does have to use the boiler to some degree, and it's expensive to operate," Truemper says. Engineer Woodsmall agrees. "The building itself was one of the first in the area designed primarily to conserve energy, and it works very well—the daylighting, mass, and the good system of insulation building. It is also a very pleasant space because of the daylighting," he says.

Georgia Power Corporate Headquarters

It seems only fitting that a power company should exemplify to its customers that saving energy is a good idea. The Georgia Power Co. corporate headquarters in Atlanta, designed by Heery & Heery, showed us that big, powerful, and slick could still be energy-conscious. Larry Lord, AIA, project architect (and now a principal of Lord & Sargent), explains, "Georgia Power's overall charge to us was to press the state-of-the-art of energy-conscious design to the limit. They were willing to take some risks, and go beyond what had been designed up to that point. Consequently, we examined all kinds of design alternatives."

"In terms of the overall building form, architects at the time were looking for ways to shade the south face of buildings, especially vision glass," Lord continues. The solution was to have the bronze-tinted, reflective insulating glass facades of its 24-story tower vary with exposure. The south facade steps back from the top, providing a natural shading cantilever that is augmented by 15-inch overhangs and aluminum sunscreen tubes on each floor, while the north facade, which requires no shading, is flat. Both north and south sides vary 50 percent vision glass with 50 percent well-insulated opaque wall sections.

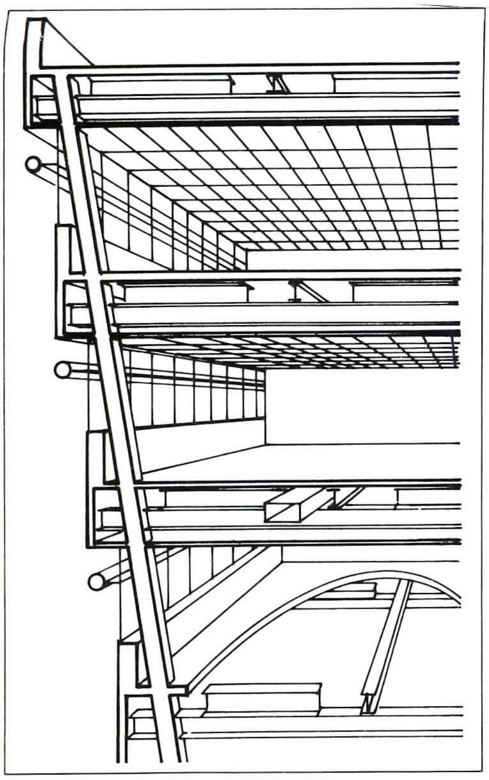
The windowless east and west walls front the elevator cores, mechanical and storage spaces, and conference rooms. "We needed a control point for each floor as you come off the elevator," Lord says, "but because it was a one-tenant building, we didn't have to locate the core in the center, so we put it against the east wall, along with services and storage spaces. The mechanical equipment is on the west wall, which has two slots—intake and exhaust—so that each floor can go onto an independent economizer cycle. The building has a very sophisticated control system, and each floor can be programmed independently. We recognize now that this kind of incremental savings is just as valid as the big-picture things, such as the building setback."

The architects zoned occupancy functions for maximum efficiency. While the tower's mechanical systems are designed to work most efficiently around a 10-hour office day, functions requiring 24-hour use (including a television studio and a microwave relay station), as well as those for high-occupancy needs (such as training rooms), are housed in an adjacent three-story brick and masonry building.

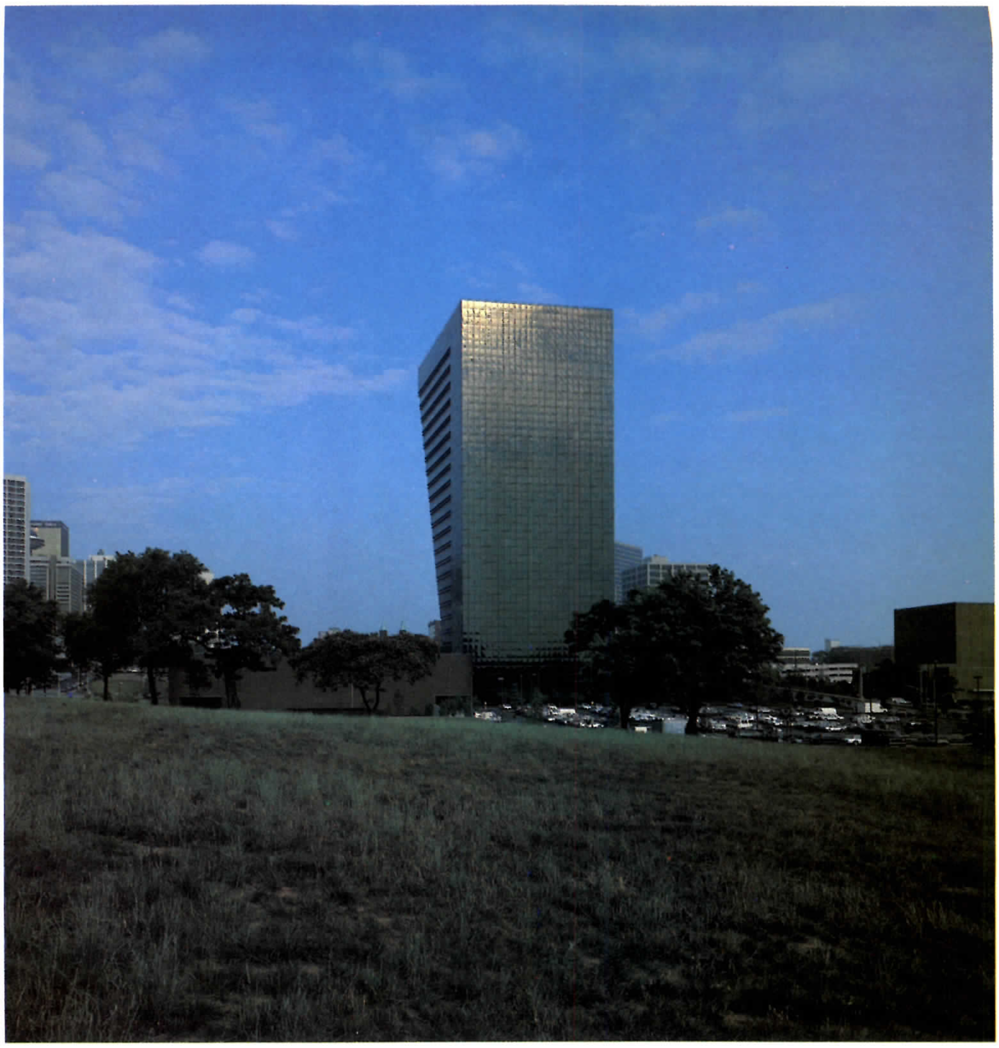
Most striking of the low-rise building's features is its topping of an array of tracking, parabolic hydronic solar collectors that were designed to provide 15 percent of the complex's cooling needs. This active solar system is still up and running. In 1987, it provided about 15 billion BTUs. (Converted to dollars at 8 cents per kilowatt/hour, that's a savings of more than $32,000 dollars in the calendar year 1987. With a cost of $6,000 dollars that year in labor and materials, the system netted Georgia Power $26,000.)

Joe Sitz, building engineer for Georgia Power, believes that the improvements may involve photovoltaics. "The hydronic collector system, being a prototype, is kind of antiquated," he says. "Many of the hydronic solar demonstration programs have shown that it is not a long-term viability in terms of payback. But we think that photovoltaics might be, and we're seriously considering converting the system to PVs, most likely using much of the existing hardware from the hydronic system."

The building, when completed in 1981, was designed to use one-third to one-half the energy of a traditional Atlanta office building. Sitz says, "The computer analysis for the designed building was not far off from the actual consumption for the first cou-



The drawing above shows the structural system of the south wall of the Georgia Power Headquarters Building, which incorporates overhangs and aluminum sunshade tubes. The photo is of the north facade.



© Timothy Hursley/The Arkansas Office

ple of years that the building was up and running. But the advent of personal computers and other electrical equipment has made a huge increase in the electrical load on the building. To show you what a difference the computers have made, originally the low-rise, with one-third of the floor space, used 50 percent of the building's energy. Now, with computer loads in the tower, the load is split one-third low-rise to two-thirds tower. Even so, the building is still very energy-efficient."

The only major change in the Georgia Power building since it was built has been in the lighting system: a few years ago the specially-designed high-pressure sodium system was replaced with energy-efficient fluorescents with electronic ballasts. Lord says, "Basic logic tells you that if you could place the light in the area where you need it, as opposed to everywhere, you would save money. Everybody got together and brainstormed the lighting system—it was a very collaborative effort. The idea was that there would be general illumination of 25 to 30 footcandles, and a focused reflector in each fixture that would reflect *down* on the task, at about 90 to 100 footcandles. We hung one of these light fixtures over everybody's desk, off to the side to avoid veiling reflections. Physiologically, you could use a light meter to prove, beyond a shadow of a doubt, that this was an extremely effective lighting system. But psychologically, the workers just wouldn't buy it—it didn't feel right because it was different. Also, the color rendition was terrible, because sodium lights fade out reds."

Sitz says, "The high-pressure sodium lighting system was hooked into the building's 110-volt circuits, and the computers we added had to be hooked into this system, which was not large enough to handle both. To keep the sodium system and add the computers, we were looking at a $200,000 expansion of the low-voltage circuits. Because the sodium system was having problems anyway, it made more sense to put in fluorescents on the building's existing high-voltage circuits and use the in-place 110-volt circuits for the personal computer expansion."

Lord applauds Georgia Power's willingness to persevere with the experimental lighting. "They lived with the system for five years, and probably would have lived with it longer if not for the new computer installation. But the system deviated a bit too much from the lighting that people are used to."

Another of the building's energy success stories is not as easy to see as the solar and the lighting systems. "The chiller absorption system, which involves a 300,000-gallon underground tank, has saved Georgia Power a lot of energy and money," says Lord. "As a utility company, they are very familiar with off-peak production; when they have to put on the fossil fuel generators, their cost per kilowatt-hour goes out of sight. As a peak-shaving device, the storage system is filled during off-peak hours at night, and stores up enough chilled water to service the building during the high-peak time [about 3½ hours] on the hottest day. Reggie Clay, Georgia Power's corporate facilities manager, recently told me that, without a doubt, the storage/chiller is a win-win deal. Georgia Power recommends the system to a lot of their corporate clients with larger buildings."

Lord & Sargent has an ongoing contract with Georgia Power for master planning, space planning, and interior renovations. So far, the only changes needed have been minor. The owners work hard to keep the building working well and looking good," says Lord. "One of its major contributions was to focus attention on building operating costs. The systems we used, although experimental, are still valid today because they reduce the operating costs. The energy crisis forced us to think about architecture and its related economics in a new light."

Occidental Chemical Center

The Hooker office building, now known as the Occidental Chemical Center, raised the status of glass curtain wall construction from energy pig to energy saver. Designed by Cannon and completed in 1981, the 200,000-square-foot corporate headquarters was to spearhead a massive urban renewal effort in the gritty and somewhat grim industrial downtown of Niagara Falls, N.Y. Therefore, the owners chose a prominent site with unobstructed views of the magnificent Niagara River on three sides, and, not coincidentally, unobstructed daylight.

It was this generous access to the sun that shaped the architects' notions of energy consciousness in a notoriously cold and cloudy climate. The solution for getting light in while keeping heat from escaping on all four building faces is a double envelope with four feet of air space separating the outer wall of green-tinted insulating glass and the inner wall of clear glass.

The air space also houses louvers—gigantic motorized venetian blinds—that adjust to let in full sun, to block direct rays, and to fully close to prevent night heat loss. The air spaces vent directly through the roof when there is excess heat. The result is an ever-changing, animated skin with four separate facades that vary independently according to weather, time of day, and season. The interior of the building is double-zoned. The 15-foot-wide perimeter zone, comprising almost half the floor space, uses daylight and supplemental task lighting, while the interior zone is fully conditioned.

Architect Mark Mendell says, "When we started on the project, we had every intention of doing a design that was state-of-the-art with respect to energy performance, but we never really intended to do a building that was totally energy driven. Our paramount concern was designing a good building, and I think that is one of the clues that has allowed the building to wear well over time. There was an era when the 'energy gurus' were almost single-issue oriented. It almost reached the point of energy conservation versus design, so I think there was a certain astonishment in the energy community that this building actually got built. At a first look, it appears to be a straightforward building. It's not until you look deeper that you realize that there are some very exceptional things that are going on inside it."

The building in its designed state was predicted to have a heating load of about 2 percent that of a conventional office building and a cooling load of about 19 percent that of a conventional building. The changing nature of Occidental Chemical's office work brought unforeseen energy advantages to the building. A major computer installation and lengthening of the workday beyond predicted use has increased the artificial lighting demand enormously. On the other hand, excess heat generated by computer use has virtually eliminated the heating demand.

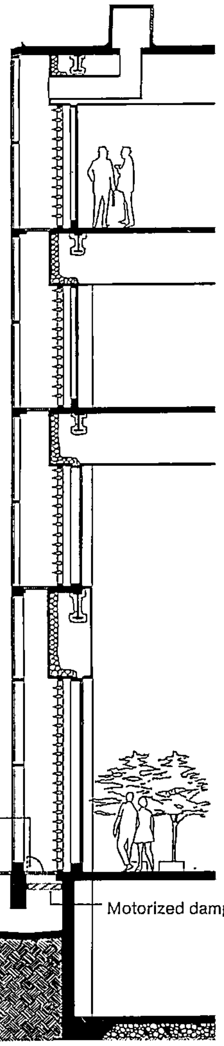
Mechanical engineer Alan Sloan says, "I did an energy study of the building about three years ago, for my own edification. We were running about 10 to 15 percent less use than the design study predicted. To derive these figures, you have to back off from the total energy use, because during the construction of the building the owners changed the program and installed a mainframe computer. The mainframe uses a great deal of energy. We were lucky, because we also were on the cutting edge of computer technology in those days, and we have one of the first 85-40 systems installed in the building. But, to study energy use, we had to monitor the computer room itself. We have three meters—one for the peripherals, one for the computer room itself, and one for the airconditioning and general power.

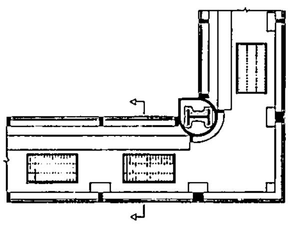
"We found that a lot of the diversification factors that we normally design for a computer room just didn't apply. In fact, the computer room has very little diversification at all. If you apply that load to what is essentially a spec office building, it has a dramatic impact. However, if you back that load out and look at the building without the computer, it is running at 10 to 15 percent below the designed predictions. A computer room of that size uses as much energy as the building itself. We are doing studies right now, because the computer load is due to increase by 50 percent next year."

Below left, day and night views of the Occidental Chemical Center in Niagara Falls, N.Y. The section and plan on the opposite page show construction of the louvered, double envelope wall.

P.L. Bazelon

B.E. Martin




Corner detail in plan

Mendell reports that the owner of the building is about to embark on an interior renovation of more than half the office space—part of a corporate reorganization, he says. Sloan adds that the only trouble with the louver system was five years ago. "Some of the electronic printed circuit boards were not of great quality, and these have since been replaced," Sloan says. "We also have discovered that the way we traditionally looked at the passive solar zoning of buildings wasn't really appropriate.

"We zoned the vertical distribution of hot water—the chiller is used all year-round. Heat rejected from the chiller is used to heat the building," Sloan says. "We discovered that the top of the building uses less hot water, or less temperature than the lower half, which is the opposite of what you would normally expect. This is because the space between the glass walls has a thermal stratification of temperature—the space between the two glass walls heats up, and variations of up to 10 degrees Fahrenheit occur. In winter, when the sun shines, if temperatures rise, say, to 65 degrees inside at the top of the cavity, the air rolls around the top of the building passively. So, the lower floors get a temperature of 55 degrees in the space between the glass, and the upper floors see 65 degrees. Therefore, for the renovation, we are splitting the zoning of the building in half—the top five floors from the bottom five floors."

The Occidental building has played its appointed role in community development. "About five years ago, Niagara Falls launched a program called the Festival of Lights," Mendell says. "Around Christmas and New Year, most of the downtown buildings are specially decorated with lights. The heart and soul of it is the Oxy Center. You've got this 130-foot-square, totally glass wall behind which can be placed any configuration of any number of any color of lights that can be imagined. According to the *Guinness Book of World Records,* it is the largest sound and light show in the world. It is all very elaborately programmed so that the whole building can pulsate through the programming of the lights, or it can be syncopated animation. The building becomes a focal point of the whole community program."

Williamson Hall, University of Minnesota

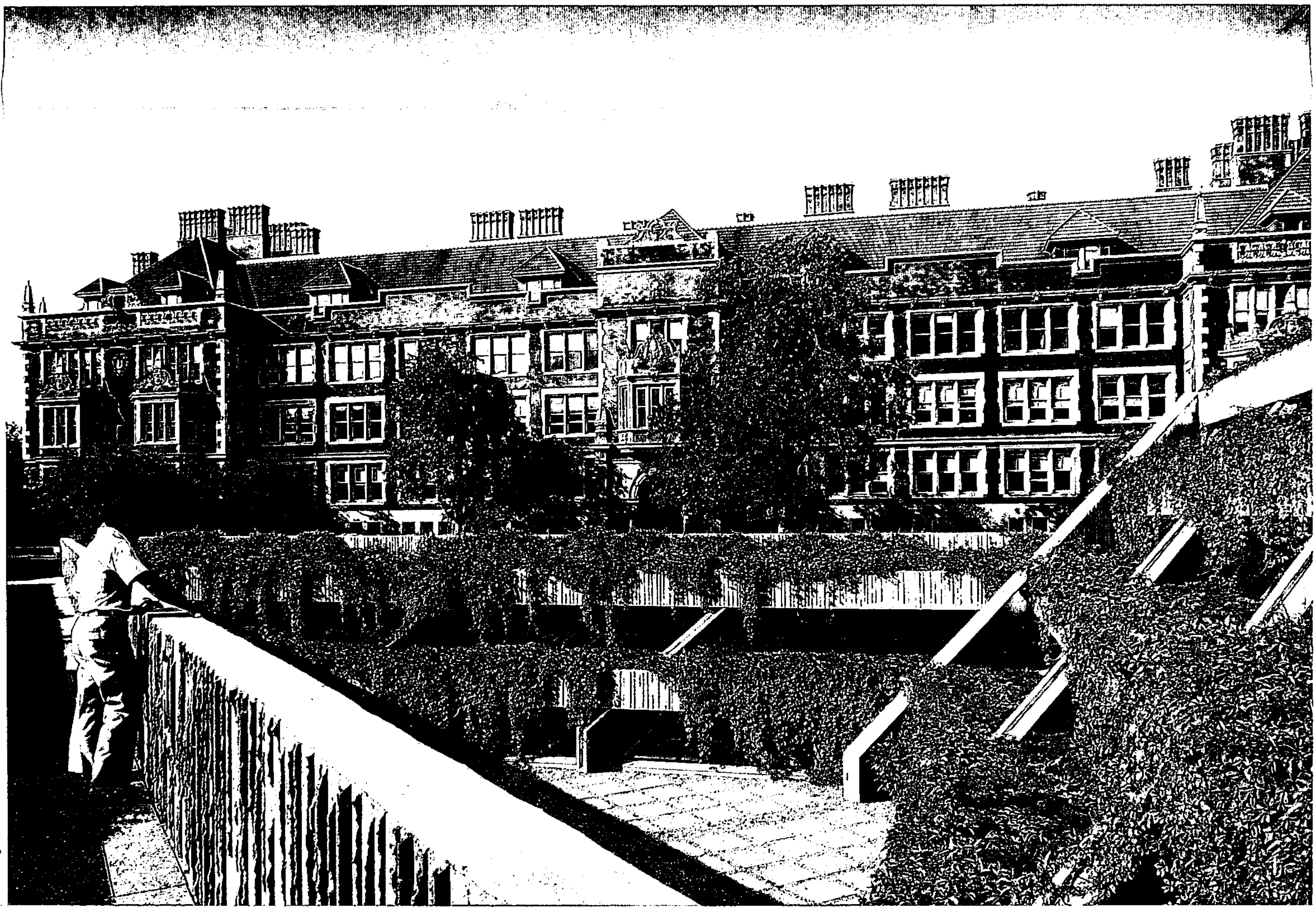
The earth, as well as the sun, provides abundant natural potential as an energy-saving device. Williamson Hall, the campus bookstore for the University of Minnesota designed by Myers & Bennett/BRW (now BRW Architects), houses 95 percent of its 85,000 square feet underground, in effect turning its back on the harsh climate of Minnesota. Like many environmentally sensitive designs, it is also socially aware of its surroundings. Placed underground, it did not disrupt established campus pedestrian patterns nor block views of and from the historic buildings adjacent to it. Just as important, when completed in 1977 it was one of the first commercial-scale buildings to demonstrate that, beyond a doubt, underground could be sun-filled and cheerily uncavelike.

David Bennett, the principal architect, explains: "Williamson Hall originally was driven by campus planning/urban design considerations. The building was on a site that was one of the few remaining open sites in a rapidly built-up part of the campus. It also was a site that we had noticed, simply by trace paths in the snow in the wintertime, was heavily used by the students to cross diagonally from the campus to the adjacent neighborhood commercial areas. So the first thing that we did was to look at three alternatives: putting the building on the ground, above the ground and walking through it, or putting the building under the ground. A rational analysis by ourselves and the clients came to the conclusion that the best of the three alternatives, the one that would serve most of the criteria of campus circulation, open space, and preservation of the views of the facades of the two historic buildings on the campus, was to put the building under the ground.

"After that, as it became evident to us that putting the building under the ground was potentially energy-conservative, and we had already developed an ongoing interest in energy conservation, it seemed to us that, given the marginality of the performance of the solar collectors, it might be a cost-effective combination to make a building that had very low energy demands and supplement the small energy demand that it had with a system that, under ordinary circumstances, would have had to work much harder. At least that was the theory—the linkage of solar energy and energy conservation."

The architect oriented 83,000-square-foot Williamson Hall to capture maximum daylighting and solar heat gain for the occupied spaces through clerestory windows and an internal courtyard. Additionally, 6,000 square feet of concentrating solar collectors banked on the roof, added to the system in 1980 with funding from a U.S. Department of Energy grant, contribute to the heating system. All in all, these systems, coupled with the insulating properties of the earth, were predicted to provide a net energy savings of 80 to 100 percent during the heating season and 45 percent during the cooling season. Figures from 1981 indicate that the system is functioning on the upper range of what was predicted.

John Carmody, an architect and director of the Underground Space Center, says, "The two buildings, Williamson and the Civil/Mineral Engineering building [see page 109], are heated and cooled with steam from the university's district heating system. Williamson Hall had a couple of minor modifications to make it more energy-efficient. The open-air curtain doors led to drafts and were replaced with double entry vestibules. Most significantly, Williamson Hall had linear, concentrating collectors that were monitored as part of a DOE experiment. It was discovered that the collectors, with their tracking devices, were expensive to operate, and contributed little energy to the system. However, the building has continued to perform extremely well regardless of the collectors.



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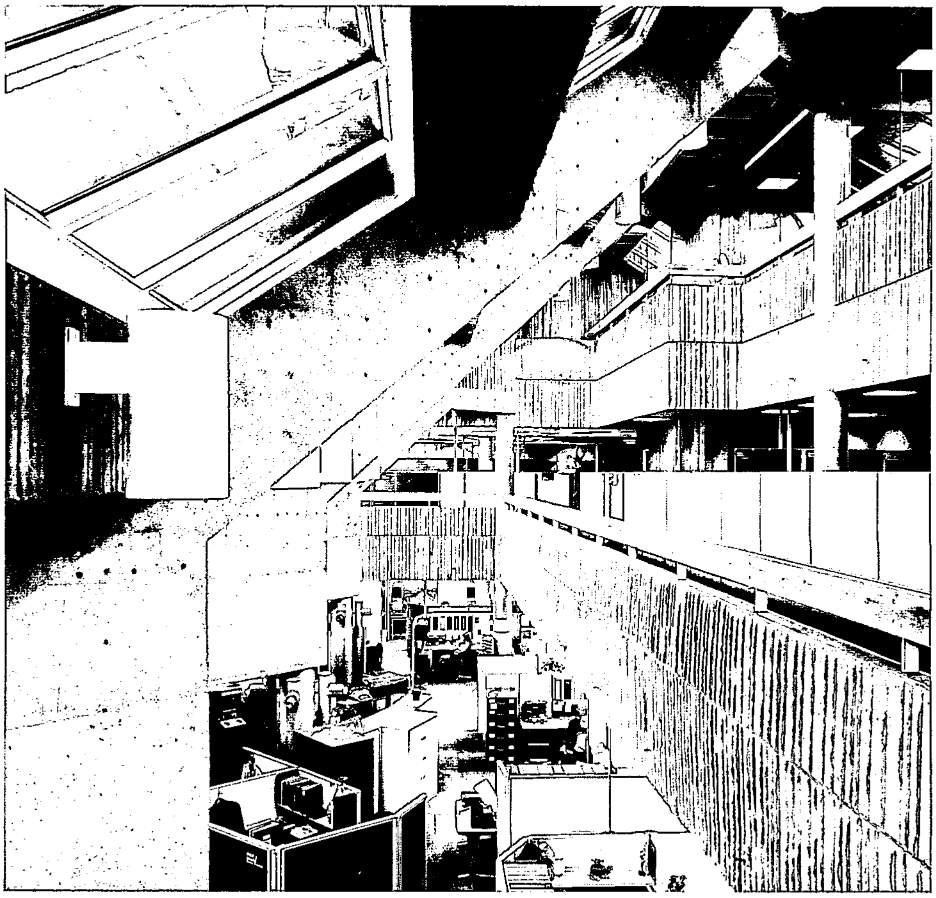
Above, a courtyard view with Williamson Hall in the foreground shows how it preserves sightlines of its historic neighbors. Note the original lush planting. Below: a light-filled interior view.

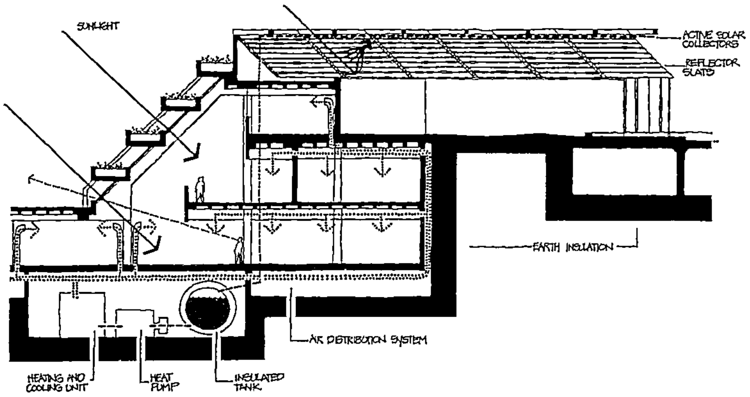


It was projected to use 80,000 BTUs per year, which is an admirably low number for this area of the country. In 1981, it used about half of that amount, and now it is using 65,000 BTUs per year, which is much better than any other building on the campus."

Bennett explains that the system was abandoned by the university. "A DOE grant built the system, and the solar system was designed and constructed as a separate project after the building was completed," he says. "The prime design contractor for the system was the mechanical engineering department of the university, and we were design subcontractors to it. The architectural design, for the architectural framework, as it were, for the solar collectors was to integrate them onto the main building. The sequence was not really as favorable as it might have been. That was our first introduction into the whole area of solar energy design.

"Ultimately, the building was hooked into the university's computers, and the university's maintenance department was responsible for monitoring the building's performance. They contended that the system was not performing in any recognizable way, given all the design ideas that were put into it. The Department of Energy then hired an outside consulting firm to monitor the performance of the building. The consultants reported that the university did not know how to measure the performance of the building; the way they were monitoring the building was wrong. It turns out that the early predictions of energy conservation for the building were correct, that the building was in fact only using a quarter or a third of the energy that it would have consumed were it an above-ground building, but that the solar collector's contribution to the building's energy conservation was rather small.

A section through Williamson Hall indicates how it admits daylight into its underground spaces. The active collectors, HVAC system, and earth insulation were planned for energy savings.



"Subsequently, we heard that the solar collector system on Williamson Hall was one of some 300 solar systems that had been funded by DOE under a national program to assess the potential of solar energy, and none of the 300 was very successful on any kind of economic payback model. Ours was calculated to pay back in decades. So, as a commercial model, it was not acceptable. As an institutional model, it was marginal."

Another energy-conserving feature of the building that didn't fare so well was the lushly planted Engleman ivy that draped down over the main facade glass to shade the interior spaces from the summer sun. Both Carmody and Bennett report that the deciduous planting worked very well, but its passive solar properties were not well understood by the university's maintenance department, which decoratively trimmed the vine enough to ruin its shading abilities. "At the time, the maintenance department was reluctant to continue the program, and they put in a much more meager planting in pots in the planters," Bennett explains. "It will take years to approach anything near the richness of the original planting. One of the things that we ultimately concluded was that for public-sector buildings there simply is no commitment to the amount of attention that plant material requires. In another community, climate, or location, the idea of plant material is a valid one."

Nonetheless, the passive systems incorporated into the building and the placing of the building itself underground have proven cost-effective.

Civil/Mineral Engineering Building, University of Minnesota

It is tempting to compare the design and construction of Williamson Hall to the *pièce de résistance* of underground architecture, the University of Minnesota's Civil/Mineral Engineering building, just two blocks away from its predecessor. "Williamson Hall was and wasn't a prototype for the C/ME building," Bennett says. "With Williamson, we had backed into the whole idea of energy conservation—it was a shallow, surface building. Between Williamson Hall and the C/ME building, I was reflecting on how you solve the problem of humanizing underground space if you're dealing with a deep building, which offers a different kind of esthetic, and that's when we began to get into the solar lighting issue."

Upon completion of the building in 1983, the architect said, "Daylight and sunlight are more important than view. We overreacted and used too much glazing at Williamson. At the C/ME, we looked for new ways of bringing in natural light through the smallest possible apertures. . . . It is a building that is at once high-tech and of the earth. It's an earthship." (See Jan. '83, page 64).

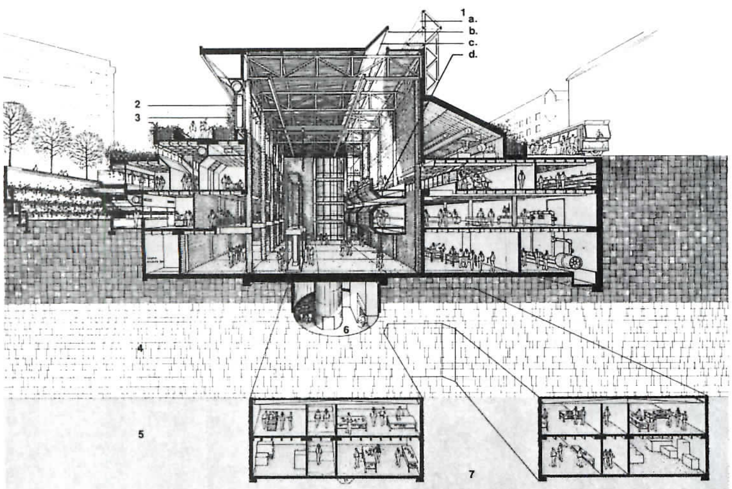
This particular earthship is 95 percent underground, with a third of its 144,000 square feet beneath bedrock at 110 feet below ground, and it houses the university's Underground Space Center as well as environmental and mineral engineering laboratories. The above-ground components include a portion of the 50-foot-tall structural testing lab, a south-facing Trombe wall of water-filled tubes, heliostats for bringing daylight down 100 feet, and passive light monitors.

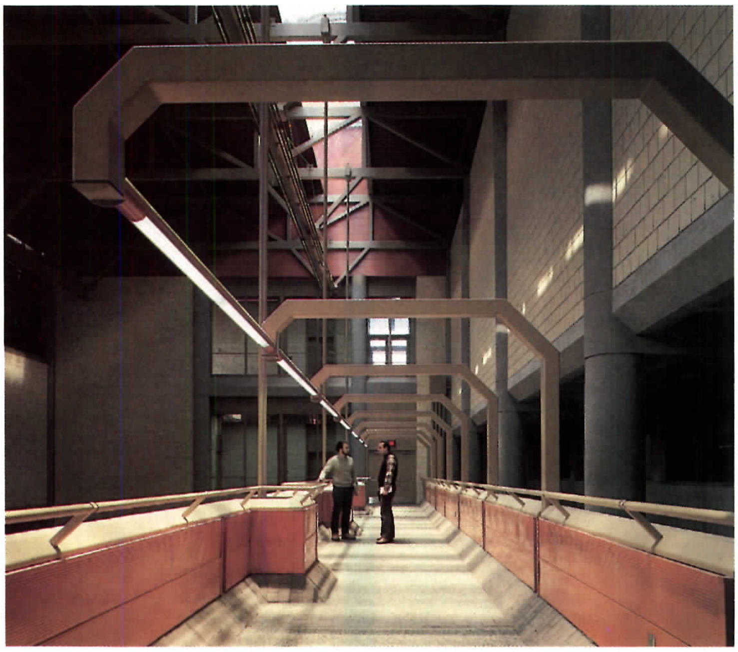
Bennett explains the development of the lighting system. "Solar lighting seems to make sense because, if you have 10,000 lumens per square foot of sun, and you need only 50 lumens to light a square foot of office space, you have a margin that is so enormous that even with a relatively crude system you can do something fairly cost-effective. But there were really no funds dedicated to this idea. We invested a lot of time and energy to get an American inventor to develop a sun-tracker for the C/ME building, and, to his credit, he made a valiant try. But, being a commercial manufacturer, he had to make compromises and the result was that he created a sun-tracker that was not very good. When it worked, it worked wonderfully, but it didn't always work."

About three or four years ago, Shimizu, a multifaceted Japanese company, designed, built, and installed an improved sun-tracker on the C/ME building as part of a joint research effort with the Underground Space Center. Shimizu is prepared to undertake long-term research in solar lighting, and, because the C/ME building was published widely around the world, the company wanted to use the building as a basis for demonstrating solar lighting that it could develop into an industry and market all over the world. Shimuzu had the will, the vision, and an extensive research arm to seize upon the idea. "The only way we do that here is through the federal government," Bennett says. "Given the attitude today, the only arm of the federal goverment that does any of that research is the military. I'm glad that somebody is doing it, and there have been valuable spin-offs from the military research."

Bennett explains that the form of the deep space is a "true modernist response" because the building form directly follows its function. "We had to marry mining technologies with building technolgies, and the mining technology at this location

1 Passive solar optic system
a. Fresnel reflector
b. North skymonitor
c. Fresnel mirror
d. Target zone
2 Trombe wall passive/active solar collector
3 Deciduous solar shading
4 Earth sheltering
5 Mined space 110 feet below grade
6 Active solar optic system beamed sunlight
7 Active ground water cooling system





This page: section shows relation of above ground and underground spaces of the C/ME building; below, daylighting collector; above, interior corridor. Opposite page: the C/ME building today.

could only create spaces that are no more than 50 feet wide. Underground work is very site-specific and depends on particular geology. The solution was driven by geological conditions. We have sandstone that lies under a thick limestone layer. The limestone has the structural capacity to span 65 feet, and with a safety factor we cut it to 50 feet. The 50-foot-wide sandstone pillars support the limestone roof above. The deep space is really a series of chambers that are interconnected, 50 feet wide, at 50-foot intervals. You can do it in both axes—they are connected at their ends."

Carmody, who has worked in the Underground Space Center of the C/ME building for five years, says that the daylighting system has been a real success story. "We also have changed the lighting from fluorescent to full spectrum lighting, which has made a big difference in the ambience of the space. We found that it is helpful to go to warmer tones. In fact, as we remodel spaces we are adding color, texture, materials, and plants.

"The problem we've had [in the underground space] is that the mechanical systems' controls were not as fine-tuned as we would like," Carmody continues. "Here, at 100 feet underground, the temperature is about 50 degrees [Fahrenheit] year-round, and when you add people, lights, and machines the temperature is close to the comfort zone. Our problem is dehumidification, caused when you ventilate with outside air. It may be wrong to blame the systems—this maybe is an inherent problem of being underground. There are too few buildings of the kind to know for sure, yet.

"I've learned the importance of orientation, high spaces, plants, glass, and light on how people perceive underground space. I think we will see the fruits of our research—five or 10 years down the road—in the ways that underground buildings are constructed."

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The energy revolution—over or ongoing?

A recent report in MIT's *Technology Review* (Jan. 14, 1989, page 14) explains that the Solar Energy Research Institute (SERI) has had its budget slashed dramatically through the 1980s yet still remains a vital agency as it shifts to the goal of long-range, high-risk solar research for commercialization by the private sector. One may argue that, as SERI goes, so goes energy-conservation policy in this country. Is the energy crunch over now that architects incorporate basic conservation premises and oil prices have stabilized? Or have we just glimpsed the tip of the iceberg?

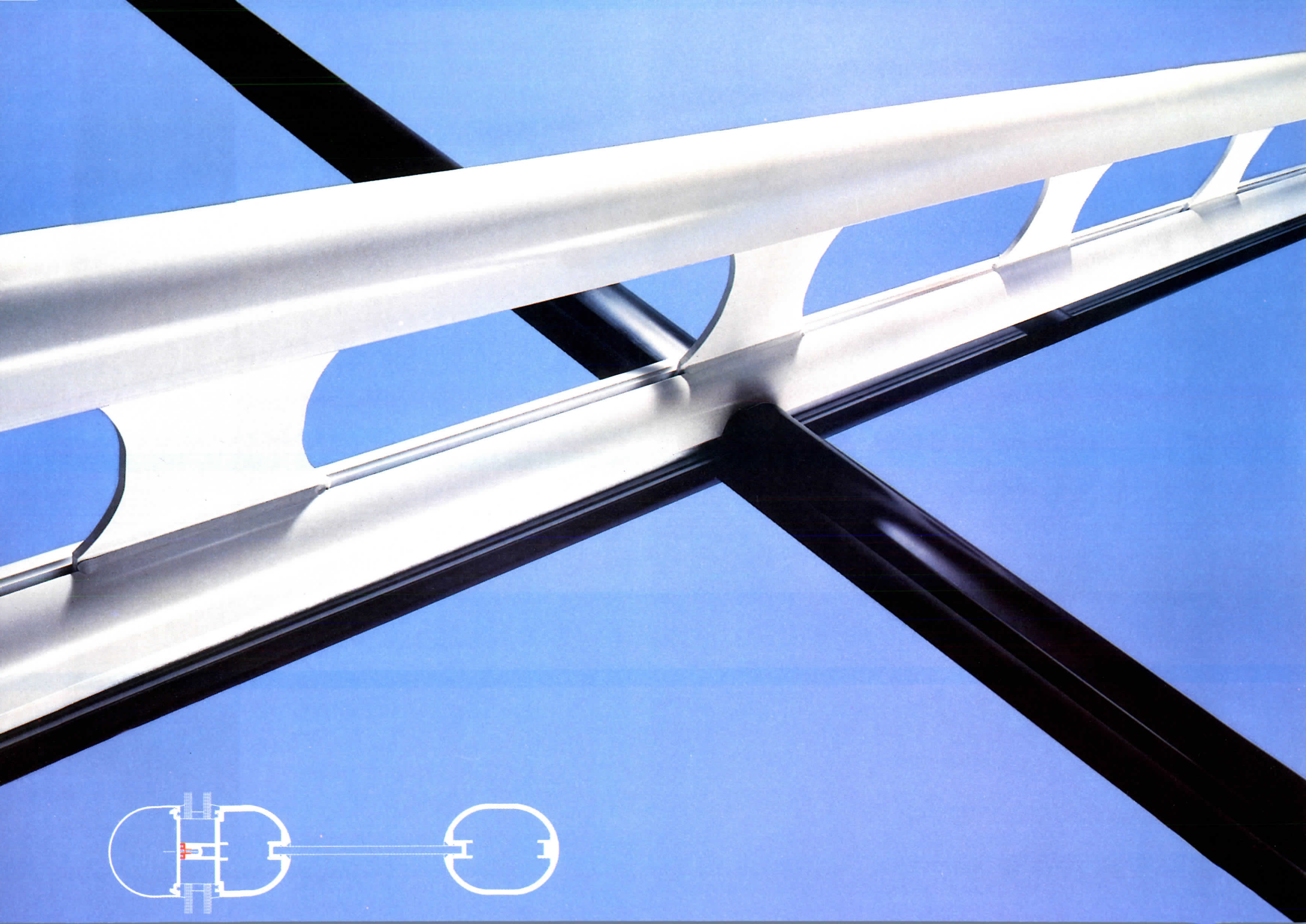
"The energy problem used to be viewed simply as where to get more energy of any kind from any source at any price," says physicist Amory Lovins, director of research at Rocky Mountain Institute, a nonprofit group working on energy and water efficiency, sustainable agriculture, local economic development, and redefining national security. "Now you ask what you want the energy for, how much energy, of what kind, at what scale, and from what source to do each task in the cheapest way. In a revolution that already is happening, efficiencies and renewables have swept the market. Since '79, for example, the U.S. has gotten over seven times as much new energy from savings as from all net increases in supply. And of the increased supply, more has come from renewable sources than from nonrenewable sources. Electric utilities can make more money selling less electricity as long as their costs go down more than their revenues. Rocky Mountain Institute's largest source of revenue is providing to utilities extremely detailed information on how to save electricity more cheaply than they can make it.

"Most of the dumb ideas from the late '70s have collapsed. They died of an incurable attack of market forces," Lovins says of the sudden withdrawal of federal energy research funds.

David Bennett, FAIA, principal of BRWJG in Minneapolis, predicts that these issues will soon return to the architecture forefront, not as an energy issue but as an environmental issue. He believes that the concept of energy conservation was a narrow focus on the larger issue of "what is our relationship with our environment to be?"

"About 25 percent of the world's population in industrialized nations enjoys the majority of the world's resources through military and economic power," Bennett explains. "That is only going to last so long, before the other 75 percent demand their share of those resources. The result of this is going to be a severe reduction in our life style and a marginal improvement in that of the rest of the world, unless we can increase the amount of resources available.

"The problem is that we have arrived at this level of wealth through a technology that is very destructive. So, if you can imagine the technology that we have now, which is poisoning the air and ocean and consuming irreplaceable resources and pushing this very flexible ecosystem to its limits, imagine that multiplied three or four times—that's what would have to happen, if the other three-quarters of the world demands this kind of mining, large-scale farming, consumption of fossil fuels, and the like. We're seeing the results of that already with the destruction of the Amazon rain forest, the ozone holes in the atmosphere, and a variety of other things. Something has got to happen within the next decade or so. Maybe it will take a period of environmental crises, or a major shift in the power balance of the world, which in a sense has already started with the rise of Japan as an industrial power and the rise of the European nations as a coalition." □



Indoor Pollution: The Issue Continues to Build

By George Rand

Complaints about health and comfort in buildings over the last decade are producing a quiet revolution in the interior design and engineering of buildings. Although rarely put to the forefront by the media and eliciting only lukewarm public concern, indoor air quality (IAQ) has risen to second on EPA's list of five priorities, behind only outdoor pollution and ozone. In 1987, Sen. George Mitchell of Maine submitted a bill supporting a comprehensive approach to IAQ, which, if passed, would fund research and development and eventually suggest alterations to building codes and to the way building products are manufactured and specified for the home and workplace.

The HVAC industry, first to be criticized, has been the leading private sector group to react in a positive manner. Mechanical engineers see their older buildings facing liability suits for systems designed to meet prevailing ASHRAE standards. Many office buildings produced in the mid-1970s and early 1980s have spawned angry employees seeking litigative relief for illnesses acquired on the job.

The Gregory Bateson building in Sacremento, Calif., for example, has problems because the building was occupied prematurely, before its environmental control systems were totally operational, balanced, and tested. Many of its innovative features were incorrectly installed, left nonoperational for budget reasons, or tampered with by employees in an effort to improve the environment. Other examples of air-quality-deficient buildings that were designed to be energy-conserving suggest that there is a limited scope of analytic procedures used to design and maintain control over unintended uses following occupancy.

The number of workers' compensation cases and civil lawsuits concerning IAQ claims is a well-guarded secret. Most cases are settled out of court because the costs of litigation are far in excess of the costs of paying off the complainant. Some analysts see a potential scenario for legal liability in which the asbestos problem pales in comparison with IAQ cases.

Once buildings are diagnosed as a source of illness, all professional participants are subject to being named in a blanket legal action. A recent case concerns a building renovation in the Los Angeles area, in which occupants of one floor of a building were allegedly subject to intrusion of toxic substances from neighboring areas in which tenant improvements were under way. The architecture firm for the tenant improvement work claims that it was limited in responsibility to space planning, and did not actually specify the products being used. Nevertheless, the firm has been named in the suit. Through a quirk in the regulations, indoor air quality problems apparently are being considered "environmental exceptions" (like hazardous waste discovered on a site) to general liability policies. This may mean normal legal support will not come from insurers to help defend against these claims. Even the cost of answering the papers is substantial, if only to prove that the architect or designer should not be held in account.

How can a firm indemnify itself against the risks of litigation? And, more important, how can the design and construction process be formulated so that it avoids risks due to noncoordination of the work of consultants, contractors on the job site, and building owners and managers both for now and for the future life of a building? There are no simple blueprints available, but there are some beginning signs of a solution.

First, a firm can indemnify itself by writing an indemnity agreement with the building owner, in which the owner agrees to defend the architect against future claims. This is possible if the owner wants the architect's work enough to be willing to take responsibility for the building throughout its life span.

A more significant approach is suggested by Elia Sterling of Theodore D. Sterling Associates in Vancouver, British Columbia. He has formulated guidelines for commissioning and auditing building systems in which the architect plays a central role as the designated "commissioning authority."

Usually, commissioning a building involves perfunctory air balance reports filed with the HVAC engineer. Adjustments to the system are made only in response to breakdowns, and there is no means of establishing continuity with the original design intent as modifications are made. However, many potential sources of problems can be controlled through a commissioning process if it starts in predesign, proceeds through all stages of construction and occupancy, and includes maintaining a historic record of the building that can be used as a basis for future assessments in the same way that a record of service history provides information to help diagnose problems with your car. The key to a successful commissioning process is for the designer to agree with the client on performance requirements that are the basis of engineering assumptions, even if these are beyond those required by code, and to specify an agreed-upon methodology for testing to see that these requirements are met at all stages of the life of the building.

ACVA Atlantic of Washington, D.C., already offers a service of this kind directly to the building owner, in which the firm sets standards for maintenance of the indoor environment jointly with the owner, instruments the building to measure baseline pollutants, and performs periodic audits of functioning to assure that standards are being met. ACVA Atlantic also offers a "preventive approach," in which it reviews architectural and engineering plans during schematic design and in design development, to ensure that there are no gaffes due to inaccessible cleanouts, or potential trouble spots in which mold might form due to condensate collection.

Some institutions are beginning to see the wisdom of incorporating this kind of preventive maintenance review into all of their architectural and engineering work, especially if they are

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self-insured. For example, the Office of Research on Occupation Safety at UCLA provides health and safety consultation for all buildings, including review of drawings and construction supervision. With millions of square feet in construction, modern campuses are a special concern because they tend to mix "incompatible" uses in close proximity, for example labs with classrooms.

Finally, it is important to distinguish fact from fiction, legal liability from litigative nuisance in this area. The recent literature is beginning to define a more suitable basis for confronting the scientific basis for future claims of injury. For example, two distinct kinds of problems, "building related illness" and "sick building syndrome," now have been articulated in the literature (see June '88, p.99). Their definition provides a good starting point for understanding the scope of the problem.

"Building related illness" refers to conditions that affect only a small number of sensitive occupants. Complaints are always accompanied by clinical signs (fever, infection, blood serology). These illnesses usually are attributable to a specific source of contaminants in a building. Examples include humidifier fever or hypersensitivity pneumonitis from exposure to bioaerosols (such as fungi or bacteria), dermatitis from exposure to fibers from duct liners, legionellosis from exposure to bacteria, and toxicity due to chemical substances such as carbon monoxide or neurotoxins. Generally, the recovery period continues long after the person leaves the building. Unless the source is removed, repeated contact with the building can aggravate the condition and even lead to irreversible, lifelong disabilities.

"Sick building syndrome" is indicated when a larger population, 20 percent or more of building occupants, complain of acute discomfort. These complaints differ from hysterical symptoms in that they emerge over time and are sustained for two weeks or more. Hysterical reactions spread very quickly and dissipate just as quickly. Familiar symptoms include headaches, sore throat, eye irritation, fatigue and listlessness, and nausea; a substantial percentage of complainants report almost immediate relief when they leave the building, or at least within a few hours of leaving. In most instances, causes of "sick building syndrome" have been traced to correctable physical problems with the design or maintenance of the building HVAC system.

Attempts to crack the causal link between the condition of the building and the symptoms experienced by the occupants involve detective work. There can be a variety of sources of contaminants. As in any other complex system, symptoms appear and disappear and function tests may not be taken at the right time to place the source of the problem.

Contamination can come from outdoor sources or from materials, processes, and people within.

Contamination can come from outdoor sources—a building may be downwind of an air pollution source or may have a parking structure leaking gases into the building from below grade. Within the building, contamination may come from the materials used in construction or furnishings, from processes that are employed (such as printing), or from the occupants themselves.

Many experts now seem to agree on a staged approach to performing the investigation, once the problems have been confirmed. The process usually begins with a walk-through. For example, the Honeywell Building Diagnostics process begins with a site visit by a team that includes a building engineer with architectural background and a health scientist trained in indoor air quality diagnostics. They define the problem and decide on measurement techniques needed for any future phase. If probable sources are found, the investigation ends and a design and implementation program is undertaken immediately.

It is especially critical in this work to solve the problem without arousing additional anxiety. Once the symptoms have been related to the built environment, diverse individuals begin to confuse chronic discomfort associated with "sick building syndrome" for symptomatology associated with "building related illness."

Investigation then moves to engineering analysis of building systems by assessing the performance of individual HVAC components, temperature, and relative humidity. Measurements of indoor air quality are more costly and involve quantitative measures or airborne contaminant concentrations obtained through bulk sampling devices, as well as measures of carbon dioxide (as a measure of contaminant buildup generated inside the building through metabolic process) or carbon monoxide (resulting from seepage of combustion gases into the building from outside). Tracer gas tests are used where the actual flow of outside fresh air is impeded in reaching work spaces.

In the sample of problem buildings examined by the Honeywell Indoor Air Quality Diagnostics team, there was frequent evidence of poor maintenance, inadequate design, and poor chain of responsibility in maintaining the building. Most buildings (75 percent) had inadequate fresh air supply. Sixty percent had malfunctioning condensate drain pans, a condition that could lead to the formation of spore colonies. Many had dirty filters, contaminated heating and cooling coils, disconnected exhaust fans, abandoned automated controls, and other physical problems.

Honeywell used a random telephone survey of 600 office workers in the United States to estimate the number of buildings that might be affected across the country. They found that 20 percent of this sample perceived job performance to be hampered by

Surveys of conditions within buildings can themselves become sources of discomfort.

poor air quality and noted by frequent symptoms of sleepiness, congestion, eye irritation, difficulty in breathing, and headache.

Similarly, a British survey of 4,373 workers in 46 buildings, reported by Sheena Wilson, suggests that as many as 29 percent experienced five or more "sick building syndrome" symptoms, and these symptoms are more likely to occur in airconditioned buildings than in naturally or mechanically vented buildings. No fewer than 80 percent of the employees experienced some workplace-associated symptoms of ill health. Open-plan offices were more likely than conventional offices to evoke these reactions. These and other studies have prompted the World Health Organization to speculate that as many as 30 percent of buildings in the developed world may have problems.

In order to establish a link, other variables that might contribute to symptoms need to be studied—education and work history, prior symptoms, general health conditions, use of office equipment and technology such as VDTs, and other environmental stressors to which the workers are exposed.

Theodore D. Sterling Ltd. of Vancouver, British Columbia, has conducted survey research of 1,200 occupants of buildings in New York City. These buildings had no history of complaints and were used to establish a baseline against which problem buildings can be profiled. Without such baseline data, questionnaire surveys can backfire and produce spurious results. In one case, a survey was conducted more than two months after suspected health problems first surfaced, allowing anxiety about indoor air conditions to mount. The survey form itself included leading questions that focused primarily on microbial contaminants ("Do you have allergic reactions at work? Have you ever had a positive skin test for molds?") In this instance, the survey became a source of heightened anxiety as a result played some role in the eventual closing of the building.

A sidelight in this case is that the most likely source of the original mold may have been cool-steam humidifiers brought in by the employees to enhance their own comfort. This would not be a legal problem for the owners or lessees of the building under most circumstances. However, in this instance, the use of the building was changed from the original intended use and the occupancy density was increased, thereby embroiling the owner in the cause for which employees sought relief by using the humidifying equipment. This gives some indication of the circuitous reasoning for which building owners and their agents—including architects—may be held to account in the future.

There have been some innovative engineering solutions that are attempting to preserve the benefits of energy management without penalizing the worker in terms of environmental comfort. For example, while older VAV boxes supplied fresh air only when the space was occupied and shut off the air supply when temperature dropped below a threshold, new systems exploit the opposite logic. Booster fans force fresh air through stratified layers to the level of the occupant and prevent the fresh air from entraining back to the return duct. Studies of ventilation efficiency have shown that in older systems 30 percent or less of the fresh air actually reached the occupied zone. (Most analysts contend that fresh air should be up in the range of 80 percent in order to assume air quality implied by the specification of 20 cfm of fresh air per occupant. This does not happen with most standard equipment; in most cases, stratified air will tend to be the rule.)

It is not at all clear that booster fans bridge the gap between the ceiling plenum system and the forest of partitions that divide up the occupied zone of modern offices. Office occupants commonly try in vain to compensate for the mismatch by taping cardboard over supply diffusers to reduce drafts. Laboratory simulation of air flow establishes the best system as one in which air is supplied up high and drawn out of the space from an area low on the wall or in the floor itself. These systems are difficult to engineer, given the typical floor system of concrete over a structural metal deck. With this type of structure, it would be necessary to cut holes in the deck to draw air through to the ceiling plenum of the floor below.

Even under the best conditions, there are concerns about defeating a good design by modifications made after the initial occupancy. In a case reported by researcher John Janssen, a St. Paul office building was designed with 300-foot-long and 60-foot-wide floors with distributed air supply in the ceiling. Returns were placed at each end of the building to reduce problems of poor ventilation efficiency. The system worked (with some exceptions), but was compromised when interior walls later were erected to create private offices. It was possible to provide adequate supply air to the offices, but these walls cut the flow of return air and a "sick building" incident resulted.

"War stories" of building failure have accumulated in the annals of civil law and in informal engineering colloquy, but they are not part of a coherent body of research literature. In fact, some analysts familiar with the health problems associated with modern office buildings see these conditions as related to a more general paradigm shift that has to do with the internal logic of offices. Jack Tanis, vice president for marketing at Sunar-Hauserman, suggests that "the need set is changing." For instance, Tanis sees flaws in the functional logic of interior-panel-based systems, especially full-height, four-wall enclosures. Their espoused flexibility is called into question. As another interviewee suggested, "we need to be able to add a computer to a workstation without calling a facilities manager to rearrange a whole corner of the floor."

The new importance of the computing environment calls for more varied and flexible horizontal connections. The provision of fresh air, controlled temperature, and light no longer is a plain vanilla background provision but has become a central concern in the ergonomic design of the workplace. It suggests the need for a new mode of thought about the indoor ecology—the new paradigm for providing generic office environments.

How quickly can the high cost of corrective measures be recovered in employee productivity?

There are several promising systems in development, some still cloaked in secrecy. Johnson Controls recently released information regarding its "personal environment," which it hopes to have in production shortly. Its system provides ducting from an HVAC unit, brought down through vertical columns from the ceiling or via a raised access floor, to support groupings of back-to-back workstations. As many as 24 stations are connected together with a nine-inch panel of serviceways for air, electric wires, and cables sandwiched between them. Stations use standard work services provided by major manufacturers, and the Johnson Controls' product merely links them.

The list of companies participating in this experiment is too long to cite, but it includes key manufacturers of furniture systems (such as Steelcase, Herman Miller, Teknion, and Westinghouse) as well as manufacturers of lighting systems, filters, white noise generators, and other component products. It is too early to measure its success, but this visionary effort attempts to link together a group of cooperating industries to develop a new paradigm. This is an attempt to do for offices what the SCSD tried to achieve for schools in the early 1960s.

At each station, there is a control panel for dialing air flow, task lighting, white noise, and radiant heat from a panel beneath the desk. In addition, the Johnson Controls system includes a readily accessible air filter, including both electrostatic filters and carbon cloth filters, that can be checked easily and replaced. Air surrounding the occupant is tempered to desirable levels with available adjustments. Air in the space above the six-foot level, which does not need to be tempered to the same standards, is unimpeded by the usual suspended ceiling and slowly drifts to the return ducts.

The product is expensive, but produces some savings both in employee productivity and in other ways. For instance, both uplighting and task lighting are integral to the system. Furthermore, there is no need to finish the ceiling. Finally, the system operates on the principle of radiant heat and does not require heating above the six-foot level.

A similar system is being introduced on a custom-design basis in a new building currently under construction in northern Canada. This complex of office buildings, designed by Bill Boucock Partnership, Architects, Calgary, is in a processing area for oil sand extraction that is subject to heavy air pollution coupled with arctic temperatures that drop to minus 40 degrees centigrade (minus 40 degrees Fahrenheit).

To compensate for this poor ambient environment, the system supplies air to private offices through two-foot-thick, wall-like millwork cabinets that bring the service elements directly from the ceiling unit to individual workstations. These "wall units" double as soundproofing devices, closets, and bookshelves.

In rare instances, experiments between good design firms and forward-thinking corporate clients are being carried out; they should be tracked carefully to determine their effects on health and ergonomics. Pat Conway of KPF/Conway in New York City tells of extensive work done for Procter & Gamble in 1985 to achieve a state-of the-art office landscape in which a combination of a six-inch raised access floor and an HVAC system in a suspended ceiling was used, with air distributed from the building perimeter and then exhausted into a central atrium.

Gensler Associates' Los Angeles office is constructing a corporate headquarters for Epson that involves a complete raised floor system with an 18-inch plenum to house an integrated services package. The energy costs and ergonomic benefits of this system also will be important to track. As with the Johnson Controls system, air is fully conditioned only up to the six-foot level and then is allowed to find its own resting temperature.

Finally, the science fiction award goes to a system being designed by Carrier Corp. in France. The Carrier M.T.A. system reportedly allows each room in an office building to be tied independently to a central system for recharge with fresh air. It does not transfer exhaust air from one room to the next (as do most systems that are hooked up in series). Room air is tempered by a miniaturized unit that can be located in the ceiling space. The portable thermostat can be placed anywhere in the room, and the unit turns itself off when no one is present.

These experiments still are in their formative stages and face many economic obstacles that will prevent widespread adoption for some time to come. Among other things, they involve high front-end costs. No matter how quickly those costs can be recovered in employee productivity, they are hard to justify in a corporate environment that is under threat of leveraged buyouts and major reorganization. ☐

Radon: Testing, Prevention and Cures

By Alex Wilson

The term meant nothing to most of us a few years ago, but today radon is a major concern in residential and light commercial buildings coast to coast. Numerous studies over the past 10 years showed radon levels to be unacceptably high in certain regions of the country, but it was not until the Environmental Protection Agency recommended last September that all houses and light commercial buildings be tested for the gas that most people took notice.

Today, we find radon testing clauses on more and more real estate sales contracts, and an entire industry has sprung up supplying products and services to test for and eliminate radon in buildings. While most architects may not be directly involved in any aspect of radon testing or mitigation, they should be familiar with the issues in order to recommend or specify testing and corrective measures as necessary.

Radon is a colorless, odorless, radioactive gas that is formed as naturally occurring uranium in bedrock breaks down into various radioactive decay products (see Figure 1). Each step of the decay is accompanied by the release of radiation—alpha, beta, or gamma particles. Alpha particles are the most destructive and our biggest worry. On an atomic level, alpha particles are large, slow, and powerful—often called the .45 caliber slugs of radiation. They are stopped quickly by most materials, but not before doing some damage. If a person breathes radon, the release of alpha particles can do considerable damage to lung tissue. Studies of uranium miners have linked high radon levels to lung cancer.

Radon levels vary widely from region to region, depending largely on the bedrock composition. Certain areas, such as the Reading Prong extending through New Jersey and Pennsylvania, have exceptionally high radon levels because of the high uranium content of the underlying granite. In other parts of the country, high radon levels cannot yet be explained. Even in regions with generally high (or low) radon levels, there is tremendous local variation, again without clear explanation. For this reason, EPA has recommended testing throughout the country.

Radon gets into a building primarily through the foundation. It seeps up from the bedrock through the soil and then finds its way into the structure through cracks in the basement floor or walls. Primary entry points are shown in Figure 2. Particularly troublesome leakage areas are basement sumps, along the slab perimeter, through concrete blocks (especially when uncapped), and piping penetrations through the foundation walls.

In addition, radon may be introduced from incoming water, particularly if the house is served by its own spring or well, and from building materials in the house. Natural stone used in fireplace construction is the building material most likely to give off radon gas, but some aggregates have been known to intro-

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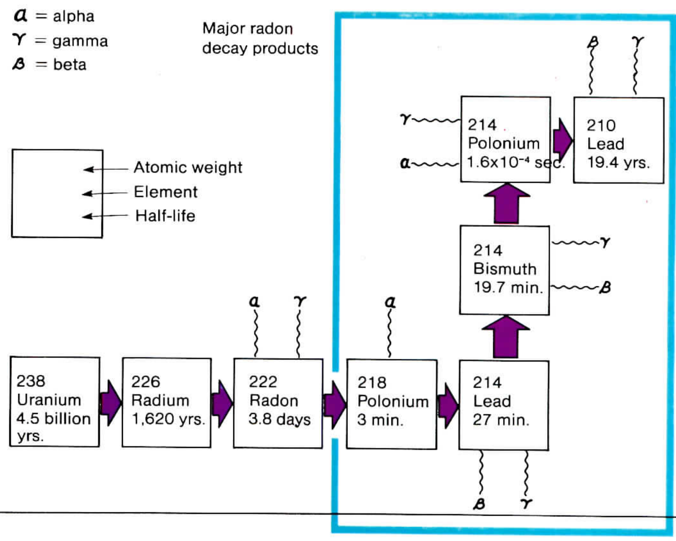
Figure 1
Radon decay chart



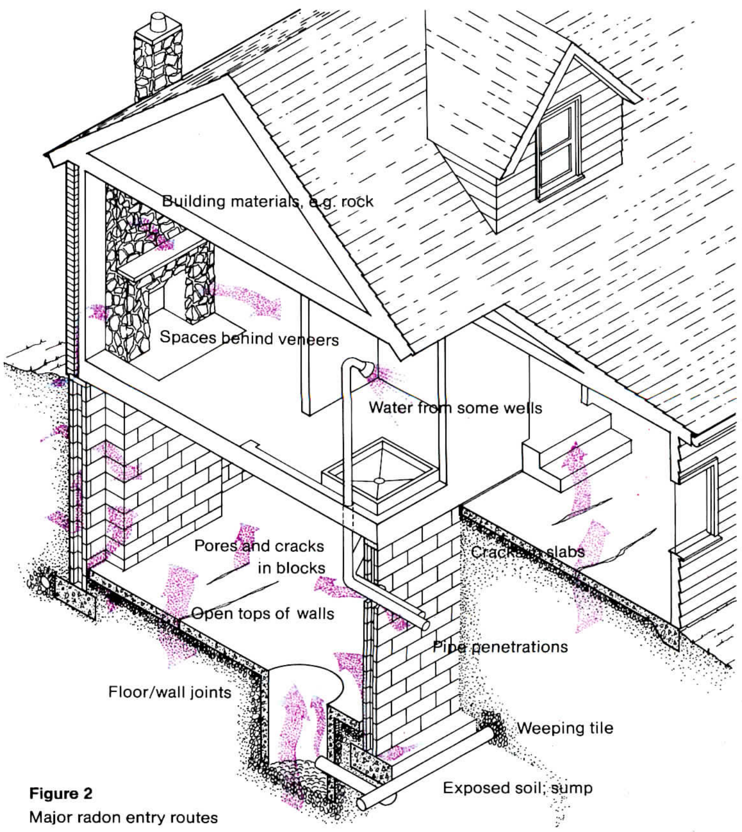


Figure 2
Major radon entry routes

duce radon (in fact, high radon levels in houses were first discovered during the mid-'70s in houses built in Colorado of concrete block produced from uranium mining slag). For the most part, however, radon from the ground is the sole concern for architects.

EPA recommends that initial tests be conducted in rooms that are closest to the ground level, where radon levels are likely to be the highest. If short-term screening tests indicate high radon levels, longer-term follow-up tests should be conducted in rooms throughout the building.

Testing techniques and devices

Charcoal canister radon collectors are the most common, simplest, and usually least costly of radon test kits. They are used for short-term screening tests of two to seven days. A small canister or packet of activated charcoal is exposed to the air for the specified time. Radon is trapped in the charcoal. After exposure, the collector is resealed and sent to a laboratory for analysis. The measured radon level is an average level for the period of exposure.

Because they operate passively (without electricity) charcoal canister radon test kits can be placed anywhere in the building. High humidity, however, may lower the accuracy of some products.

Alpha track detectors are the most common long-term radon measurement devices. Radon can enter the plastic housing when it is opened and exposed to the air. As the radon breaks down, alpha particles etch the polycarbonate inner surface. After the desired period of exposure, the user reseals the device and sends it back to the laboratory that supplied it. At the laboratory, the alpha tracks are counted under a microscope and the average radon concentration for the period is calculated from the density of radon "tracks." If radon levels in the building being tested are relatively low, a long exposure time for the alpha track detector is recommended (up to a year), while a shorter exposure time of one to three months is sufficient if the radon concentration is higher. Like the charcoal canister radon collectors, alpha track detectors operate passively and so can be placed anywhere.

A new type of radon testing device has recently been introduced: the electret radon detector, a proprietary device that makes use of the electrical properties of an electret, which is made of polytetrafluoroethylene and carries an electric charge. As ions strike it, the charge is reduced. Because ions are created when alpha particles from the decay of radon strike air molecules, the drop in charge of the electret can be calibrated to measure radon concentrations.

Air and radon are allowed to enter the re-usable glass testing chamber that houses the electret (ionized particles are filtered out). After the desired exposure period, the charge on the electret is measured in a specialized voltmeter supplied by the manufacturer. The radon concentration required to produce the change in electret charge is then calculated or determined from a table. Depending on the radon levels, an electret generally can be used for five to 10 radon tests before its charge is "used up." Electret monitors offer the advantages of rapid results (if you own the voltmeter) and passive operation. Two types of electrets are available for the radon test kits: one with a relatively low charge that is recommended for short-term tests, and one with a higher charge that is recommended for tests of one to 12 months.

The last category of radon testing equipment is continuous monitors. These are more complex and more expensive than the passive monitors, but the radon levels are available immediately simply by reading the instrument, without sending anything off to a laboratory or carrying out any calculations. Most monitors function by taking instantaneous measurements and averaging or plotting the results over time. The actual mechanism involved in continuous monitors varies widely among the equipment on the market. Some are far more complex than others, and their accuracy varies considerably.

Results from radon tests are given either in picocuries per liter of air (pCi/l) or in "working levels" of radiation. The picocurie is a measure of radioactive decay: 1 picocurie equals 2.2 decays per minute. The working level (WL) is an older unit of measure that comes from the uranium mining industry. Technically, working level refers to the level of radon decay products, not radon itself, but for most purposes the two measures can be used interchangeably, with 1 WL equal to about 200 pCi/l.

Although radon is a proven carcinogen, the threshold of acceptability set by EPA (4 pCi/l) is based not on epidemiological data but on interpolation from such data. Standards setters count backward from the high levels of radon and dust (which helps carry radon into the lungs) that uranium miners experience, and the incidence of cancer they suffer, to calculate an acceptable radon level. The accuracy of this method is still a point of debate. For instance, Bernard Cohen of the University of Pittsburgh analyzed radon and lung cancer data from 415 counties around the United States and reported at the American Chemical Society's annual meeting last year that the lung cancer rate was actually lower in counties with higher radon levels. It is important to note, however, that such findings do not change the 4 pCi/l EPA threshold.

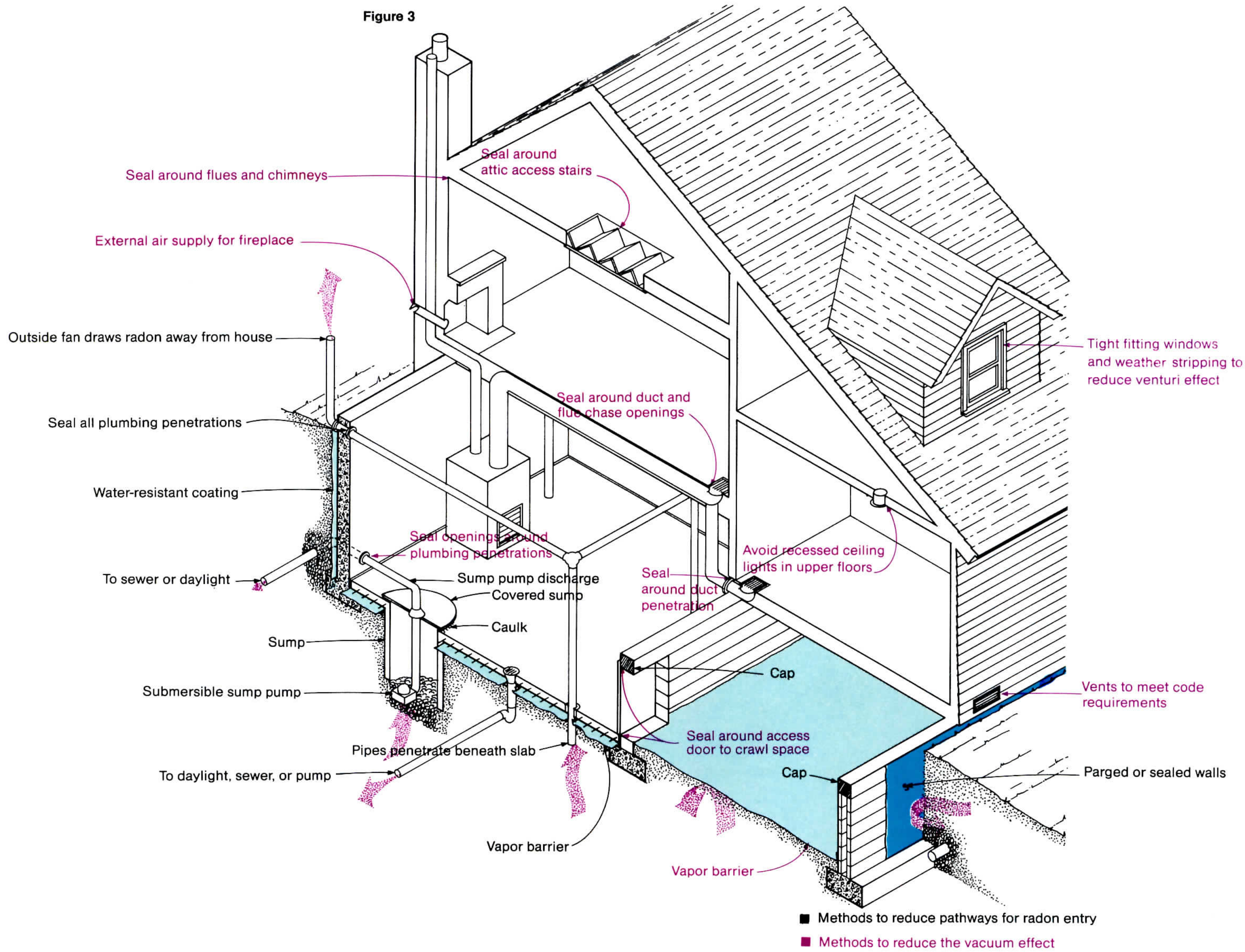
Radon prevention in new construction

Designing buildings to deal with radon involves a three-part strategy: minimizing radon entry pathways, maintaining neutral or positive pressure in buildings, and incorporating strategies to facilitate future radon mitigation if necessary.

Ways to minimize radon entry into buildings are shown in Figure 3. Important guidelines are as follows: install a polyethylene moisture barrier under the basement slab; put steel mesh and rebar in the slab to minimize cracking; install expansion joint material where the foundation wall and slab meet; caulk any cracks and joints in the foundation floor and walls; remove grade stakes and screed boards as the slab is being finished (otherwise they will eventually rot away, leaving an open channel to the subslab gravel); seal around any slab or basement wall penetrations; run floor and perimeter drains to daylight, sewer line, or sump; seal the sump cover; avoid using concrete block for the foundation walls if possible (if you do use it, cap the top of the block wall); waterproof the outside of the foundation wall and provide adequate drainage along it; with slab-on-grade construction, use a monolithic pour if possible; and, with crawl space construction, lay a polyethylene moisture barrier on the ground in the crawl space.

To minimize negative pressure in a building, which will tend to draw radon in through any entry point, use the strategies shown in Figure 3. These include the following: provide outside combustion air for all combustion appliances; provide replacement air for clothes dryers; follow good construction practices to eliminate bypass air leakage areas and the stack effect (avoid recessed lights in insulated ceilings, seal around chimney, piping, and duct

Figure 3



penetrations, etc.); ventilate crawl spaces; and where practical use air-to-air heat exchangers rather than conventional exhaust-only ventilation.

To facilitate future radon mitigation if it ever becomes necessary, a number of construction practices should be followed. Most of these strategies are relatively inexpensive if done at the time of construction.

The most important is to install four inches of clean aggregate (pea gravel or larger) under the slab. Install perforated drainage pipe around the interior of the footing, draining to a closed sump that can, if necessary, be vented to the outside. Finally, install a section of four-inch pipe into the subslab aggregate before pouring the slab. This standpipe should extend about one foot above the finished slab level; it should be capped at the top and sealed where it penetrates the slab.

It is a good idea to label this standpipe clearly as a subslab radon ventilation pipe so that it is not confused with a drainpipe sometime in the future. If high radon levels are found later, this pipe can be extended through the roof or foundation wall and fitted with an in-line fan for ventilation. Keep these strategies simple so that the builders install them properly.

Radon mitigation in existing buildings

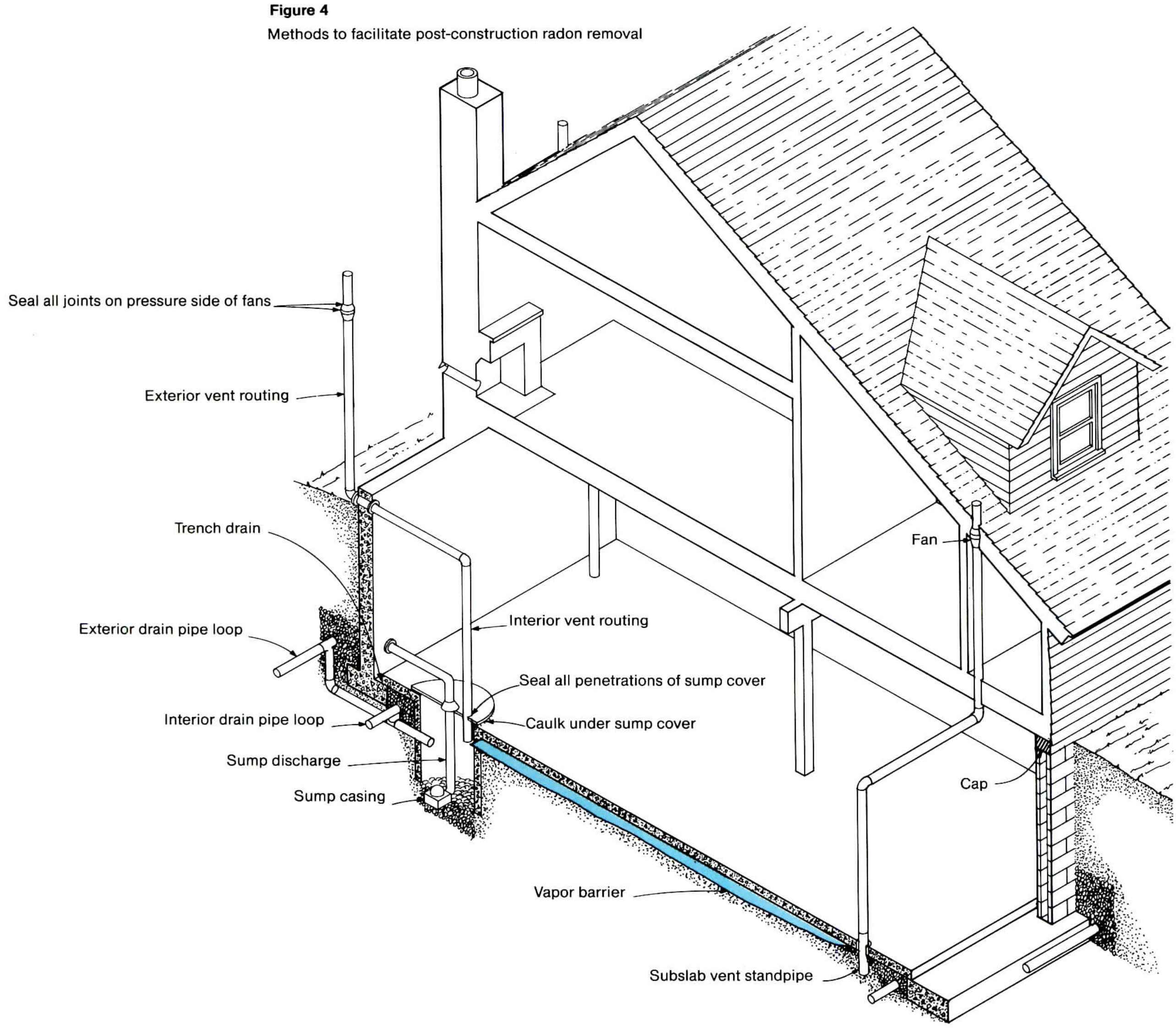
If high levels of radon are found in existing buildings, radon mitigation work may be called for. EPA recommends increasing urgency according to the level of radon that is discovered in an existing building. Below the recommended threshold of 4 pCi/l, EPA requires no action. At levels between 4 and 20 pCi/l, action should be taken within a few years to bring levels down to 4 pCi/l; at levels of 20 to 200 pCi/l, action should be taken within a few months to bring levels down to 20 pCi/l or lower; for levels over 200 pCi/l, EPA recommends taking action within a few weeks to bring levels down as much as possible, and, if owners are unable to take action quickly, they should consider temporary relocation.

In most cases, radon levels in existing buildings can be lowered relatively easily and inexpensively. Many of the basic strategies are the same as those for new construction, but there will be many more variables, depending on the construction. The four major strategies are ventilation, reducing negative pressure, sealing entry pathways, and installing radon vents.

Ventilation removes stale air from the building and introduces

Figure 4

Methods to facilitate post-construction radon removal



outside air, which has a very low radon concentration. Ventilation is most important in the basement or crawl space, where most radon enters. Both natural and forced ventilation can be used to reduce radon levels to some extent, but it usually will not be enough to deal with very high radon levels—over about 40 pCi/l. Ventilation also has some drawbacks. Exhaust-only ventilation can actually increase radon entry into the building by creating negative pressure, which pulls air in through cracks in the foundation and slab floor. Furthermore, unless air-to-air heat exchangers are used, ventilation will significantly reduce energy efficiency during winter.

Reducing the negative pressure in a building can greatly cut radon levels. Strategies for this include providing makeup air for combustion appliances and clothes dryers and installing heat recovery ventilation systems in place of exhaust-only systems.

Sealing off radon entry points is a key part of radon mitigation. All leakage areas discussed previously and shown in Figure 1 should be sealed with caulk, foam sealant, foam backer rod, or another suitable sealing material.

Finally, for high radon levels that can't be brought down otherwise, you may need to install a radon vent to depressurize the ground under the basement slab or around the foundation. Fortunately, most slabs are poured on a layer of crushed stone or gravel. Depressurization of the subslab may be as simple as cutting a four-inch-diameter hole through the slab, inserting PVC pipe through the slab, running the pipe up through the wall and installing an in-line fan to pull air out of the subslab area (see Figure 4).

To depressurize the outside of the foundation wall, it may be possible to install a water trap and riser with in-line fan in the drainage pipe outlet. A second riser is required to maintain water in the trap so that the fan's suction will draw air from around the foundation rather than from the drain outlet. If drainage pipe around the house is not already in place, it may have to be installed, which will be quite expensive and disruptive to landscaping. Such a measure should be required only for severe radon problems.

In some situations, depressurization of the foundation wall can be accomplished by drilling into hollow block walls from the inside and ventilating the cavity, or by installing a hollow baseboard raceway around the basement perimeter, which is open to the floor-wall joint, and ventilating it. □

Circumventing Chlorofluorocarbons in Building Uses

By Barbara Golter Heller, AIA

Ozone depletion has become a major concern during this decade. Along with other environmental problems, such as acid rain, indoor air pollution, and toxic waste, it will become a major challenge to architects of the 1990s.

Ozone depletion seems to be due in large part to the presence of chloride ions in the stratosphere—very likely from man-made chemicals—and appears to be occurring faster than anticipated by scientific models. Ozone (O_3) in the stratosphere blocks much of the sun's ultraviolet light. Ozone depletion, therefore, will increase UV exposure, which will increase the incidence of skin cancer and cataracts in people and cause crop failures and widespread destruction of aquatic life, among other effects.

Fully halogenated chlorofluorocarbons, or CFCs, have been identified as the chief contributor of stratospheric chloride ions. While scientists debate whether newly discovered holes in the ozone layer are a result of nature or humanity, the atmospheric lifetime of CFCs (in some cases as long as 120 years) has prompted industries and governments around the world to take immediate remedial action. The task is enormous. CFCs are widely used as refrigerant for chillers and iceboxes, blowing agent for plastics, cleaning agent for electronics, gas filler for insulation, and aerosol propellant. The refrigeration and electronics industries are most dependent on the CFCs, and car airconditioners are the largest single source of CFC emissions in the United States. Of further interest in the building industry, bromine, another ozone-depleting halogen, is found almost exclusively in the fire-extinguishing agent Halon.

In 1987, the Montreal Protocol, a document drafted under the auspices of the United Nations Environment Programme, was ratified by 30 countries and the European Community to call for a 20 percent phasedown in the manufacture of CFCs by 1992, to 680 million pounds a year (the 1986 production level), and a 50 percent phasedown by mid-1998. The document will go into effect July 1, 1989. Since ratification of that document, new scientific evidence about ozone depletion has been sufficiently alarming that Du Pont Chemical, the world's largest manufacturer of fully halogenated CFCs, has announced its intention to phase out production of CFCs entirely by the year 2003. Most people in industry and government who are involved in this issue expect that the Montreal Protocol will be modified to accelerate the withdrawal of CFCs and Halon from the market.

The challenge to both industry and government is to make an orderly transition from CFCs to substitute chemicals. In a position paper released last July, in which Du Pont announced its support of the Montreal Protocol and its commitment to phase out CFC production while searching for replacements, Joseph P. Glas, director of the Freon products division, stressed the need for thoughtful progress. "Elimination of CFCs before viable alternatives are commercially available could result in the obsolescence of products and equipment worth $135 billion that are essential to human health and safety and also contribute to the efficient use of the world's energy resources," Glas wrote. Replacement of CFCs obviously will have far-reaching effects on initial and operational costs and effectiveness of many construction-related products and processes.

CFCs are very stable, nontoxic, fire-resistant chemicals under normal circumstances, which is why they were so readily adopted in so many different applications. What wasn't known when CFCs were developed in the 1930s was the consequence of the fact that CFCs break down molecularly when exposed to ultraviolet light. The result has been that a sizable percentage of the millions of tons of CFCs that have been produced since the '30s have slowly been drifting, stable and intact, upward to the stratospheric ozone layer. The ultraviolet rays break down the CFCs into charged particles that react catalytically, according to popular theory, to unbalance ozone molecules (Figure 1). A depleted ozone layer means more UV light penetration, which increases CFC breakdown, and on and on in an ever-worsening cycle.

Two categories of replacement chemicals that show promise are hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). Similar in behavior to CFCs in commercial applications, HCFCs and HFCs are different chemically (they contain hydrogen and therefore tend to oxidize before reaching the stratosphere). HFCs, furthermore, have no chlorine in them and cannot contribute chloride ions even if they do reach the stratosphere. Substitution with these chemicals depends both on their performance and their comparative cost. Intense research is going on, Du Pont reports.

CFCs and airconditioning

Building owners and architects need to consider refrigeration chemicals in new buildings. There certainly will be a conversion to substitute chemicals within the 20- to 40-year life of new refrigeration plants.

Most major commercial systems now use CFC-11 or CFC-12. Some use HCFC-22, which is not an ozone-depleting substance. Replacement chemicals for CFC-11 and CFC-12 are HFC-123 and HFC-134a, respectively. But these are not "drop-in" substitute chemicals. Existing systems may require extensive conversion to accommodate substitute chemicals.

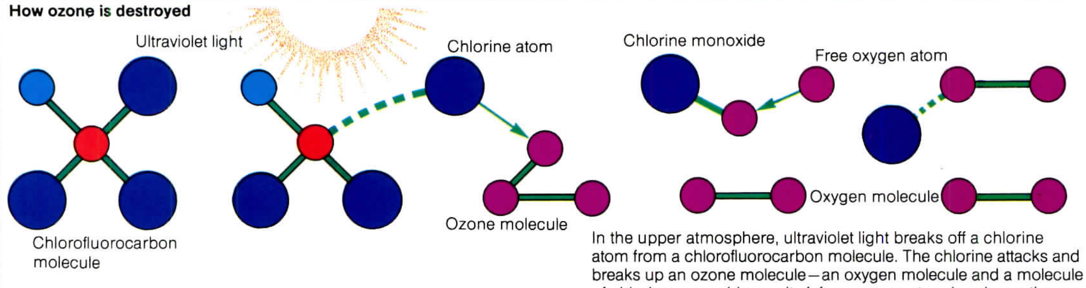
Du Pont discussed the problem candidly in its July 1988 position paper:

"Tests on operating units have confirmed a significant decrease in capacity and an increase in power consumption when HFC-134a replaces CFC-12. In addition, increased discharge pressures may require redesign of some systems. . . . Du Pont estimates that it will take a minimum of two years of field testing before refrigeration equipment manufacturers will be willing to warranty new equipment using the new refrigerant/oil combination.

"Another concern is that any new HFC-134a/oil combinations may be totally incompatible with existing refrigerant/oil combinations. If traces of the existing oil/refrigerant remain in the system, the compressor may be destroyed after short operation of the new HFC-134a/oil combination. . . . For HCFC-123 . . . Du Pont's major concern is the more aggressive solvent strength

Ms. Heller is a principal of Heller and Associates, a specifications consulting firm in Washington, D.C.

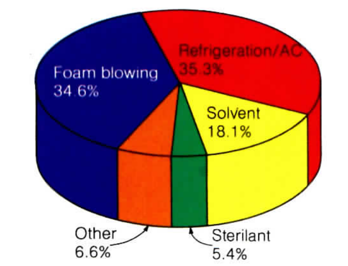
How ozone is destroyed



In the upper atmosphere, ultraviolet light breaks off a chlorine atom from a chlorofluorocarbon molecule. The chlorine attacks and breaks up an ozone molecule—an oxygen molecule and a molecule of chlorine monoxide result. A free oxygen atom breaks up the chlorine monoxide. The chlorine is free to repeat the process.

Source: U.S. Environmental Protection Agency

United States end uses of CFCs



Source: U.S. Environmental Protection Agency

of HCFC-123. There are also concerns about compatibility of HCFC-123 with existing elastomers and motor windings in some of the existing installed systems, so retrofits of some existing machines may be very costly."

The major refrigerant machinery companies are working on new prototypes and recommendations for converting existing equipment, but none would comment publicly on their efforts because of the preliminary nature of their research and because competitive pressures are intense.

Du Pont announced in January that it has developed a drop-in replacement for CFC-12 that should be commercially available in 1993. Du Pont states that the new gas is 97 percent less destructive to the ozone layer than CFC-12, although more expensive to produce. A true drop-in replacement for CFC-12 eliminates the need for chiller manufacturers to redesign equipment and thus accelerates the CFC replacement schedule.

An important point to consider with existing chillers and refrigerators, though, is that CFCs are in a closed system and can be viewed as a re-usable resource. EPA is hoping that scarcity will prompt industries to save and even scavenge existing CFCs from defunct systems to use in maintaining existing CFC equipment. Jean Lupinacci of EPA's global change division says, "Current practice does not conserve or recover existing CFCs. Our largest effort now is to encourage conservation and recycling. We're talking to utility companies about recapturing CFCs from defunct systems for resale to other customers."

CFCs and insulation

CFC-11 is used by most of the foam insulation industry as a blowing agent. Urethane, polyisocyanurate, phenolic foams, and polystyrene all require CFC to develop insulating products. Not only is CFC instrumental in forming the insulation, it is a better insulator than air, and its lingering presence tends to increase the R-value of insulation products. CFC leakage from insulation into the atmosphere is a major factor for loss of R-value in aging insulation.

The polystyrene industry can convert to existing, widely available chemicals, HCFC-142b or HCFC-15a. Dow Chemical Co. has announced plans to completely phase out CFC-11 as a blowing agent for Styrofoam brand insulation within three years. According to Lon Brenner, national quality manager for Dow, the company does not expect any significant change in the insulating properties or longevity of its products as a result. The effect on cost is not yet clear.

To date, early work suggests that HCFC-141b and HCFC-123 may be substitute chemicals for the other foam insulation types, but the conversion is more problematic. According to the Du Pont position paper: "Results to date have shown that both [chemicals] can be used to replace CFC-11, but costs of the resulting foam will be higher and an inferior product will be produced relative to today's product. . . . We do know that foams made with CFC-11 should always provide about 10 percent better insulating properties than foam made with HCFC-123 or HCFC-141b. Thus, it is likely that an inferior insulating product will be produced at a higher cost with the new alternatives."

Replacing Halon systems

Other ozone-depleting chemicals are Halon 1301 and Halon 1211, which are halogenated hydrocarbons used as fire extinguishing material. (The last three digits in the number suffix of these compounds refer to the occurrence of halogen atoms in the Halon molecule, where the second digit refers to fluorine, the third to chlorine, and the fourth to the number of bromine atoms within the molecule.) The ozone-depleting potential of Halon 1301 is nine times greater than that of CFCs; of Halon 1211, three times greater. To date, no adequate substitute chemical has been found.

Paul Huston, an engineer with Amarex Corp., a major fire extinguisher manufacturer, says, "There's a big effort to find an ozone-happy replacement that can be retrofit in existing equipment. But we haven't found it yet." This industry now is promoting recapture of existing Halon and reducing unnecessary emission in testing, training, and demonstrations.

There are circumstances where Halon is the only appropriate choice for fire extinguishing. It is unparalleled in controlling electrical fires and avoiding damage to electronic machinery. With the increased price and long-term undesirability of using Halon, however, and with no substitute for the gas itself, designers are faced with finding alternative strategies altogether. Protection of water-sensitive computer equipment is an example. Demonstrations indicate that a water sprinkler system combined with watertight cabinets for computer equipment allow normal operation and accessibility yet protect the equipment from dust, smoke, and heat to 2,000 degrees Fahrenheit, without the need for Halon, says David Hsieh of Shihyung Security Technology in McLean, Va. The U.S. Navy already has established performance specifications for such cabinets.

A few strategies for architects can contribute to minimizing industry disruption as ozone-depleting chemicals are phased out:

- Halon extinguishing systems should not be specified unless absolutely necessary.
- Airconditioning systems should be designed to use HCFC-22 instead of CFC refrigerants when possible.
- Advise building owners of possible supply restrictions on materials using CFCs and Halon.
- Hope that our efforts are timely and will prevent significant future damage to the biosphere. □

Computerized Control Systems

By Elena Marcheso Moreno

Smart, intelligent, automated. Call them what you will, computerized controls for integrating building systems such as HVAC, electrical, life-safety, security, and communications are an application of technology to building operations that is being considered more and more frequently by designers and developers alike.

Building automation systems are not new. They were developed and marketed in the late 1950s and were quite simplistic—a building's fire alarm system connected to a local municipality's fire reporting system. The early systems were not computerized. It took two decades for computers to find a role in building operations, and the oil embargo of the early 1970s set the stage for computerized energy management, which has since been the driving, but not the sole, force for automating buildings.

Change is the chief characteristic of office occupancy today, says Ronald J. Caffrey, vice president of Johnson Controls and chairman of the Intelligent Buildings Institute, based in Washington, D.C. Change in job requirements. Change in types of people occupying jobs. Change in management structure within companies. And change in available productivity tools. Change is characteristic of the electronic technology available in the work environment as well as the physical surroundings, he says; it affects telecommunications, office automation, and building automation. It also affects the building structure and the wiring structure, both of which must be designed and maintained and managed in a way that ensures flexibility, not only for today's occupancy but also for any possible future occupancy and technologies.

The idea of a control system is simple enough. Just measure what is going on in each space and provide the heating or cooling required to handle it. Meanwhile, turn the lights off where they are not needed, ventilate as required, and start all equipment just early enough to make the building comfortable when the occupants arrive.

The problems of building controls start when the walls go up. Each side of the building must be dealt with separately because the cooling requirements due to sunlight penetration can be great, and they vary by orientation and time of day. On a bright winter day it might be necessary to cool the east side of a building in the morning, the west side in the afternoon, and heat the north side all day long. The problem is compounded in moderate climates, where the temperature swings widely during spring and fall. One day may be cold enough to require heat in much of the building, while the very next day may be warm enough so that most of the spaces require cooling. Various energy management and control systems are available, and virtually all are based on the Variable Air Volume concept, which controls airflow to building spaces by providing a series of controlled dampers.

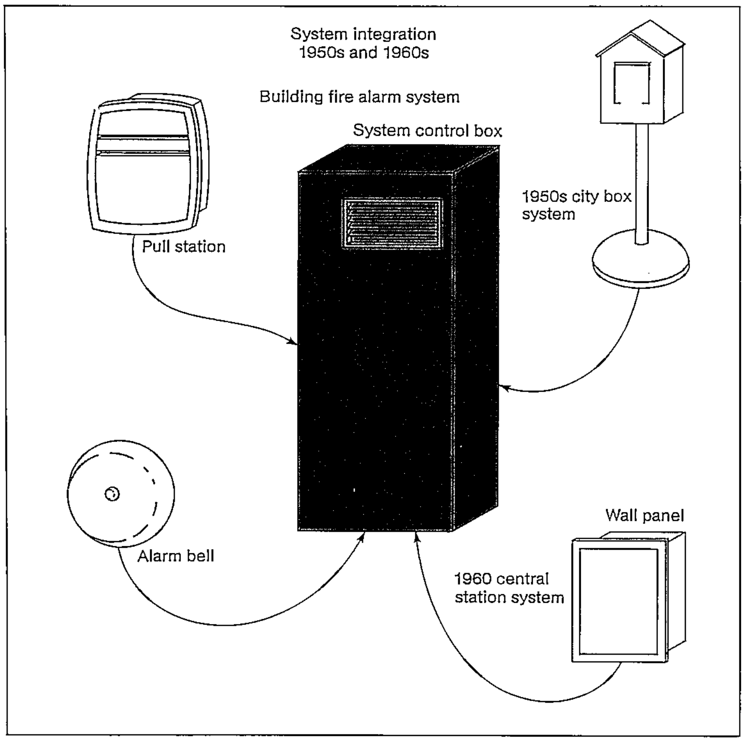
Building controls have evolved on the assumption that they would provide cost-effective building operations. Not long ago, new micro-electronic technologies began overcoming some of the limitations of standard pneumatic controls, which had a restricted ability to sense building conditions, select the most important for the moment, and vary the mechanical system to meet the need. Moreover, there is a practical limit to the number of hoses that can be run from one place to another in a building.

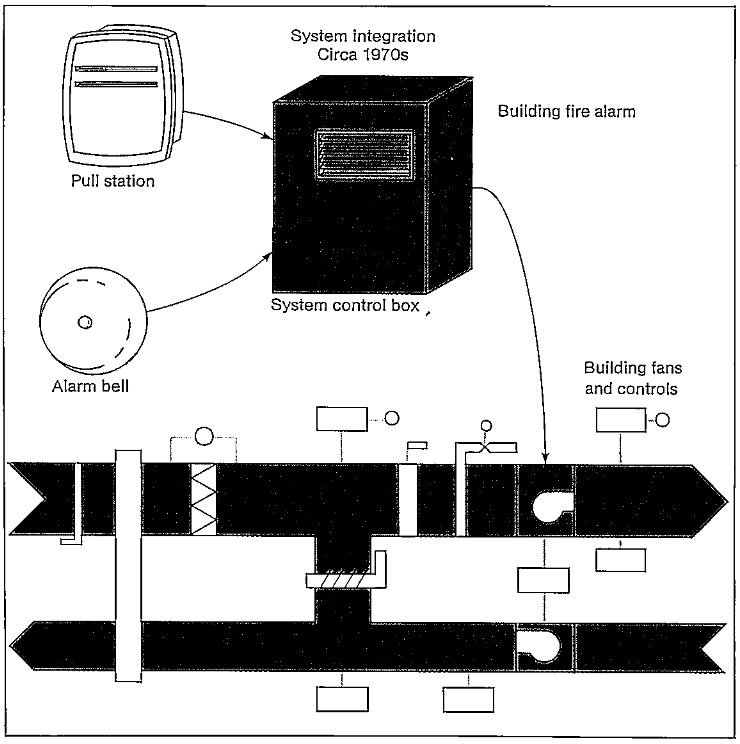
With the advent of micro-electronics, an ideal system is being approached that is capable of collecting a great deal of data about building conditions, conditions of HVAC equipment, and the needs of the occupants, as well as security and telecommunications if those are included in the program, and then using that information to make intelligent decisions. It is possible to provide this information to a central controller by using only a pair of twisted wires. Direct digital control systems make intelligent decisions and perform dynamic control. They operate HVAC equipment by projecting time-based changes in heat flow patterns inside a building, then adjust controls to keep a building at some set point. This provides not only more comfortable conditions but also more energy economy and less local temperature variation throughout the interior spaces.

A major concern, however, is that sensors and receivers speak different languages. Critical parts of a sophisticated system that do not interface well, if at all, can create substantial problems. Specifying equipment and accessories all from the same manufacturer helps ensure compatibility but, of course, also limits the competition in bidding a job.

Facility management systems automatically run a variety of programs designed to use energy more efficiently. For example, in a load management program, the computer will monitor the average rate at which energy is being consumed, compare it to some target appropriate to the time, temperature, and season, and armed with that information determine the necessary control action. Computerized controls with duty-cycling programs help reduce energy consumption by periodically turning off less critical loads for short intervals. And these systems control morning start-up and evening shut-down to optimize equipment usage. The computer uses real-time data to control equipment so that it can be turned on at the last possible moment and still maintain comfort. Manufacturers claim that the savings from building management systems can amount to close to 20 percent of the annual energy cost.

Microcomputer-based facilities management systems are not limited to controlling building services. They also can serve as management workstations for running business computer soft-





ware programs, for property management, leasing management, and technology management. HVAC system monitors can register the location of an alarm, and messages can instruct operators how to respond. Also, a system's stored historical data can be transferred to a floppy disk and used to generate system reports.

Recently there has been a move toward small-zone heating, airconditioning, and lighting, which results in small-zone billing. That means a company pays for the services supplied only to the individuals who work overtime or on weekends, versus conditioning a whole building or several floors. It can mean the difference between $5 an hour to heat a small space and $200 an hour to heat several floors.

Maintenance personnel are not required to turn on the lights or heat with small-zone utilities, another reason costs are kept low. Instead, the person who will use a space during off hours just picks up the telephone to call the building's central control system. The desired building operations are engaged by answering a set of preprogrammed questions.

Automated building controls tend to be found in new buildings, and small-zone control is employed almost exclusively in new construction because of the difficulty and expense of retrofitting an older building. Every floor of an old building would have to give up rentable space to fans. Also, existing HVAC equipment could not be used, and the idea of buying a number of completely new systems does not appeal to most building owners. But the cost advantage to tenants may spur some retrofits in the future, particularly in areas with a glut of office space.

Integration of systems and technology is a prime concern in new commercial construction. Most new office buildings incorporate the newest technologies in HVAC, lighting, communications, etc., to some extent. Where buildings differ is in the degree to which those technologies are centralized. A single computer *can operate all* functions in some buildings, while in others individual systems are controlled by separate computers. One manufacturer of computerized building controls estimates that fewer than 20 percent of new buildings are run by a single automated source but projects that within the next six years the need to integrate building systems and user technologies will cause that percentage to double.

Integration of electronic systems provokes some controversy. Manufacturers often advocate integration, but they tend to have a vested interest. Caffrey suggests that integration of electronic systems is necessary insofar as it benefits the building occupants or provides overall cost savings, which are not guaranteed. True functional integration between systems is seen, for example, in a building's HVAC and fire alarm systems, says Caffrey. The need for this sort of interaction can be defended, but, when all the electronic functions in a building are considered, the need for integration is not always clear. Communications and automation systems are both computer-based and should be interfaced so that the telephone can be used as an input/output device, but there is no compelling reason for their standard integration.

Proponents of integrated automation systems say that costs of energy, labor, and telecommunications would be dramatically lower for tenants and would provide a marketing advantage. Manufacturers contend that integrated control and communications systems are more functional and cost less to install than standalone systems because construction is simplified, less space and less equipment are required for mechanical and electrical systems, and energy costs are more easily controlled.

The concept of common protocol, however, may make integration of building systems and other technologies the next logical step for many building applications. It is important that some subsystems be able to communicate with one another effectively and economically; this is being done now at the level of the operator terminal. But within subsystems proprietary protocols are the rule rather than the exception. There is a real need for systems from many manufacturers to work together effectively. □

Weatherproof Masonry Walls

Time and technology have changed the primary use of masonry from massive structural elements to relatively thin, flexible building envelopes. With this flexibility and thinness comes the increased risk of water permeation. However, building weatherproof masonry walls is not impossible, and the key to good design lies in controlling moisture flow. Designers must understand the behavior of brick masonry; select suitable materials for the geographic location and environmental conditions during construction; understand and provide for thermal, moisture, and differential movement; detail flashing and weepholes carefully; and strive for good workmanship through specifications and job site observation.

Brick and mortar are porous materials, but it is not porosity that causes masonry walls to leak. It is cracks, leaky copings, faulty flashing, improper materials, and poor design and workmanship that present the greatest problems. Masonry construction must be treated as a composite of various materials and elements requiring a thorough and integrated moisture-control system.

The first critical step in design is selection of the proper wall type: solid walls, solid walls of hollow units, cavity walls, or veneers (see Figure 1). This decision will depend not only on building type and structural system but on expected environmental exposure as well. In the arid Southwest, rainfall is so slight and humidity so low that moisture generally is not a problem. Most areas of the country, however, do have heavy rainfall, snow, humidity, and often wind-driven rain. Thicker solid walls are not prone to significant leakage—historic masonry structures with solid walls not only bore heavy compressive loads but also kept out the heat, cold, and rain. A thin, contemporary, 10-inch solid brick bearing wall with grouted collar joints provides good moisture protection except in severe climates. Whatever the thickness is, though, a solid wall is *less* effective in resisting moisture penetration than a drainage-type wall.

Drainage walls include both cavity walls and veneers. Cavity walls may be structural load-bearing or not load-bearing, while veneers bear only their own compressive weight plus lateral wind and seismic loads. The thin exterior wythe is assumed to be permeable, and the cavity is designed to collect both penetrated and condensed moisture and redirect it to the outside.

Differential movement

One of the primary causes of leakage in masonry walls is cracking. The chief contributor to cracking is the stress developed from differential movement among two or more building elements acting against one another. Buildings are dynamic, constantly moving structures. They are subject to the stresses of thermal and moisture expansion, shrinkage, creep, and deflection. When brick is used in combination with other materials, the relative movement characteristics of each must be taken into consideration in designing joints and connections. All materials expand and contract with temperature changes, but at different rates (see Jan., page 103). All materials change dimension due to stress, and some materials develop permanent deformations when they are subjected to sustained loads.

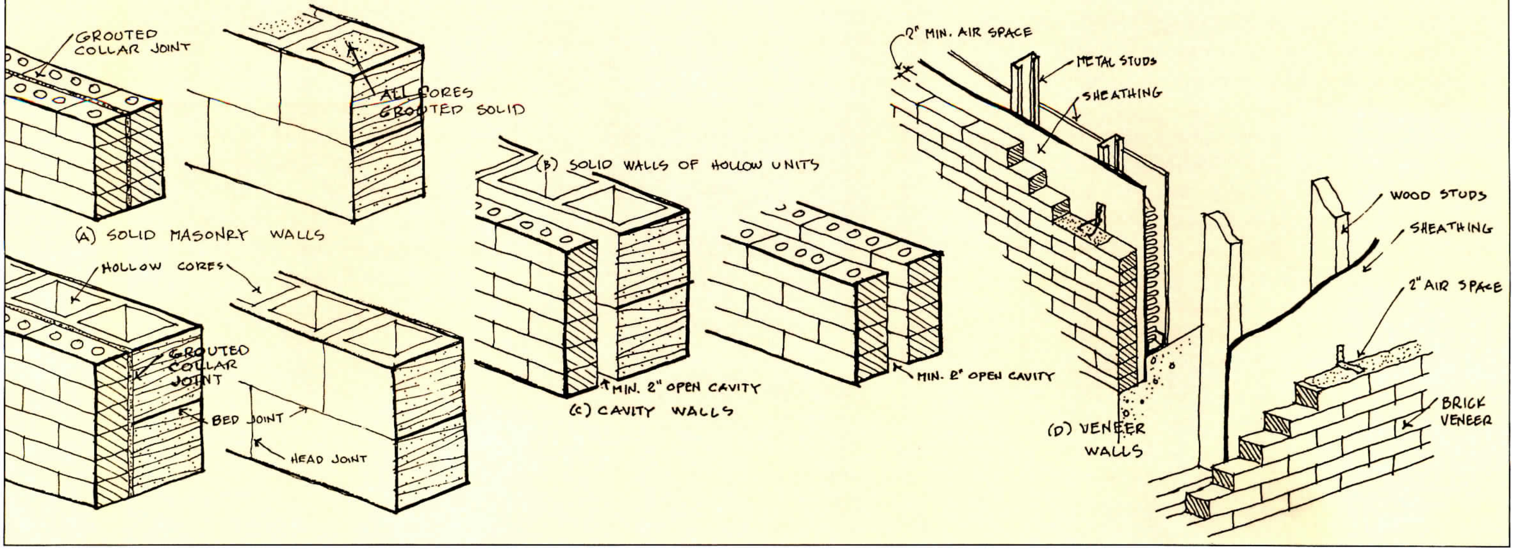
Thermal movement: The potential for thermal expansion/contraction varies from the relatively stable characteristics of clay masonry to the highly active movements of metals. Thermal movement can be estimated from the coefficients of thermal expansion. The stress developed in a restrained element due to temperature change (measured in pounds per square inch) is equal to the modulus of elasticity multiplied by the coefficient of thermal expansion multiplied by the mean wall temperature change. For instance, the stress in a fully restrained brick wall with a thermal coefficient of 3.6×10^{-6} and a modulus of elasticity of 3.2×10^{6} for a temperature change of 100 degrees Fahrenheit would be:

$0.0000036\times3{,}200{,}000\times100 = 1{,}152$ psi.

The wall must accommodate movement to alleviate this stress.

Moisture movement: Many building materials expand with increasing moisture content, then shrink when drying. Concrete or concrete masonry, for instance, will shrink as it dries. Clay brick, on the other hand, sustains permanent dimensional change. Clay brick expands from the time it leaves the firing kiln and is exposed to atmospheric moisture, especially in the first few weeks. The total linear expan-

Figure 1

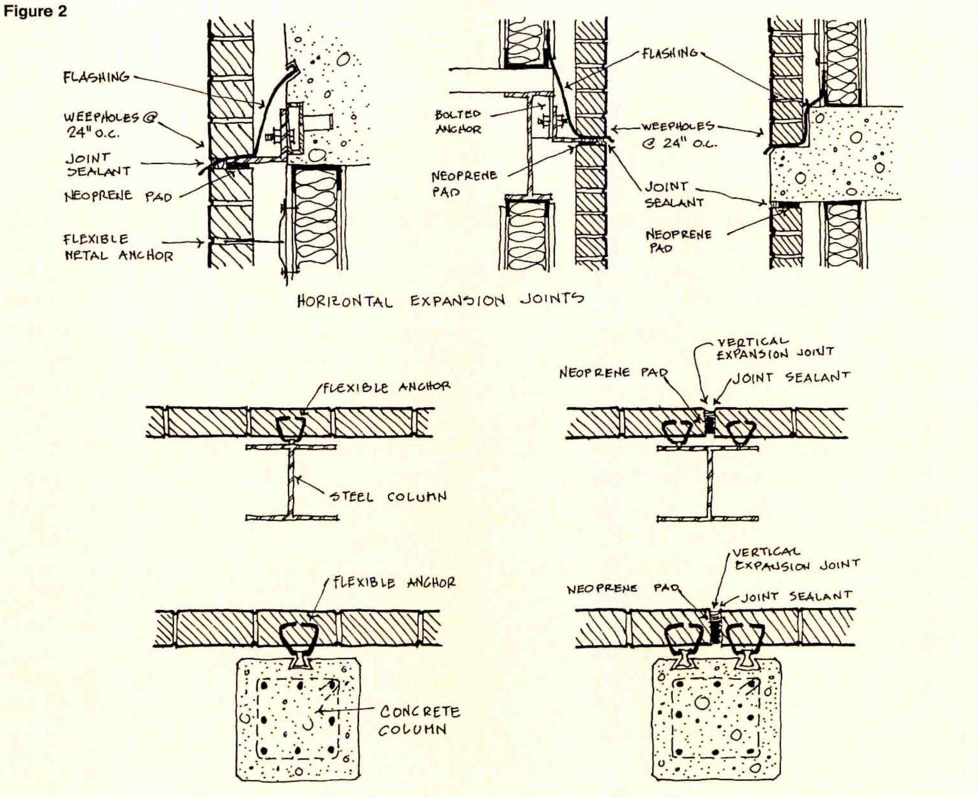


sion of a wall approximates the sum of the expansions of the individual units. Although researchers have not yet developed a means to predict accurately the moisture expansion potential of clay masonry, a tentative coefficient of $2x10^{-4}$ is recommended. When this is combined with thermal expansion and both are in conflict with the opposing shrinkage characteristics of a concrete supporting frame, the resulting stresses can be significant and must be anticipated in the design.

Elastic deformation, plastic flow, and creep: The shortening of axially loaded masonry walls and columns is seldom critical. More often, problems arise with elastic deformation of horizontal elements such as beams and lintels. Most standards limit allowable deflection to 1/600 of the clear span, but the design of the system again must anticipate and accommodate such movements.

In clay masonry construction, the units themselves are not subject to plastic flow, but the mortar is. Plastic flow of the mortar, in fact, helps prevent joint separation in brick walls by compensating for the differential movement of the units. The creep deflection of a concrete or steel frame to which masonry is rigidly anchored is the most potentially damaging. Steel shelf angles and concrete ledges that sag over a period of time can exert tremendous force on the masonry veneer. Without horizontal pressure-relieving joints, the lower courses can buckle or spall under the load (see Figure 2).

Figure 2



Expansion and control joints

Differential movement creates problems in masonry construction only if excessive stress is allowed to develop. Reinforcing steel, flexible anchorage, concrete and concrete masonry control joints, and brick expansion joints can counteract or relieve this stress. Total expansion of a brick masonry wall will be modified by indeterminate compensating factors such as degree of restraint, plastic flow of mortar, creep and shrinkage in the backup material, temperature of the brick when installed, variations in workmanship, and the amount of insulation behind the brick. This makes it difficult to determine the necessary width of expansion joints. The Brick Institute of America recommends the size and spacing of vertical expansion joints as shown in Figure 3. Additional joints should be located near corners, at offsets, openings, returns, and intersections with dissimilar materials, Also, locate expansion joints in close proximity to masonry control joints in composite walls, and horizontally below all shelf angles.

Spacing of control joints in concrete masonry should not exceed 20 to 25 feet on center. They should be spaced even closer together if ASTM Type I "moisture controlled units" are not specified or if horizontal reinforcement is not used. Control joints should be laid out in straight walls to form panels of approximately equal width and height. Additional joints are needed at openings, pilasters, offsets, returns, intersecting walls, and at changes in wall height or cross section. Control joints should be constructed with mortar, which later is raked out and replaced with a backer rod and sealant. Expansion joints should contain no mortar but be filled with a compressible, elastic material such as neoprene and then closed with a backer rod and sealant.

Figure 3

Joint width and spacing for brick cavity walls[1]

Anticipated expansion (Δ L), inch	Joint width (2Δ L), inch	Joint spacing(L), feet
1/16	1/8	7
1/8	1/4	14
3/16	3/8	21
1/4	1/2	28

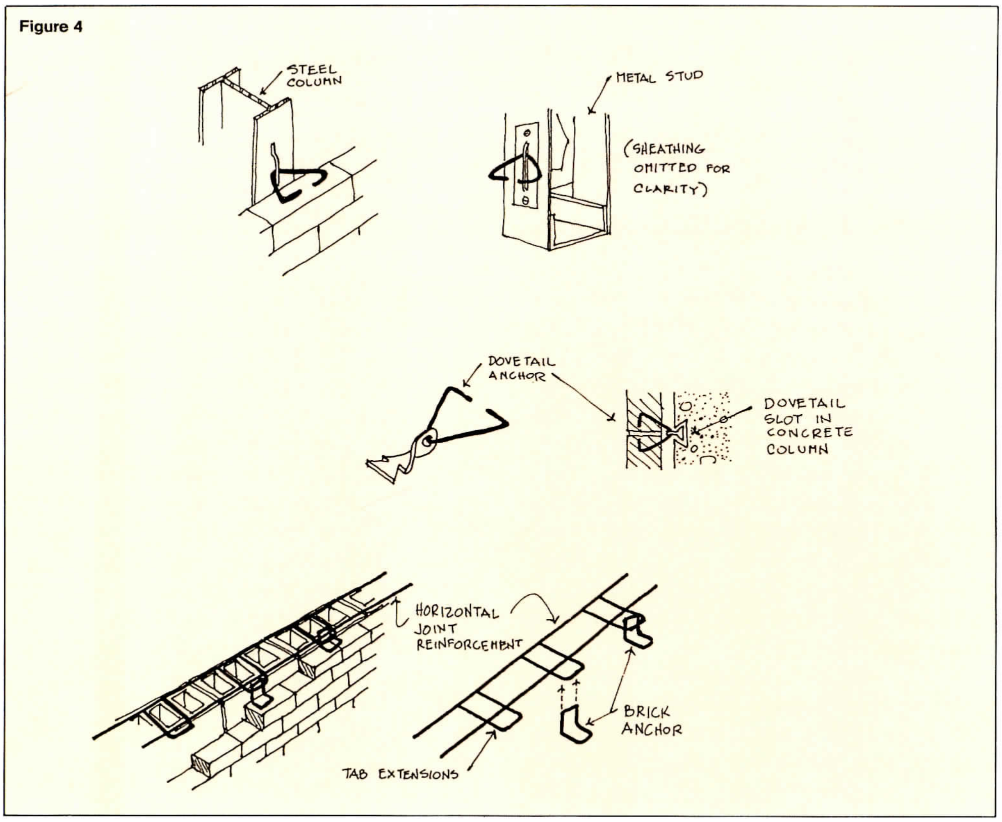
[1] Based on the amount of brick expansion caused by a 140° F temperature swing. Brick expansion is calculated by the formula:

$$\Delta L = (0.0002 - 0.000004 \, \Delta T) \, L$$

Source: Brick Institute of America, Technical Note 18A, 11490 Commerce Park Drive, Reston, Virginia 22091.

Where and why brick walls crack. The architect must be aware of the ways different brick walls develop cracks.

Long walls constructed without expansion joints develop shearing stresses in areas of minimum cross section. Diagonal cracks will appear between window and wall openings, usually extending from the head or sill at the jamb of the opening. In a cavity wall, the temperature variation in the outer wythe is considerably greater than that of the inner wythe, especially if the wall contains insulation. Without proper expansion joint planning, cracks can form at external corners because of the greater relative expansion of the outer wythe. Brick parapet walls can be particularly troublesome because, with two surfaces exposed, they are subject to temperature and moisture extremes far greater than those of the building wall below. Dif-



ferential expansion can cause parapets to bow, to crack horizontally at the roof line, and to overhang corners. Flashing, although necessary, creates a plane of weakness at the roof line that may amplify the problem. If parapets must be a part of the building design, use the same material for the entire thickness of the section, extend all vertical expansion joints up through the parapet, and space additional joints halfway between those running the full height of the building. Steel reinforcement also can help counteract excessive movement.

Rigid attachment of brick to concrete, steel, or CMU backing also can cause cracking. Flexible anchorage is required to permit differential movement, but at the same time must transfer lateral loads to the structure (see Figure 4).

Material selection

The materials selected for use in exterior masonry walls not only must be of high quality themselves but also be compatible with each other and suited to environmental conditions during construction.

Because of the thermal isolation of the exterior wythe in a cavity or veneer wall, Grade SW brick (ASTM C216, C62, or C652) generally is most suitable. In dry climates, however, Grade MW usually is adequate. Brick with a high initial rate of absorption (IRA) should be thoroughly wetted before construction and then allowed to "surface dry." A high-suction brick, if laid dry, will absorb excess water from the mortar, thus impairing the hydration process and weakening the bond of the finished masonry.

A general rule for mortar selection is to use the weakest mortar that will provide the necessary durability and strength. In most instances, a Type N mortar (ASTM C270) is adequate. However, if wind loads exceed 25 psf, specify a Type S mortar in order to develop maximum flexural tensile strength. Good mortar bond also is critical in minimizing water permeation of masonry walls. Voids at the mortar-to-unit interface offer no resistance to moisture infiltration and can facilitate subsequent masonry disintegration and failure if freezing occurs when saturated. The strength and extent of the bond are affected by many variables of material and workmanship. Complete and intimate contact between the mortar and the unit is essential. The moisture contact and suction (IRA) of the units, the water retention of the mortar and its workability, and curing conditions such as temperature, relative humidity, and wind combine to influence the completeness and integrity of the mechanical and chemical bond.

Mortar with a high content of hydrated lime (Type S, ASTM C207) retains water well and is particularly suited to use with high-suction brick or for summer construction where evaporation is a problem. Mortar with a high portland cement content is more suitable for low-suction brick and for winter construction. A Type III (ASTM C150) high-early-strength cement also can aid in winter, but any type of air entrainment should be limited to 14 percent or less.

Metal ties and anchors should be of corrosion-resistant material or galvanized in accordance with ASTM A153, Class B3. Ties and anchors should not be crimped to form a drip since such deformation substantially reduces the lateral load transfer capacity of the metal. Flashing should be of high-quality, puncture- and tear-resistant material. It also should be impervious to moisture, corrosion-resistant, and able to withstand ultraviolet exposure. Sheet metals, coated metals, heavy plastics, and composite materials all are used commonly. Asphalt-saturated felt is not suitable. The flashing material should have sufficient flexibility to allow ease of forming around corners and projections. Sealants for control and expansion joints should be a good grade of polysulfide, urethane, silicone, or butyl rubber. Do not specify oil-base caulking.

Design for dryness

In order to redirect moisture to the outside of a brick cavity or veneer wall, a system of flashing and weepholes must be carefully detailed and installed.

Flashing should be located at the base of the wall, at all heads, sills, lintels, shelf angles, and other similar interruptions, as well as at the roof and the top of the parapet. The flashing should turn up six to nine inches inside the cavity and be anchored in a bed joint of the backup wythe, a reglet, or behind the sheathing board. All horizontal runs should be terminated by an end dam. Do not carry flashing across control or expansion joints. To drain the water that is collected by the cavity flashing, install weepholes in the brick course immediately above. These may be open head joints or plastic tube inserts spaced 24 inches on center, or wick material spaced 16 inches on center.

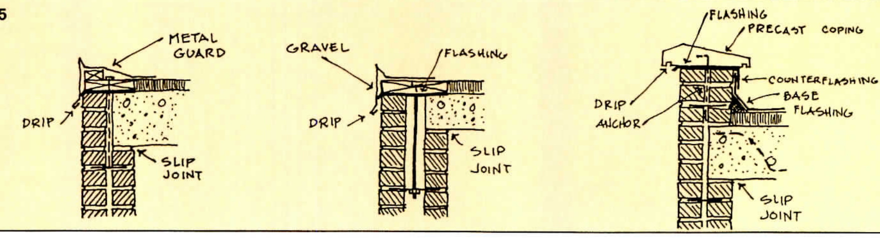
In high-humidity environments, vapor barriers often are installed on the cavity face of the backup wall. However, differences in humidity and vapor pressure between inside and outside air cause vapor flow within the wall. Unless controlled by proper placement of the vapor barrier or by ventilation, the vapor may condense within the wall under certain temperature conditions. Condensed moisture within the wall can be just as damaging as penetrated or absorbed moisture. Condensation results from saturated air. The higher the air temperature, the more water vapor the atmosphere can contain before reaching its saturation, or dew point. If warm, humid air is sufficiently cooled, the water vapor it contains will condense.

Problems of moisture condensation occur most frequently in insulated buildings of tight construction with occupancies or heating systems that produce above-normal indoor humidity levels. If the moisture content of the indoor air is above that of the outdoor atmosphere, it will tend to drive vapor outward from the building through any porous materials in the outside envelope. When wall surface temperatures are substantially below air temperatures, condensation may occur on the wall surface. The higher the humidity level, the less the temperature differential needed to form the condensation.

Warmer air has higher saturated vapor pressures. If separated by a wall, the higher-pressure vapor will migrate through the wall toward the lower-pressure atmosphere. During the winter, this flow is from inside the building toward the outside. In warm, humid climates, the flow may reverse during the summer. When vapor passes though a wall that is warm on one side and cool on the other, it may reach its dew point and condense into water within the wall. Vapor condensation within a wall can cause extensive damage to many types of building materials. Wood framing can warp or decay; metal can corrode; insulation can lose its effectiveness; concrete and concrete masonry products can undergo destructive volume changes; and freeze/thaw cycles under moist conditions can deteriorate both clay and concrete masonry as well as stone.

Vapor pressure differentials can cause other moisture problems as well. High winds during a driving rain and low pressure in the building interior can create a significant differential across the wall section. Under such circumstances, rainwater that normally would cascade down the face of a vertical wall is literally driven or sucked into the building, usually through cracks at the mortar-to-unit interface. The simplest way to correct this problem is to vent the wall cavity itself. This will help equalize the outside air pressure and the pressure in the cavity. Venting the wall cavity eliminates the force that pushes or pulls moisture through the outside brick wythe. The vents should be located in the vertical head joints by omitting the mortar as you would for an ordinary weephole. Special metal ventilator inserts can be installed for esthetic considerations. If the cavity is blocked either horizontally or vertically to prevent wind tunnel and stack effects, be sure that the flashing, weepholes, and vents are designed properly for each "compartment" of the wall.

Figure 5



The introduction of vapor barriers with a wall assembly must be studied carefully to avoid trapping moisture in an undesirable location. Regional climatic conditions and the resulting direction of vapor flow must be analyzed and condensation points determined under both summer and winter conditions. If vapor flow is impeded by a highly vapor-resistant material on the warm side of the wall, the vapor cannot reach that point in the wall where the temperature is low enough to cause condensation.

Masonry cavity and veneer walls, unique in their configuration, can accommodate vapor flow in either direction without retarding natural moisture drainage. A vapor barrier on the cavity face of the interior wythe will prevent warm, moist air inside the building from reaching a lower saturation temperature farther out in the wall. Conversely, the path of hot, humid summer air moving toward air-conditioned interior spaces is blocked at the cavity and condenses within the drainage space. Each design condition, of course, must be studied individually to determine the need for and proper location of a vapor barrier within the wall assembly.

If wall surface condensation does occur, it may be eliminated in one of three ways: (1) reducing the indoor humidity by natural or mechanical ventilation; (2) increasing the surface temperature of the interior wall by air movement or other means; or (3) increasing the thermal resistance of the wall by adding or increasing insulation.

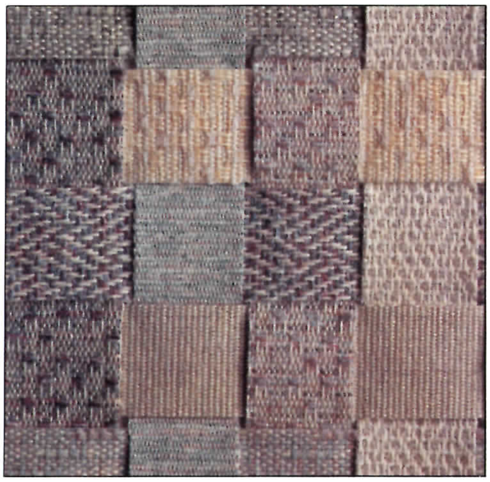
Another troublesome aspect of water penetration in masonry construction is wall caps or copings. Their horizontal exposure to rain and snow gives them a high potential for leakage. Brick copings (and sills, for that matter) are best avoided because of the large number of mortar joints susceptible to direct penetration. Metal or stone copings can function well if they are designed and installed properly (see Figure 5.) No matter which system is used, it is imperative that through-wall flashing be placed under the coping. Any penetrations through this membrane that are required for anchorage should be sealed carefully with a good elastomeric sealant. Coping should not be flat but should slope toward the roof to avoid ponding or run-off down the face of the wall. Metal copings should allow for thermal expansion and contraction without damage to the underlying flashing. Stone or precast copings should be cut in lengths sufficient to minimize the number of vertical joints required. All of these joints should be raked out to a depth of about ⅜ inch and caulked with a good grade of sealant. Control joints should coincide with brick expansion joints in the wall or parapet below. All copings should overhang the wall on both sides and form a positive water drip. The flashing beneath the coping, and at all other locations as well, should extend beyond the wall face and turn down 45 degrees to form a drip. Concealed flashing can trap moisture inside the wall.

Responsibility for building construction lies ultimately with the contractor. The architect or engineer, not party to the construction contract, acts solely as the owner's representative in the field. As part of the team, the architect can guide the contractor and offer advice and expertise in solving or avoiding problems, Safeguarding work quality without impeding its progress is best achieved through cooperation with the contractor and the masons.

—CHRISTINE BEALL

Ms. Beall is an architect and specifications consultant in Austin, Tex., and the author of Masonry Design and Detailing *(second edition, McGraw-Hill, 1987).*

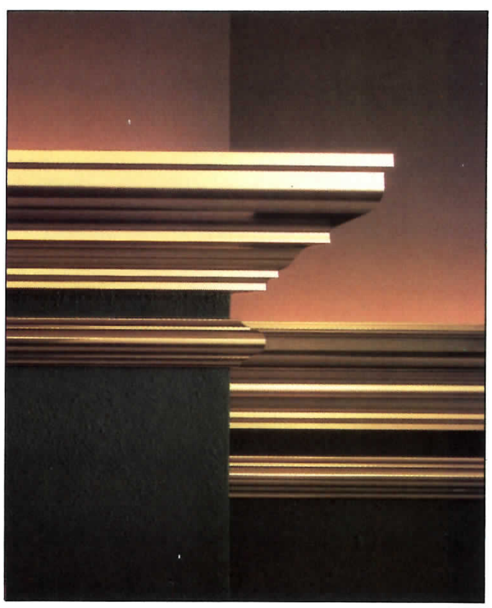
PRODUCTS



Upholstery Fabric
Doodads fabric, left, designed by Merle Lindby-Young for Stendig Textiles, is a striking contemporary jacquard upholstery fabric. The large-pattern design features multicolored curves and lines, triangles, and spheres that play in a random repeat of dark, medium, and light backgrounds.
Stendig International
Circle 402 on information card

Belgian Contract Wall Coverings
The purpose behind the Color Weave collection of woven wall coverings by OJVM, above, is to provide architects and designers with a wide-ranging, colorful palette from which to choose. Textile designer and colorist Laura Deubler Mercurio styled the palette, which comprises 72 coordinated individual colors, for the U.S. contract market. Four separate patterns make up the collection: a two-color, multitone file rib; a complex vertical rib in a two-tone multitone; a geometric twill; and a unique twist on a classic waffle weave with linen accent dots.
OJVM Wallcoverings
Circle 404 on information card

Ceiling Cornice/Light Soffit
The HollowForm #8 ceiling cornice/light soffit from Cullar/LaCuesta, right, is constructed of aluminum with a specular finish and is 6¼ inches wide with a 4⅝-inch projection from the wall. The product is suggested for use as a ceiling cornice molding and for light soffits, wall sconces, chair rails, or casement trims. With slight modification, the molding is suitable for interior or exterior applications.
Cullar LaCuesta
Circle 403 on information card



Versatile Sofa
The Clou sofa, designed by Christian Heimberger for Brayton International, is an offshoot of the popular Clou series of lounge designs. The featured two-seat version, above, is accented by an optional arm patch detail. All the versions of Clou are available in a chair, two-seat, or three-seat sofa. They are for both residential and commercial environments.
Brayton International
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Products *is written by Amy Gray Light*

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New Line of Dead Bolt Lock Sets
Omnia Industries has a new series of dead bolt lock sets (below) that feature a flush-mounted lock cylinder. They are offered with either single or double cylinder functions. The lock sets have solid brass trim that fits doors with a backset of 2⅜ or 2¾ inches, and stiles of less than four inches.

Each dead bolt has a pointed marker on its face, designed to aid installation by spotting the location for the receiver hole on the door jamb. The new series features 10 styles of trim that range from traditional to contemporary. Finishes include polished brass, polished chrome, satin chrome, and shaded bronze.
Omnia Industries Inc.
Circle 407 on information card

Panel Combines Drainage and Insulation
Dow Chemical Co.'s new Styrofoam Thermadry Brand Insulating Drainage Panels, made of Styrofoam brand insulation, feature an exterior foundation insulating panel with integral drainage channels. The exterior is a matrix of horizontal and vertical channels designed to drain groundwater away from below-grade wall structures and provide a flow path of least resistance for soil gases (not to be interpreted with radon gas) to vent toward the surface. This drainage minimizes seepage into the structure and reduces hydrostatic pressure and the potential for structural damage.

A spunbonded filtration fabric helps keep the channels clear of dirt to allow water to flow freely. The foam's uniform, closed-cell structure resists compressive creep, provides resistance to water penetration, helps insulate the structural foundation and building interior from adverse temperature changes, and is designed to withstand numerous freeze/thaw cycles.

Panels are 2 feet wide by 8 feet high, 1½ or 2¼ inches thick, and available in two densities. Suggested applications include basement and foundation walls, earth-sheltered structures, bridge abutments, retaining walls, culverts, lagging, forms, plaza decks, and planters.
Dow Chemical Company
Circle 408 on information card

Radon Resource Directory
"Everything you need to know, everyone you want to reach," exclaims the subtitle of a new radon sourcebook published by Radon Press Inc. *The Radon Industry Directory* attempts "to document and systematize all that comprises the radon industry," writes its publisher, Larry Siegelman, in the foreword. And an impressive compilation it is.

The directory lists page upon page of consultants, manufacturers, research facilities, workshops, associations, government agencies (local, federal, and international), and publications, all with one thing in common—radon, of course.

The 550-page, $75, softbound directory is well cross-referenced and carries information on groups and persons all across the United States and Canada. The publisher also carries other publications on radon.
Radon Press Inc.
Circle 409 on information card

NAAMM Flagpole Guidelines
The National Association of Architectural Metal Manufacturers (NAAMM) offers two publications that provide a comprehensive
continued on page 146

Products *from page 145*
guide to the design, fabrication, and installation of metal flagpoles. With the current trend of flying larger flags from higher poles, accommodating increased loads is an important criterion. *The Metal Flagpole Manual* describes and illustrates different types of flagpoles and lists their advantages, as well as types of materials used in their construction, design details, and various accessories and techniques for mounting flagpoles. The manual also contains sections covering everything from flagpole maintenance to lightning protection.

Another publication, entitled *Guide Specifications for Design Loads on Metal Flagpoles*, helps designers calculate the effects of wind loads on flagpole designs. The manual includes guide specifications for determining the wind pressure on flagpoles, flag loading, bending moments, shear forces and torsional moments on poles, stress analysis, and the calculation procedures for each. An appendix of sample calculations is also included.
The National Association of Architectural Metal Manufacturers
Circle 406 on information card

Public Videoconferencing
Conference Express, a joint venture of Olympia & York, the Canadian real estate development company, and US Sprint, provides access to the largest videoconference network in the world, linking point-to-point more than 400 U.S. and international business centers. Staffed conference centers are available to the public in New York City, Chicago, and Toronto on an hourly usage basis, with training programs and consulting services also available. The meeting rooms are equipped so that conferencing takes place via full-color, full-motion two-way television. The rooms are equipped with large boardroom tables, lecterns, overhead cameras, video recorders, slide projectors, and a facsimile machine.
Conference Express
Circle 405 on information card

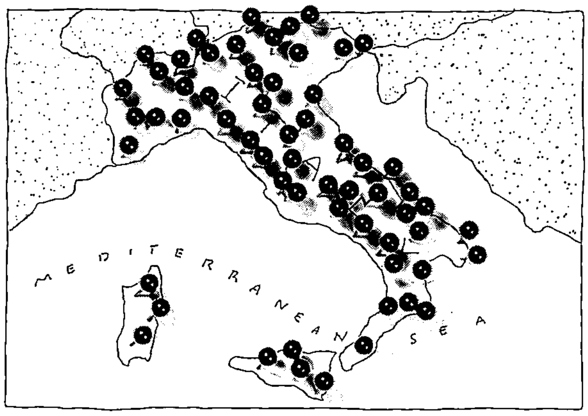
Intumescent Fire Stop Wrap
Dow Corning's Fire Stop 2002 Intumescent Wrap Strip (below) is designed to create a fire barrier when wrapped around plastic piping and creates a rigid barrier against flame, water, toxic fumes, and smoke migration. It is designed to avoid inadequately sealed wall and floor penetrations and holes left when plastic pipe burns or melts during a fire.

The protective material is triggered by heat and begins expanding when exposed to temperatures of 300 degrees Fahrenheit. The material expands to about 10 times its volume, filling voids left in burning plastic pipe by encapsulating it, thereby stopping the fire's progress and protecting against gases emitted by the burning pipe.

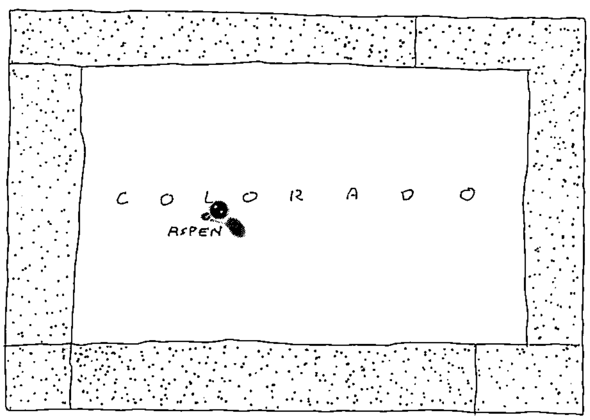
The Wrap Strip has no noxious odor, is flexible, and comes in 12-foot rolls packaged in lightweight carrier/dispenser boxes. It is part of the Dow Corning Fire Stop System, and is recommended for use with the manufacturer's Fire Stop Sealant or Fire Stop Foam, depending upon the particular application.
Dow Corning Corporation
Circle 411 on information card

Media Storage Cabinet
Meridian's Media Storage Cabinet is designed to keep pace with all the storage needs that arise in electronic offices, and it can be changed easily for maximum working flexibility. The cabinet coordinates with the manufacturer's Stackable Storage system of lateral files. The cabinet has removable and adjustable shelves for software and computer peripherals; coat rod and shelf combinations; hanging bars for computer or letter paper; and all sizes of com-
continued on page 148

The Centers of Italian Design.*



*Except June 13-18th.



For one week, the true center of Italian design will be Aspen. That's where outstanding designers, artists, architects, and writers will unite for "The Italian Manifesto: The Culture of Nine Hundred and Ninety-Nine Cities." Speakers will include architects Aldo Rossi, Renzo Piano, Joseph Rykwert and Tobia Scarpa; designers Mario Bellini, Michele de Lucchi, Achille Castiglioni, and Emilio Ambasz; fashion designers Luciano Benetton and Gianfranco Ferre; and museum director Philippe de Montebello. Italian design will never be more accessible.

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Circle 123 on information card

Products *from page 146*
puter reels. The cabinet comes in four standard heights ranging from 29 to 69 inches and in 30-or 36-inch widths. Optional top and base heights also are offered. The exterior is a nonglare, textured steel matte finish and is available in a wide variety of colors.
meridian inc.
Circle 416 on information card

Communications Workstations
The Axial desk, manufactured by ICF/Spec'built, is a steel-frame, modular workstation flexible enough to accommodate sophisticated communications equipment. The desk can be configured and reconfigured into a variety of forms, T, L, and U shapes as well as single rows, double rows, and small or individual workstations.

The Axial's features include vertically adjustable video display terminal bridges designed to accept any equipment configuration including large monitors; a structural steel frame base console with a footrest; access panels and rail panels for equipment height adjustment; work surfaces in three sizes; flexible pullout boards and slide-out trays; a file pedestal with a shelf to store a keyboard and two pedestals to house standard processing equipment.

The desk was designed by architect Gerd Althofer, who is a recognized expert in trading room projects.
International Contract Furnishings Inc.
Circle 414 on information card

Home Radon Monitor
The E-Perm (Electret-Passive Environmental Radon Monitor) is a simple radon detector capable of both short-term (two to seven days) and long-term (two to 52 weeks) readings.

E-Perm uses an electrostatically charged disk called an electret to collect and detect the level of radon in the air. The electret is fixed inside a plastic chamber. When ready to use, the electret cover is raised to expose the charged surface. Radon diffuses into the chamber through filtered holes inside the neck of the cover. The electret can be used repeatedly until all the voltage in it is used up; then it can be replaced. The electret is processed to hold the charge so that it does not dissipate from changes in temperature and humidity.

The results are designed to be read instantly using a small portable voltmeter called a Surface Potential Electret Reader (SPER), or the user can screw the lid back on and send the canister to the manufacturer for analysis.
Rad-Elec Inc.
Circle 410 on information card

New Vinyl Tile Introduced
The latest vinyl tile manufactured by Flexco Co. is called Achievement, and it is distinguished by having the texture of an orange peel. The nubby texture is designed to resist scratching and heel

marks. Achievement is available in ⅛-inch gauge and comes in 12x12-inch and 36x36-inch tiles and in 10 colors. Each of the contemporary colors has a contrasting chip pattern blended in.
Flexco Company
Circle 415 on information card

Polyester Film
Du Pont's "Mylar" polyester film protects old or fragile documents and frequently handled material from grime, pollution, and general usage when one encapsulates the material between two sheets of the Mylar film and seals the edges with double-sided tape. The finished transparent sleeve makes a border around the material so that it can be cut open with scissors without damaging the encapsulated product.

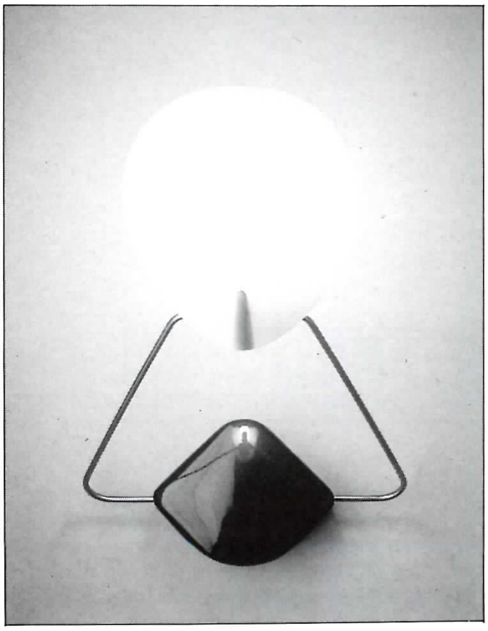
The film commonly is used by architects because drafting, erasing, and corrections can be performed on it without damage. Mylar Type D film also is archival in that it won't react with an object in any way to cause further damage.

Du Pont donated 12,000 square feet of the Mylar film to help continue a process undertaken by the Frank Lloyd Wright Foundation in Scottsdale, Ariz., to preserve Wright's original drawings and his handwritten and edited manuscripts. Bruce Brooks Pfeiffer, director of archives for the foundation, estimates the donaiion will keep the preservation project going for another five months. Pfeiffer estimates the entire project will take four more years and $20,000 in materials alone to complete.
Du Pont Company
Circle 412 on information card

World's First Modular Water Chiller
The Multistack modular water chiller system, recently introduced in the United States, is said to require only half the space of conventional chillers, significantly saving space and construction costs.

The system consists of a bank of individual modular chillers, each containing two independent reciprocating refrigeration systems. (Most conventional chillers have only one refrigeration circuit.) Because Multistack has two separate and independent refrigeration circuits, while most conventional chillers have just one circuit, it offers greater dependability. Each module delivers 37.5 tons of cooling.

Additional chillers may be added as the building expands, and their compact size ensures easy installation. A single built-in micro-processor controls and monitors the system. Although the system originated in Australia, the Multistack chillers meet U.S. standards, practices, and codes for water chiller products; the unit is certified in compliance with UL Standard 465.
Multistack Inc.
Circle 418 on information card

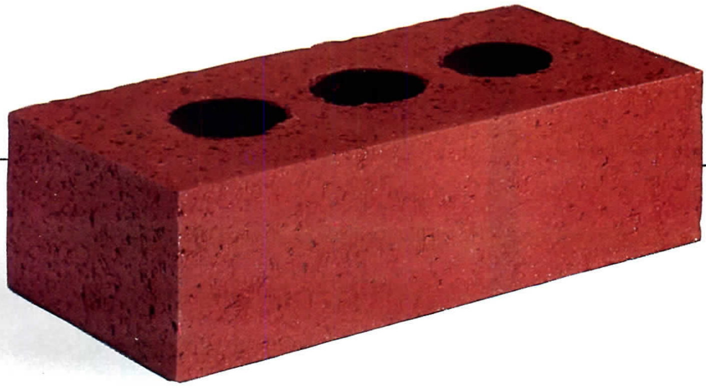


Bali Wall Sconce
The Bali sconce, described as a "floating island of light," is an adjustable sconce, above, that emits both direct and diffused light through an opal glass diffuser. Designed by Italian architect Luciano Pagani, the triangular-shaped tubular arms and the diffuser they support both pivot to create different lighting effects and to position light where it is needed. The white

continued on page 152

Sixty second guide to Belden Brick:

COLORS



Belden Brick is made in over 116 colors that include 2 choices in black, 28 browns, 7 tans, 8 buffs, 3 creams, 18 grays, 16 pinks, 26 reds, and 8 whites.

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Belden also offers a choice of extruded brick or molded brick (with the character of hand-made brick.) Each category includes a wide range of colors and textures providing more than adequate design latitude.

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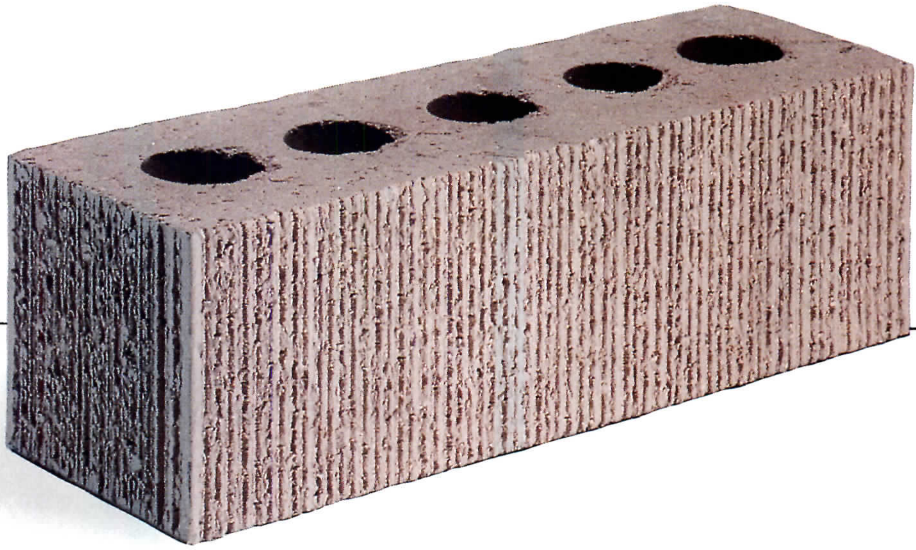

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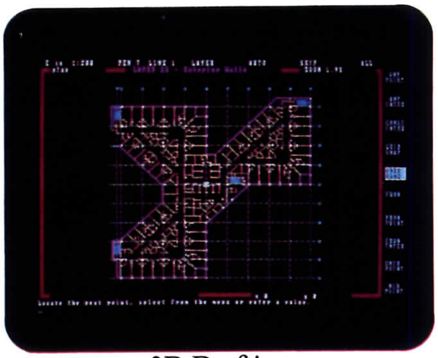
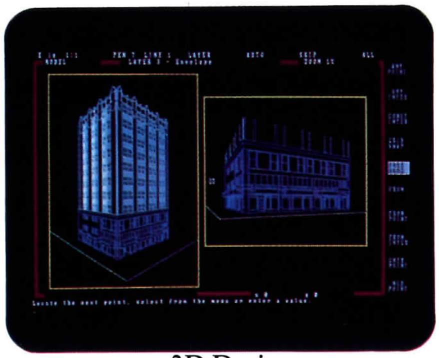
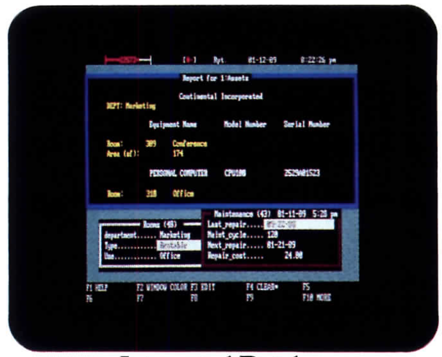


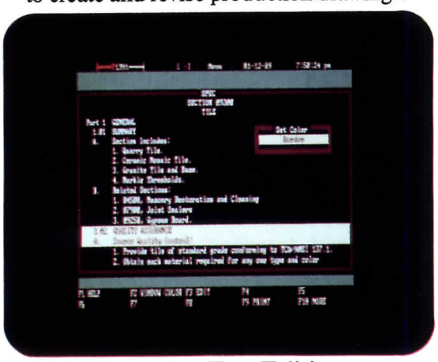
2D Drafting
to create and revise production drawings.



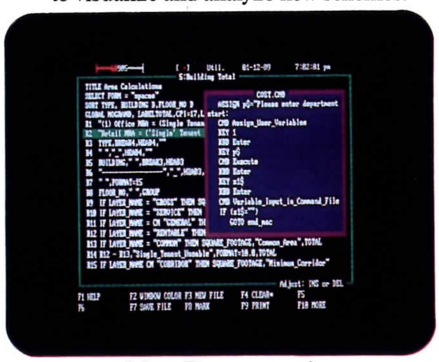
3D Design
to visualize and analyze new schemes.



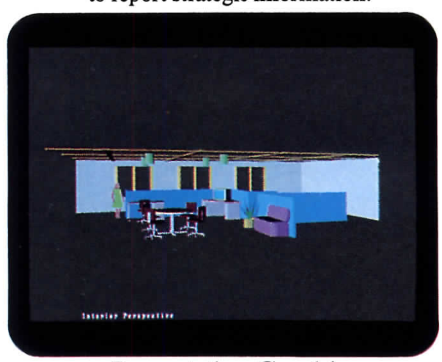
Integrated Database
to report strategic information.



On-Line Text Editing
to create and revise documents.



User Programming
to streamline repetitive tasks.



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Circle 131 on information card

Products *from page 149*
opal glass diffuser is attached to twin brushed-stainless-steel arms. A cast aluminum wall rose, in an anthracite color, mounts directly to a standard four-inch octagonal junction box.
Atelier International Lighting
Circle 419 on information card

Mist Collector
The AR Mist Collector from American Air Filter is designed to collect mists from petroleum-based and soluble cutting oils in metalworking processes, animal fats and vegetable oils in food processing industries, plus mists generated from other industries. The AR Mist Collector removes the mist and cleans the air so it can be recirculated back into the workplace. The collector is self-cleaning and operates continuously, so there is no need to shut it down to drain the collected mist.
American Air Filter
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Software for the Architectural Industry
Berol Corp., has introduced the Rapi-Design Drawing Symbols library, a computer software library of the most common commercial architectural symbols used in CADD. Over 1,000 symbols, all of which conform to the American National Standards Institute (ANSI), comprise the system.

The libraries are divided into four professional disciplines: Commercial Architectural, Residential Architecture, Electrical/Electronic, and Mechanical Design. It is designed to work as an accessory with Claris' MacDraw, MacDraw II, and other "PICT" format drawing programs for the Apple Macintosh computer.
The Berol Corporation
Circle 421 on information card

Color Selection System
The Colorcurve System is described by the manufacturer as a universal tool for color selection, communication, and control. The system is composed of color atlases, swatch libraries, and special services for design professionals and manufacturers.

Because it is based on the precise physical measurement of a color sample's reflectance curve, users of the system need only use the Colorcurve alpha-numeric notations. The manufacturer uses those notations to produce the best possible color matches with the colorants they typically employ in their manufacturing process.

Robert Dillon, president of Colorcurve Systems Inc., explains the system this way: "Every color has a curve. These curves are not subjective interpretations of color, but actual physical 'facts.' Colorcurve uses these curves to establish objective and universal descriptions of virtually any color in the world."

Primary benefits of the system are that it enables designers to review the color spectrum systematically and then communicate precise selections to manufacturers. The system expands to an almost unlimited selection of colors from a base of 2,185 color samples, and it provides an objective description of color that holds true for any material or industry.

Reference tools include a master atlas and a gray and pastel atlas. Color samples are arranged according to the three properties of color—hue, saturation, and lightness. Each color sample also is described by its physical property, called a reflectance curve. Additional design tools include swatch decks, swatch books, and color sheets. Services available to system owners are an identification program to measure existing color samples and locate them within the Colorcurve system, and a custom color program to create samples of a new color or series of color lying between samples in the atlases.
Colorcurve Systems Inc.
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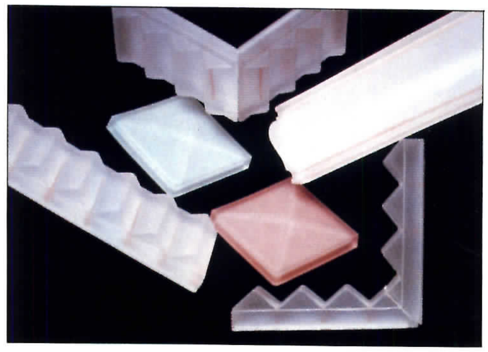

Handmade Tile Collection
A new collection of tile trim pieces designed to resemble Lalique glass is molded by hand by Florentine crafters for the Hastings Tile and Il Bagno Collection.

The collection consists of 2x8-inch shapes in curved moldings or an accordion design, and corner pieces in the accordion shape. The tile is available in opaque white, white with charcoal gray, peach, or black stripes. Also available are 2½-inch squares with a raised pyramid surface, in several accent shades to complement a variety of tile and fixture colors.
Hastings Tile and Il Bagno Collection
Circle 413 on information card

Breuer Seating Collection
A chair designed by the late Marcel Breuer, an AIA Gold Medalist and winner of five national AIA design awards, remained a prototype in New York City's Museum of Modern Art's permanent exhibition of Breuer's furniture until Herbert Beckhard, a former partner of Breuer's, convinced his widow to let it be manufactured by Cadsana furniture company on the condition Beckhard control the design decisions and production details.

It was dubbed the "double spring chair," by Breuer when he designed it because the chair's seat and arm supports work together, and each one has the action of a spring. Constructed of aluminum frame with wood slats and arms, the frame is first extruded and then separated to the point where the arm supports turn up.

The frame then is polished and drilled, and the slats attached with articulated rivets. Fabric and leather-covered models are available, with the stitching of the leather models reminiscent of the slats of the wood chairs.

The entire collection includes dining or desk chairs, a lounge chair, and a chaise lounge, in seats of natural or painted wood slats or in upholstered fabric or leather. Beckhard has designed a line of cocktail tables employing the double spring principle, as well as a series of compatible square and rectangular dining tables.
Herbert Beckhard
Frank Richlan & Assoc.
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CREDITS

Red Mountain Visitor Center, Phoenix (page 82). *Architect: Frankeberger Associates, Phoenix.* Principal in charge: Robert Frankeberger, AIA. Structural engineer: Caruso Turley Scott. Plumbing, electrical, and mechanical engineer: Peterson Associates.

Douglas Research Conservatory, Seattle (page 86). *Architect: Jones & Jones Architects, Seattle.* Principal in charge: Johnpaul Jones, AIA. Project architect: Chapin Krafft. Structural engineer: Howe Engineering. Mechanical engineer: deMontigny Engineers. Electrical engineer: Sparling & Associates. Civil engineer: Anne Symonds & Associates. Geotechnical engineer: Rittenhouse-Zeman & Associates. General contractor: George Sollitt Corp. Project owner: University of Washington, Seattle.

Missouri Botanical Garden Climatron Dome, St. Louis (page 88). *Architect: Morgan Associates Architects, Pittsburgh.* Principal in charge: James A. Morgan. Landscape architect and project coordinator: Environmental Planning and Design. Structural engineer: Skilling Ward Magnusson Barkshire. Glazing consultant: Heitmann & Associates. Mechanical and electrical engineer: Ross & Baruzzini. Contractor: Wasco Products.

Day Butterfly Center (page 90). *Architect: Jova Daniels Busby Architects, Atlanta.* Principal in charge: Henri V. Jova, FAIA. Design team: Stanley L. Daniels, FAIA, Kelly Dunn, Doug Kleppin, Don Nelson, Milan Vancura. Interiors: Jova/Daniels/Busby. Interior consultant: Jenny White. Landscape architect: Marvin & Associates. Project director: William E. Barrick, Ph.D. Electrial and mechanical engineer: Nottingham, Brook & Pennington. Civil engineer: Wiedeman & Singleton. Structural engineer: O'Kon & Co. General contractor: West Point Construction. □

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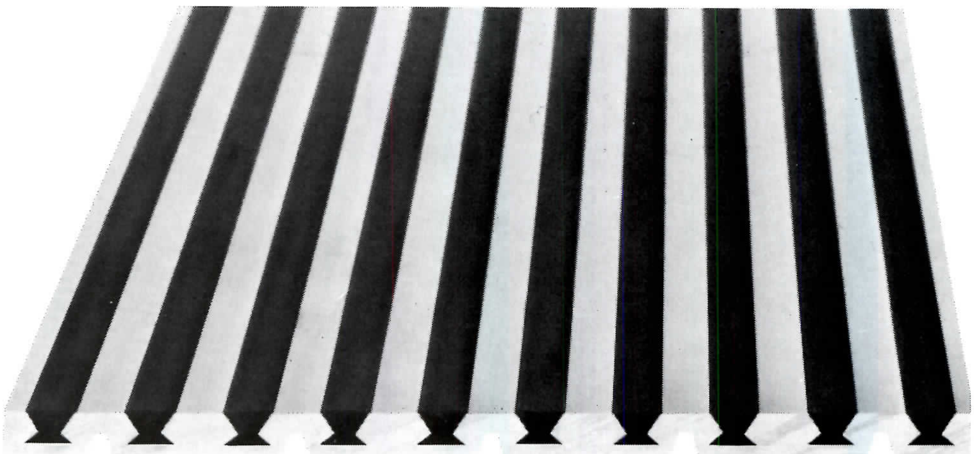

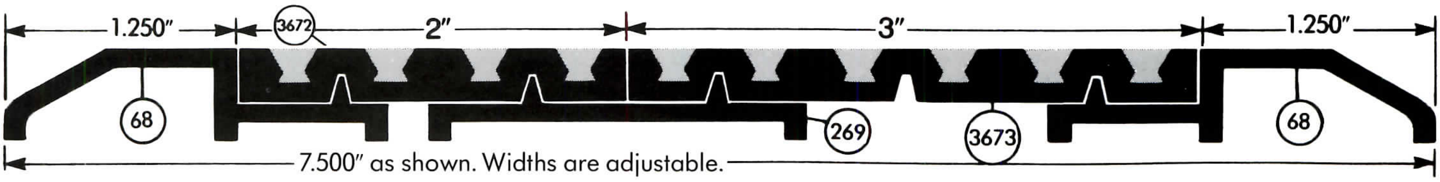

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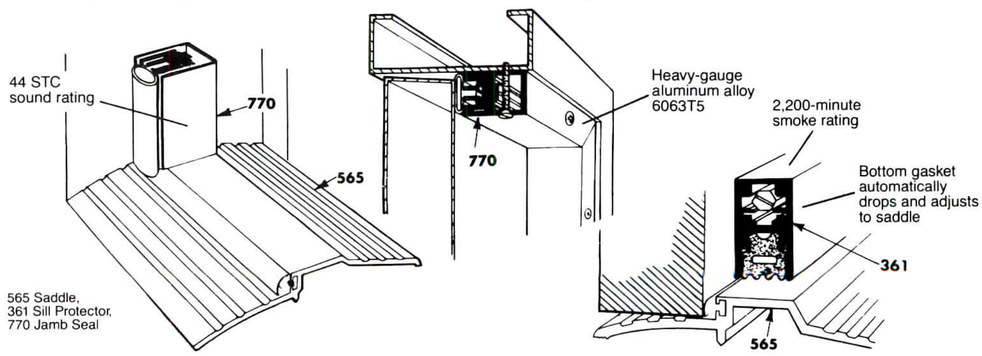

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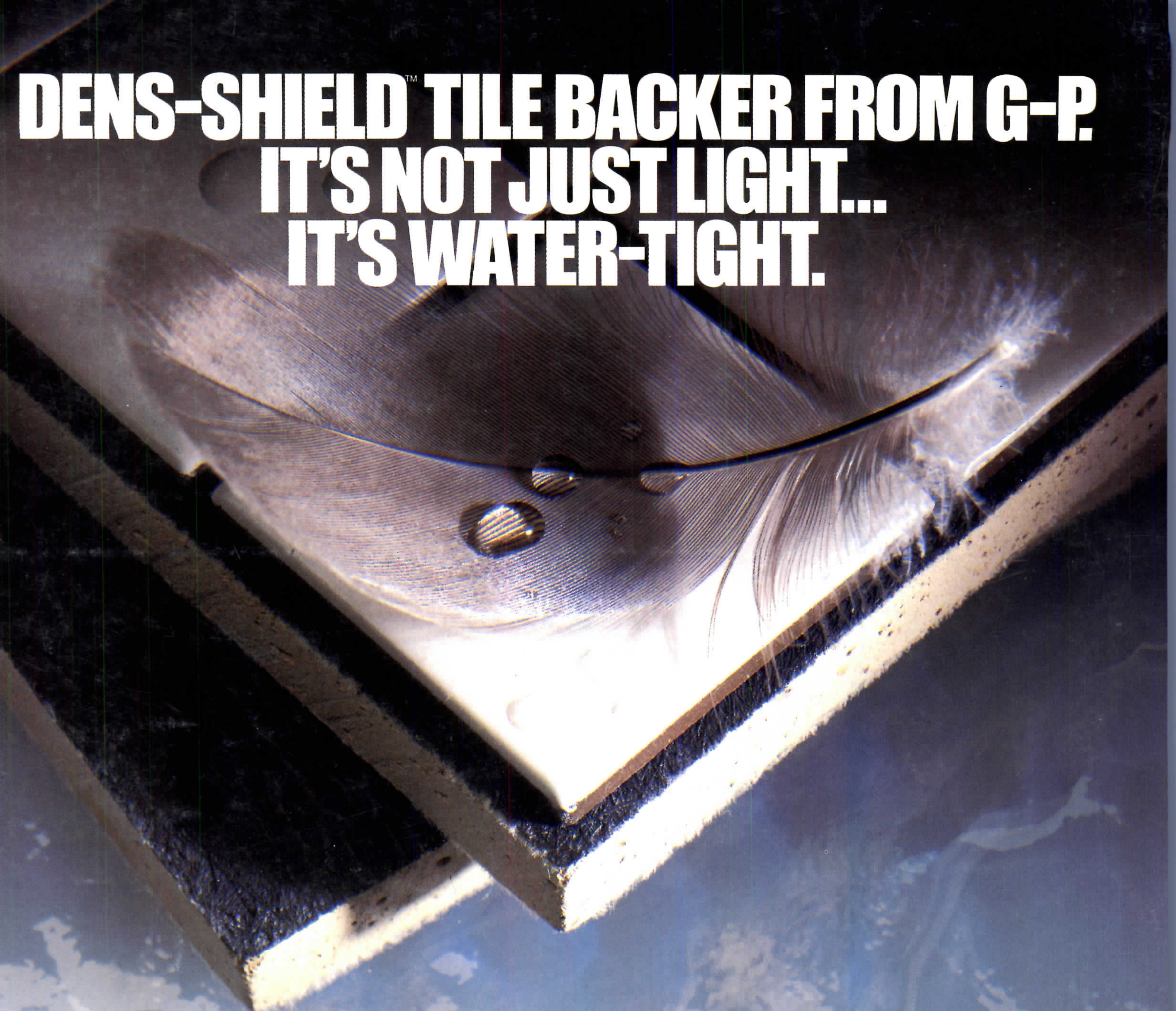

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