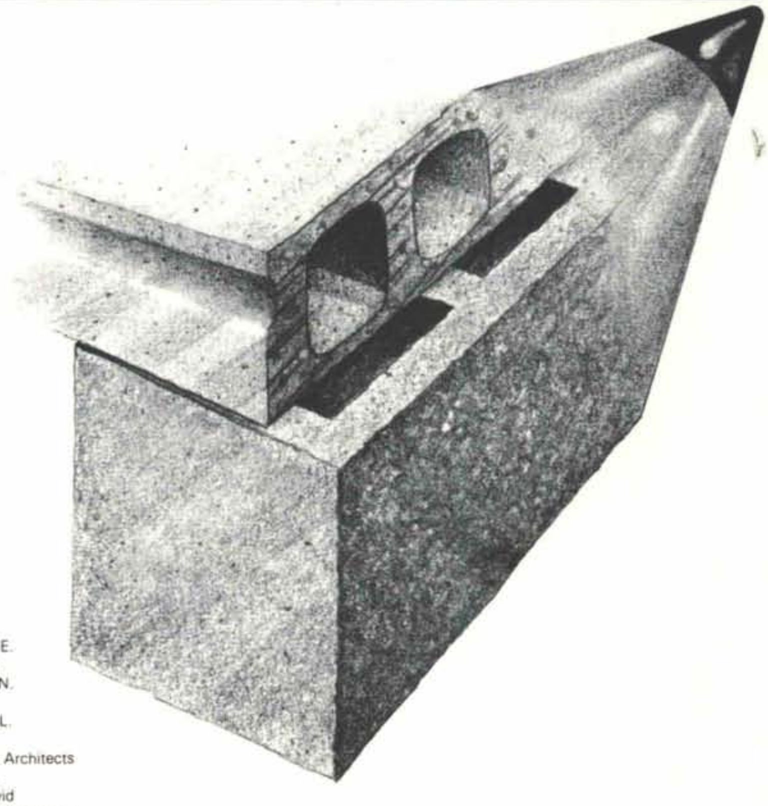
new mexico architecture

May-June 1981 $1.00

Solar—an Energy Source
—third in a series—

IN PROGRESS...

CREGO BLOCK COMPANY FIRST ANNUAL DESIGN COMPETITION



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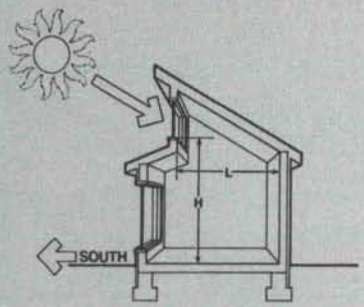

nma

• vol. 23 no. 3 • • may-june 1981 • new mexico architecture

This issue continues the series **Solar—an Energy Source** begun in the November/December 1980 issue of **NMA.** The series will be continued in the July/August and September/October issues.

We wish to extent our congratulations to Robert W. Peters, AIA, a principal in Alianza Arquitectos of Albuquerque. The passive solar residence shown on page 11 of this issue recieved a $5000.00 award in the 1978 passive solar residential design competition sponsored by the U.S. Department of Housing and Urban Development. *JPC*

Cover Photograph: Weather monitoring instruments on the Los Alamos Scientific Laboratory Solar Heated Mobile Home, designed by The Burns/Peters Group.

□ □ □ □

The entire "staff" of **NMA** would like to express its congratulations to two members of the AIA for their recent elevation to the rank of Fellow in the American Institute of Architects. Fellowship in the Institute is a honor of the highest distinction. It is conferred upon members, with a minimum of ten years good standing, who have made notable contributions to the advancement of the profession of architecture. Congratulations:

JOHN W. McHUGH, FAIA

ANTOINE PREDOCK, FAIA

(Cover: Weather monitoring instruments, Los Alamos—William L. Burns, Photographer)

—Official Publication of the New Mexico Society of Architects, A.I.A.—

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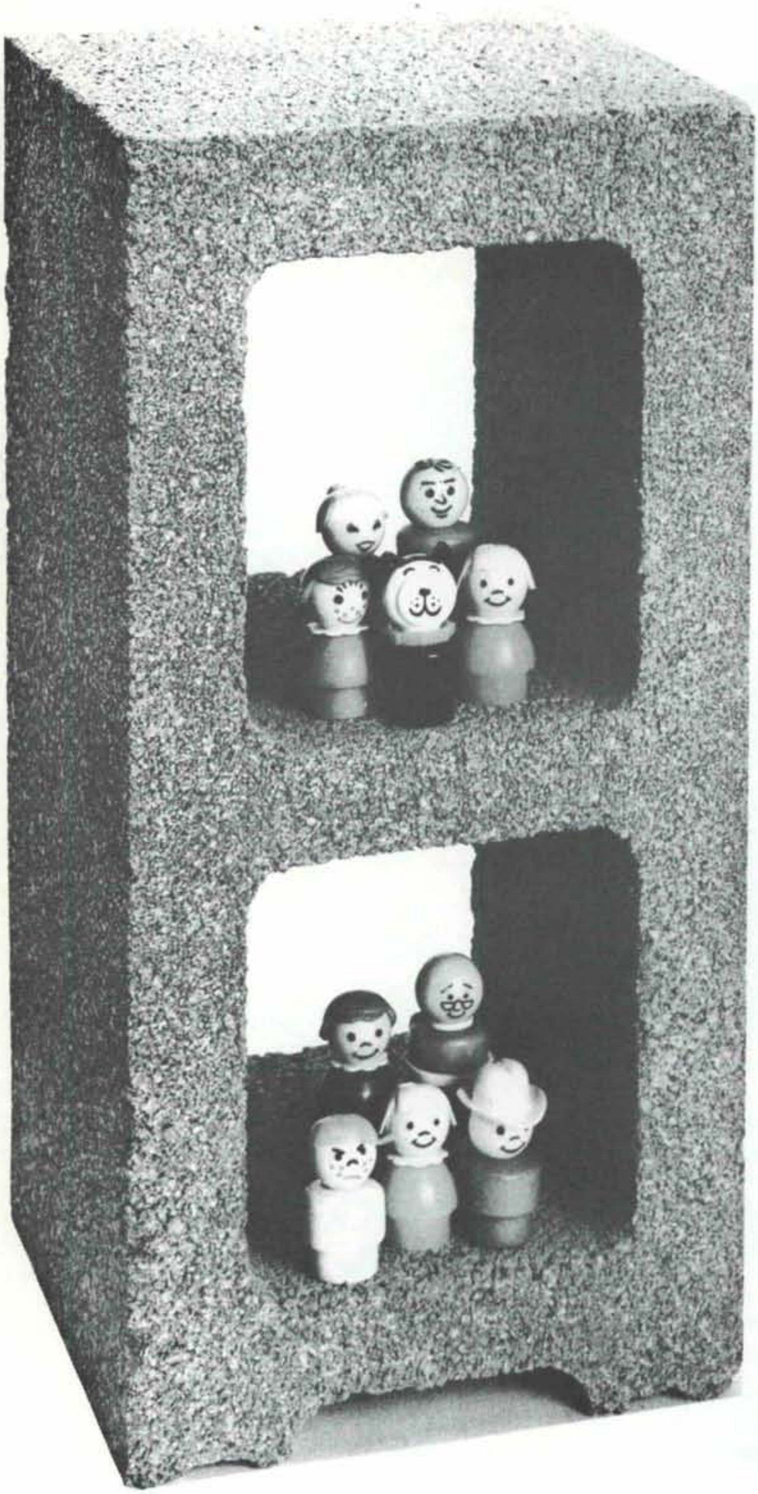
The multi-benefits of masonry for multi-family construction.



If you want your next building to be your best, consider the best building system for multi-family construction—masonry. Whether it's a high-rise, low-rise, or townhouse development, you can count on the multi-benefits of masonry to multiply your sales and profits.

ENERGY EFFICIENCY: Masonry walls, because of their mass, keep a building warmer in winter, cooler in summer, thus reducing energy consumption year round.

LOW MAINTENANCE: Masonry buildings have low maintenance costs, never need painting and virtually no repairing.

ECONOMY: Masonry buildings go up fast so they can be occupied fast—an initial economy that is matched by long-term cost savings on energy and maintenance. And because the value of masonry buildings lasts, they're as profitable to resell as they are economical to own.

PEACE OF MIND: Fire walls built of masonry won't burn and can keep flames and smoke from spreading from one unit to the next. Solid masonry walls provide excellent sound control as well as fire protection.

AESTHETICS: Masonry comes in thousands of colors, textures, shapes and sizes that enhance the visual appeal of a building. Brick, block, tile, terrazzo and stone create warm, inviting interiors and striking exteriors that harmonize gracefully with any environment.

CRAFTSMANSHIP: Masons are craftsmen. Every building they construct reflects their skill, dedication and pride in their craft. In an age where convenience often takes precedence over quality, masonry construction is an unparalleled combination of expert craftsmanship and the best materials ever devised for building.

If you'd like to know more about the multi-benefits of masonry for multi-family construction, contact the International Masonry Institute, 823 15th Street, N.W., Washington, D.C. 20005.

INTERNATIONAL MASONRY INSTITUTE
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MASON CONTRACTORS ASSOCIATION of NEW MEXICO

ACTIVE SOLAR SYSTEMS WITH LARGE THERMAL STORAGE FOR COMMERCIAL AND INSTITUTIONAL BUILDINGS

by Frank H. Bridgers, P.E.

Solar energy is not "free" energy as so many people have been led to believe. On the contrary, it is "capital cost intensive" and as a result, it is very difficult to justify in competition with energy conserving conventional systems for buildings. Even a passive solar system, such as Trombe Wall is capital intensive when you consider you build a glass wall you cannot see through and an 18" structural wall you do not need for structural reasons. It is probable not possible to justify any kind of solar system is competition with energy conserving systems using thermal storage for office buildings.

Thermal storage in this article refers to comparatively large 2-compartment storage tanks (approaching 1-gallon per sq. ft. of building space) where a heat pump can be used at night-time during off-peak electrical demand periods to generate sufficient chilled water and hot water to provide the heating and cooling needs for the following day, thus eliminating the need to cause additional peaking of electrical demand by operation of the cooling and heating units while lights and fans are on. In many areas of the country severe penalties are paid for pyramiding of electrical "demand" and incentives of "off peak" electrical use make thermal storage for heating and cooling a worthwhile investment. Solar energy systems in conjunction with thermal storage may have a better chance of being justified than "conventional" active solar system using the normal amount of solar storage or passive systems using heavy walls or barrels of water as storage, particularly in commercial buildings.

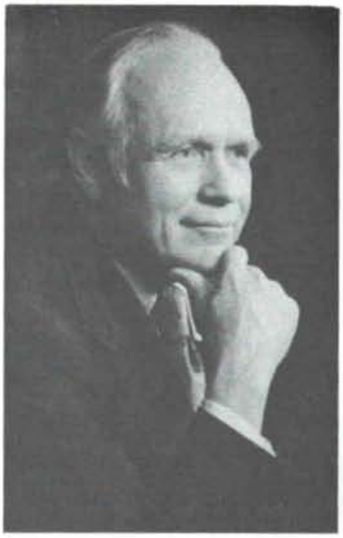
In establishing the true premium cost of solar systems over conventional systems, all cost components must be considered. The cost of the "collector" is only the beginning. Fig. No. 1 shows the total cost of different active solar systems, including solar collectors, structural supports for collectors, plumbing for solar collectors and storage tank for solar system.

NOMINAL COST (Per Sq. Ft.) OF SOLAR COLLECTING SYSTEMS—1980

	Collector	Installation	Collector	Storage	
	Cost and	Plumbing	Support	Tank	Total
Single Cover Flat Plate (N.S.)	$12	$15	$5	$6	$38
Double Cover Flat Plate (N.S.)	$15	$15	$5	$6	$41
Double Cover Flat Plate (S.S.)	$16	$15	$5	$6	$42
High Performance:					
Vac. Tube Type	$20	$15	$5	$6	$46
Conc.-Tracking	$25	$15	$5	$6	$51

Notes: N.S. signifies Non-Selective Absorber Surface
S.S. signifies Selective Absorber Surface

Figure No. 1



Frank H. Bridgers, P.E.

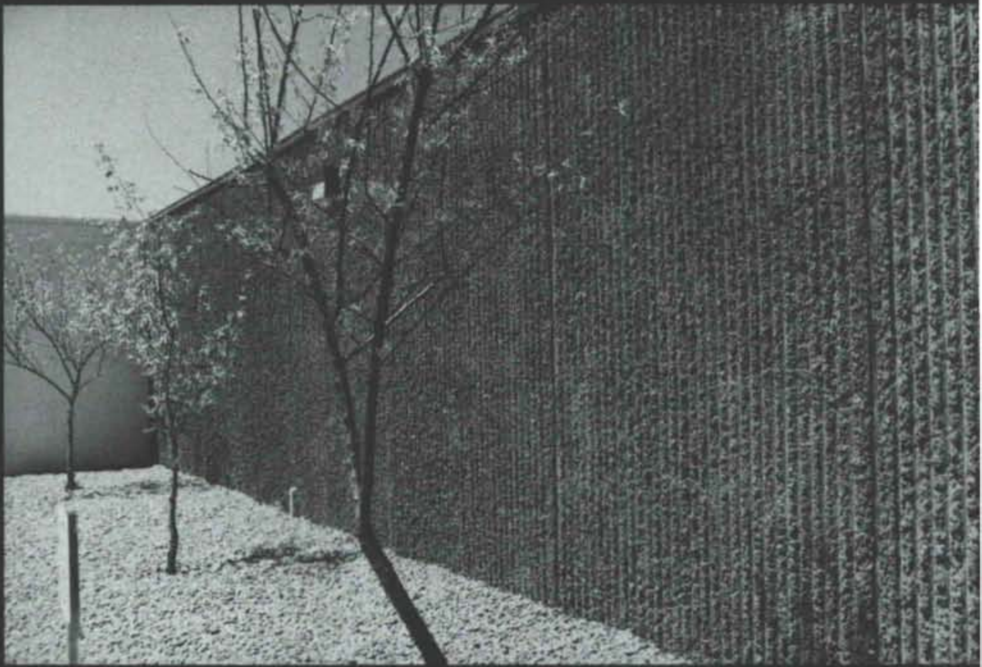
Frank H. Bridgers, P.E., President of Bridgers and Paxton Consulting Engineers, Inc., received a BSME in 1944 from Auburn University and MSME in 1948 from Purdue University. He is a Registered Professional Engineer in seven (7) states. Mr. Bridgers has gained national recognition for innovative design of energy conservation systems including heat pump systems using different heat sources such as well water, internal building energy (people and lights) and solar energy applications. He was the Co-designer of Bridgers and Paxton Solar Building, the world's first solar-heated commercial building which was opened in 1956. Mr. Bridgers supervised the design of 20 other solar projects which have been funded for construction or are under construction.

Fig. No. 2 shows the cost per Million Btu for different solar systems. The first line is a cost per Million Btu presented by a particular solar collector manufacturer showing the most idealistic possibility, assuming that all energy collected is beneficially used for a geographical location having the equivalent sunshine of 50% clear days per year. The remaining comparisons are based on computer modeling of a number of solar systems that are either operational or under construction with varying solar collector system costs and varying amount of solar energy collected and utilized per sq. ft. of collector per year. It is obvious that if ideal conditions could be attained, such as having a low cost collector system ($20 Btu/Sq. Ft.) on clear days, good percentage of sunshine (50% clear days), and all collected solar energy utilized, solar energy would be a very competitive source of energy.

The comparison of the ideal with the real world conditions is similar to the case that not many years ago was made for "on site electrical generation" for total energy systems assuming 100% utilization of "free waste heat for building HVAC systems. It didn't take us long to learn that the demand for heating and cooling and the availability of waste heat did not

Continued on page 9

Stan-Wall I-8



New from Stanley Structures, Stan-Wall I-8 . . . an energy efficient and economical wall system which is fire resistant and durable.

Stan-Wall I-8 is a prestressed/precast insulated sandwich wall panel. It has the ability to withstand stresses caused by handling, temperature and wind, as well as roof and floor loads.

Stan-Wall I-8 provides you with an attractive, sculptured exterior finish and a smooth interior wall surface.

Consider Stan-Wall I-8 for your next building project as an economical way to achieve an architecturally pleasing look with considerable savings in energy, maintenance and insurance costs.

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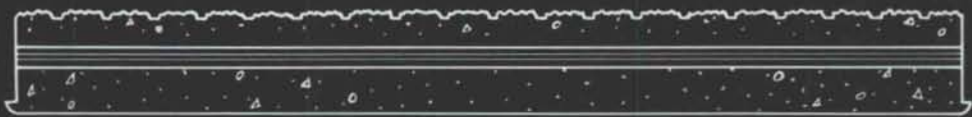
☐ Our Stan-Wall I-8 sculptured exterior surface is manufactured in a tasteful, modern design. Panels are 8 feet wide with thicknesses of 8, 10, or 12 inches with varying heights according to your design requirements.

☐ A layer of quality foam assures even insulation over the panel's entire surface.

☐ The layer of insulation is sandwiched between two prestressed concrete panels, forming a resilient wall that flexes without cracking.

☐ Compatible with any framing system.

☐ The hard interior surface forms a functional wall that resists damage from forklifts or other handling equipment.



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(Frank Bridgers continued from page 7)
necessarily coincide, and that most of the "free" waste heat had to be dissipated to the atmosphere.

COST PER MILLION BTU PER YEAR FOR SOLAR (INTEREST AND PUMPING COST NOT CONSIDERED)

Cost Range Solar Collecting Systems	Average Btu Collected Per Sq. Ft./Year	20 Yr. Life	30 Yr. Life
$20/Sq. Ft.*	365,000*	$2.73	$1.83
$25/Sq. Ft.**	142,000	$8.80	$5.90
$40/Sq. Ft.**	150,000	$13.33	$8.93
$45/Sq. Ft.**	165,000	$13.64	$9.14
$50/Sq. Ft.**	180,000	$13.88	$9.29

*Theoretical data given by Manufacturer for 2000 Btu/day, 50% clear.

**Data based on computer simulation for projects that have been bid.

Electric Resistance @ $0.05 per KWH

$$\text{Cost per Million Btu} = \frac{1{,}000{,}000 \text{ Btu X } \$.05/\text{KWH}}{3413 \text{ Btu/KWH X } 1.0 \text{ C.O.P.}} = \$14.64$$

Electric w/Heat Pump @ $.05/KWH

$$\text{Cost per Million Btu} = \frac{1{,}000{,}000 \text{ Btu X } \$.05/\text{KWH}}{3413 \text{ Btu/KWH X } 4.5 \text{ C.O.P.}} = \$3.25$$

Natural Gas Cost @ $2.50 per MCF

$$\text{Cost per Million Btu} = \frac{1{,}000{,}000 \text{ Btu X } \$2.50}{1 \text{ MCF X } .70 \text{ Eff.}} = \$3.57$$

No. 2 Oil Cost @ $0.90/Gallon

$$\text{Cost per Million Btu} = \frac{1{,}000{,}000 \text{ Btu X } \$0.90}{120{,}000 \text{ X } 0.70} = \$10.71$$

Figure No. 2

A similar situation occurs for many systems. The conventional solar system has the storage designed for a 4 to 8 gallons of storage per sq. ft. of collector. This does not allow retainage of all solar energy collected until it is required by the heating or cooling system and, as shown on Fig. No. 2, the actual amount of heat that can be collected and utilized is less than half the idealistic values.

An examination of Figs. No. 1 and No. 2 would indicate two important requirements to make solar systems more economically feasible:

1. Increase the utilization of the solar energy collected.

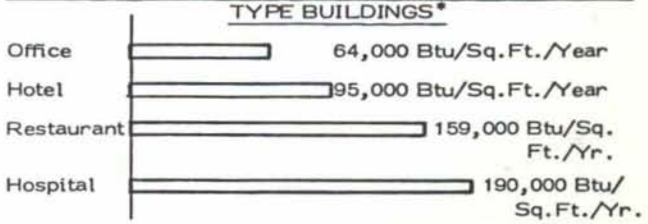
2. Lower the premium cost of the solar collector system.

In this article we will show that thermal storage systems can contribute to both of the above requirements, along with some other important considerations.

Mr. Robert Tamblyn and his associates of Toronto have convinced many engineers that for office buildings, using sound energy conservation principles and thermal storage systems, that you almost get the last "squeal out of the pig" and there is very little HVAC energy requirements left to be saved by using solar energy. If you can't save a significant amount of energy with solar energy, you certainly can't afford the high capital of the solar system.

Therefore, it is obvious that we must look to other types of buildings that require considerable more annual energy consumption than office buildings to obtain a greater utilization of solar energy. Fig. No. 3 shows a comparison of energy consumption for office buildings with hotels, restaurants and hospitals. These

AVERAGE ANNUAL ENERGY CONSUMPTION FOR HVAC, LIGHTS, PUMPS AND FANS FOR DIFFERENT TYPE BUILDINGS*



*Final Report January 1978, Phase One/Base Data for the Development of Energy Performance Standards for New Buildings, U.S. Department of Housing and Urban Development

Figure No. 3

comparative annual energy requirements do not include domestic hot water heating which would increase the differential in energy consumption shown by an additional significant percentage. Another important difference is that the lighting level and the percent of energy contributed by the lighting system is considerably less for hotels, restaurants and hospitals than for office buildings. The lower lighting give less internal heat source for the heat pump system.

You might ask—"What does this have to do with thermal storage?" The answer is that with greater year around energy requirements and a storage system sized to take advantage of night-time storage of energy, a larger percentage of available solar energy can be utilized. This increases the Btu/Sq. Ft./ Year of solar energy utilized for the solar collector and approaches the idealized condition shown in Fig. No. 2, thus lowering the cost per Million Btu. This would help satisfy the first of the two requirements mentioned previously that would make solar energy more economically feasible.

The second condition is to reduce the cost of the complete solar system. If the plumbing and installation cost can be reduced by shipping collector systems that have a maximum amount of factory pre-assembly and pre-piping, the field labor cost can be significantly reduced. The nominal size of most modular flat plate collector panels is approximately 6 ft. X 3 ft. For field installation, two plumbing connections and manual handling and placement of each 18 sq. ft. of collector are required.

To overcome the large amount of field labor and reduce the plumbing cost, the fabrication of large preassembled modules with provisions for internal headers so that several modules can be connected in series has been used on solar projects such as the Denver Community College as shown in Fig. No. 4. Collectors having a module size of 20 ft. X 3 Ft. with

internal headers that allow easily coupling of from 3 to 6 modules in series can significantly reduce the field labor and therefore, the total cost of the solar collector system.

Another way to improve the economics is to make dual use of the solar collector panels. Solar collector modules can be arranged to shade south glass in the summer and allow passive solar energy collection in winter. This scheme was a part of the design for the Program Support Facility for the Argonne National Laboratory, one of the award winners of the 1979 Owens-Corning Energy Conservation Awards Program. For the summer cooling season, this can provide a shading factor that might cost $33 to $5 per sq. ft. of glass for heat absorbing or reflecting glass and not allow as efficient passive energy collection in winter time.

If the cost of the storage system could be eliminated that would normally be charged to premium cost of the solar system, the economics of the solar system would be improved. It has been shown by Tamblyn and others the entire cost of the thermal storage system is economically justified due to savings in electrical energy demand cost and refrigeration capacity initial cost.

The total credit that could possibly be allowed for a solar system with a properly justified thermal storage system on a building having an energy consumption requirement of over 120,000 Btu/Sq. Ft./ Year might be as much as indicated below:

Credit for Storage	$ 6.00
Credit for Large Modules, Installation and Plumbing	$ 7.00
Credit for Shading South Glass	$ 3.00
Total Possible Credit	$16.00

A system that would normally have to be justified for a cost of $50 per sq. ft. of collector could be computed on $35/sq. ft. premium and 200,000 Btu per sq. ft. collector per year, which would give a 30-year energy cost of $7.00/Million Btu as compared to $9.29 per Million Btu without such credits. An energy cost of $7.00 per Million Btu could be justified against electric resistance heating with energy cost above 2-½ cents per KWH not considering interest. *F.H.B.*

Figure 4. Denver Community College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WASHERLESS FAUCETS IN THE KOHLER TRADITION


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tyling that's elegant, a **washerless"** cartridge that's ependable, and Water-Guard vater-saving flow control for avatory and sink faucets with erators put Centura faucets in a lass above the rest.

Vith Centura, Kohler offers a hoice of single lever or push-ull lavatory and sink faucets nd an elegant push-pull ath/shower control.

dd to that a choice of nishes — 24 carat gold elec-roplate for push-pull lavatory aucets and bath/shower con-rols, and gleaming chromium or lavatory and kitchen sink aucets and bath/shower con-rols.

On the inside, Centura features a vasherless cartridge you can de-end on for long-lasting service nd no-leak, no-drip water con-rol.

entura — all the beauty, conve-ience, selection and depen-ability anyone could ask for in faucet line.

ictured at left: Centura push-ull Water-Guard lavatory aucet in 24 carat gold elec-roplate. A touch of richness for ny bath or powder room. With old, cleanly sculptured lines nd lustrous finish. K-6882.

Single Lever Centura Water-Guard lavatory faucets offer fingertip operation and easy, positive selection of water temperature and water volume. One hand controls the faucet for the utmost in convenience. Shroud is made of high impact corrosion-resistant A.B.S., a material that offers longer life and less corrosion than faucet parts made of zinc. Centura single lever lavatory faucet available in chromium only. K-6883.

Sink Faucets in the Centura line offer a pleasing combination of beauty, practicality and Kohler's Water-Guard water-saving flow control.

Chromium finish retains lustre with a minimum of care. One-hand controls water flow and temperature. Handles rotate a full 180 degrees for maximum control of water temperature; no inconvenient temperature variations caused by minute handle movements. Washerless cartridge is designed to help conserve water. Positive water shutoff remains at the predetermined temperature; cartridge does not return to an inconvenient neutral setting when faucet is shut off. Nine-inch swing spout puts water over the work area of the sink. Celcon bearings on spout posts insure smooth operation and extended no-leak, no-drip dependability.

Centura Water-Guard sink faucets are offered in your choice of single lever or push-pull control.

Centura simplifies back-to-back lavatory, kitchen sink and bath/shower installations. Hot and cold supplies can enter either side of the faucet. In installations where the supplies are reversed, the valve stem can be rotated 180 degrees to compensate for the reversal. Saves time and money.

Centura push-pull faucets and bath/shower controls offer smart styling for bath, powder room or kitchen. Sparkling acrylic handles are easy to grip, easy to control. You dial the exact temperature you desire — left for warm-hot, right for cool-cold. Easy up-down or in-out movement controls water volume at the same time.

Elegant Centura tub/shower ensemble in gleaming chromium features push-pull mixing valve that provides water volume and temperature selection with one easy movement. Sparkling acrylic handle and handsome dial plate add beauty to the bath. Also available in 24 carat gold electroplate. K-6872.

ONTROL

ntura single control faucets and bath/shower ntrols have comfort zones that are five times der than most other single control faucets. You ntrol water temperatures easily; you don't have get chilled or burned before you get comfor-ble. And that's especially important in th/shower controls. An ingenious tapered cam s you turn the handle a full 180°. So you set e temperature exactly where you want it. Cen-ra. It puts control right where it belongs. Right your hands.

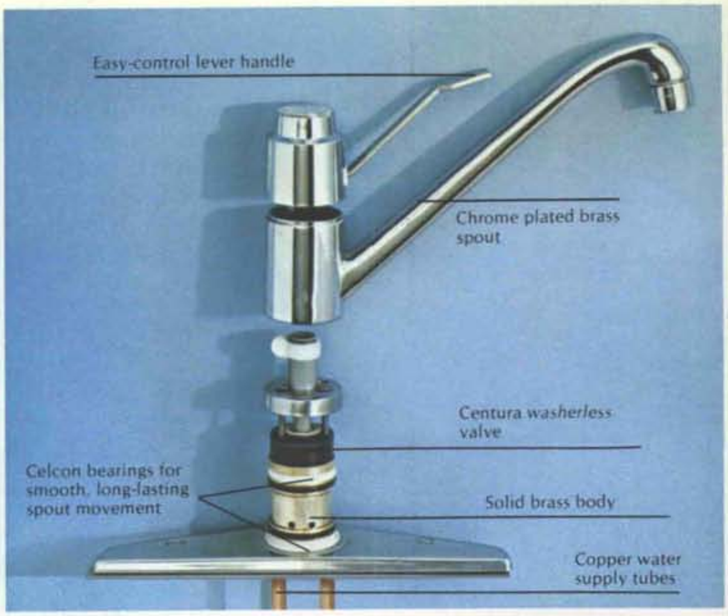
Centura lets you enjoy a comfort zone five times wider than most.

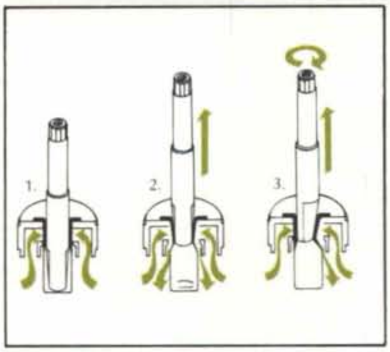
CENTURA

Kohler Centura single control faucets work as well as they look. They will serve you better, longer than other single control faucets. . .thanks to a dependable, washerless cartridge combined with thorough Kohler engineering and craftsmanship.

Compare these Centura features and you'll see why:

- **Centura cartridge has no washers, O-rings or springs — parts that can cause leaks in ordinary faucets;**
- **Washerless cartridge is self-contained, non-metallic and corrosion-resistant;**
- **Washerless cartridge has only one moving part. . .and that part is permanently lubricated and completely isolated from the water so that it is not affected by adverse water conditions — sand, silt, akalines, etc.;**
- **Internal parts — other than the cartridge — are made of long-lasting, corrosion-resistant brass that is precision machined to fine tolerances;**
- **Handle rotates 180 degrees for maximum water temperature control, and "lifts" more than one inch for maximum control of water volume;**
- **Smooth opening and closing. . .eliminates sudden bursts of water that can splash out of the bowl;**
- **Copper inlet tubes are securely attached and brazed to body to prevent leakage;**
- **Centura shrouds are made of non-corrosive plated ABS, and stainless steel for long-lasting durability and easy-care beauty;**
- **All Centura lavatory and sink faucets with aerators offer Kohler's Water-Guard water-saving flow control at no additional cost to help lower water bills and water heating costs;**
- **Autel Water-Guard showerhead offered with Centura bath/shower features maximum 3 GPM flow control and Delrin face to resist build-up of clogging, corrosive salts;**
- **Centura offers push-pull and single lever controls for consumer preference and convenience.**





Kohler's Centura washerless cartridge is designed with built-in dependability. It has only one moving part. And that part is permanently lubricated and completely isolated from water.

Water conditions such as alkalinity, sediment or high iron content will not cause the Centura cartridge to deteriorate or leak because water does not come in contact with the control cam.

Illustrations above show how the Centura washerless cartridge controls water flow:

1. **Off Position** — Fully inserted cam seals rubber sleeve against both hot and cold water supply ports.
2. **Mix Position** — Withdrawing cam permits sleeve to flex away from ports. Allows water to flow.
3. **On. . .Single Temperature** — Turning cam aligns bevel with one port, flat side with other. Result is one supply flowing and the other sealed.

Centura sink faucet features Celcon bearings on the spout post for smooth operation, easy spout swing action, and extended no-leak, no-drip dependability. Low-friction bearings help support the spout and virtually eliminate wear and tear for years of trouble-free service.

Centura faucets feature full 180-degree handle rotation for maximum control of water temperature. No more sudden temperature changes caused by minute handle movements. Handle also features more than one inch of "lift" for maximum volume adjustment.

Internal parts — other than the washerless cartridge — are precision machined from non-corrosive solid brass stock.

Contact your local Kohler representative for more information today . . .

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(505) 345-8587

KOHLER

KOHLER CO. KOHLER, WISCONSIN 53044

FORM P-880-75-7781

Project: Passive Solar Residence

Location: Santa Fe, N.M.

Architect:
Robert W. Peters, AIA
Alianza Arquitectos, and Architect's Alliance

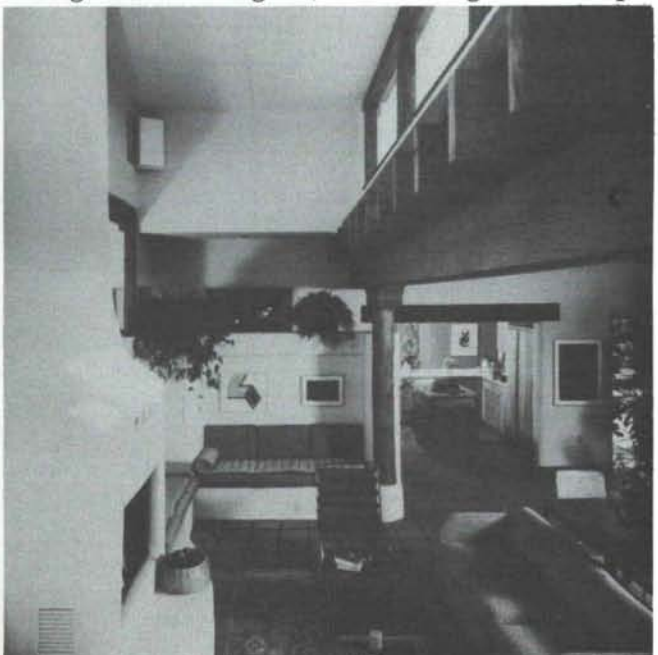
Solar Engineer: Susan Nichols

The design blends elements of traditional Pueblo architecture with contemporary solar design. The building materials and construction details are standard to any trade craft in the country. The solar system uses adobe, concrete and cinder block for interior thermal mass.

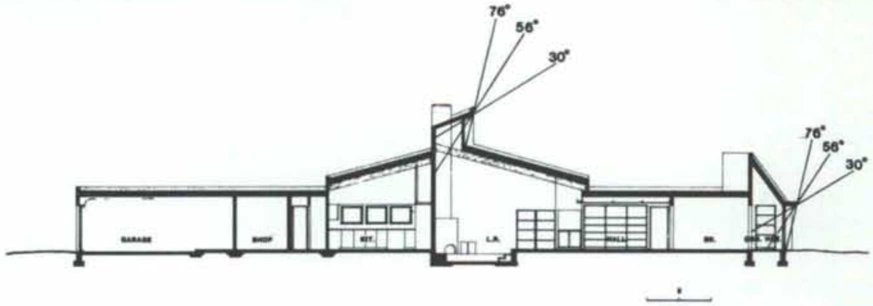
The other special features of the home are its openness for interior convective flows and the central mass of the fireplace and the built-in concrete and adobe furniture. The use of high mass built-in furniture solves some of the problems inherent in low cost frame building systems and the need for interior mass with passive solar techniques. The open room plan is an example of matching passive solar requirements with a quality home design that has market appeal.

The house contains 2084 SF with 1795 SF of it heated area, in a compact rectangular form which maximizes south exposure while minimizing north exposure through recessed east and west corners, and setting the building 18" below grade along the north front. The house is located approximately 100 feet south of the ridge line to further protect from prevailing NE winter winds, while open exposure to the south allows summer SE winds to enter through vents for natural cooling. Walls are 2 X 8 stud construction with 7½" fiberglass batt insulation yielding an R. of 28.86. Roof is 2 X 10 joists and built-up roof with 9¼" fiberglass batt, R 36.17. Windows are double-glazed Pella Units with U of .65. Wood doors at airlock entrys have U of .34. The passive solar system is a blend of direct gain and trombe walls with greenhouses providing inner adobe thermal mass walls, operable windows for direct gain into adjoining rooms and thermostatically controlled fans to move heated air into bathrooms. Natural cooling system introduces air low at window seats and through vents high in clerestory tower and through north windows. Backup heating is provided by electric radiant cable system in tile floor, baseboard heating in carpeted master bedroom and bath, and by heatilator fireplace.

Occupancy since January 1, 1979 has shown minimal need for backup heating, and complete success of summer cooling through natural ventilation.



Project: Lee Residence
Location: Los Chavez, N.M
Architect: Schlegel & Lewis

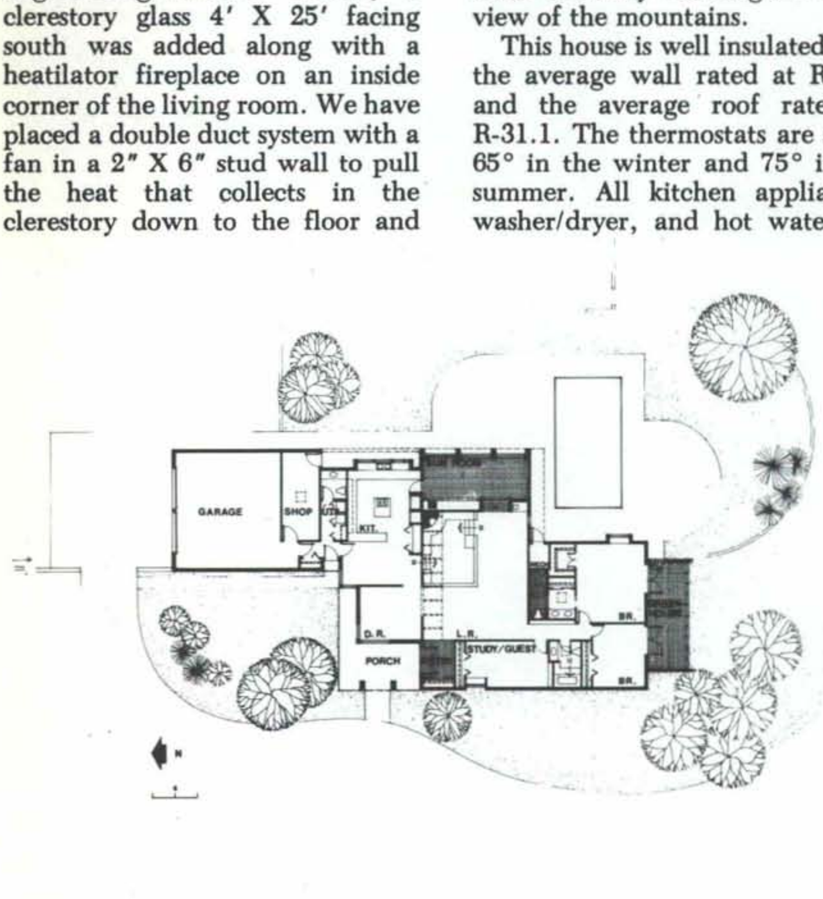


In the past four years we have designed a number of active and passive solar houses. From these experiences we have come to the conclusion that even with the future escalation of energy costs, it is difficult to justify the cost benefits of active solar systems with the present high interest rates and minimum State/Federal tax benefits for residential design. Our work now has concentrated on passive design solutions, and the Lee house is the most recent.

Passive considerations were developed in a number of ways. A small greenhouse (5′ wide, 20′ long with glass 7′ high), with an 8″ thick concrete floor for heat storage was added to the south. Glass doors opening from the greenhouse provide most of the heat required for two adjoining bedrooms. The glass greenhouse wall is vertical with a roof projecting 1½ ft. to keep the glass shaded in the summer. To supplement the heat in the living/dining/kitchen areas, a clerestory glass 4′ X 25′ facing south was added along with a heatilator fireplace on an inside corner of the living room. We have placed a double duct system with a fan in a 2″ X 6″ stud wall to pull the heat that collects in the clerestory down to the floor and then recirculate it. Two other passive elements exist to assist in heating these spaces: A sunporch with doors opening to the living and kitchen area; and a large bay window running the length of the kitchen counter, both design elements facing east in order to catch the early morning sun and a view of the mountains.

This house is well insulated with the average wall rated at R-10.6 and the average roof rated at R-31.1. The thermostats are set at 65° in the winter and 75° in the summer. All kitchen appliances, washer/dryer, and hot water are electric, and a heat pump provides the heating and refrigerated cooling. The costs of this energy over the past year have averaged $125/month based on 7¢/kwh. For three months (May, June and October) there was no heating or cooling.

1216 kwh is the average consumption per month for heating. Therefore, when considering that the heated area is 3,000 SF and the average degree days for this area 4300, the efficiency of the system can be judged on the basis that it requires 2 BTU's/degree day/S.F. to heat.



USE OF NATURAL DAYLIGHTING IN ENERGY EFFICIENT BUILDINGS

By Dean Powell

W. Dean Powell, P.E.

W. Dean Powell, P.E. directs the Electrical Engineering Division of Allison Engineering, Inc., Albuquerque, New Mexico. He holds a Bachelor of Science in Electrical Engineering from Texas Tech University and is a registered Professional Engineer in New Mexico, Colorado and Arizona. In addition to conventional building systems, Mr. Powell has been actively involved in designing energy-conserving features into lights and power systems.

The illumination of interior spaces by natural lighting has been used throughout the centuries in as many ways as there are styles of architecture. When the only means of artificial lighting was through the use of crude torches or inefficient oil lamps, all lighting during the daylight hours was accomplished by natural lighting. Many of the techniques developed in historical times can be applied to present day usage through architectural adaptation of basic concepts.

The methods utilized for daylighting, fall into two broad areas. The first is the use of direct sunlight through windows or other openings located on the south, east, or west side of a building. This is a harsh, gross use of the maximum amount of light available from the sun and has been used, quite effectively, throughout history, for lighting large volumes of space, with openings that were quite often small in comparison to surrounding structural masses. Tall buildings made the best use of this type of lighting, since the height of the exposed walls allowed the use of openings so placed to illuminate opposite walls effectively. When used in Cathedrals, these openings were usually arranged to provide dramatic lighting of the altar area and oriented to, in general, direct this light from the side or rear of the building. Since reading or fine seeing tasks were not involved, the brightness contrasts were not important. The second general method used for daylighting, has been through the use of "north lighting" or redirected lighting. North lighting is, in itself, a description of the method. All areas of the sky are filled with air, water and dust molecules which produce a natural scattering of the sunlight throughout the air space resulting in a diffused lighting source which, when utilized through openings facing north, result in high levels of direct lighting without the glare which is present when direct sunlight is used.

Natural lighting fell into disuse with the advent of higher efficiency artificial lighting sources and the concept of a totally controlled environment (windowless spaces, all season air conditioning, etc.). When we became aware of the fact that our fuel/energy sources were not unlimited, immediate attention was directed to the use of solar energy for heating of buildings. "Active" solar collector systems were the first to gain prominence as being a "new and developing" art. Not far behind this search was the "passive" solar system. "Back to basics" became the watchword for a more economical method of using solar energy. In the rush to utilize the sun's rays directly, however, the effect of sunlight on seeing ability was largely ignored. The use of direct sunlight for passive heating of spaces is, in general, a reasonably economical method of solar heating. To combine this direct sunlight method for heating and for providing natural daylighting within a space becomes a much more difficult task. We can learn from our historic predecessors about the use of free lighting from the sun and the open sky. We can also learn to integrate this sun for both heating and lighting.

Control is the essence of all systems utilizing natural light. Control and the ability to calculate with some reasonable degree of accuracy, the end results. Ability to handle the variability of lighting conditions presented by natural light is also of primary importance. The extreme variability of natural daylighting sources in Albuquerque is indicated in Figure No. 1.

As can be seen in this graph, the use of daylighting in the high altitude areas of the southwest involves an extra burden of control due to the high intensity of available sunlight and the clarity of the air. Measurements of the unobstructed sun in the latter part of June on a clear day, reveals readings of 7500 footcandles. This same unobstructed sun in December measures 4000 foot-candles. Equivalent measurements, with light obscuring clouds, reveal an intensity of approximately 6000 footcandles of summertime light in all directions including horizontal, north, east, south and west. Measurements with heavy cloud cover (with light rain) drops this available light to approximately 1000 footcandles in all directions. In considering daylight designs in this area, the problem of control is one of major importance. In northern areas of the United States, buildings can be oriented toward the south to take maximum advantage of the

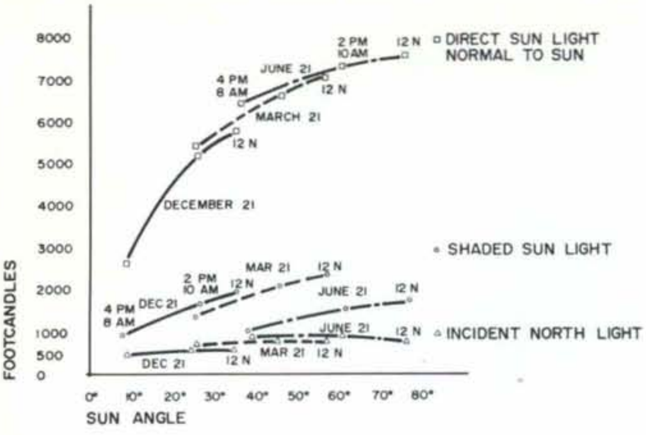


FIGURE 1 DAYLIGHTING ILLUMINANCE
FROM IES LIGHTING HANDBOOK, 5TH EDITION
FIGURES 7-7 AND 7-8 MODIFIED TO CORRELATE
WITH CLEAR SKY READINGS IN ALBUQUERQUE

heat of the sun and the light of the sun. In this area, heat and lighting become two distinct design problems. With a two to one ratio of intensity between winter and summer and the very high candle power available, the use of direct sunlight for daylighting becomes one of reducing this direct sunlight to a usable level. Many different factors contribute to the amount of light received on a vertical or horizontal surface of a building. In this area, ground light itself (reflection of skylighting onto the ground) also becomes a problem of control. Many different architectural considerations should be made for the use of natural daylighting. One of the time honored methods for control of sunlight is the use of an overhang above windows. An overhang, however, is a detriment to the proper utilization of north lighting. Any openings facing the south should use an overhang and proper placement of windows to prevent the direct entry of sunlighting into the space.

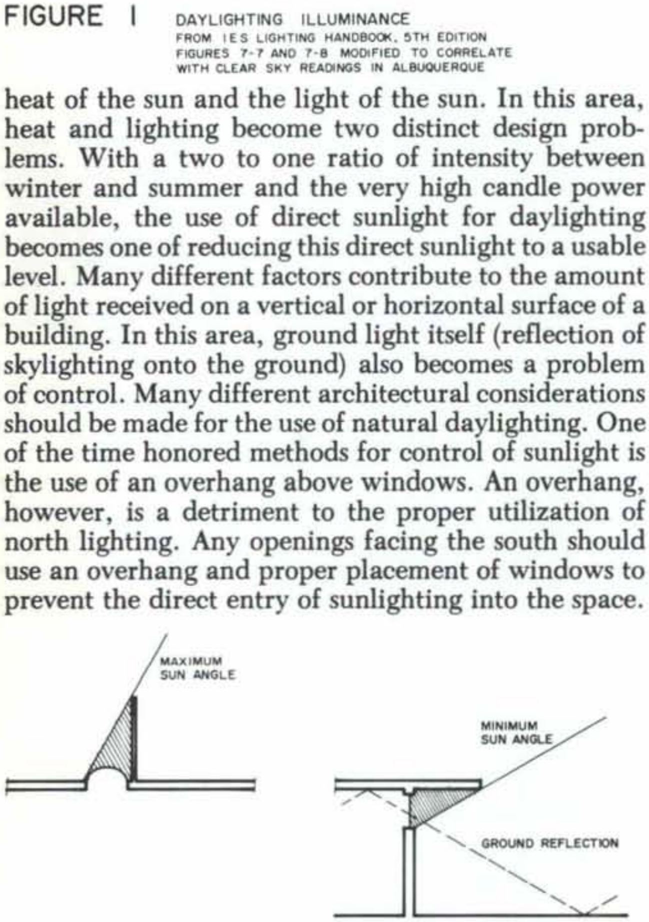


FIGURE 2 DIRECT SUN LIGHT CONTROL

In addition, direct visual contact to harsh ground lighting areas should be avoided. Propitiously placed screen walls along the south side of a building, which would prevent direct entry of sunlight and reduce the direct component of ground lighting, is an excellent way of controlling the entry of these harsh, high intensity rays of light.

Figure No. 2 illustrates several methods for control of direct sunlight and ground lighting. These methods of control include the redirecting of sunlight, through a series of baffles, to absorb and scatter direct rays onto a large enough surface to keep the contrast levels between a normal interior space and the lighted surface to a level which does not produce excessive eye fatigue. It is in this area of contrast, between lighting surfaces and working planes, that can produce high fatigue and increase chances for accident in an industrial environment. Vertical sunlight traps can also be used to redirect sunlight on to surfaces that could then be considered as the light source for lighting a space. Louvers and baffles can be used, as well as low transmission glass.

In utilizing "north lighting" or natural sky scattering of light particles to produce the necessary diffusing medium within a space, the control of the entry of the natural light is greatly simplified. In Albuquerque, the natural north light varies from slightly more than 900 footcandles per square foot in the summertime to slightly more than 600 footcandles per square foot in the wintertime, producing an overall uniformity of lighting levels that is not dependent upon the seasons or ordinary sun angles. This natural light scattering by air molecules results in a lighting source for which, when seen through unobstructed clear glazing, the brightness does not appear at the glazing point, but is distributed throughout the depth of field. With properly sized glazing, enough of this well diffused light source can be admitted to light most spaces without resorting to baffles, moveable louvers, or other devices.

Under high overcast conditions, where the sunlight is scattered through light colored clouds, the "high sky" effect results in as much as 6000 footcandles in all directions. This lighting is reduced to approximately 2000 footcandles under shaded conditions. This additional light would, under these conditions, produce a greater brightness from shaded north and south light glazed areas but should still be within acceptable limits of glare. The number of days that this condition exists in New Mexico does not exceed 5 or 6 during the year and, as such, can be considered to be of negligible importance. Even under heavy cloud conditions, with light rain falling, the north light still maintains a level of around 600 footcandles.

One major solution to the use of natural light scattering by air molecules is through the use of a vision strip at the top of a wall on the south side of a building, with overhang to shield it from the direct rays of sun at minimum winter conditions, and vertical baffle to shield this strip from a setting west sun. If a space, which is lighted by this means on the south side, also has available north light fenestrations, the overall illumination within the space can be

reasonably uniform. If the space is unusually large, the use of facing clerestories or baffled skylighting will average out the illumination in the space. Through judicious use of natural daylighting (both north and south light) different spaces can be lighted in a variety of ways to suit the use and to accommodate the exposure. For instance, in an area reserved for general storage which can use some heating through natural solar means, a combination of passive solar heating and direct sunlight would be tolerable. On the other hand, lighting in an office space must consider maintenance of lighting at contrast levels of less than 2 to 1, a maximum of 200 footcandles or less.

In considering daylighting design for any building, it should be kept in mind that relatively even illumination in the working space must be maintained during operational hours. This usually means that some artificial lighting must be installed to aid the natural daylighting available to provide lighting during non-daylight hours. The location of artificial lighting fixtures should be placed to boost only those areas where additional lighting is required. The use of the concept of task lighting both for natural daylighting and artificial lighting should be considered, in order that a minimum amount of energy be expended for general lighting. If the space is to be used during other than daylighting hours, the artificial lighting task should be considered with minimum acceptable lighting levels. This artificial lighting should also be arranged in such a manner as to allow a variation in the artificial levels to match variations which will occur in the daylighting levels. "Storage" of energy for solar heating can be accomplished but such storage of light cannot be accomplished. This supplementary artificial lighting then is most efficiently used when it is compatible with and complementary to the designed daylighting. Control of the artificial lighting to provide the complement and boost to daylighting can be accomplished in its simplest form through proper switching or through more sophisticated means of automatic control. Systems are presently available, on the market, that can either control the intensity of artificial lighting by automatic sensing of the daylighting available or can control certain areas of artificial lighting to serve a complementary light to natural daylighting at all times.

In summary, daylighting design can be most efficiently used when the conditions available for natural daylighting are considered initially in orientation of the building and when architectural features such as clerestories, north facing fenestration, screenwalls, properly located skylights, etc. Proper use of reflecting and diffusing surfaces, high transmission glass, special and orientation of openings and balance of natural and artificial lighting sources, can produce a building that can be energy efficient for heating and cooling while utilizing a minimum of energy expenditure for lighting *W.D.P.*

UNIVERSITY ENERGY INSTITUTES

by Dr. James D. Dritt

Dr. James D. Dritt

Dr. James D. Dritt is responsible for the planning, coordination, and direction of all project operations of Solar America, Inc. Dr. Dritt earned a Bachelor of Science degree in Civil Engineering and Military Science from the United States Military Academy, West Point, New York. He earned a Master of Science degree in Industrial Engineering and Management from Oklahoma State University. His PhD in Civil Engineering and Environment Science was earned at the University of Oklahoma. Prior to joining Solar America, Dr. Dritt served with the New Mexico Energy Institute as Director (acting), Senior Program Director, and Senior Research Associate.

The New Mexico Energy Institutes at the University of New Mexico (Albuquerque), New Mexico State University (Las Cruces), and the New Mexico Institute of Mining and Technology (Socorro) officially inaugurated a formal New Mexico Energy Research and Development program in June 1976. The 1974 Legislature, spearheaded by Mr. Bob Grant, created the opportunity for this arrangement by allocating $2 million annually for an energy R & D program.

The proposed intent of this unique arrangement between state government and the universities through the Energy Institutes was to take advantage of and utilize the available expertise at the universities to address fuel and energy problems of New Mexico and seek solutions for the benefit of the citizens of New Mexico.

The first problem facing this program of the New Mexico Energy Resources Board (ERB) was, what university was going to do what energy research work? this was "solved" by dividing energy into convenient

categories and assigning each university specific research areas as follows:

UNM	NMSU	NMIMT
Conservation	Solar	Coal
Nuclear Fuel Cycle	Wind	Enhanced Oil Recovery
Synthetic Fuels	Biomass	Oil
Socioeconomic Impacts	Geothermal	Gas

And, in June 1976, in an atmosphere of anticipation and excitement, with all territories distinctly marked, the New Mexico R & D program was launched. The "staff" at each institute consisted of a Director and a secretary as follows: UNM, Mr. T. T. Sishman; NMSU, Dr. R. L. Sam Martin; NMIMT, unnamed.

By January, 1977, as the Institute struggled to life, it became apparent that Institute activities at UNM were taking three separate tracks: 1) individually instituted energy research projects by university personnel, 2) directed research programs by the ERB, and 3) technical assistance programs conducted in support of the state Energy Conservation Office.

The first track was the traditional one whereby the directors of all the institutes contacted individual professors, deans, and others statewide in an attempt to generate activity and interest in participating in the R & D program. This PR effort was fairly successful in generating some first round proposals in August 1976 and early 1977. Peer review of each proposal, arranged by the Institute director, would be followed by Institute Advisory Board (IAB) review. A consensus funding recommendation would be presented to the Energy Research and Development Review Committee (ERDRC). Final funding recommendations would be presented to the ERB and the Administrator would authorize appropriate programs. Then a project could get started.

Overall, this proposal review procedure, even though cumbersome, did result in the conduct of many successful and significant research projects at all the Energy Institutes in all energy areas.

The second track of research projects involved those directed by the ERB. Not all the energy research needs of the state could be satisfied by responses to calls for proposals. The Administrator (and later the Secretary) of the ERB would, therefore, occasionally direct an institute to undertake a particular specified research activity. In such instances, it was up to the institute director to seek out the necessary expertise either within or outside the university system, solicit their participation, and direct the total program effort.

This technique resulted in several significant programs. For instance, the governor used this method to establish an energy information outreach program which later proved to be one of the foremost and successful programs in the nation.

The third track, that of technical support to the state's energy conservation efforts, proved to be one of the most significant of all energy activities. The impetus which really started this activity originated with federal legislation known as the ECPA and EPCA acts. These public laws required the states to undertake certain activities in the area of energy conservation, such as right turn on red and the adoption of an energy conservation building code.

While the state was required to do these various conservation items during late 1976 and 1977, there was no state-level in-house capability or technical support to conduct projects such as developing and conducting a building code training program for all building officials statewide, or developing energy audit procedure workbooks for public schools and office buildings, or developing a computerized annual energy simulation program for commercial and residential buildings. Consequently, the state turned to the energy institutes for assistance, who responded positively and enthusiastically to their requests. At the EI at UNM, about a dozen specific projects were identified in early 1977 and proposals were developed, submitted, and approved. The successful execution of this concept was the key which resulted in the most benefit to the citizens of New Mexico as well as propelling New Mexico to the forefront of national energy activities. By late 1977 and 1978, New Mexico led the nation in a variety of energy endeavors, and New Mexico was widely recognized and accepted as being a national leader of energy programs.

Another assistance project undertaken by the EI at UNM involved providing technical support to the Energy Extension Service (EES) in addition to developing energy outreach materials for public use. The EI at UNM developed the proposal for the state to submit to DOE for a pilot EES program grant and New Mexico was selected as one of the ten pilot states.

Other research was also developed. Under the leadership of Governor Jerry Apodaca, state officials agreed in September 1976 to adopt the proposed Chapter 53 of the Uniform Building Code (UBC) published by the International Conference of Building Officials (ICBO). Implementation was scheduled for July 1, 1977. It was recognized, however, that the strict interpretation of the code would jeopardize certain traditional and innovative construction techniques unique to New Mexico. Therefore, this action was taken with the proviso that research would be undertaken to study the code and devise methods for implementing the provisions of the code specifically for New Mexico. Another stipulation was that a training program be developed and presented to building officials throughout the state prior to the code implementation date.

R & D projects funded by the ERB were immediately initiated through the Energy Institute at UNM. These projects were to focus on innovative concepts which would specifically address the shortcomings of the code, and advance the technological state-of-the-art in heat transfer and energy conservation.

An analysis of the difficulties of implementing the energy conservation code in New Mexico resulted in the conclusion that the key was a failure to distinguish between the steady-state U values of different materials and their dynamic performance. The problem with the method using steady-state, laboratory U values is that it does not consider or reflect diurnal

temperature cycles, solar radiation, mass effect, thermal storage, re-radiation to the night-black sky, or wind conditions. Therefore, the main thrust of the research centered on New Mexico's varying climatic regions (from low arid desert to high Canadian alpine) characterized by large diurnal temperature differences and a very high incidence of solar radiation. The research objective was to establish a quantitative basis for the incorporation of the basic concept of solar flux through windows and onto walls into architectural design. The proposed strategy was to replace steady-state U values, with "effective U values" or (vermeer value) which characterize the synamic performance of various wall types. In essence, the effective U value, which takes into account solar input and time-dependent boundary conditions, is the ratio of the average heat flux on the inside surface of the wall over an extended period of time to the average temperature difference between inside and outside over the same time interval.

The effective U values led to a better understanding and documentation of the performance characteristics of building components in the climatic regions of New Mexico. Most important, the research pointed the way toward implementing the energy conservation code through utilizat... of dynamic performance-based criteria under certain specified conditions.

Effective U values for 26 different wall types in 11 climatic regions of New Mexico were tabulated and disseminated throughout the state.

While energy conservation codes specifically address new buildings, this new methodology would provide a great deal of insight on all existing buildings and could be applied in relation to energy consumption data, energy audit capability, and developing retrofit opportunities. Once the performance characteristics of building components were thoroughly understood and documented, a realistic cost/benefit life cycle analysis of retrofit actions could be recommended.

Initial implementation of the energy conservation code throughout New Mexico was the goal of a statewide training program conducted for all building officials during the month of June 1977.

The development of an Energy Conservation Code Applications Manual by the Institute (funded by the ERB) served as the nucleus of the training program and provided a working reference document. The subject matter was developed as follows:

> Part I - What you need to know about ENERGY FUNDAMENTAL — general knowledge about energy and heat transfer with emphasis on certain factors of energy conservation in buildings, i.e., heat measurement, heat flow, heat loss.
>
> Part II - What does the CODE mean? — information on what the code regulates, and how.
>
> Part III - APPLICATIONS of the Code — how the code is applied by all elements of the construction industry.
>
> Appendices — charts, graphs, and reference data are consolidated into tabular form based on New Mexico climatological areas.

To complement the normal extensive reporting of research project results, the Institute briefed the New Mexico public on this research breakthrough at public hearings conducted by the Energy Resources Board. In addition, special briefings for key officials of what is now the Department of Energy as well as several State officials, were held in Washington, D. C., during the month of May 1977. The results of the research on effective U values were also introduced and discussed at the June 26-28 Public Meeting for 16 western states, conducted by the Energy Research and Development Administration in Phoenix, Arizona. Key members of the National Conference of States on Building Codes and Standards (NCSBCS), ICBO, Local members of VA, FHA, HUD, and FEA, were also briefed on the training program as well as the Applications Manual and the use of the effective U value concept.

Energy conservation in buildings was further addressed by developing such materials as Class C Energy Audit Workbooks (TEEM) for nine different categories of buildings plus residential, an on-site (Class A) residential energy audit procedure utilizing a microprocessor, a Class B (or A) residential annual simulation computer program (a first in the nation) which was used extensively in support of the EES program, and conducting computer analysis on commercial buildings utilizing DOE 1 and 2, BLAST, NVSLD, and AXCESS computer programs.

The range and scope of all the projects cannot be described within the bounds of this article. If the reader desires to learn more about all the programs and the publications resulting therefrom, two documents are available which describe these materials in detail. They are:

1. New Directions in Energy Research and Information and
2. List of Projects and Project-Related Publications at the New Mexico Energy Institute at The University of New Mexico.

The institute and/or EMD probably would be happy to respond to your request. *J.D.D.*

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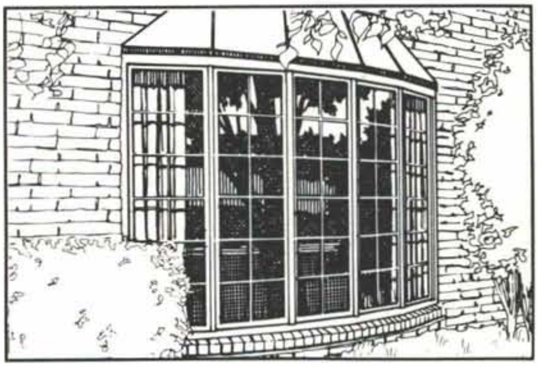

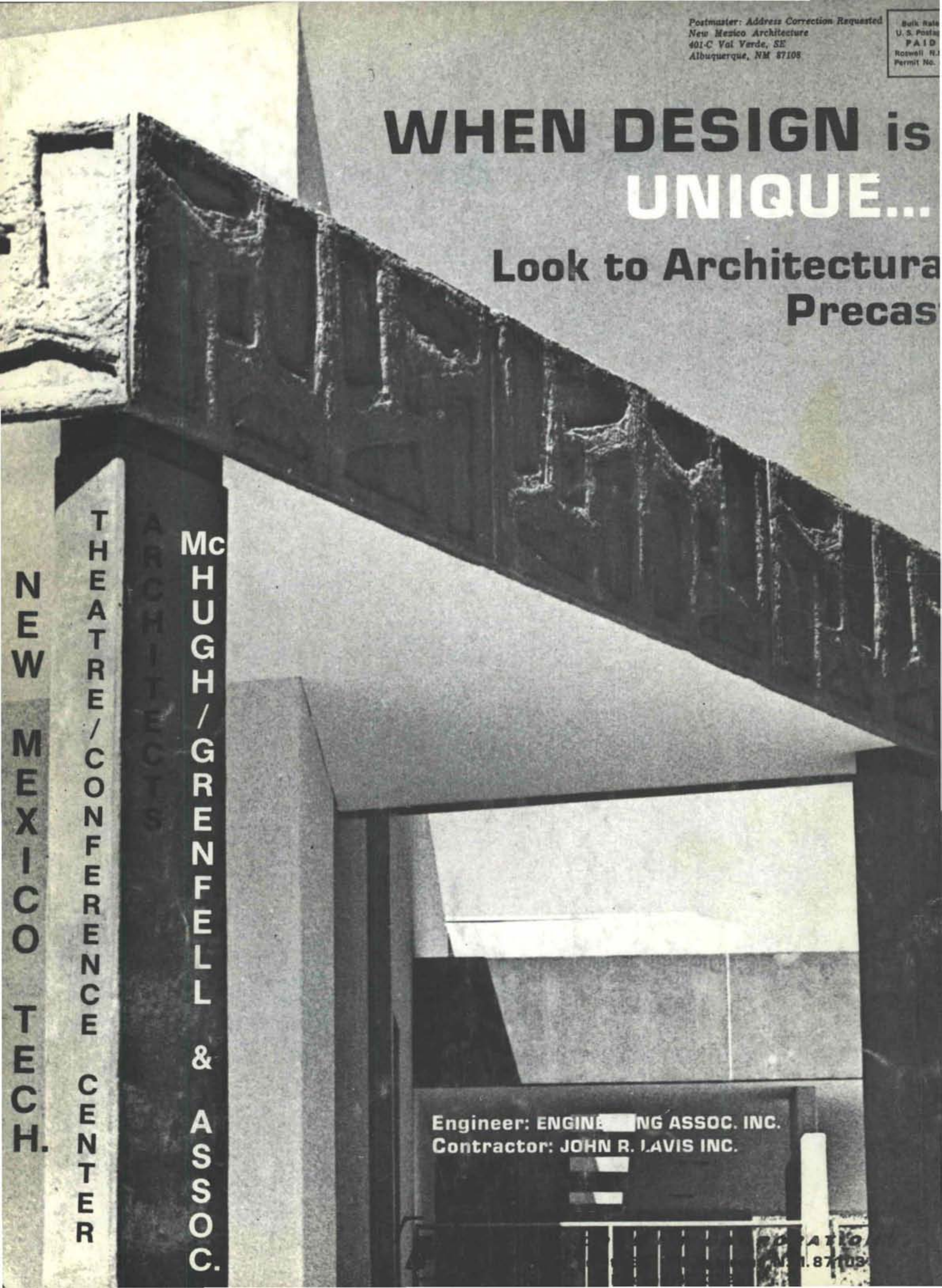
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