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Author
Lawrence Berkeley National Laboratory

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WINDOWS

For Energy Efficient Buildings

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United States
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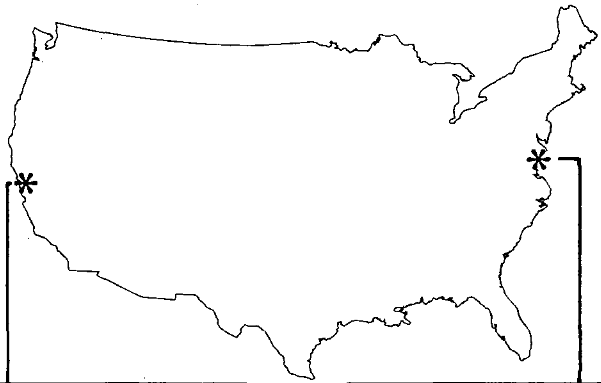
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
ENERGY & ENVIRONMENT DIVISION

Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48

Windows for Energy Efficient Buildings is available free of charge to individuals or firms involved in any aspect of the development, manufacture, and utilization of energy-efficient windows, components and accessories.

Support for this publication comes from the U.S. Department of Energy as shown below. The Energy Efficient Windows Program functions within a broader research program on Energy Efficient Buildings conducted within the Energy & Environment Division at Lawrence Berkeley Laboratory.



Lawrence Berkeley Laboratory Director: Andrew Sessler	U.S. Department of Energy
Energy & Environment Division Head: Elton Cairns	Assistant Secretary for Conservation and Solar Applications: Thomas Stelson
Energy Efficient Buildings Program	Office of Buildings and Community Systems Director: John P. Millhone
Energy Efficient Windows Program Sam Berman Stephen Selkowitz	Building Division Director: John H. Cable
Windows for Energy Efficient Buildings	Architectural and Engineering Systems Branch

Prepared by the Energy and Environment Division, Lawrence Berkeley Laboratory, University of California for the Assistant Secretary for Conservation and Solar Applications, Office of Buildings and Community Systems of the U.S. Department of Energy.

Statement of Intent

Windows are visually prominent and functionally important elements of buildings. They provide light and view; alter heating, cooling, and ventilation requirements; and affect the psychology, esthetics, and safety of building occupants.

The heat loss from windows under the worst climatic conditions (a cold winter night) has often caused windows to be considered villains in a building's energy performance. Architects and engineers generally understand, however, that by supplying solar heat in winter and natural lighting year round, windows may actually reduce overall energy consumption in a building.

This understanding is not yet reflected in design guidelines for choosing the right type, size, and placement of windows in specific buildings and climates. Building codes and voluntary guidelines still generally tend to limit or restrict the use of windows.

A primary goal of the Department of Energy (DOE) is the development and commercialization of new building design strategies, products, and technologies to improve the design, construction, and operation of energy efficient buildings. Lawrence Berkeley Laboratory is providing technical assistance to DOE by managing its energy efficient window program.

To help building industry and government efforts in research, development, and demonstration (RD&D) of new, energy efficient window products and design techniques, DOE research funds should be used to:

- Accelerate the efforts of private industry
- Complement the efforts of private industry
- Undertake research with high risk and long lead times
- Foster the acceptance of energy-saving technology
- Maximize the effectiveness of energy use
- Minimize adverse socio-economic and environmental impacts.

This publication seeks to accelerate exchange of information by: 1) bringing together inventors and manufacturers, 2) bringing new products and research results to the attention of architects and engineers, and 3) bringing "grass roots" communications to the attention of those in the complex structure of federal, state, and local energy programs. We feel that a single contact between individuals or firms resulting from information contained in this review may have considerably greater impact in advancing the commercialization of a new window product than would a substantial direct RD&D investment by DOE.

The cause of energy efficient windows is advanced by backyard inventors as well as by multi-national corporations; all readers are urged to contribute newsworthy items in any of the categories covered in this review. Your suggestions for changes in content and format are also welcome. Let us know about your experience in using information we have presented, and give us suggestions for additional features. We will also print letters, comments, and requests for information.

This publication will be distributed periodically as additional information is reviewed and compiled. Future issues will include a review of window testing laboratories and their test capabilities, and a review of fire safety issues related to windows and window coverings. The next issue will feature a review of the state of the art in daylighting design methods and applications. We are particularly interested in receiving information on buildings (new and old) which successfully incorporate effectively daylit spaces.

Please circulate this review to interested colleagues and invite them to send for their own copy.

WINDOWS

Energy Efficient Windows Program
c/o Stephen Selkowitz
Bldg: 90 Rm: 3111
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley, CA 94720
(415) 486-5605

Research & Development

Research and development (R&D) activities range from exploring obscure subjects to focusing on investigations that are directly applicable to architecture and engineering. We include the full range of activities in this section, reporting R&D projects concerned with windows and energy conservation. (The Demonstration section of this publication also contains some project reports.)

We would like our readers to inform us of additional projects, particularly nonproprietary university and private-sector projects, suitable for coverage in future issues.

ENERGY EFFICIENT WINDOWS PROGRAM PLAN

Research Organization:
Windows Program
Lawrence Berkeley Laboratory
Bldg. 90, Room 3111
Berkeley, CA 94720
(415)486-5605

Support: Office of Buildings and Community Systems, U.S. Department of Energy (DOE)

Status: First draft in progress

This program plan will lay out program tasks, priorities, and funding requirements for DOE's activities relating to energy efficient windows and skylights over the next five years. The Windows Plan will be coordinated with other DOE plans: the Thermal Envelopes and Insulating Materials Program Plan and the Passive Solar Program Plan. Input to the first draft will be requested from all major industry organizations with an interest in the plan, as well as from government organizations and professional societies with interests and concerns in this field. Copies of the resultant draft will be made available early in 1980 to those requesting them for review and comment.

WINDOW REPLACEMENT DESIGNS AND STRATEGIES FOR PRACTICAL USE BY LOW-INCOME WEATHERIZATION PROGRAM

Research Organization:
Energy Project
Office of Community Services
Department of Local Government Affairs
303 East Monroe Street
Springfield, IL 62706
(217) 782-5883
William Harris, Energy Management Adviser

Support: National Center for Appropriate Technology
Grants Office
P.O. Box 3838
Butte, MT 59701

Status: In progress

This study has been funded by the National Center for Appropriate Technology (NCAT). The project will be carried out by the Office of Community Services, Department of Local Government Services, State of Illinois.

The program objectives are to: 1) study and assess conventional and innovative window designs and strategies; 2) design and construct prototypical energy efficient window systems; 3) evaluate and test window design and construction, refining or modifying these systems for practical use in low-income weatherization-rehabilitation programs; and 4) produce a handbook for the NCAT.

ENERGY SAVING DRAPERY SYSTEM

Research Organization:
Alvin Reiner
Drapemasters of Hartford
266 Prospect Avenue
Hartford, CT 06106
(203) 523-5243

Support: Internal research and development

Status: Test installation

Drapemasters of Hartford, Inc., has completed initial testing and development of a two-layer energy-saving drape system consisting of a 70% Verel, 20% Rayon, and 10% Flax facing with a fibreglass lining. Both layers are mounted on a single special purpose rod, providing a one inch air space between the pleated facing material and the planar fibreglass lining. Each layer can be removed separately for cleaning. The Hartford National Bank & Trust has recently ordered these drapes for its 22 story headquarters in order to increase the thermal comfort of employees who sit near windows. Mr. Reiner, developer of the system, estimates that the drapes can lower interior temperatures by eight degrees in the summer and raise it by five or six degrees in the winter compared with conventional draperies. More quantitative data on energy savings will be obtained from the Hartford National Bank installation.

WINDOW SOLAR COLLECTOR/STORAGE PANEL

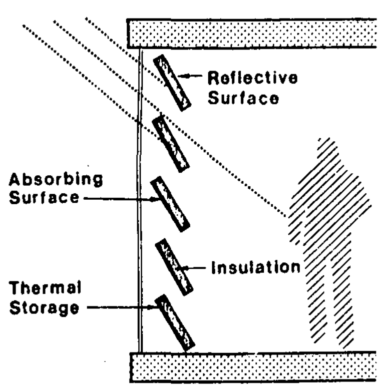
Researcher:
James Stice
RR2
Roseville, IL 61473

Support: Internal

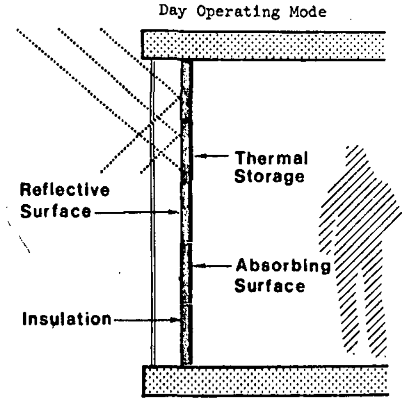
Status: Under development

The Solar Collector Storage Panel is a passive heating system which integrates thermal storage (using phase change) and insulation within one component. Placed directly behind a window in a room to be heated, the panels are rotated to control room temperatures and reduce heat loss. When heat loss through the window is greater than solar gain, the panels are closed with their thermal storage toward the room. On the other hand, when solar gain is greater than the heat losses, the panels are opened, thus allowing solar energy to enter both the room and the storage. The panel resembles a large flat shutter or venetian blind, consisting of composite trays made of compartmentalized plastic extrusions for containing the storage medium. One side of the tray has an absorptive surface, the other side is insulated and has a reflective surface.

Test results are available in an offprint (Paper 78-WA/Sol-12, $3.00 per copy) from the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y. 10017.



Day Operating Mode



Night Operating Mode

REFLECTIVE INSULATING SHUTTERS

Research Organization:
SUNSPACES
2520 Sacramento Street
San Francisco, CA 94115
(415) 922-0382

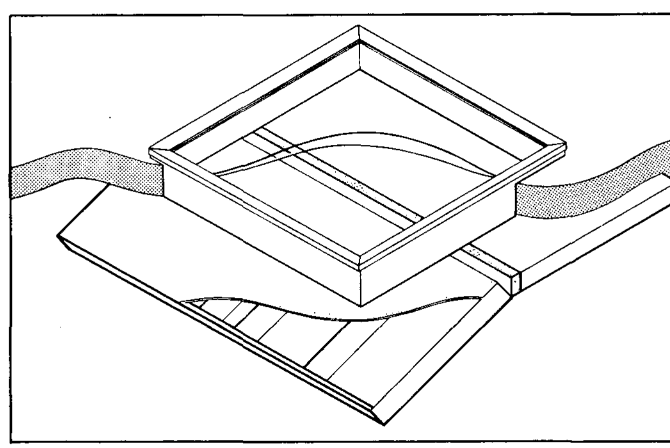
Support: Small Scale Appropriate Technology Program, United States Department of Energy & the California Office of Appropriate Technology

Status: Research project completed

Reflective insulating shutters are used to control direct sunlight entering a clerestory or skylight. This project summarizes the daylighting and thermal characteristics of these shutters and describes their construction, installation, and control.

Materials and construction are described for: 1) Seals; 2) Reflective Upper Skin; 3) Internal Reinforcements; 4) Interior Baffles; 5) Lower Surface and Perimeter; 6) Support Beam; 7) Hinges; 8) Brackets; and 9) Controls.

Copies of this report are available from Nyle Werthman at Sunspaces for $2.50 each.



INTERNAL/EXTERNAL MOVEABLE INSULATING DEVICE

Research Organization:
Raymond N. Auger
Solar Power West
709 Spruce St.
Aspen, CO 81611
(303) 925-4698

Support: Internal

Status: 85 units installed and under test

Sol-R-fold is a movable insulating device that can be mounted internally or externally to the window. The device consists of sections of one-inch-thick rigid insulating board hinged together at the long edge so that the assembly rolls up into a rectangular bundle at the top or side(s) of the window. The insulating board may be painted or covered with wallpaper or fabric. The unit seals tightly to the window frame reducing air infiltration and noise transmission.

Units are currently undergoing field test and evaluation.

WINDOW THERMAL BARRIER

Research Organization:
Harold E. Clark
Solar Living Industries, Inc.
c/o RFD # 3
Georgetown, MA 01833

Support: Internal

Status: In development phase

This project involves the development of the Thermoblind*, an accordion-fold thermal insulating curtain for windows (patent applied for).

The Thermoblind curtain is mounted on the inside of the window in the space typically occupied by a venetian blind. The curtain is 2 inches thick and composed of multiple "trapped" air spaces which minimize conductive heat transfer losses. A special sealing bellows inside the vertical casing channel minimizes infiltration losses.

The outermost plastic fabric is designed to provide structural integrity and to allow controlled accordion-folding with no change in the 2-inch thickness of the curtain.

Calculations of the performance of the Thermoblind in conjunction with a single pane window indicate a U-value of 0.12 Btu/hr-ft^2-°F. For the Thermoblind made with semi-transparent fabric, the U-value is calculated to be 0.22.

*Thermoblind is a trade name of Solar Living Industries, Inc.

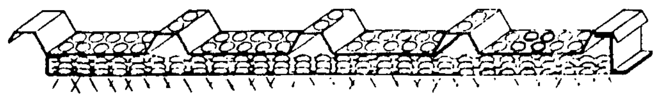
PERFORATED SKYLIGHT PANEL

Research Organization:
Arthur H. Middleton, AIA
160 Grand View Avenue
San Francisco, CA 94114
(415) 282-8805

Support: Internal

Status: Under development

The Sky*Perf Perforated Skylight Panel has been developed to provide light transmitting metal panels for the metal building industry, which supplies pre-engineered, pre-fabricated metal buildings for commercial and industrial requirements. The panel is a metal and fibreglass composite, providing illumination without sacrificing structure or durability. The traditional metal panel is perforated, and a coating of transluscent fibreglass resin is applied, admitting 40% to 55% of the incident light. By providing structural integrity for these monocoque building systems, light can be admitted while seismic and wind resistance is retained. This overcomes the structural disadvantage of traditional window panels in pre-fab metal systems.



An insulated version of Sky*Perf is also available, containing a layer of transluscent insulation beneath the metal panel. The visual light transmission is somewhat reduced (15-25%) but a U-value of 0.30 Btu/hr-ft^2-°F is attained.

WINDOWS

Demonstrations & Applications

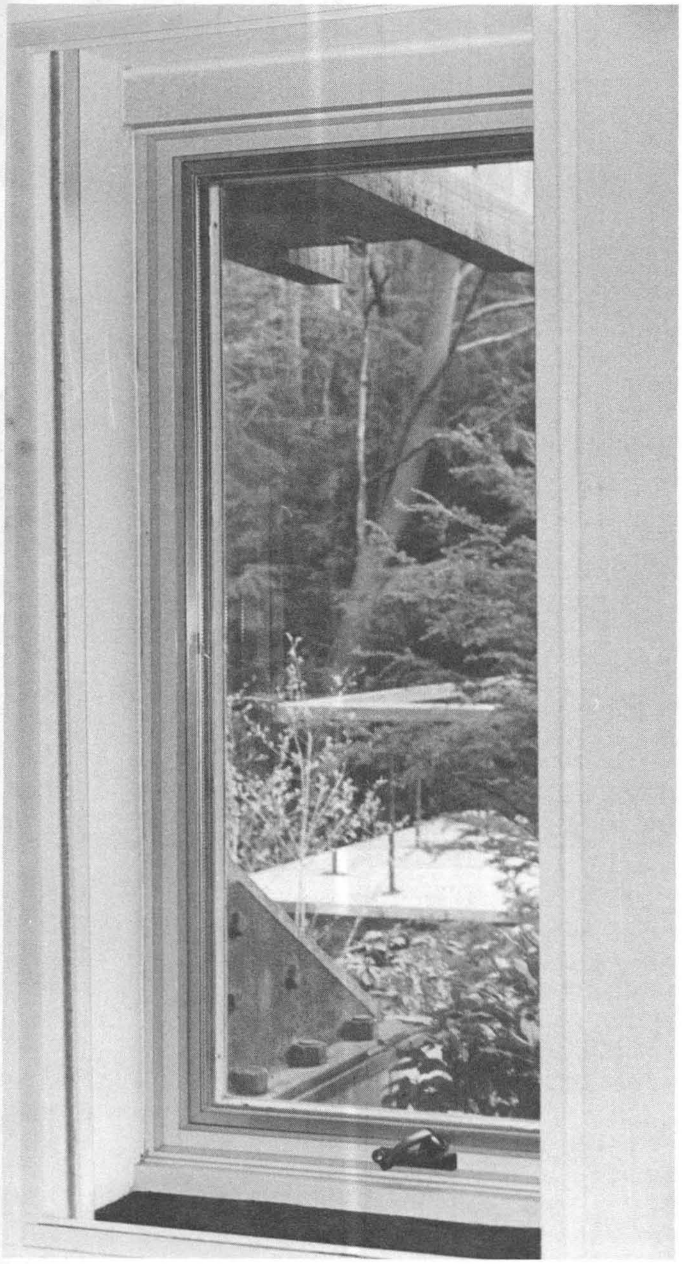
Although laboratory measurements of the thermal performance of new products provide data for researchers and scientists, they frequently do not provide architects and engineers with a sense of how a product really performs in a building.

Demonstrations give designers and specifiers performance details they need before deciding to use a new product—particularly information on long-term performance of devices used to save energy.

We would appreciate information about completed, ongoing, or planned demonstrations incorporating energy-efficient windows, skylights, and accessories.

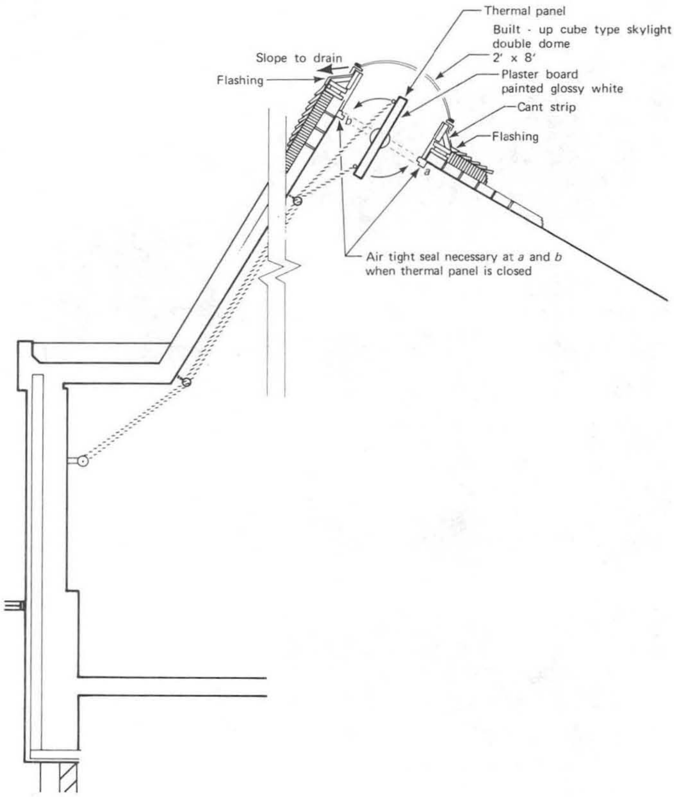
THE CARY ARBORETUM OF THE NEW YORK BOTANICAL GARDEN,
Millbrook, New York

The Cary Arboretum, a 27,400 sq. ft. plant science research facility, uses numerous energy conservation and solar energy innovations. Movable window and skylight insulation devices have been incorporated into the building's glazing systems. These devices play



a central role in reducing the building's heat loss and in providing a more efficient use of solar energy for spacing heating.

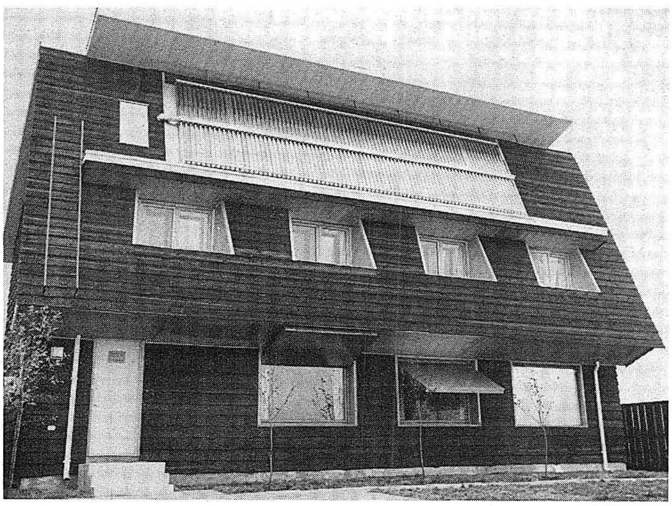
The sliding window insulating panels have been designed to slide at fingertip pressure and to withstand daily opening and closing without any loosening or wear. The weatherstripping detail is important and requires good installation workmanship to get a tight fit. Panels are 1-inch rigid insulating board with a vinyl coated fabric covering. Some bulging occurred in the larger sliding door panels due to moisture freezing on the outside, making panel operation difficult in both single and multi-panel situations. The skylight panels have been designed for manual operation using a loop of ½-inch rope for pivoting the shutter. The panels are made of a 2-inch core of Owens Corning #705 rigid foam with glasstrate hardboard surfaces in a rigid, steel reinforced wood frame, covered with the same Victrex perforated vinyl fabric as the sliding wood panels. Both panel systems were fabricated by the Capital Cabinet Corporation, 252 B Lake Avenue, Yonkers, N.Y. 10701.



Architect: Malcolm Wells
Consulting Engineer: Dubin Bloome Associates
Capital Projects Manager: The Carey Aboretum of the New York Botanical Garden
Box AB
Millbrook, N.Y. 12545

SASKATCHEWAN CONSERVATION HOUSE,
Regina, Saskatchewan, Canada

In the snowy north, where annual Farenheit degree-day averages exceed 11,000, substantial passive gains may be attained from an abundance of both direct sunlight and solar energy reflected from the snow covered ground. An energy conserving demonstration project, directed by the Saskatchewan Department of Mineral Resources, has survived its first Canadian winter with minimal fuel consumption. Among the many energy conserving features of the project are the primarily south-orientated glazing units that are protected by two types of insulating shutters. On the lower level, double glazed units are protected by a motorized, top-hinged exterior shutter which opens under an overhang during the day. The shutter is a sandwich of 6 inches of polystyrene with an aluminum casing and has thermal resistance of R-22. The upper units are triple glazed, with an internal sliding shutter that recedes into a wall pocket. The shutter is situated inside a 4-inch space, between the outermost and middle panes.

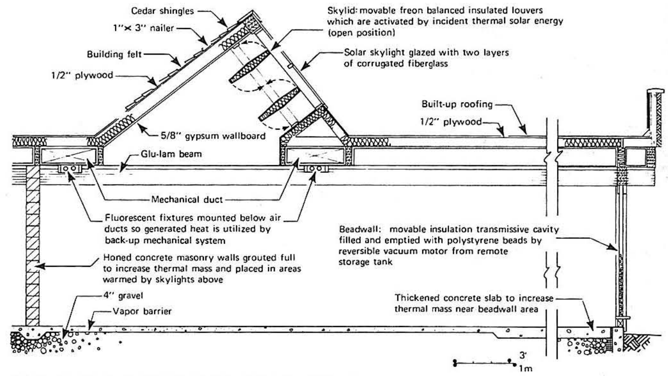


Fact sheets are available from:

Heather Sanguins
Office of Energy Conservation
Saskatchewan Mineral Resources
1914 Hamilton St.
Regina, Saskatchewan S4P 4V4
CANADA

PITKIN COUNTY AIRPORT TERMINAL
Aspen, Colorado

A large scale application of two window-insulating products has been incorporated into the construction of a 17,000 sq. ft. air terminal at Aspen, Colorado. According to project designer Larry Yaw, the passive solar approach incorporating the Beadwall and Skylid systems (developed by Zomeworks) provides 40-45% of the space heating requirement. The Beadwall uses a double glazed window with a wide air gap which is filled with (or emptied of) anti-static treated polystyrene pellets by a reversible vacuum motor and a remote storage tank; the Skylids are movable freon-balanced insulating louvres, which are activated by incident solar energy. The weak link in the system is human—not remembering to throw the switch on the beadwall. The architect would recommend automatic controls for



TYPICAL CROSS SECTION THROUGH PITKIN COUNTY AIR TERMINAL

installations of this scale as justifiable investment.

For further information contact:

Copland Finholm Hagman Yaw Ltd.
P.O. Box 2736
Aspen, Colorado 81611

WINDOWS

Contracts

Although research, development, and demonstration activities are supported mostly by the private sector, some support for improved window design is provided by the U.S. Department of Energy, and state and local governments through contracts.

This section contains information about contract opportunities and recently awarded contracts in the field of energy efficient windows.

Program Opportunity Notices

Three Program Opportunity Notices (PON) have recently been issued in the Passive Solar Energy field. Each may present contract opportunities to developers of efficient window systems. The "Windows" mailing list has been provided to the DOE Passive Solar Program office so that timely notification of these and other related contract opportunities may be provided to our readers.

The three PONs cover the following areas:

- Marketable Products (Closing date — February 7, 1980)
- Commercial Buildings (Closing Date — August, 1979)

- Manufactured Buildings (Closing Date — July, 1979)

Copies of these and future PONs can be obtained from:

Department of Energy
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439

Related information can also be obtained from the National Solar Heating and Cooling Information Center. The Center can be contacted by calling toll-free: 800-523-2929 (in Pennsylvania, 800-462-4983; in Alaska and Hawaii, 800-523-4700). The mailing address of the Center is P.O. Box 1607, Rockville, MD 20850.

Marketable Products

This PON solicits proposals for product development and product commercialization activities for passive (and hybrid) solar heating and cooling systems. Proposals will be accepted from firms which currently manufacture and market products whose application to passive solar systems have not yet been thoroughly explored, from firms which currently manufacture products which might be applicable to passive solar systems if appropriately modified, from individuals and firms who have conceptual or schematic designs for new products, and from individuals or firms who have design concepts for site-built assemblies which will simplify the architectural or engineering specification of passive solar systems. These may include windows and skylight systems, as well as appropriate components and accessories.

Pure research activities, by themselves, will not be eligible for support under this PON; the goal is to sponsor only those efforts which have a high probability of leading to commercial products in the near term. However, research activities which are part of a full product development and commercialization plan will be considered for support.

Two of the primary barriers to early commercial availability of passive systems are: (1) the lack of readily available components and assemblies specifically designed for these applications and (2) the lack of information regarding the use of existing products in these applications. This PON is intended to address both of these barriers. Initially, projects will be supported in any of four phases which span the product development and commercialization process: preliminary design, design development, engineering field testing, and commercialization. Upon successful completion of this entry phase, it is anticipated that follow-up support will be available for selected contractors to complete all subsequent phases of the process.

Manufactured Buildings

This PON provides an opportunity for manufacturers to propose the incorporation of passive solar energy concepts in their manufactured building product lines. Adaptations of window and skylight systems designed to provide both thermal benefits and daylighting are considered under the scope of this PON. Financial assistance will be provided by DOE for:

Phase 1: Design Development
Phase 2: Prototype Fabrication/
Assembly and Engineering
Field Tests
Phase 3: Test Marketing

Commercial Buildings

This PON provides an opportunity for interested parties to propose commercial (non-residential) integrated passive solar energy demonstration projects. Prior PON's have supported development and demonstration of passive systems in residential buildings. This PON is intended to stimulate public interest, designer understanding, and client awareness of the potential of passive system use in commercial buildings. Due to the importance of lighting loads in commercial buildings, daylighting is explicitly identified as a passive solar technique for the purposes of this PON.

DOE anticipates that these demonstration projects will follow a three phase process:

Phase I - Design
Phase II - Installation
Phase III - System Evaluation and
Commercialization

Other Opportunities

The residential passive solar demonstration program is administered by the Department of Housing and Urban Development (HUD), which will be issuing requests for residential integrated demonstration projects. Information on these solicitations can be obtained from:

Solar Energy Staff
Room 8158
HUD
Washington D.C. 20410

Proposals for Health Care Facilities are administered by the Department of Health, Education and Welfare (HEW). For information on this program contact:

Department of Health Education and
Welfare
Health Resources Administration
Energy Action Staff, Room 10-20
Center Building
3700 East-West Highway
Hyattsville, MD 20782

New Products, Materials, & Components

Studies that identify potential energy savings with improved window design and window products will have little effect if: (1) building designers do not incorporate the improved designs in new and renovated buildings, and (2) if new and improved materials and products are not specified by building designers and consumers. It is the purpose of this section to bring new and potentially energy-conserving window products, materials, and components to the attention of designers, researchers, manufacturers, contractors, and do-it-yourselfers.

It is our desire to provide exposure for new window related products, particularly those which are not highly publicized elsewhere. The intent is not to "advertise" products but rather to inform readers about them and provide a source for further information. Although we review a substantial number of trade periodicals, we must still rely on contributions from readers to supply new product information for upcoming issues. We will include information on materials and components which we believe may have limited but important implications for some aspects of innovative window design.

Future issues will contain product sections that focus on a particular class of products, just as insulating products are emphasized in this issue. Over a longer period of time we will generate a sourcebook of all window related, energy-conserving products. In addition to these products, this section will contain information on design aids such as slide-charts and computer programs — useful in the design of energy efficient window systems. Finally, we will provide information on test and measurement devices for the benefit of those engaged in laboratory and field testing, or in other aspects of product evaluation.

Although products are listed here under appropriate headings, many products are designed for multiple functions and might well be listed under two or more headings. Manufacturers, distributors, and retailers should be consulted for information on price and availability. Note that some products are in development or are being marketed on a test basis and may not be available.

In this issue we feature window insulating products and systems. To assist the reader in comparing related

products we describe general design and performance issues relative to insulating products and have summarized key product design and performance attributes in the Table on page 41. Since the array of available products is expanding rapidly, it is difficult to keep abreast of all newly offered products. Many similar or even identical products are offered under different product names by different distributors. For completeness, we have repeated several product descriptions which were shown in Volume 1, Number 1 of this publication.

We solicit comments regarding the format and content of this section and suggestions for the content of future issues.

WINDOW INSULATION PRODUCTS

In order to minimize the energy costs associated with windows, it is generally desirable to minimize winter thermal losses. In recent years there has been a major shift in patterns of prime window sales, with double glazed units now accounting for over 60% of annual sales nationwide, and triple glazing capturing over 20% of the market in the northernmost states. In addition to multiple glazing and storm windows there is a wide variety of window insulating options available to a building designer for new construction, and to an owner and/or occupant for existing buildings. The use of conventional drapes, shades, and blinds to reduce heat losses is well known.

The array of available insulating options has been enlarged by the appearance of numerous new window insulating products. Some of these are static (fixed) devices — others are designed to be deployed over the window on a daily or seasonal basis. Many of the new products are variations on traditional roller shades, shutters, or storm windows. Two "new" classes of products have appeared: roll-up insulating shutters (which have been used extensively in Europe and now are being marketed in the U.S.); and low emissivity plastic films (which reduce the heat loss rate by reducing radiative heat transfer) which are now marketed by several solar control film manufacturers. Intended for solar control, they have low shading coefficients and thus reflect a substantial fraction of the incident solar radiation. However, they break ground for more transparent low-emissivity coatings ("heat mirrors") that should be available in the next 1-3 years.

Window insulating devices have certain common characteristics and a common set of *potential* flaws. An insulating layer (air gap, rigid board, flexible batt, multilayer films, granular materials, etc.) reduces heat loss associated with conductive, convective and radiative flows, and mass transfer. The insulating layer may be located in three positions relative to the existing glazing: internally, externally, or between glass. Many of the simpler devices such as interior and exterior storm windows may be installed "permanently" (or changed seasonally). Other types of insulating devices require "active" window management on a daily basis. When not in use, the insulating material slides, rolls, collapses, folds, or is otherwise removed from the window. Control and deployment of the devices may be initiated by automatic or manual means.

In addition to providing winter insulation, these devices may provide sun control, reduce infiltration, and fulfill requirements for privacy, security, thermal comfort, and aesthetics. This section focuses on approaches for reducing undesired winter heat losses.

Several important issues concerning potential performance flaws arise in any discussion of window insulating products. These are identified briefly below and should be considered when evaluating the products listed at the end of this section.

Condensation: Insulating devices placed on the interior of an existing prime window will reduce glass temperatures and increase the likelihood of condensation. The magnitude of this effect will depend in part on the degree of air leakage around the insulating device and the prime window. Severe condensation problems may be evidence of excess humidity in the building.

Infiltration/Air Leakage: Infiltration through poorly fitting windows is a major energy loss factor in many buildings. Tight fitting window thermal barriers will substantially reduce this loss. Significant air leakage around the edge of the insulating device may negate its nominal insulating value. Since many of these devices have extensive moving surfaces, seals and air leakage at the edges will be critical design problems.

Overheating: Many insulating devices may be left in place or utilized year round. If the device seals effectively to the window, overheating may occur when the sun strikes the window while the device is deployed. This is particularly true if the device is opaque or semi-transparent. Unless provision is made to vent the accumulated heat, the insulating device, window, and all adjacent components must be designed to withstand the resultant high temperatures without failure or degradation.

Fire Safety: Many window insulating devices incorporate substantial quantities of plastic foams, plastic films, and synthetic fibers. If used improperly these may constitute a smoke and fire hazard. Material properties, total flammable mass, and extent of coverage are all important factors in assessing fire safety.

Operational Reliability: Although many movable insulating devices might be automated and motorized, cost constraints make it unlikely that single windows will be automated in a cost-effective manner. Thus, if potential savings are to be fully realized, movable insulating devices must be closed and opened conscientiously. The degree of user responsibility is critical because a fixed permanent solution with low thermal resistance will perform better than a device with higher thermal resistance which is deployed only occasionally. One solution is to couple the deployment of the thermal insulating device with an action that will be routinely taken to achieve thermal comfort or privacy. For example, if the roll-up shade that is pulled to provide privacy has good insulating qualities, the thermal benefits will accrue on a regular basis. Effective energy conservation will be promoted and accelerated by coupling new thermal control functions to existing habits and lifestyles wherever possible.

Thermal Comfort: Like any other window with good insulating properties, if air leakage is reduced and interior surface temperatures rise, thermal comfort will be increased, particularly in the vicinity of the window. An equivalent level of thermal comfort can be achieved at lower air temperatures when drafts are eliminated and the mean radiant temperature of the room surfaces is raised. Occupant acceptance of lower air temperatures results in additional energy savings.

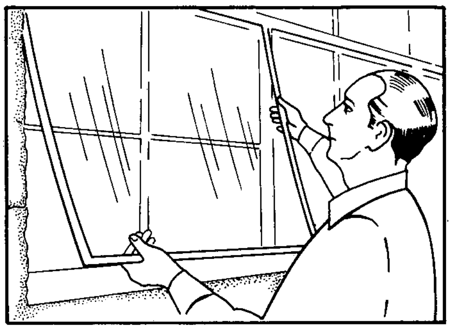
The following two sections focus on interior and exterior systems of some typical window insulating products. The listing is representative of the state of the art; however, it is not complete. The products in these sections are divided into two main groupings — internal and external devices. They have wide implications, not only for energy saving aspects, but for such design concerns as privacy, ergonomics, aesthetics, etc. We wish to thank manufacturers who provide us with information for this section of WINDOWS.

Products that are used as exterior or interior thermal barriers are tabulated on Page 41 for easy comparison.

Window Thermal Barriers/ Interior Systems

STORM WINDOWS

Interior Storm Window, Plastic. This is an interior storm window system for residential, commercial, and industrial applications. For residential purposes, .065 inch clear acrylic is used and is sold in 30 stock sizes. Custom sizing with clear or bronze tint is available in .080-inch acrylic for residential/commercial market. For custom commercial/industrial applications, .125-inch to .250-inch acrylic is available. The permanently mounted, operable units come with gasketed acrylic frames to reduce air leakage.

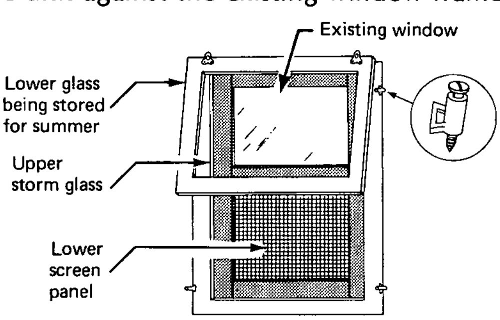


(Thermatrol® Storm Window, Perkasie Industries Corp., 50 East Spruce St., Perkasie, PA 18944, 215/257-6581)

Interior Storm Window, Flexible Plastic. The interior storm window uses a .015-inch flexible PVC film stretched over an aluminum frame.

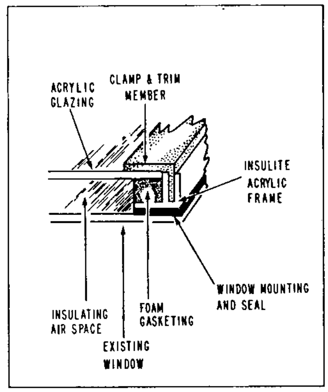
(Vinyl Therm, Insulated Pane Industries, Inc., 2227A Heybourne Rd., Minden, NV 89423, 702/782-5479)

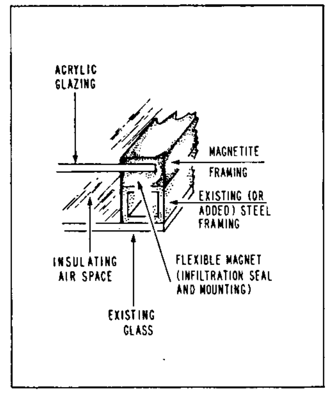
Interior Storm Window, Glass Panels. The lower glass panel of this interior storm window may be replaced with a screen for summer use. The glass is held in an aluminum channel frame with a vinyl gasket. Vinyl weatherstripping is used to seal the unit against the inside casing of the original window. Spring loaded clips hold the unit against the existing window frame.



(Kent Air Control Panel, Kent Air Control, Inc. 19 Belmont St., South Easton, MA 02375, 617/238-1453)

Interior Storm Window, Rigid Plastic. This product incorporates clear or tinted acrylic glazing in an acrylic frame which is attached (adhesively fastened) to an existing window. A variation uses a strip magnet to hold the unit against either an existing steel frame, or an add on steel strip.



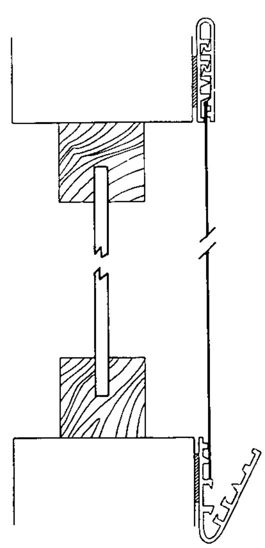


(Insulite, Magnetite, Northeast Energy Corp., 11 Beacon St., Boston, MA 02108, 617/523-5632)

Interior Storm Window, Flexible Plastic. Polyester film is stretched across an extruded plastic frame to form an interior storm window.

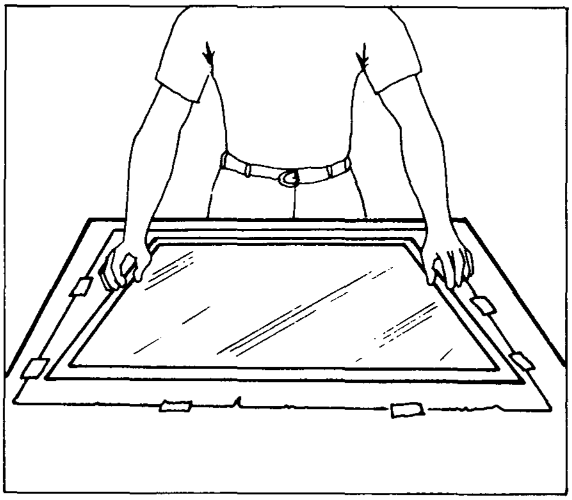
(Window Film™. Thermotech Corp., 410 Pine St., Burlington, VT 05401, 802/658-6230)

Interior Storm Window, Rigid Plastic. Styrene or acrylic sheet is set in a vinyl mounting trim which attaches to the prime window with an adhesive backing strip. Glazing panel may be removed from trim for cleaning or summer storage.



(In-Sider® Storm Window, Plaskolite, Inc. P.O. Box 1497, Columbus, OH 43216, 800/848-9124)

Exterior/Interior Storm Window, Plastic Film. This storm window kit consists of Flexigard laminated film, double adhesive backed tape, foam tape, aluminum frame, and corner brackets. The film is composed of a high strength polyester laminated to a weather resistant acrylic film with a total thickness of .011 inches. It is suitable for indoor or outdoor application.



(Flexigard Storm Windows, Special Enterprises Department/3M, 223-2 3M Center, St. Paul, MN 55101, 612/733-0306)

MULTIPLE GLAZING

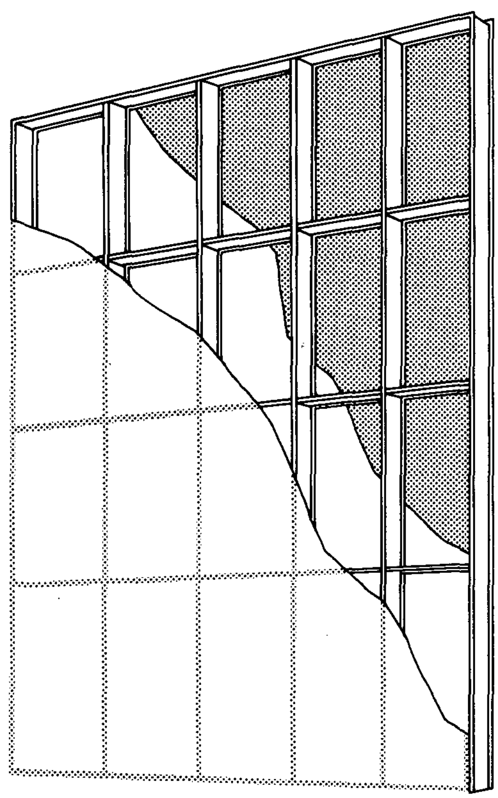
Conventional Multiple Glazing. Double and triple glazing (and occasionally even quadruple glazing) are finding increased application in new construction and renovations. Two general approaches are used: 1) sealed insulating glass which incorporates glass to glass or polymeric sealant systems, or 2) multi-glazing units in which the second (or third) glazing layer is removable. Multiple glazing with very small air gap spacing may contain a non-air gas fill to improve thermal performance. Sealed insulating glass systems do not require additional cleaning and will not have condensation problems as long as the seals remain intact. Air space dimensions are typically small. Heat transfer rates are further reduced if low emissivity solar control coatings are applied to the glass surface facing the air space. Double glazing with removable sash typically allows wider air gaps and the inclusion of venetian blinds or other devices. Air movement into the air gap must be controlled to minimize condensation.

(Glass Manufacturers, Insulating Glass Manufacturers, Window Manufacturers)

Low Conductance Insulating Glass Assembly. This sealed insulating glass system utilizes a low thermal conductivity gas fill between coated glass panes of relatively high solar transmittance. Type 1.4 has a warm coloring and a U-value of about 0.28 Btu/hr-ft^2-°F. Type 1.6 is almost neutral in color and has a U-value of approximately 0.32. Note that these values are less than those of conventional triple glazing. Both windows have a light transmittance of 60-65%.

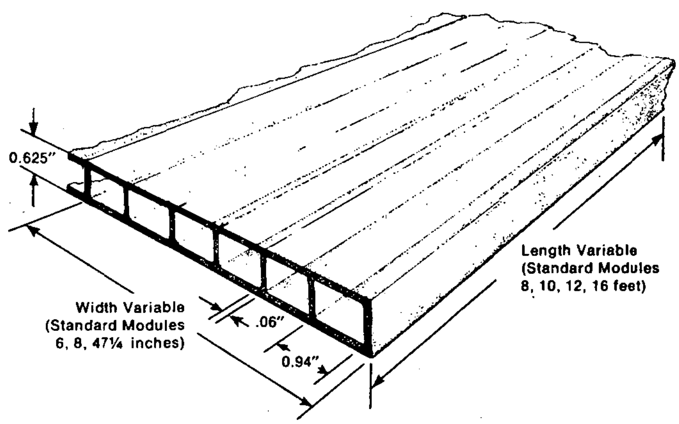
(Thermoplus, Flachglas AG, Auf der Reihe 2, P.O. Box 669, D-4650 Gelsenkirchen, West Germany)

Translucent Sandwich Panel. Two sheets of translucent fiberglass bonded to an aluminum grid core structure. The resultant air gap (1-9/16 in. to 11 in.) is filled with varying amounts of fibrous insulation to reduce heat loss (U ranges from 0.4 to 0.06 Btu/ft^2-hr-°F) thereby reducing solar transmission as well. (Light transmission: 60% to 1%)



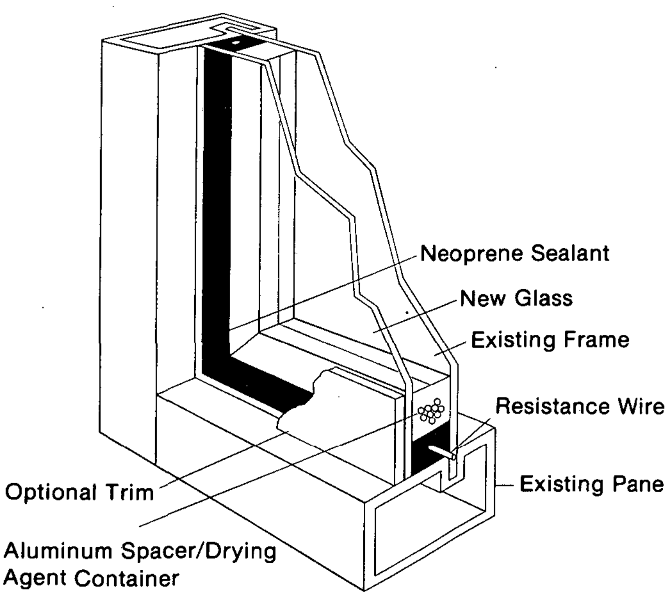
(Kalwall®, Kalwall Corporation, 1111 Candia Rd., P.O. Box 237, Manchester, NH 03105, 603/627-3861)

Double Wall Plastic Glazing. Acrylic or impact resistant polycarbonate for windows, skylights, and partitions; clear or tinted translucent plastic provide visible transmission up to 83%; U-values of approximately 0.58 Btu/ft^2-hr-°F. Some specialized hardware is available although the panes can be used with standard commercial fittings.



(Alkcobar, Alkco Manufacturing Company, 734 North Pastoria Avenue, Sunnyvale, California 95086, 408/7333344 ● Acrylite, SDP, and Polycarbonate, SDP, CY/RO Industries, Wayne, New Jersey 07470, 201/839-4800)

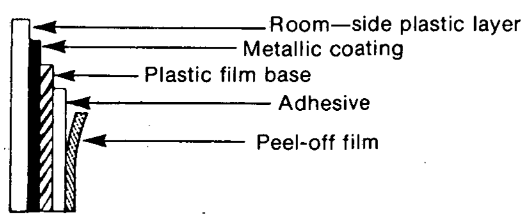
Retrofit Insulating Glass System. This retrofiting glazing system converts single glazing to sealed insulating glass. An electrical heating wire is embedded in a neoprene sealant which is used to attach a desiccant-filled aluminum spacer and second sheet of glass to the existing glazing. A low voltage electric current cures the neoprene to produce a permanent seal.



(Energy Seal Thermal Add-A-Pane System, 1 North Wacker Dr., Chicago, IL 60606, 312/263-3132)

INSULATING WINDOW FILMS

Insulating Window Films, Self-Adhesive. Solar control plastic films which are glued to windows prevent solar energy from entering a room by two mechanisms; some are absorbtive (which allows some of the absorbed energy to enter the room), other higher performance (lower shading coefficient) films are reflective (See WINDOWS, Vol. 1, No. 1, p. 10). The reflective films utilize a thin vacuum-deposited aluminum layer, which is thick enough to reflect most of the solar radiation, but sufficiently transparent in the visible region to see through. Because the aluminum layer also reflects long wave (infrared) radiation from room temperature surfaces, the films reduce the winter U-value of glazing by about 10%. By altering the properties of the roomside plastic layer which protects the aluminum coating, the thermal infrared reflective properties of the film are enhanced and the U-value is further reduced. The films achieve a net emittance of 0.2-0.25, with a corresponding U-value of about 0.82 Btu/hr-ft^2-°F under standard ASHRAE conditions. Note that the U-value will be lower (about 0.7) if the outdoor temperature is mild, rather than cold.



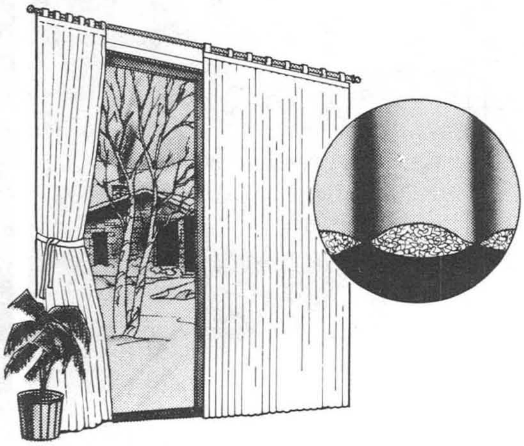
(3M Company, Energy Control Products, 3M Center, Saint Paul, Minnesota 55101, 612/733-1110 ● Madico, 64 New Industrial Parkway, Woburn, Massachusetts 01801, 617/935-7850 ● Solar-X Corporation, 25 Needham Street, Newton, Massachusetts 02161, 617/244-8686 ● National Metallizing Division, Solar Control Products, Standard Packaging Corporation, Cranbury, New Jersey 08512, 609/655-4000)

DRAPERY, PANELS, AND SHUTTERS

Conventional Drapery. Drapes form a radiation barrier when closed over a window but must provide a relatively air tight seal (by touching the floor or window sill) in order to achieve a significant performance improvement. It is difficult to estimate savings due to the wide variation in installation practice and materials properties.

(Multiple Sources)

Drapery, Quilted. Quilted polished cotton filled with polyester is energy and noise absorbing, and it is claimed to have a thermal resistance of R-2. Available in standard and custom sizes in three colors.



(windowBlanket®, windowBlanket Co., Inc., Route 1, Box 83, Lenoir City, TN 37771, 615/986-2115)

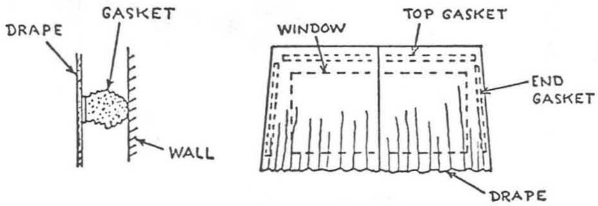
Drapery Liner/Shade. An opaque aluminized polyester material is hung with grommets from a drapery rod and incorporates interlocking tabs to reduce air leakage at the side. The unit provides summer sun control in addition to winter heat loss reduction. The same material is also available as a roll-up shade which comes with a bracket which allows the shade to be reversed (either side facing the room).

(Wind-N-Sun Shield, Commercial Drape and Design Co., P.O. Box 1434, 464 N. Harbor City Blvd., Melbourne, FL 32935, 305/725-7291)

Drapery Liner/Shade. The product is made from aluminized polyester, embossed with vertical ribs to provide stiffness. It provides summer sun and glare control, as well as winter heat loss reduction. Also available either as a roll-up shade or an interior window insulating panel.

(NRG Drapes, NRG Shield, Inc., 288 Willow Drive, Levittown, PA 19054, 215/943-8850)

Drapery Gasket. This flexible, self-sticking gasket is meant to be applied to the top and sides of drapes in order to provide a better seal against the wall and thus reduce air infiltration.

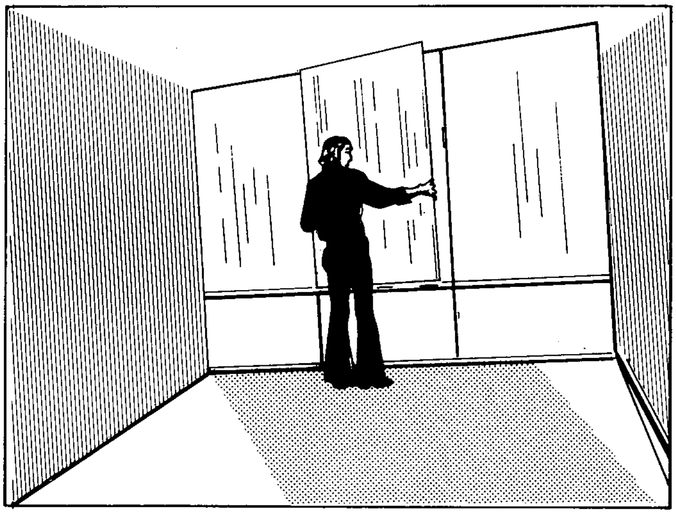


(Fluff Gasket, D. Russell and Assoc., 110 Riverside Ave., Jacksonville, FL 32202, 904/356-2654)

Interior Insulation Panel, Manufacturing Instructions. Plans are available to produce a panel made from rigid insulation board, black on one side and white on the other. This is inserted against the window for increased thermal resistance, as well as desirable reflection/absorption of solar energy and room radiation.

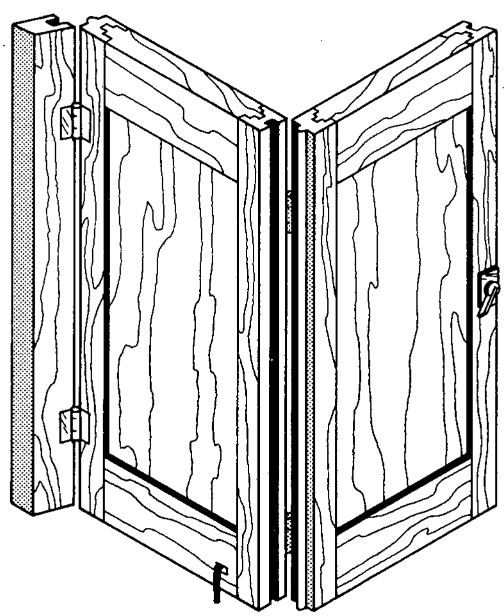
(Solar Insolator/Insulator Panel, Solpub Co., P.O. Box 2351, Gaithersburg, MD 20760)

Movable Insulating Window Panel. Sheets of beadboard plastic insulation are cut to size and deployed over windows at night. They are held in place against the glass or window frame by magnetic clips. The panels are removed from the glazing during the day and stored.



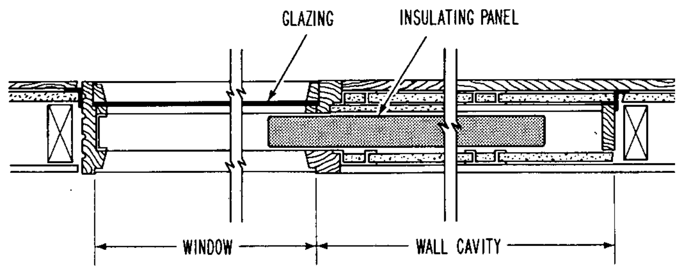
(Nightwall, Zomeworks, P.O. Box 712, Albuquerque, NM 87103, 505/242-5354)

Interior Folding Shutter. This interior folding insulated shutter system incorporates a rigid polyurethane foam core between birch plywood panels. The unit is supplied with an integral wood frame lined with a flexible foam infiltration barrier to ensure a tight seal on all sides. Available in standard or custom sizes.



(Insul Shutter, Inc. P.O. Box 338, Silt, CO 81652, 303/876-2743)

Window/Sliding Insulating Panel. The Sunflake window system incorporates a movable insulating panel (rigid urethane) which is stored in a pocket concealed in the adjacent wall and deployed on the interior side of single glazing when desired. The sliding urethane panel (1¾ in. thick) is covered with a UV stablized plastic shell and slides in an extruded track system which is designed to minimize air leakage around the shutter. Locked in place, the insulating shutter acts as a security panel. The rough wall opening must be twice the size of the desired glazed area. Available in both a casement version and picture window version.

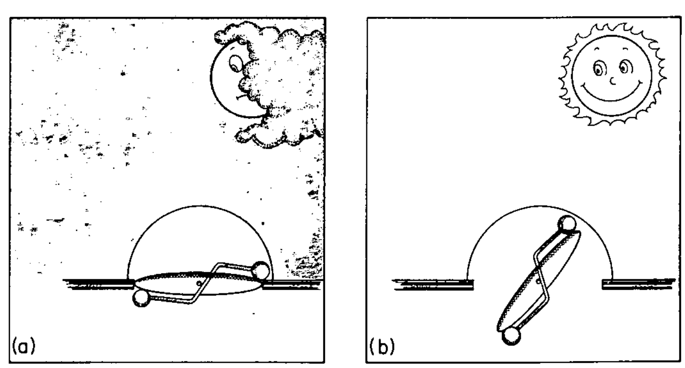


(Sunflake Window, 625 Goddard Avenue, P.O. Box 676, Ignacio, CO 81137, 303/563-4597)

Interior Shutter, Heater. This is an interior shutter with air flow channels that allow room air to circulate through the shutter and return to the room delivering some of the heat absorbed by the shutter. When opened the shutters allow the window to function normally.

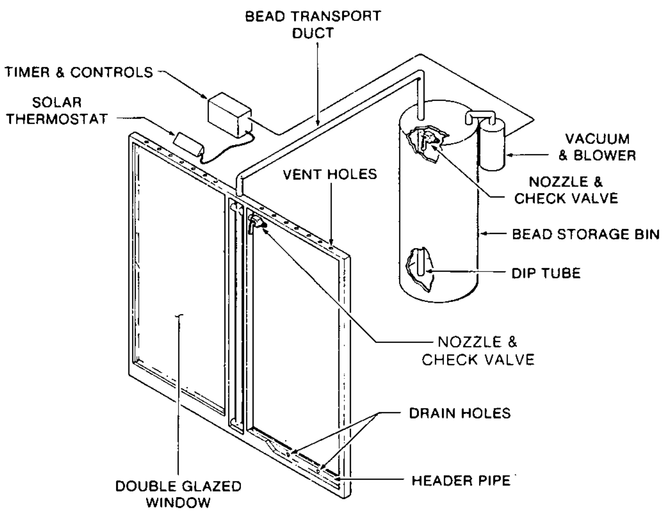
(Window Solar Heater/Thermal Barrier, Solar Master, Inc., 223 E. Knight Avenue, Collingswood, NJ 08108, 609/854-2960)

Interior Shutter, Automatic. This is a movable insulating interior shutter, well-suited for insulating skylights. The device is automatically operated by the movement of Freon between two reservoirs.



(Skylid, Zomeworks Corp., P.O. Box 712, Albuquerque, NM 87103, 505/242-5354)

Window Cavity Insulation. A double glazed window with 2-in. to 3-in. air gap. Polystyrene beads fill the cavity when a blower is activated (automatically or manually) and are removed by suction when the blower is reversed.



(Beadwall, Zomeworks Corp. P.O. Box 712, Albuquerque, NM 87103, 505/242-5354)

SHADE AND BLIND SYSTEMS

Interior Roller Shades, Conventional. This well established class of products provides sun control and insulating functions in addition to visual privacy. The insulating value is maximized if: 1) the shade is tight fitting and 2) a metallized surface faces the air space. Available in a very wide range of materials, textures, colors, patterns, and sizes. May be used in vertical, tilted, or horizontal applications.

(Multiple sources)

Single Layer Metallized Interior Shades. Semi-transparent roller shades, available in tinted (heat absorbing), reflective, patterned, and perforated versions, are sold primarily for solar control. A tight fitting aluminized shade will add approximately R-2 to a window when rolled down.

(Plastic View Transparent Shades, P.O. Box 25, Van Nuys, CA 91408, • Energy Shields, The Created Look, 288 Willow Drive, Levittown, PA 19054 215/943-8850 • Solar Control Film Manufacturers)

Interior Roller Shades, With Side Tracks. Two features provide improved performance for this version of a roller shade. Side tracks are added to reduce air movement and leakage around the edges of the shade. The use of a semi-transparent aluminized shade material results in a lower emittance surface facing the air space, providing additional insulating value.

(NRG Shield, NRG Shields, Inc., 288 Willow Drive, Levittown, PA 19054, 215/943-8850)

Interior Roller Shades With Tape Seal. This roller shade is made from transparent plastic film and comes with special tape for sealing the edges and bottom of the shade to the window trim. The tape is reusable from season to season.

(Minute Man storm windows-adjustable™, Minute Man Anchor Company, 305 W. Walker Street, East Flat Rock, NC 28726, 704/692-0256)

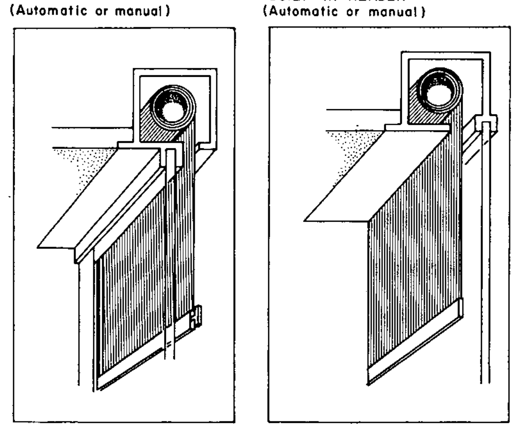
Interior Shade System. The MRS/Printaroll is an architectural roll-down shade system using an extruded aluminum roller tube. An 'inertia gravity' mechanism allows positive stopping of the shade at any point of its travel, without tying down the control cord. This product is available in a motorized version, with sun sensing devices for special control applications.

(MRS/Printaroll, MRS, 1800 New Highway, Farmingdale, NY 11735, 212/895-4788)

Interior/Exterior Roll-Down Shade. This roll-down shade, woven from PVC coated fiberglass, is used for interior and exterior applications. It is available in a variety of finishes and hardware options, including automatic sun control. The exterior version can be controlled by a wind sensor to prevent wind damage. In addition to its basic solar control function, the shade will reduce winter heat losses if properly installed.

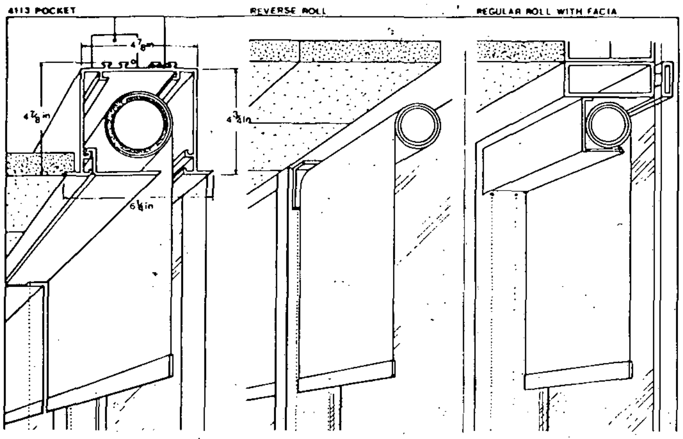
EXTERIOR SHADES BUILT-IN HEADER (Automatic or manual)

INTERIOR SHADES BUILT-IN HEADER (Automatic or manual)



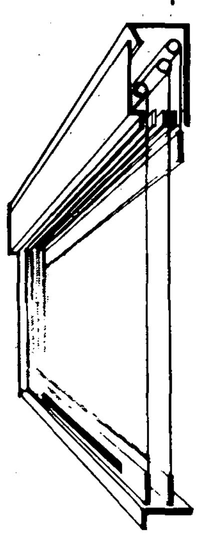
(Sol-R-Veil®, Sol-R-Veil, Inc., 60 West 18th Street, New York, NY 10011, 212/924-7200)

Motorized Window Shading System. A variety of plastic and fabric shades is available for use with a motorized window shading system. Reversible motor is located within the shade tube roller and contains a brake mechanism to stop and hold in any position. Motor controls may be ganged and operated locally or from a master station. Automatic photoelectric controls are available.



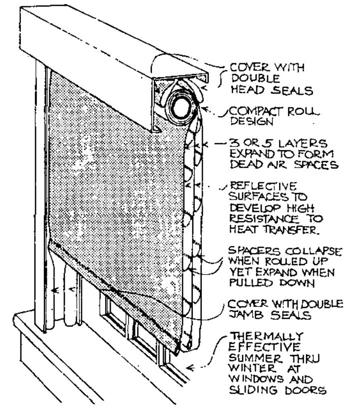
(Electro Shade System, Joel Berman Associates, Inc., 102 Prince Street, New York, NY 10012, 212/226-2050)

Multiple Insulating Shade System. Three plastic roll-up shades are mounted in the same frame. One shade is transparent, one is reflective, and one is heat absorbing (though perforated to allow viewing). Appropriate deployment of one or more shades provides night insulation, summer sun control, or winter passive solar gain. In the winter gain mode, heated air rising in the unit opens a temperature sensitive valve to allow air circulation. With one or more of the shades pulled down the unit is designed to reduce air infiltration. Models are available for both windows and patio doors.



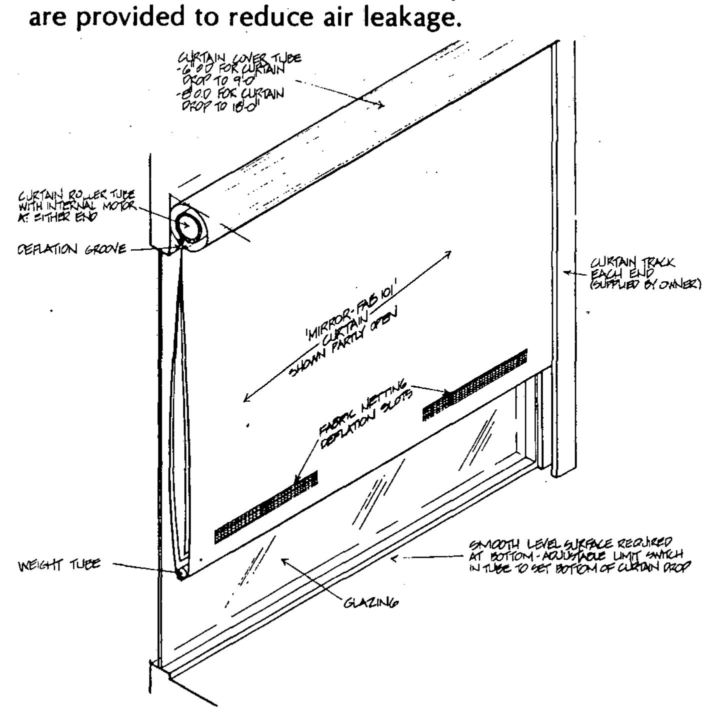
(Insealshaid™, Arc-tic-Seal Systems, Inc., P.O. Box 428, Butler, WI 53007, 414/276-0711)

Multilayer Roll-Down Shade. This interior, roll-down shade contains multiple layers (usually five) of aluminized plastic, which separate as the shade is unrolled. This creates four air spaces in series, bounded by low emittance surfaces, providing a thermal resistance of approximately R-12. Top, bottom, and edge sealing pieces are available to reduce air leakage.



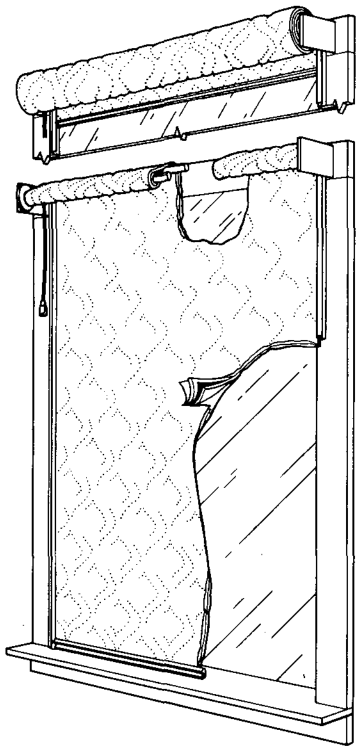
(High "R" Shade™, Insulating Shade Co., Inc., P.O. Box 282, Branford, CT 06405, 203/481-2337)

Multilayer Roll-Down Shade. This interior roll-down shade is made of several layers of aluminized nylon. When the shade is deployed, warmth from the room (or an adjacent Trombe wall) expands the air between the layers. This separates the layers and provides an insulating air space. The shade is available in large sizes with both manual and automatic operation. Side tracks are provided to reduce air leakage.



(Curtain Wall, Thermal Technology Corporation, P.O. Box 130, Snowmass, CO 81654, 303/963-3185)

Quilted Shade System. This roll-down interior shade utilizes a quilted material as a thermal barrier. The quilt is comprised of five layers, ultrasonically welded together: fabric, polyester fiberfill, reflective vapor barrier, polyester fiberfill, fabric. The side track system encases a sewn-in rope at the edges of the shade to reduce infiltration.

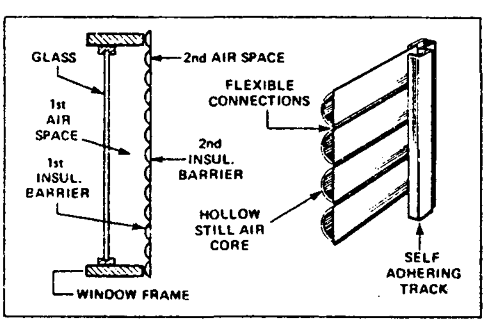


(Window Quilt, Appropriate Technology Corporation, P.O. Box 975, Brattleboro, VT 05301, 802/257-1773)

Quilted Shade System (Do-It-Yourself). Instructions for building a quilted roll-down shade. Cost: $2.50.

(Rainbow Energy Works, 2324 Moraine Circle, Rancho Cordova, CA 95670)

Interior Roll-Down Slat Shade. This roll-down shade uses hollow rigid white PVC slats. Air infiltration is minimized through the design of the connecting joints and by side tracks in which the edges of the shade slide.



(Thermo-Shade, Solar Energy Construction Company, P.O. Box 718, Valley Forge, PA 19481, 215/783-7735)

Interior Venetian Blinds, Conventional. These familiar products are available with either 1 in. or 2 in. slat widths in aluminum and steel and on a more limited basis with wood slats. By control of slat color(s), slat tilt and raising or lowering the entire blind, the solar optical properties may be varied over a wide range. With the blinds lowered and the slats in a closed position, the venetian blind acts as a thermal radiation barrier although the overall insulating effectiveness is reduced somewhat due to the "leaky" nature of the blinds. May be used on vertical and sloped surfaces.

(Multiple sources)

Venetian Blinds, Reflective/Absorptive. This unit is a venetian blind with slats that are white on one side and black on the other. It thus can reflect sunlight outside for summer cooling, as well as absorb solar energy for winter heating.

(Solar Heating Venetian Blinds, Solar Master, Inc., 223 E. Knight Ave., Collingswood, NJ 08108, 609/854-2960 • Conventional Blind Manufacturers)

Window Thermal Barriers/ Exterior Systems

STORM WINDOWS

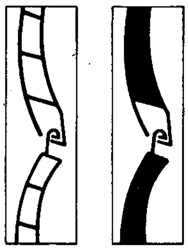
Exterior Storm Windows, Glass. Standard glass storm windows, framed in wood, aluminum or plastic, are widely applied outside both existing and new windows. Double and triple track systems allow operation of glass panels and insect screening on a daily or seasonal basis, as desired. Storm windows should be tight fitting to reduce infiltration.

(Multiple local sources)

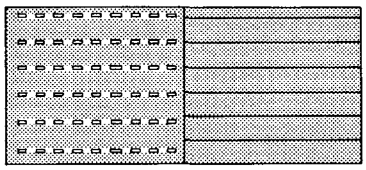
EXTERIOR SHUTTERS

A major type of exterior shutter is the rolling shutter. They utilize interlocking slats which are raised or lowered with a manual crank or pull tape from the inside, or by a motor. The units provide thermal control in winter and summer, and some degree of weather protection, security, and privacy. When tightly closed, the slats form a solid barrier; with the shutter closed but the slats 'cracked' open, some light is admitted. The shutters may be used in new construction or as a retrofit device in existing residential and commercial buildings.

Exterior Roll-Down Shutter. These shutters are available with either reinforced hollow plastic slats, or with polyurethane-filled aluminum slats. An automatic locking device prevents forcible entry.



HOLLOW SLAT FILLED SLAT



SLATS OPEN SLATS CLOSED

(Rolladen, American German Industries, 14611 North Scottsdale Rd., Scottsdale, AZ 85260, 602/991-2345)

Exterior Roll-Down Shutter. Interlocking PVC slats are rectangular in cross section and are .55 in. thick. Test measurements indicate that the shutter provides an additional R-value of 1.6 hr-ft^2°F/Btu.

(Roll-Awn, Abox Corporation, 629-3 Terminal Way, Costa Mesa, CA 92627, 714/645-0623)

Exterior Roll-Down Shutter. Interlocking slats are either plastic extrusions or wood profiles.

(Rolsekur™ rolling shutters, The Rolsekur Corporation, Fowler's Mill Road, Tamworth, NH 03886, 603/323-8834)

Exterior Rolling Shutter. Available with interlocking slats of PVC extrusions.

(Ever-strait Rolling Shutter, Pease Company, Ever-strait Division, 7100 Dixie Highway, Fairfield, OH 45023)

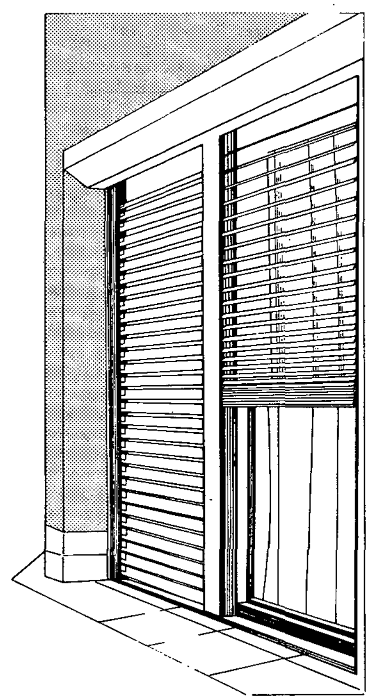
Exterior Roll-Down Shutters. Available with plastic or wooden slats.

(Serrande Shutter, Serrande of Italy, P.O. Box 1034, West Sacramento, CA 95691, 916/371-6960)

Exterior Roll-Down Shutter. This roll-down shutter is available with several varieties of wooden slats: Douglas Fir, Cypress, Southern Pine, Ramin, Phillipine Mahogany, Honduran Mahogany. The Ramin and Mahogany slats are well suited for harsh environments.

(Solex Wood Roll Shutters, ELR Inc., Solex Division, 244 San Lorenzo Ave., Coral Gables, FL 33134, 305/443-1053)

Exterior Shutter/Blind. The unique feature of these external shutter/blinds are their pantograph mechanisms for raising and lowering the blind and for tilting the louvres. The louvres are easily removed from clips for maintenance and cleaning. The blind is chain-driven and operated with automatic sun sensors and electrical control.



(Guardian Shutter Blind, Nichols-Homeshield, Inc., 1000 Harvester, West Chicago, IL 60185, 312/231-5600)

Exterior Shutters, Hinged or Sliding. These shutters have been primarily used for protection against hurricanes, but they may provide benefits similar to those of the other shutters presented here. Available in sliding or hinged models.

(Willard Shutters, Willard Shutter Co., 4420 N.W. 35th Court, Miami, FL 33142, 305/633-0162)

Glazing Materials

Plastic Greenhouse Glazing. Monarfol-Ultra is a heavy reinforced polyethylene sheeting suitable for glazing greenhouses. It contains filaments of polyester yarn to resist tearing, is UV stabilized, and is available in widths of 43 in. or 157 in. on rolls of 50 or 100 yards. Other products by the same manufacturer are used for building vapor barriers, tarpaulins, and landfill membranes.

(Monarfol-Ultra, Polysheet, 41-43 Marielundvej, 2730 Herlev, Copenhagen, Denmark)

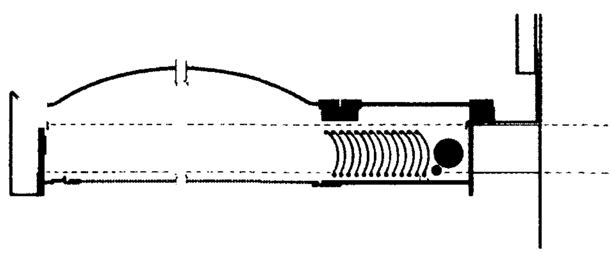
Components

Insulated Plastic Absorber. Solar Bubble is a polyethylene film similar to bubble packing except that the bubbles are formed from black plastic behind a clear film. Incoming solar energy is absorbed by the black film and is removed as heat by air flowing behind the unit. The product is suitable for use as the collector surface in air solar heaters with applications for space heating, industrial processes, and crop drying.

(Solar Bubble, Solarway, P.O. Box 217, Redwood Valley, CA 95470, 707/485-7616)

Skylights

Skylight with Motorized Shade. This skylight features a built-in, motor operated shade. An acrylic pleated shade stacks to one side of the skylight, and can be deployed by a push-button switch or a remote transmitted signal. The skylights are available with bronze or clear plexiglass domes, and the shades come in white or bronze colors.



(Skyview™, Skyview Control Systems, Inc., 4780 Birdler Rd., Willoughby Hills, OH 44094, 216/953-1100)

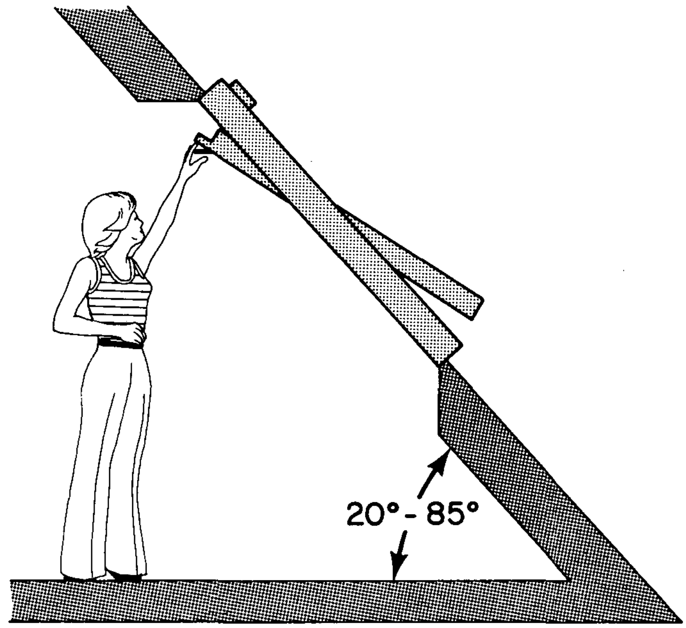
Solar Control

Vertical Venetian Blind. The MRS/Sundrape Vertical Blind System is an interior window treatment for control of solar gain and natural light. A single control cord sets the spacing, rotation, and stacking of the slats, which are available in a different widths and fabric textures. The product is available in a motorized version with sun sensing devices for special control applications.

(Sundrape Vertical Blind, MRS, 1800 New Highway, Farmingdale, NY 11735, 212/895-4788)

Windows

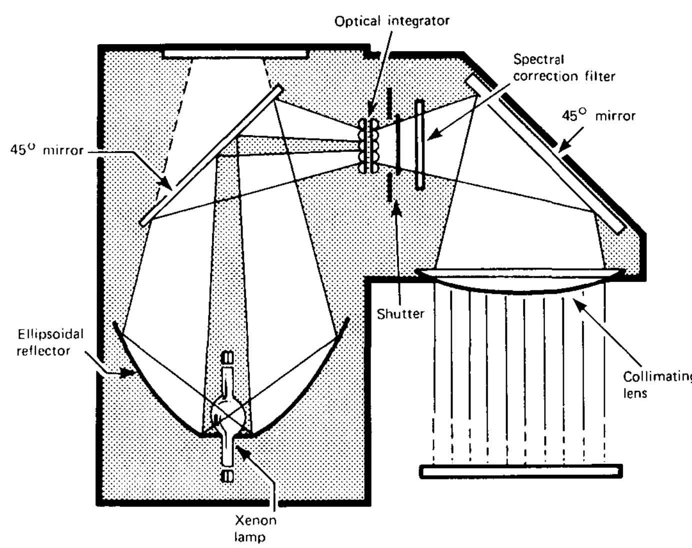
Roof Windows. The Velux Roof Windows are designed for installation on pitched roofs, typically to enable window placement in attic spaces. The exterior frame/flashing is aluminum, designed for compatibility with a variety of roofing materials. Double glazing is standard, with triple, absorbing, tempered, and reflecting glasses available as options. The window rotates on a center-mounted friction hinge, and has a filtered ventilation flap, as well as external awnings and interior shades/blinds available as options.



(Velux Roof Windows, Velux-America, Inc., 74 Cummings Park, Woburn, MA 01801, 617/935-7390)

Instrumentation/Testing Equipment

Indoor Solar Simulators. Solar simulators are laboratory instruments that produce a beam of radiation similar in spectral characteristics and intensity to that from the sun. They normally utilize a xenon lamp with a variety of filters. Primarily used to test photovoltaic devices, larger systems can be used to test the performance of window systems.

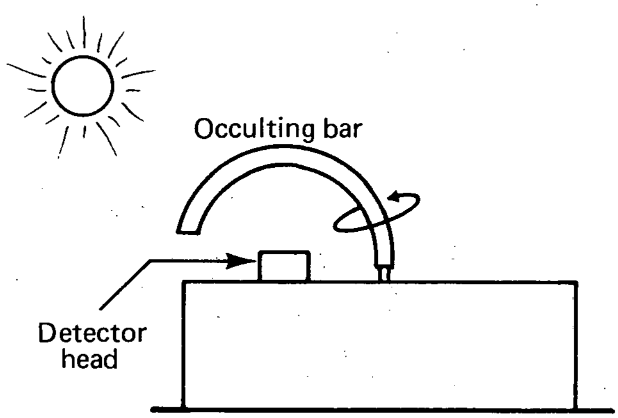


(Spectrolab, 12500 Gladstone Avenue, Sylmar, CA 91342, 213/365-4611 • Oriel Corporation of America, 15 Market Street, Stamford, CT 06902, 203/357-1600)

Smoke Generators. Smoke bombs and candles are designed to assist in detecting leaks in plumbing, heating, and air conditioning systems. They may also prove useful for locating air leakage through window systems in laboratory testing. They leave no residue, contain no explosives, and can be shipped by mail.

(Smoke Bombs and Candles, Superior Signal Company, Inc., West Greystone Road, Spotswood, NJ 08884, 201/251-0800)

Solar Radiation Measurement. The Shadow Bar is a device that measures both direct and diffuse components of insolation and records the results on a chart recorder. An occulting bar blocks direct radiation once each minute so that a single chart shows both total radiation as well as diffuse only. This will be useful to those wishing a quick visual check of the relative contribution of diffuse and direct radiation components.



(Shadow Bar, Arizona Scientific Research, 10121 Catalina Hwy., Tucson, AZ 85715, 602/749-3954)

Optical Properties Measurements. The Alphatometer is a small thermopile type pyranometer which is designed to measure solar radiation and thus transmissivity, reflectivity, and absorbtivity of glazing materials. It should be useful to those working with solar collectors, window sun control products, and novel window systems. The Emissometer is a differential thermopile which measures the total hemispherical emittance of a sample at 150°F by comparing the sample reading to that of a known high emittance standard.

(Alphatometer, Emissometer, Devices and Services Company, 3501-A Milton, Dallas, TX 75205, 214/368-5749)

Patents

Patent files contain a wealth of information that may be of interest and use to readers. Some patents ultimately reach the marketplace in product form, others are technically sound but never fulfill their commercial promise, and still others are plagued by insoluble technical problems. In any case, a review of pertinent patents will often provide an innovator with ideas and approaches that might never be found by a more conventional literature search. For this reason we will include patent abstracts, both new and old, of familiar and unfamiliar devices and products related to windows, their components, and accessories.

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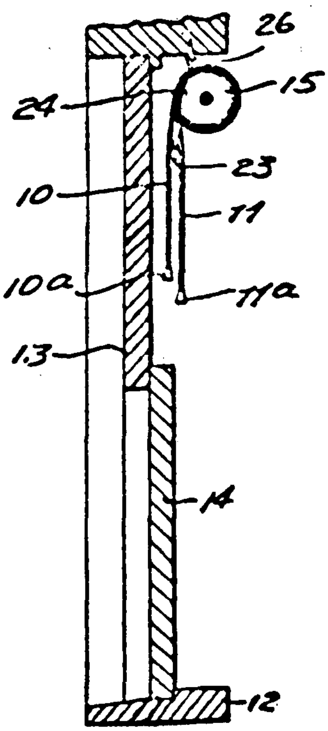
Patent No. 2,306,086

THERMALLY INSULATING WINDOW SHADE CONSTRUCTION

Inventor: Franklin S. Smith, North Hewin, CT

Filed: September 23, 1942

This invention is intended to provide an easy to install, easy to use, inexpensive, dependable window shade construction for efficiently reducing heat transfer in either direction through the window or window opening in the wall of a building or the like. The shade material, roller mechanism, and rod ("spacer-member") are all described as being made from standard, readily available materials. The space-member can be proportioned according to average climatic conditions and is essentially self-adjusting.



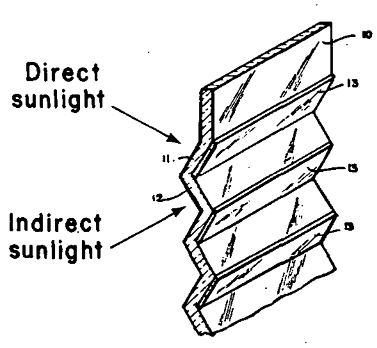
Patent No. 2,874,611

COMBINED HEAT REFLECTOR AND LIGHT TRANSMITTER STRUCTURE

Inventor: Sergius N. Ferris Luboshez, Bethesda, MD

Issued: February 24, 1939

This invention intends to provide a lightweight, inexpensive shielding structure in the nature of a shutter or blind that will selectively admit light while excluding direct solar radiation from a building, that will prevent heat radiation from the interior of the building to the exterior, and that will allow a complete block to all light and heat radiation in either direction. The invention uses a pair of flexible transparent corrugated sheets (e.g., 3-to 10-mil cellulose acetate), each of which has predetermined (upper) portions of their corrugations coated with a metallic radiation reflective material. The upper ends of each sheet is attached to a roller about which it may be wound.



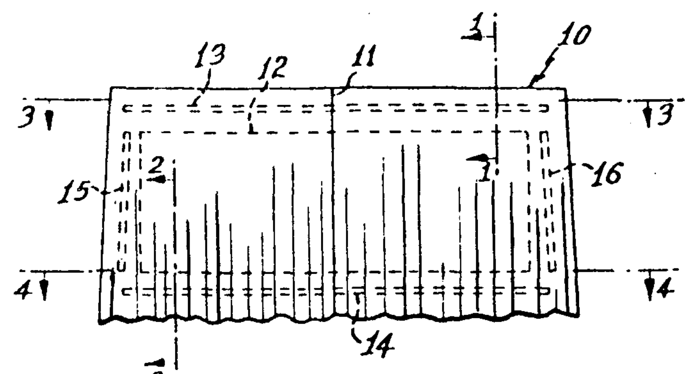
Patent No, 3,857,432

CURTAIN AND ATTACHED AIR SEAL

Inventor: David E, Russel, Jacksonville, FL

Issued: December 31, 1974

This air seal gasket for attachment behind window curtains or drapes reduces the flow of cold downward air currents in the winter and reduces the flow of warm upward air currents in the summer. The gasket is secured to the rear of the curtain or drape with a pressure adhesive tape or similar continuous fastening device to permit removal for cleaning. Characteristics of the gasket are selected to suit the curtain or drape so that the inside appearance of the drape is not affected. The gasket material can be any suitable soft, floppy material that can be easily compressed into a very flat configuration when a very gentle pressure is applied and that returns to its original shape when pressure is released. A foamed plastic such as polyurethane that has a density considerably less than one pound per cubic foot and closed cell construction is preferred, although any suitable substance may be used.



Patent No. 3,860,055

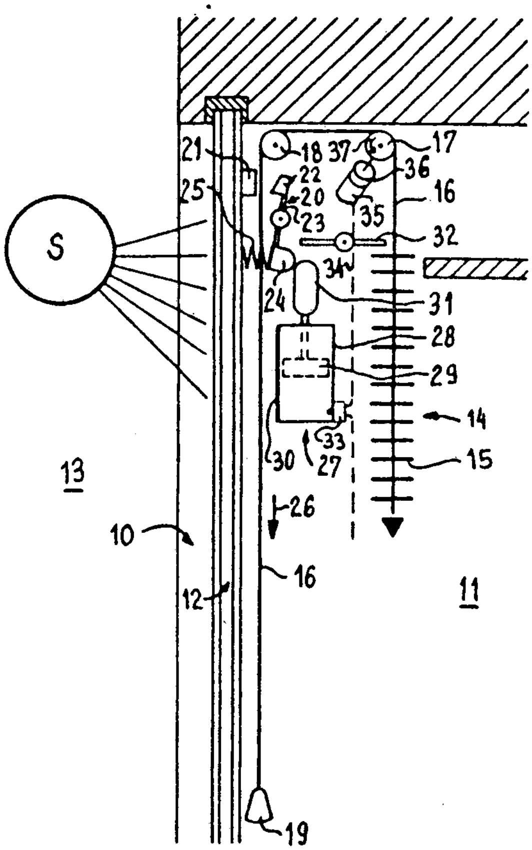
SHUTTER DEVICE

Inventor: Ernst Wild, Stafa, SWITZERLAND

Assignee: Stafa Control System, Stafa, SWITZERLAND

Issued: January 14, 1975

This shutter device has a mechanism for raising and lowering the shutter and a sensor for external thermal and light radiation. The sensor is coupled with the raising and lowering mechanism so that the shutter is lowered when a predetermined radiation intensity is reached. The raising and lowering mechanism can use an actuating mechanism that is operated by a piston drive by a fluid, such as Freon, that expands with the temperature increase generated by the incident solar radiation. The piston pushes the actuating mechanism to release a brake jaw, thereby allowing the shade or venetian blind to fall by its own weight. When the piston falls to its lowest point, as the temperature decreases, a switch can activate an electric motor that will raise the shutter or shade.



Patent No. 3,884,414

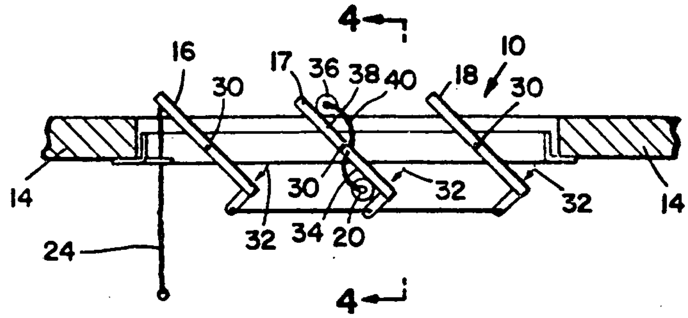
SOLAR HEATING DEVICE

Inventor: S. C. Baer, Albuquerque, NM

Assignee: Zomeworks Corporation, Albuquerque, NM

Issued: May 20, 1975

Pivotal insulating louvers that can be used to cover a skylight or other aperture are the basis of this invention. The louvers are opened and closed automatically as temperature (and thus vapor pressure) changes in response to the presence or absence of solar radiation. An interior reservoir is fixed to the interior surface so that the weight of the interior reservoir will bias the louver to open it. An exterior reservoir is mounted so that its weight can bias the louver to close. The tube allows Freon to pass from one reservoir to the other. A higher temperature on the exterior will raise the vapor pressure in the exterior reservoir, forcing liquid through the tube into the interior reservoir and opening the louver. A higher interior temperature will raise the vapor pressure of the interior reservoir, closing the louver. The louvers have an aluminum skin with a foam core so that they are thermally insulative, light-weight, and sturdy. The louvers can be closed manually to prevent overheating on extremely warm days.



Patent No. 3,923,485

METHOD OF FABRICATING A FLUOROCARBON-FILLED MULTIPLE GLAZED WINDOW UNIT

Inventor: Helmut Franz, Pittsburgh, PA

Assignee: PPG Industries, Inc., Pittsburgh, PA

Issued: December 2, 1975

An improved method for fabricating a welded fluorocarbon-filled multiple glazed window unit made from a pair of rigid transparent sheet is disclosed. The improvement made by the invention resides in treating the pair of rigid transparent sheets, which are subsequently welded together around their edges to form the multiple glazed unit, with a high purity, finely divided silica powder. The sheets are then placed in face-to-face contact, preheated, and then heated to fuse the edge portions of the sheets together. The use of the high purity silica powders prevents the sheets from sticking together during preheating and ensures that when the units are filled with a fluorocarbon gas, the fluorocarbon will not photochemically decompose upon exposure to solar radiation.

Patent No. 3,928,953

PACKAGED ADD-ON MULTIPLE GLAZING UNITS AND METHOD

Inventor: Renato J. Mazzoni, Tarentum;
John L. Stewart, Murrysville,
George H. Bowser, New Kensington, all of PA

Assignee: PPG Industries, Inc., Pittsburg, PA

Issued: December 30, 1975

Two prefabricated add-on glazing subassemblies are

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- ☐ Researcher
- ☐ Manufacturer: Windows
- ☐ Manufacturer: Components, Accessories
- ☐ Engineer
- ☐ Library/Publications
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	Very Satisfactory	Satisfactory	Unsatisfactory
Timeliness of information	☐	☐	☐
Level of technicality	☐	☐	☐
Subject matter	☐	☐	☐

2. How useful do you feel the kind of information in "Windows" articles will be to your organization?

Very Useful ☐ Somewhat Useful ☐ Not At All ☐

3. Do you plan to seek additional information on anything you read in this publication?

Yes ☐ No ☐ Not sure ☐

4. What subject area(s) would you like to see covered in future issues? Specify: ______

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Comments: ______________________

6. Other comments and suggestions: ______________________

18010M

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METRIC CONVERSIONS FOR WINDOW DESIGN AND CONSTRUCTION

LENGTH

1 m	= 1.09361 yd	(0.9144)*
	= 3.28084 ft	(0.3048)
1 cm	= 0.3937 in	(2.54)
1 mile	= 1.6093 km	(0.6214)

AREA

1 m^2	= 1.19591 yd^2	(0.8362)
	= 10.7636 ft^2	(0.0929)
1 cm^2	= 0.155 in^2	(6.4516)
1 hectare	= 2.47 acres	(0.4049)
1 acre	= 43,560 ft^2	(2.2957x10^{-5}

VOLUME

1 m^3	= 1.30795 yd^3	(0.7646)
	= 35.3147 ft^3	(0.0283)
1 cm^3	= 0.061 in^3	(16.3934)
1 liter	= 0.0354 ft^3	(28.3170)
	= 0.2642 gal	(3.7854)
1 barrel (bb1)	= 42 gals	(0.0238)

MASS

1 kg	= 2.2046 lb	(0.4536)

TEMPERATURE

t °C	= 0.556 (t °F-32)	
t °F	= 1.8 t °C + 32	
Δ°F	= 1.8 Δ °C	(0.5556)
T °K	= t °C + 273	
T °R	= t °F + 460	

DENSITY

1 kg/m^3	= 0.0624 lb/ft^3	(16.0256)

ENERGY, HEAT

1 MJ	= 0.2778 kWh	(3.600)
1 kJ	= 0.9478 BTU	(1.0551)
1 J	= 0.7376 ft-lbf	(1.3557)
1 kWh	= 3412.4 Btu	(2.93 x 10^{-4})

FLOW

1 liter/s	= 2.1189 ft^3/min (CFM)	(0.4719)

HEAT STORAGE

1 KJ/°C	= 0.5269 Btu/°F	(1.8979)	Thermal Mass
1 Wh/°C	= 1.8969 Btu/°F	(0.5272)	
1 kJ/m^2-°C	= 0.04895 x 10^{-3} Btu/ft^2-°F	(20.4290)	
1 kJ/kg-°C	= 0.2390 Btu/lb-°F	(4.1841)	Specific Heat

HEAT TRANSFER

1 W/m-°C	= 0.5782 Btu-ft/hr-ft^2-°F	(1.7295)	Conductivity
	= 6.9380 Btu-in/hr-ft^2-°F	(0.1441)	
1 W/m^2-°C	= 0.1762 Btu/hr-ft^2-°F	(5.6745)	Transfer Coefficient
1 W/°C	= 1.8956 Btu/hr-°F	(0.5275)	Conductance
1 W/m^2	= 0.3172 Btu/hr-ft^2	(3.1526)	Heat Flux

POWER

1 W	= 3.4144 Btu/hr	(0.2929)
	= 0.7380 ft-lbf/sec	(1.3550)
1 kW	= 1.3423 hp	(0.7450)

PRESSURE

1 Pascal	= 0.1450 x 10^{-3} psi	(6894.759)
	= 0.0040 in. water	(250.00)

VELOCITY

1 m/s	= 196.85 ft/min	(0.0051)
	= 2.2369 mph	(0.4470)

BUILDING HEAT LOSS

1 Wh/DD $_{(°C)}$	= 3.600 kJ/DD$_{(°C)}$
	= 1.896 Btu/DD$_{(°F)}$
1 Wh/m^2-DD $_{(°C)}$	= 3.6 kJ/m^2-DD$_{(°C)}$
	= 20.4 Btu/ft^2-DD$_{(°F)}$

ILLUMINANCE

1 lux	= 0.0929 lm/ft^2 (footcandle)

VALUES FOR SELECTIVE PROPERTIES

Property (Typical Values)	Specific Heat (Btu/lb-°F)	Density (lb/ft^3)	Thermal Conductivity (Btu-ft/hr-ft^2-°F)
Air	0.24	0.076	0.015
Aluminum	0.214	171	128
Concrete	0.156	144	0.54
Hardwood	0.55	50	0.1
Water	1.0	62.3	0.348

MISCELLANEOUS CONVERSIONS & EQUIVALENTS
(Note: Many are rough approximations, as indicated by use of ≐)

1 Quad = 10^{15} Btu ≐ 1.05 x 10^{18} Joules ≐ 2.9 x 10^{11} kWh
≐ 180 x 10^6 bbl oil ≐ 10^{12} ft^3 gas ≐ 44 x 10^6 short tons coal
1 Therm = 10^5 Btu
1 bbl crude oil = 5.8 x 10^6 Btu (1 bbl = 42 gals)
1 ft^3 natural gas ≐ 1050 Btu
1 lb bituminous coal ≐ 12,500 Btu
1 lb hardwood (dry) ≐ 8,600 Btu
1 kWh (electric) ≐ 11,000 Btu (thermal)
Solar constant (above atmosphere) = 1353 W/m^2
Average solar noon intensity (at Earth's surface) = 900 W/m^2

Total U.S. Energy Consumption	100%	75	Quads
Building sector consumption	38%	28	Quads
Building sector: heating/cooling	20%	15.2	Quads
Attributable to windows	5%	3.8	Quads

*Use the figure in parenthesis to make the inverse conversion of units. For example, since 1m = 1.09361 yd, it is true that 1 yd = 1/1.09361 m, and 1/1.09361 = 0.9144, the figure in parenthesis.

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1 kJ/m^2-°C	= 0.04895 x 10^{-3} Btu/ft^2-°F	(20.4290)	
1 kJ/kg-°C	= 0.2390 Btu/lb-°F	(4.1841)	Specific Heat

HEAT TRANSFER

1 W/m-°C	= 0.5782 Btu-ft/hr-ft^2-°F	(1.7295)	Conductivity
	= 6.9380 Btu-in/hr-ft^2-°F	(0.1441)	
1 W/m^2-°C	= 0.1762 Btu/hr-ft^2-°F	(5.6745)	Transfer Coefficient
1 W/°C	= 1.8956 Btu/hr-°F	(0.5275)	Conductance
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	= 20.4 Btu/ft^2-DD$_{(°F)}$

ILLUMINANCE

1 lux	= 0.0929 lm/ft^2 (footcandle)

VALUES FOR SELECTIVE PROPERTIES

Property (Typical Values)	Specific Heat (Btu/lb-°F)	Density (lb/ft^3)	Thermal Conductivity (Btu-ft/hr-ft^2-°F)
Air	0.24	0.076	0.015
Aluminum	0.214	171	128
Concrete	0.156	144	0.54
Hardwood	0.55	50	0.1
Water	1.0	62.3	0.348

MISCELLANEOUS CONVERSIONS & EQUIVALENTS
(Note: Many are rough approximations, as indicated by use of ≐)

1 Quad = 10^{15} Btu ≐ 1.05 x 10^{18} Joules ≐ 2.9 x 10^{11} kWh
≐ 180 x 10^6 bbl oil ≐ 10^{12} ft^3 gas ≐ 44 x 10^6 short tons coal
1 Therm = 10^5 Btu
1 bbl crude oil = 5.8 x 10^6 Btu (1 bbl = 42 gals)
1 ft^3 natural gas ≐ 1050 Btu
1 lb bituminous coal ≐ 12,500 Btu
1 lb hardwood (dry) ≐ 8,600 Btu
1 kWh (electric) ≐ 11,000 Btu (thermal)
Solar constant (above atmosphere) = 1353 W/m^2
Average solar noon intensity (at Earth's surface) = 900 W/m^2

Total U.S. Energy Consumption	100%	75	Quads
Building sector consumption	38%	28	Quads
Building sector: heating/cooling	20%	15.2	Quads
Attributable to windows	5%	3.8	Quads

*Use the figure in parenthesis to make the inverse conversion of units. For example, since 1m = 1.09361 yd, it is true that 1 yd = 1/1.09361 m, and 1/1.09361 = 0.9144, the figure in parenthesis.

METRIC CONVERSIONS FOR WINDOW DESIGN AND CONSTRUCTION

LENGTH

1 m	= 1.09361 yd	(0.9144)*
	= 3.28084 ft	(0.3048)
1 cm	= 0.3937 in	(2.54)
1 mile	= 1.6093 km	(0.6214)

AREA

1 m^2	= 1.19591 yd^2	(0.8362)
	= 10.7636 ft^2	(0.0929)
1 cm^2	= 0.155 in^2	(6.4516)
1 hectare	= 2.47 acres	(0.4049)
1 acre	= 43,560 ft^2	(2.2957x10^{-5}

VOLUME

1 m^3	= 1.30795 yd^3	(0.7646)
	= 35.3147 ft^3	(0.0283)
1 cm^3	= 0.061 in^3	(16.3934)
1 liter	= 0.0354 ft^3	(28.3170)
	= 0.2642 gal	(3.7854)
1 barrel (bb1)	= 42 gals	(0.0238)

MASS

1 kg	= 2.2046 lb	(0.4536)

TEMPERATURE

t °C	= 0.556 (t °F-32)	
t °F	= 1.8 t °C + 32	
Δ°F	= 1.8 Δ °C	(0.5556)
T °K	= t °C + 273	
T °R	= t °F + 460	

DENSITY

1 kg/m^3	= 0.0624 lb/ft^3	(16.0256)

ENERGY, HEAT

1 MJ	= 0.2778 kWh	(3.600)
1 kJ	= 0.9478 BTU	(1.0551)
1 J	= 0.7376 ft-lbf	(1.3557)
1 kWh	= 3412.4 Btu	(2.93 x 10^{-4})

FLOW

1 liter/s	= 2.1189 ft^3/min (CFM)	(0.4719)

HEAT STORAGE

1 KJ/°C	= 0.5269 Btu/°F	(1.8979)	Thermal Mass
1 Wh/°C	= 1.8969 Btu/°F	(0.5272)	
1 kJ/m^2-°C	= 0.04895 x 10^{-3} Btu/ft^2-°F	(20.4290)	
1 kJ/kg-°C	= 0.2390 Btu/lb-°F	(4.1841)	Specific Heat

HEAT TRANSFER

1 W/m-°C	= 0.5782 Btu-ft/hr-ft^2-°F	(1.7295)	Conductivity
	= 6.9380 Btu-in/hr-ft^2-°F	(0.1441)	
1 W/m^2-°C	= 0.1762 Btu/hr-ft^2-°F	(5.6745)	Transfer Coefficient
1 W/°C	= 1.8956 Btu/hr-°F	(0.5275)	Conductance
1 W/m^2	= 0.3172 Btu/hr-ft^2	(3.1526)	Heat Flux

POWER

1 W	= 3.4144 Btu/hr	(0.2929)
	= 0.7380 ft-lbf/sec	(1.3550)
1 kW	= 1.3423 hp	(0.7450)

PRESSURE

1 Pascal	= 0.1450 x 10^{-3} psi	(6894.759)
	= 0.0040 in. water	(250.00)

VELOCITY

1 m/s	= 196.85 ft/min	(0.0051)
	= 2.2369 mph	(0.4470)

BUILDING HEAT LOSS

1 Wh/DD $_{(°C)}$	= 3.600 kJ/DD$_{(°C)}$
	= 1.896 Btu/DD$_{(°F)}$
1 Wh/m^2-DD $_{(°C)}$	= 3.6 kJ/m^2-DD$_{(°C)}$
	= 20.4 Btu/ft^2-DD$_{(°F)}$

ILLUMINANCE

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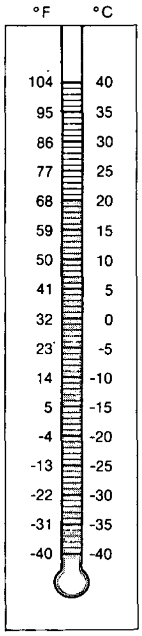
January, 1980

WINDOWS

For Energy Efficient Buildings

METRIC AND CELSIUS CONVERSION CHARTS



LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
ENERGY & ENVIRONMENT DIVISION

Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48

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January, 1980

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For Energy Efficient Buildings

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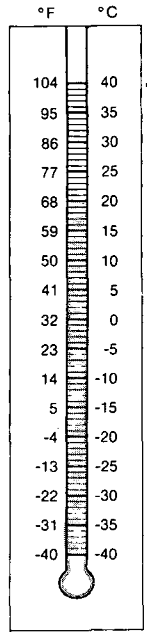

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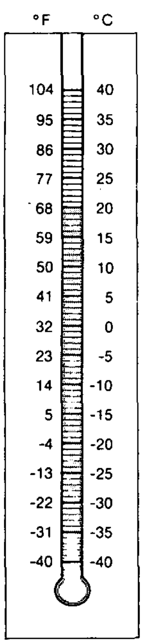

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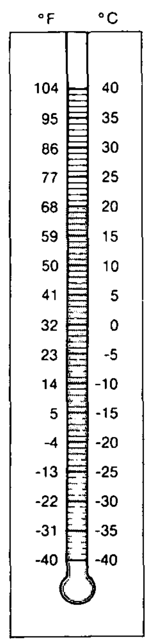

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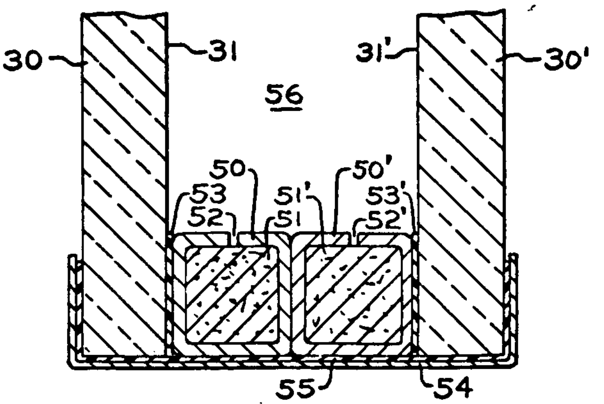
sealed together to form a package for handling, shipping, and storage. When separated, each subassembly is mounted onto an existing single glazed window to convert it into an insulating, sealed, multiple glazed installation.



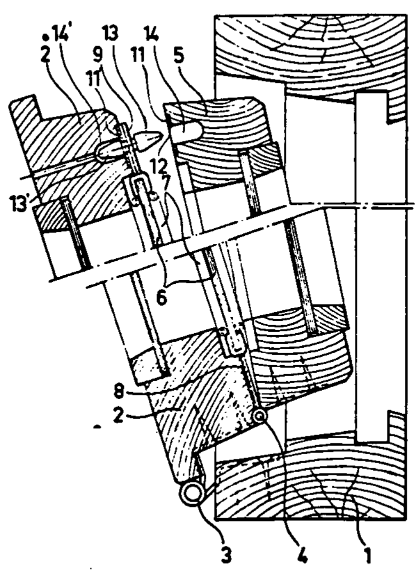
Patent No. 3,947,997

COUPLED WINDOW WITH TWO CASINGS AND THREE PANES

Inventor: Arvo Mursula, Alavus, FINLAND

Issued: April 6, 1976

The invention is a coupled window having two casings hinged to each other with an intermediate pane having one edge secured to hinge flaps carried on the same hinge pins as the hinges connecting the casings to each other. At the opposite edge the intermediate pane is provided with one single-switch coupling co-operating with counter plates in the inner and outer casings, respectively, in such a manner that the immediate pane may be alternatively coupled to the inner casing or to the outer casing or to both casings.



Patent No. 3,947,998

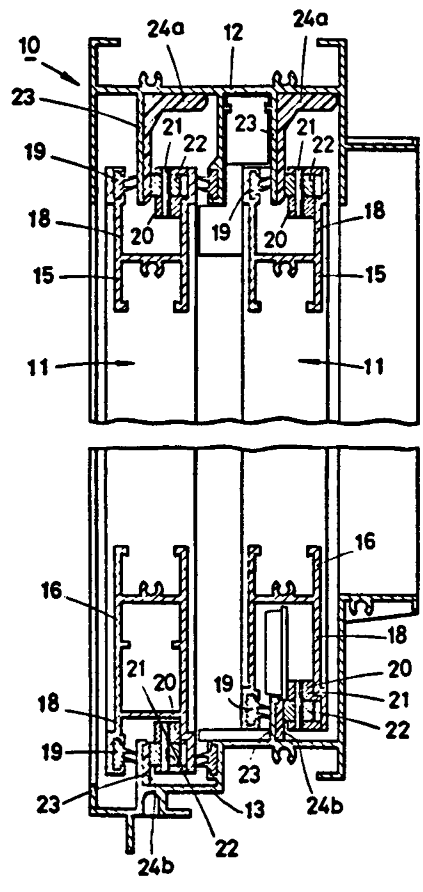
DUAL SASH WINDOW ASSEMBLY WITH WEATHERTIGHT SEALING MEANS

Inventor: Isamu Matsubara, Nyuzen, JAPAN

Assignee: Yoshida Kogyo Kabushiki Kaisha, JAPAN

Issued: April 6, 1976

In a window assembly having a pair of sashes mounted within a supporting frame for relative horizontal movement, each sash is integrally provided with a pair of opposed rims defining an outwardly open channel along each of its top and bottom horizontal members and along one of its side vertical members which is to be held against one of the jambs of the supporting frame upon closure of the sash. When the sashes are moved to their closed positions, a plurality of vertical rolls mounted in selected positions inside the channels of each sash ride on respective raised roll seats formed on stationary flanges intruding into the respective channels from the supporting frame. Upon resulting lateral displacement of the sashes relative to the supporting frame, sealing strips, which are also arranged internally of the channels, become pressed against the flanges.



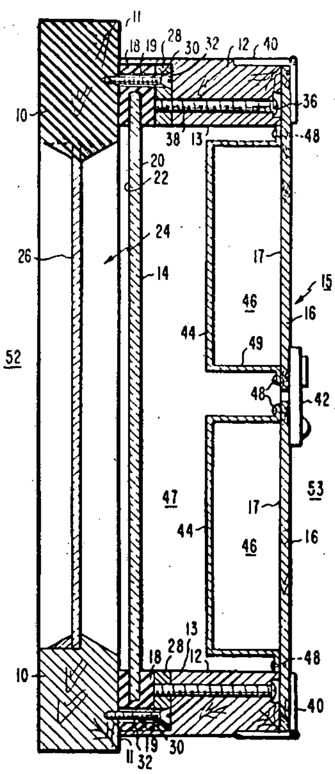
Patent No. 3,960,135

SOLAR HEATER AND THERMAL BARRIER

Inventor: Domenick J. Angilletta, Collingswood, NJ

Issued: June 1, 1976

A distribution of solar heat into the ambient air of an enclosed space and a reduction of thermal energy loss from the ambient air and enclosed space is provided by means of a box attached to the inner side of a conventional window sash. A vertically oriented, highly heat-absorptive surface within the box has its temperature increased as solar radiation, generally in the form of direct sunlight, passes through the glass of the window sash, enters the front of the attached box, and impinges on the energy absorbing surface. Ambient air from the enclosed space, moving by natural convection action, enters the box through side and bottom openings, and passes over the heated surface and is warmed, leaves the box at or near the top, and re-enters the enclosed space at an elevated temperature. The front cover of the box consists of a pane of clear glass that stands parallel to the existing glass of the window. A flexible gasket at the outward-facing periphery of the front cover creates a sealed airspace between the two panes of glass. The heat absorbing surface (usually a painted piece of sheet metal) is attached to the back panels, which hinge open to allow unobstructed viewing through the window.



Top view

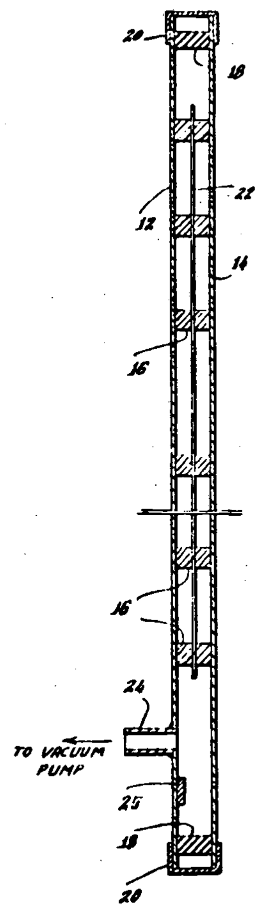
Patent No. 3,990, 201

EVACUATED DUAL GLAZING SYSTEM

Inventor: Gerald Falbel, Stamford, CT

Issued: November 9, 1976

An evacuated dual pane window structure is provided for reducing heat loss through the window structure. The window structure includes a pair of closely spaced panes of glass having a spacing of less than 0.25 inch with a spacer means positioned between them and uniformly spaced in the area between the panes, and a sealing means, such as an O-ring, positioned around the perimeter and between the panes of glass. A vacuum pump may be provided for evacuating the area between the panes of glass to reduce thermal losses through the window structure. Reflective coatings may be provided on the inside surfaces of the glass. Many such windows may be connected by manifold piping to a single vacuum pump which is actuated by a thermostat when a preset temperature differential exists between the outside and the inside of the building where the windows are used. In an alternate version, a low-emissivity layer of polyester film is provided with a reflective coating and mounted between the panes of glass with the spacers positioned in between.



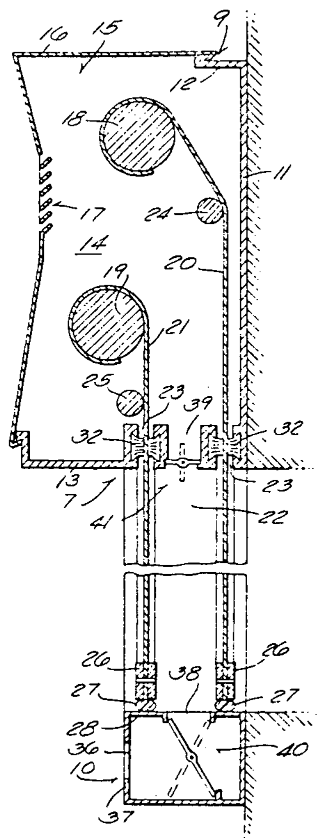
Patent No. 3,990,635

WINDOW MOUNTED SOLAR HEATING UNIT

Inventors: J. W. Restle, A. J. Algaier, G. R. Kruger

Issued: November 9, 1976

This invention consists of overlying sheets of flexible transparent material that are spaced apart and held in a frame. The outer sheet is fully transparent and the inner sheet is treated to reflect heat energy on one side and treated to absorb it on the other side. The rollers can be reversed to allow the reflective sheet to face outwards in summertime. The top and bottom cross bars have dampers that will allow or block air flow through the space between the sheets to transfer solar-heated air by convection to the room.



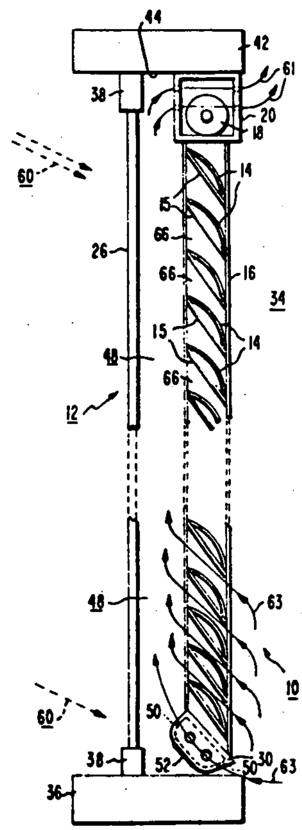
Patent No. 4,002,159

VENETIAN BLIND FOR SOLAR HEATING

Inventor: Domenick J. Angilleta, Collingswood, NJ

Issued: November 7, 1975

A venetian blind with a heat-absorptive surface on one side of the slats distributes solar heat into the ambient air of a room. For space heating the vertically oriented, highly heat-absorptive surface of the blind has its temperature increased as solar radiation passes through the glass of the window sash and impinges on the energy-absorbing surface. Ambient air from the room, moving by natural convective action, enters the air space between the window sash and venetian blind through openings in the bottom rail and between slats of the blind, passes over the heated surface and is warmed, leaves the air space through openings in the head rail of the blind, and re-enters the room at an elevated temperature. The other side of each slat of the blind has a reflective surface which when turned to receive the solar radiation, as in the summer, reduces heat entry into the room. The concave surfaces of the slats are coated with heat-absorbing black paint, and the convex surfaces use a reflective coating (either polished aluminum or white paint).



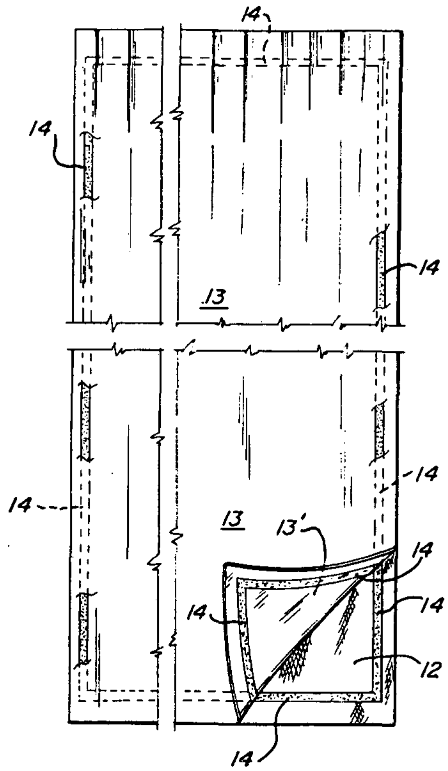
Patent No. 4,020, 826

SOLAR ENERGY SYSTEM

Inventor: Robert Alan Mole, Bolder, CO

Issued: May 5, 1977

A solar energy system for selectively absorbing or reflecting radiant energy entering through a window of a structure. The system includes a window drape having a decorative side and a back side, and a removable liner adjacent to the back side of the window drape. At least one side of the liner or window drape back side is a radiant energy reflecting surface. Thus, depending upon the season of the year, the system may be arranged to selectively provide the appropriate surface to optimize or minimize the radiant energy gain by the structure. The lining may be fastened with drape hangers, complimentary snaps, or Velcro.



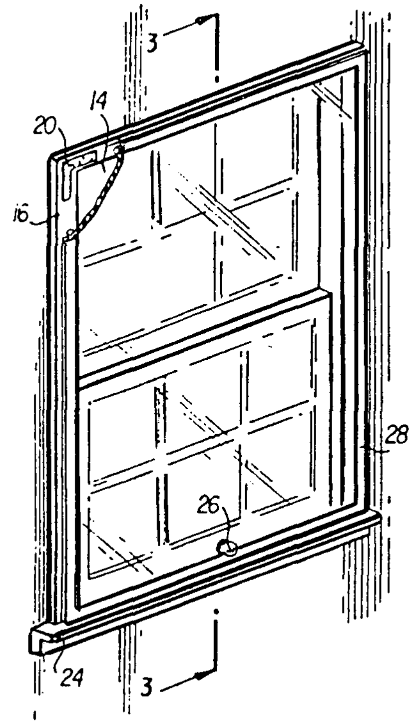
Patent No. 4,068,478

INSULATION WINDOW

Inventor: O. James Peterson, III, Midlothian, VA

Filed: October 22, 1976

An insulation window to be mounted on internal, in situ, window frames of buildings comprises a sheet of 3/16-inch rigid transparent plastic. The plastic sheet has space "hook-and-loop" fastening elements adhered directly to the plastic sheet about the margin of an inner face and complementary hook-and-loop fastening elements are attached to the window-casing frames of the building. A weatherstripping is adhered directly to the plastic sheet about the margin of the inner face. The transparent sheet of plastic is rigid and can be of the type sold under the trademark Plexiglas. The loop, hook-and-loop fastener elements are preferably of the cloth type sold under the trademark Velcro. The weatherstripping is formed of a resilient plastic tube which extends continuously about the margin of the transparent sheet of plastic.



WINDOWS

Legislation

This section will consider national and state legislation, codes, and standards which affect a building designer's use of windows and a manufacturer's ability to successfully market energy efficient windows and window accessories. We would appreciate information from readers on their experience with state and local legislation, codes, and standards.

This issue's column focuses on the successful federal legislation from the 95th Congress, and its implications for the feasibility of energy efficient window systems. Some significant state legislation has also been enacted, but space does not allow description of each of these. The reader is encouraged to contact a local legislator for more specific information about state energy laws. The National Energy Act, which was signed into law on November 9, 1978, is composed of five public laws: the Energy Tax Act of 1978; the National Energy Conservation Policy Act of 1978; the Powerplant and Industrial Fuel Use Act of 1978; the Public Utilities Regulatory Policy Act; and the National Gas Policy Act of 1978. Two of these will have a significant effect on some energy conservation projects (including windows).

For further information about existing solar or energy conservation tax credits in your state, contact the state's tax agency (Franchise Tax Board, or Bureau of Taxation or Revenue) or energy agency.

Contact the Internal Revenue Service for the latest information on the federal tax credit regulations.

The Energy Tax Act of 1978 (P.L. 95-618)

Residential Solar Tax Credit. This would mean a tax credit of up to 30% of the first $2,000 and 20% of the next $8,000 of expenditures for solar or wind energy equipment. The maximum federal solar tax credit is therefore $2,200. The credit will be in effect from April 20, 1977 to December 31, 1985, and will be applicable to both new and existing homes. Solar, geothermal, and wind-energy equipment are eligible if such equipment meets U.S. Department of Energy (DOE) performance standards and can reasonably be expected to last five years. Passive solar energy systems are eligible for the credit with the exception of the costs of labor and materials which will serve a significant structural function. The exact meaning of this particular exception (and its implications for the eligibility of glazing systems) will be determined by an IRS regulation that has not yet been issued. A discussion of the eligibility of glazing follows the listing of relevant legislation.

Business Energy Tax Credits. A number of tax credits have been adopted as incentives for businesses to use alternatives to gas and oil. The energy investment credit will allow industry to claim 10 percent of the acquisition or construction costs for certain "energy property," in addition to the existing 10 percent business property investment credit. Solar and wind energy equipment and systems installed on an existing industrial or commercial building between October 1, 1978 and December 31, 1982 will be eligible for this credit.

The National Energy Conservation Policy Act of 1978 (P.L. 95-619)

Utility Conservation Program. This program mandates the utilities implement an energy conservation and renewable energy sources public information program for their residential customers, and provide lists of local businesses that will finance, supply, and install energy conservation, solar, and wind power devices.

Small Utility Loans. Utilities could make loans of up to $300 for the purchase or installation of specified energy conservation devices (including solar).

Purchase of Loans for Solar Energy Systems. The Government National Mortgage Association (GNMA) would be authorized to purchase loans for residential solar heating/cooling systems from commerical lenders and resell them in the secondary lending market to ensure reasonable interest rates. Banks and other lenders could make solar loans of up to $8,000 each for periods of up to 15 years at interest rates between 7% (the Treasury borrowing rate) and 12% (the statutory ceiling for Title I HUD loans). A revolving fund of $100 million would be available for purchase of the loans and use of the loans by homeowners would not preclude their taking advantage of tax credits.

FHA and FmHA Mortgage Insurance for Solar Equipped Homes. The ceiling on basic Federal Housing Authority (FHA-HUD) and Farmers Home Administration (FmHA) insured mortgages may be raised by 20% (for FHA loans, this means $72,000 instead of only $60,000) if the increase is used for the costs of passive or active solar energy systems or for wind energy systems.

Secondary Financing of Solar Home Improvement Loans. The Federal Home Loan Mortgage Corporation (FHLMC) and the Federal National Mortgage Association (FDNMA) will be allowed to purchase ordinary home improvement loans made for solar or energy conservation systems or equipment.

Two other energy-related bills, initiated during the 95th Congress, were signed into law and may have some impact on projects incorporating energy-efficient windows and firms producing such systems.

P.L. 95-315 (HR11713) Small Business Loans. The Small Business Administration is authorized to make $30 million in direct and immediate participation loans, and $45 million in loan guarantees, to finance the start up or expansion of small businesses involved with solar or other renewable energy source systems.

P.L. 95-476 - Veterans' Housing Benefits Act of 1978. This bill grants the Veterans Administration authority to guarantee loans for general home improvements and for energy-related home improvements. Passive solar systems are eligible as energy-related home improvements, as are energy conserving window treatments and systems.

Eligibility of Window Systems

The eligibility of glazing areas that exceed the conventional amount of windows for energy income tax credits has been the subject of some debate in energy and tax agencies around the country. Since windows fulfill many functions (light, heat, ventilation, etc.), a prime concern is the avoidance of abuse of the credit in a claim for an element that would have been installed regardless of conservation efforts. While some states (notably California, New Mexico, and Oregon) include passive systems in their solar tax credit programs, the federal regulations described in Internal Revenue Service Publication 903 exclude windows, skylights, greenhouses, roof overhangs, and any other materials or components that serve a significant structural function from the renewable energy source credit. The renewable energy source credit is equal to 30% of the first $2000, plus 20% of the next $8000 of expenditures for qualified components, to a maximum credit of $2200.

Some window-related energy saving components do qualify as home energy conservation expenditures, under the same regulations, and are eligible for a credit equal to 15% of the first $2000 to a maximum credit of $300. The components must be installed on the taxpayer's principle residence after April 19, 1977 and before January 1, 1986. The components must be new when installed and must be expected to last at least three years. These items will be required to meet the IRS's performance and quality standards if they are installed after those standards are published. Publication 903 specifies the following currently allowable window-related components.

Storm Or Thermal Windows. These include the following:

1) A window placed outside or inside an ordinary or prime window, creating an air space and providing greater resistance to heat flow and reduced air infiltration.

2) A window with enhanced resistance to heat flow through the glass area by multi-glazing, or with reduced air infiltration through weather stripping. Multi-glazing is an arrangement in which two or more sheets of glazing material are fixed in window frame to create one or more closed insulating spaces.

3) A window in which the glazed area consists of glass or other glazing materials with heat-absorbing or heat-reflecting properties that reduce the penetration of radiant heat through the window.

Storm Or Thermal Doors. These include the following:

1) A second door, installed exterior to an existing outer door, to provide greater resistance to heat flow and to reduce air infiltration.

2) A prime exterior door with enhanced resistance to heat flow through the door area because of reduced air infiltration through weather stripping and reduced heat flow through insulating wood or plastic frame material or metal material incorporating thermal breaks.

3) A glass door in which the glazed area is multi-glazed, or consists of glass or other materials with heat-absorbing or heat-reflecting properties that reduce the penetration of radiant heat through the door.

Caulking. This consists of non-rigid materials placed in the joints of buildings to reduce the passage of air and moisture.

Weather Stripping. This consists of narrow strips of flexible material placed over or in movable joints of windows and doors to reduce the passage of air and moisture.

In California, window energy conservation measures can be eligible as part of the solar tax credit even if they are not part of a passive system. Such measures must reduce the total conventional energy requirements of the installed solar system or of its conventional back-up system, and must exceed the energy conservation building standards required by law at the time of original construction of the building.

Further information about California's tax credit regulations can be obtained from the California Energy Commission, 111 Howe Avenue, Sacramento, CA 95825.

Readers are advised to contact their local office of the Internal Revenue Service for the latest details about solar tax credits. As this issue goes to press, Congress is considering enlarging the federal solar tax credit to 50% and including passive systems, regardless of other functions their components might serve.

WINDOWS

Industry Organizations

Hundreds of trade organizations and industry associations have been established to further the goals and interests of their memberships. The activities of these groups generally benefit both the firms which participate and the public at large, through direct and indirect activities. These organizations and associations sponsor educational activities; develop test procedures and certification programs; publish industry directories, handbooks, and statistical reviews; provide an industrywide voice on vital issues; and provide a vehicle for focussing political and economic pressures.

No single organization represents the broad concerns of windows in their entirety, although the National Fenestration Council has recently been formed to fill this gap. Two well known professional organizations are included in this listing, ASHRAE (American Society of Heating Refrigeration and Air Conditioning Engineers) and IES (Illuminating Engineering Society). Each has technical committees which have, over the years, respectively developed and formulated the thermal and illumination engineering fundamentals on which current building design and engineering is based. The remainder of the organizations listed below are industry trade groups and associations, ranging in size from very large to small and in activity from very active to dormant. They may be useful information sources for specifiers and building designers and may provide inventors and manufacturers with valuable contacts.

In the next issue this section will contain a listing of professional and governmental organizations whose activities are relevant to the design, manufacture, marketing, and use of energy efficient window systems.

AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR CONDITIONING ENGINEERS (ASHRAE)

Address: 355 East 47th St., N.Y., N.Y. 10017
Phone: (212) 644-7953
Director: A.T. Boggs, Exec. Director
(Lester Schutrum, Chairman of the Fenestration Technical Committee)
Founded: 1894
Members: 33,000
Staff: 128 in 60 local groups

Purpose/Services: Professional society of heating, ventilating, refrigeration, and air-conditioning engineers. Carries out research programs in cooperation with universities and research laboratories regarding such subjects as heat transfer, thermal performance of buildings, energy conservation, solar applications, and thermal performance standards. Research and general technical programs are conducted through eighty-seven technical committees.

Technical Committee 4.5, Fenestration (TC 4.5), is responsible for research and technical activity in the area of windows and skylights. TC 4.5 is currently revising and updating the Fenestration chapter for the 1981 Handbook of Fundamentals.

Publications: (1) Journal, monthly; (2) Handbook, annual; (3) Transactions, annual; (4) Membership Roster, biennial; also publishes research reports, codes and engineering standards, and bulletins.

Conventions/Meetings: Semi-annual, Los Angeles, CA, Feb. 3-7, 1980; Denver, CO, June 22-26, 1980.

ARCHITECTURAL ALUMINUM MANUFACTURERS ASSOCIATION (AAMA)

Address: 35 E. Wacker Drive, Chicago, IL 60601
Phone: (312) 782-8256
Director: Edward Haggarty, Exec. VP
Founded: 1962
Members: 250
Staff: 11

Purpose/Services: Manufacturers of architectural aluminum products; prime and combination storm windows; sliding glass and combination storm doors; window and curtain-walls; store fronts and entrances; siding; other thermal, ventilating and insulating products. Conducts research on topical industry subjects including energy related performance of windows and skylights. Sponsors certification programs and standards development activities. Speakers' Bureau presents film programs to architectural, builder organizations, and governmental agencies. Maintains library. Conducts placement services.

Publications: (1) Journal, quarterly; (2) Certified Products Directory, quarterly; (3) Membership Directory, annual; (4) Statistics review of industry; also publishes product specifications and design criteria.

Conventions/Meetings: Semi-annual.

ASSOCIATION OF INDUSTRIAL METALLIZERS, COATERS AND LAMINATORS (AIMCAL)

Address: 61 Blue Ridge Road, Wilton, CT 06897
Phone: (203) 762-5611
Director: William H. Troph
Founded: 1970, as successor to the Vacuum Metallizers Association.
Members: 73
Staff: 2

Purpose/Services: A non-profit industrial trade association of firms engaged in the manufacture and supply of materials for the purpose of producing flexible, industrial, coated, laminated, and metallized products. Objectives are to collect and disseminate information, to identify common problems, and to improve service to the public and government agencies.

The Window Film Technical Committees, under the chairmanship of Alan Taylor, is concerned with solar control window films.

Publications: Newsletter, quarterly.

Conventions/Meetings: Three meetings a year.

CANVAS PRODUCT ASSOCIATION INTERNATIONAL (CPAI)

Address: 350 Endicott Building, St. Paul, MN 55101
Phone: (612) 222-2508
Director: Robert Mead, Vice President
Founded: 1912
Members: 850
Staff: 11

Purpose/Services: Provides information, representation in government affairs, access to productivity research, a discount service corporation channel for communication between consumers, government, and industry. Divisions within CPAI focus on specific objectives, markets, or products: air structures, awning, camping, coaters and laminators, finishers, industrial fabric research, marine, outdoor clothing, production, sailmakers, sleeping bag, tarpaulin, tent rental, trailer awning, and truck cover.

Publications: (1) Industrial Fabric Products Review; (2) CPAI membership newsletters; (3) Buyers' Guide (comprehensive directory of products and services of the industry); (4) Membership Guide.

Conventions/Meetings: Annual convention, Toronto, CANADA, Nov. 4-8, 1979.

FLAT GLASS MARKETING ASSOCIATION (FGMA)

Address: 3310 Harrison, White Lakes Professional Bldg., Topeka, KA 66611
Phone: (913) 266-7014
Director: William Birch
Founded: 1949
Members: 140
Staff: 6

Purpose/Services: Industry association of independent glass distributors and contractors covering all flat glass (plate, window, building, and industrial) products.

Publications: (1) Glazing Manual; (2) Glazing Systems Sealing Manual; (3) Fabrication, Erection Glazing Hours Manual; (4) Membership Directory.

Conventions/Meetings: National Conventions—The Greenbrier, White Sulfur Springs, W. V. April 1-5, 1979; The Registry, Scottsdale, AZ, February 24-28, 1980.

GLASS TEMPERING ASSOCIATION (GTA)

Address: 3310 Harrison, White Lakes Professional Bldg., Topeka, KS 66611
Phone: (913) 266-7014
Director: William Birch, Exec. Dir.
Founded: 1958
Members: 42
Staff: 6

Purpose/Service: Industry association of firms engaged in tempering glass.

Publications: Engineering Standards Manual.

Conventions/Meetings: Semi-annual—Spring, Palm Beach, FL; Fall, San Diego, CA.

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA (IES)

Address: United Engineering Center, 345 E. 47th Street, N.Y., N.Y. 10017
Phone: (212) 644-7913
Director: Frank Coda, Exec. VP
Founded: 1906
Members: 10,500
Staff: 20
Sections and Chapters: 114

Purpose/Services: Professional society with a broad based membership dealing with the art and science of illumination. Provides assistance with technical problems, reference help, speakers, and training aids. Maintains liaison with schools and colleges. Conducts local, regional, and national meetings, conferences, symposiums, and seminars. Undertakes research projects to develop basic principles or test methods. There are numerous committees, including a Daylighting Committee, headed by Prof. Benjamin Evans, which recently updated *Recommended Practices for Daylighting.*

Publications: (1) *Lighting Design and Applications,* monthly, 2) *IES Journal,* quarterly, (3) *Lighting Handbook,* revised every five years (next revision, 1980), (4) numerous reports, booklets,and guides.

Conventions/Meetings: Annual, Atlantic City, N.J., Sept. 9-13, 1979; Dallas, TX, August 24-29, 1980.

NATIONAL FENESTRATION COUNCIL (NFC)

Address: 3310 Harrison White Lakes Professional Bldg., Topeka, KS 66611
Phone: (913) 266-7014
Director: William Birch, Exec., Director
Founded: 1979
Member: 12 organizations
Staff: 6

Purpose/Services: Composed of manufacturer's associations and industry organizations concerned with fenestration systems. Established to encourage the proper design and use of windows and window systems; sponsors related research including studies of the net energy performance of windows. Its purpose is to advance the design of fenestration, inform the public, and provide liaison between its members and other technical, governmental, and legislative groups.

Conventions/Meetings: Annual meeting held third Wednesday in June.

NATIONAL GLASS DEALERS ASSOCIATION (NGDA)

Address: 1000 Connecticut Ave., NW #802, Washington, DC 20036
Phone: (202) 296-1662
Director: Robert W. Stanley
Founded: 1948
Members: 1,050
Staff: 5

Purpose/Services: Flat glass and auto glass dealers and distributors. Provides insurance programs, governmental affairs information, legal services for regulatory issues concerning glass dealers business interests.

Publications: (1) *The Glass Dealer,* monthly; (2) *Washington Report,* monthly; (3) *Membership Directory,* Annual; (4) *Glass Gazette;* (5) *Legal Sourcebook for Glass Dealers;* (6)*Auto & Flat Glass Locator Services.*

Conventions/Meetings: Annual convention and National Glass Show; Semi-annual Glass Expo trade show.

NATIONAL WOODWORK MANUFACTURERS ASSOCIATION (NWMA)

Address: 205 West Touhy Ave., Suite 101, Park Ridge, IL 60068
Phone: (312) 823-6747
Director: John Shoemaker, Exec. Vice President
Founded: 1927
Members: 110
Staff: 7

Purpose/Services: Manufacturers of stock woodworks, such as doors, windows, frames, cabinets, and kindred products. Establishes product standards; conducts research in all areas of door and window manufacture and thermal performance. Issues seals (no pun intended) of approval for wood preservative treating and hardwood door manufacture.

Publications: Publishes product standards and materials on proper care and finishing of windows, sash, doors, and frames; issues folders on modular standards.

Conventions/Meetings: Semi-annual, Colorado Springs, Colorado, August 5-8, 1979.

SCREEN MANUFACTURERS ASSOCIATION

Address: 410 N. Michigan Avenue, Chicago, IL 60611
Phone: (312) 321-1646
Director: Frank S. Fitzgerald, President
Founded: 1955
Members: 40
Staff: 3

Purpose/Services: Association of manufacturers of metal window, patio, swimming pool, door and porch screens and sections. Solar Screen Subcommittee of the Fiberglass Screen Committee represents manufacturers of woven solar control screens. Sponsors research programs and compiles statistics. Maintains speakers bureau.

Publications: (1) *Screen Industry News,* quarterly; (2) *Membership Directory,* annual; also publishes guides to product standards and test methods.

Convention/Meetings: Semi-annual; April and October—Chicago.

SEALED INSULATING GLASS MANUFACTURERS ASSOCIATION (SIGMA)

Address: 111 E. Wacker, Chicago, IL 60601
Phone: (312) 644-6610
Director: Charles Hockenberry, Exec. Vice President
Founded: 1963
Members: 160
Staff: 3

Purpose/Services: Manufacturers of Insulating Glass. Concerned with certification, labor-management issues, durability, and quality standards.

Publications: (1) Newsletter, quarterly; (2) Membership Roster, annual; also information on test methods.

Conventions/Meetings: Semi-Annual, 1979 Summer meeting—Hyatt Regency, Cambridge, MA.

SOLAR ENERGY INDUSTRIES ASSOCIATION (SEIA)

Address: 1001 Conneticut Ave., Suite 800, Washington, DC 20036
Phone: (202) 293-2981
Director: John Blake, Exec. Director
Founded: 1974
Members: 650

Staff: 3

Purpose/Services: Manufacturers and designers of solar energy systems and components; also distributors, contractors, engineers. Purpose is to accelerate and foster commercialization of solar energy conversion for economic purposes.

Publications: (1) *SEIA News*, monthly; (2) *Solar Engineering Magazine*, monthly; (3) *Solar Industry Index* (catalog and directory), annual.

Conventions/Meetings: Semi-annual conference & Trade Show.

STEEL WINDOW INSTITUTE

Address: 1230 Keith Building, Cleveland, OH 44115
Phone: (216) 241-7333
Director: Fred A. Petersen, Thomas Associates, Inc.
Founded: 1920
Members: 14
Staff: 1

Purpose/Services: Association of Manufacturers of steel windows, solid section steel windows, and window operating devices. Conducts research to lower production and distribution costs by standardization and simplification.

Publications: 1) *Recommended Specifications for Steel Windows;* (2) *Permanent Windows Explode Myths;* (3) *Permanent Windows Are Steel Windows;* (4) *Permanent Windows for Permanent Value,* (5) *Permanent Windows & Air Corrosion.*

Conventions/Meetings: Three times a year.

WESTERN AWNING ASSOCIATION

Address: 9911 Inglewood Ave., Suite 205, Inglewood, CA 90301
Phone: (213) 671-7767
Director: Clay M. Johnston
Founded: 1954
Members: 70
Staff: 2

Purpose/Services: To assist manufacturers and retailers of awnings, patio covers, and related products.

Publications: Newsletter, quarterly.

WINDOW SHADE MANUFACTURER'S ASSOCIATION

Address: Oak Brook Executive Plaza, 1211 W. 22nd St., Oak Brook, IL 60521
Phone: (312) 887-8867
Director: George M. Schlosser, Exec. Sec.
Founded: 1954
Members: 7
Staff: 4

Purpose/Services: Prime manufacturers of cloth window shades and window shade rollers. Conducts promotional and product design program, sponsors research, and conducts educational programs to communicate about the energy efficiency of window shades.

Publications: Contact the Window Shade News Bureau, 6 East 43rd St., N.Y., N.Y. 10017, (212) 867-8888.

Conventions/Meetings: Semi-annual.

WINDOWS

Literature, Publications, Reports

Accurate and rapid information exchange and dissemination is vital to most energy conservation efforts. In the area of energy efficient windows, there is a tremendous amount of innovation occurring on a decentralized level due to the accessible nature of the subject matter. This in turn generates a large volume of publications and product announcements as well as requests for data, test results, materials specifications, etc. In addition, due to the importance of windows in passive solar design and glazings in the solar collector area, a substantial body of related literature in those fields is of interest and value to developers and specifiers of efficient windows. The purpose of this section is to provide references and abstracts of recent work in any related area that may be of interest to energy-efficient windows, as well as to republish references to older works which may be of significant value to those new to the field.

We would also like to receive references or copies of new titles for possible inclusion in this section. We are particularly interested in previously unpublished reports or data which have not already received wide distribution through existing channels and networks.

The following represents a sampling of papers presented at recent professional society conferences that are relevant to energy-efficient windows. The proceedings of those conferences are available as shown. Conference proceedings offer a wealth of current technical information and some surprises to those willing to work their way through a usually large volume of material. These brief reviews may help the reader by pointing to papers specifically related to energy-efficient windows.

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THERMAL SHUTTERS AND SHADES, William A. Shurcliff, Brick House Publishing, 3 Main Street, Andover, MA 01810

A compendium of information on thermal shutters and shades. Emphasis is primarily on low cost, do-it-yourself schemes, many of which have been built and tested by the author.

* * *

PASSIVE SOLAR HEATING AND COOLING CONFERENCE WORKSHOP PROCEEDINGS, MAY 18-19, 1976, UNIVERSITY OF NEW MEXICO, ALBUQUERQUE, NEW MEXICO (LA-6637-C available from National Technical Information Service, Springfield, VA 22161, $10.50 full-size, $3.00 microfiche)

Daylight Utilization In Passive Solar Systems Using Life-Cycle Cost-Benefit Analysis

J. W. Griffith (p. 316)

This paper discusses some of the basic concepts involved in daylighting design and the need for integration of daylighting and passive heating systems with conventional HVAC and artificial lighting systems. A description of the use of cost-benefit analysis is included.

Movable Insulation

Stephen C. Baer (p. 70)

The problem of sealing air leaks around the edges of movable insulation is the main point of this paper. The relative effects of several window shading devices are discussed, as are some of the author's experiences with movable insulation devices.

Beadwalls

David C. Harrison (p. 283)

Beadwall is a movable insulation system in which polystyrene beads are blown from a storage container to a space between two glazings of a window wall. The paper describes the development of the system including insulating materials, glazing materials, blower motors, and automatic controls. A brief discussion of economics and performance evaluation is included.

Freon Actuated Controls

Stephen C. Baer (p. 282)

The "Skylid" is an insulating louver system that is opened and closed by the shifting weight of Freon in response to the heat of the sun. An historical perspective on the device is included.

* * *

PROCEEDINGS OF THE 1977 ANNUAL MEETING AMERICAN SECTION OF THE INTERNATIONAL SOLAR ENERGY SOCIETY, JUNE 6-10, 1977, ORLANDO, FLORIDA (Available from AS/ISES, P.O. Box 1416, Killeen, TX 76541, 3 vol. set, $45 non-members, $25 members)

Solar Energy Applications For Heat Absorbing Glass

C. Deminet (p. 12-6)

The applicability of infrared-absorbing glass to liquid or air solar collectors, greenhouses, and Trombe walls is discussed. These glasses are designed to transmit the visible spectrum while strongly absorbing the short wave infra-red radiation. They can be tailored to specific applications by changes in their composition.

Analysis And Application Of The Performance Of The Pivotable Solar Heat Exchanger Window Wall

Robert A. Golobic, Stanley A. Mumma, Walter S. White (p. 12-9)

The operating principles of a system that uses heat absorbing glass as an interior absorber plate in the winter and an exterior heat rejector in the summer precede a report of the results of testing the system. In the winter, air is heated by contact with the interior heat absorbing glass sheet and distributed to heat the living space or the storage. In summer, the arrangement is pivoted 180° so that the heat absorbing glass is on the outside which prevents incident radiation from reaching the inner glazing layers.

* * *

PROCEEDINGS OF THE CONFERENCE ON ENERGY CONSERVING, SOLAR - HEATED GREENHOUSES, NOVEMBER 19-20, 1977, MARLBORO COLLEGE, MARLBORO, VERMONT (Available from Marlboro College, Marlboro, VT 05344, 282 pages, $9.00)

The Use of Retractable, Insulated, Reflective Shutters For Augmenting Radiation and Retaining Heat in Greenhouses

Michael Piserchio, William DuPont, John Hayes, Jeremy Coleman (p. 166)

This article presents a simplified method for estimating the additional solar gain that can be achieved by the use of horizontal specular reflectors. Two greenhouses have been constructed at Marlboro College and comparative performance due to design differences is discussed. The effect on plant growth of using removable insulation for better thermal efficiency is being evaluated experimentally.

* * *

PASSIVE SOLAR: STATE OF THE ART, PROCEEDINGS OF THE 2nd NATIONAL PASSIVE SOLAR CONFERENCE, MARCH 16-18, 1978, UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PENNSYLVANIA (Available from the Mid-Atlantic Solar Energy Association, 2233 Gray's Ferry Avenue, Philadelphia, PA 19146, 3 vol. set $20.00)

A Self Inflating Movable Insulation System

Ronald Shore (Vol. 2, p. 305)

A self-inflating thermal curtain consisting of multiple layers of thin, flexible material with high reflectivity and low emissivity is discussed in this paper. The curtain relies on the expansion of air heated by the sun or by a thermal storage wall to create air spaces between the layers of material. Performance tests of the system have been made and the results are promising.

Window Coverings

Gary Starr, Bruce Melzer (Vol. 2, p. 317)

Two homemade window insulation systems: a blanket made of three inches of polyester batting and light cotton cloth, and a sandwich of two-inch rigid styrofoam between matboard, were constructed and performance tested against a variety of conventional roller shades. The styrofoam shutter proved to be the most effective system tested.

Movable Insulation: New Developments At Zomeworks

Robert Hymer (Vol. 2, p. 310)

This paper discusses some design improvements on movable insulation systems developed by Zomeworks of New Mexico. Skylids (sets of insulating louvers which open and close by means of a thermally actuated, selfcontained weight-shifting device) now use hinged shutters to accommodate reflectors which can augment the low winter sun. Nightwall clips (self-adhesive magnetic strips that allow rigid insulation to be applied to window glass) have been redesigned to prevent deterioration of adhesives.

The Window Quilt Insulating Shade

John Schnebly, Thomas Lowell, Michael Moss (Vol. 2, p. 314)

The "Window Quilt" consists of two layers of polyester batting separated by a metalized fabric. Thermal performance, low flammability, and ease of installation and use are virtues of the shade cited in this paper.

Variable Transmission Solar Membrane

Day Chahroudi (Vol. 2, p. 343)

The transparent plastic insulation film called the Solar Membrane is described as having solar transmission of 95%, a U-factor or 0.2, a service temperture of 400°F, and an expected lifetime of over 30 years. The primary application of this commercially available material is for solar collectors, but it will find other uses as well. Cloud Gel, which switches reversibly from transparent to opaque as ambient temperature changes about a predetermined set point, is also discussed.

Energy Transport Control In Window Systems

A. L. Berland, R. Jaung, Y. J. Yen, N. Tutu (Vol. 2, p. 326)

Conductive, convective, and radiative heat transfer can be reduced in window systems using larger than normal (4") inter-pane separations with single or multiple arrays of blinds (between the panes) made of highly reflective materials that have low thermal conductivity. This paper analyzes heat transfer mechanisms as they are affected by the design features of this window system.

A Comprehensive Approach To Window Design for Energy Conservation

S. Robert Hastings (Vol. 2, p. 321)

This summary of the author's more detailed report, "Window Design Strategies to Conserve Energy" (see Literature section, WINDOWS, Volume I, No. 1), presents an organizational structure in which the various window energy control mechanisms can be better understood. It considers the mechanisms of daylighting, insulation, air tightness, ventilation, and solar gain in the context of design strategies that can be characterized as: site design; exterior appendages; window frame and orientation; glazing material; interior accessories; and building interior design.

The Development and Use of The Computer Program UWLIGHT for the Simulation of Natural and Artificial Illumination in Buildings

J. R. Bedrick, M. S. Millet, G. S. Spencer, D. R. Heerwagen, G. B. Varey (Vol. 2, p. 365)

The use of the program UWLIGHT to simulate the quantifiable aspects of light distribution on interior surfaces and at specified work plane heights has helped this research group to develop energy conservation guidelines for buildings. Measurement of daylight is based upon the C.I.E. Daylight Factor concept. The logic and use of the program are discussed and a case study example provided.

* * *

PROCEEDINGS OF THE 1978 ANNUAL MEETING AMERICAN SECTION OF THE INTERNATIONAL SOLAR ENERGY SOCIETY, INC., AUGUST 28-31, 1978, DENVER, COLORADO (Available from AS/ISES, P.O. Box 1416, Killeen, TX 76541, 2 vol. set, 1796 pages, $60 nonmembers, $25 members)

Daylighting Design for the Sacramento State Office Building Competition

Douglas S. Stenhouse, Cecile H. Wolf (Vol. 2.2, p. 128)

Daylighting considerations determined the form of the building design to a great extent in this project. Computational procedures for daylighting are discussed, as are the effects of natural and artificial illumination on a building's heating and cooling loads.

Sundows and Windows

Richard S. Levine (Vol. 2.2, p. 140)

Because "the conventional window is a universal device that is designed to perform several functions but in fact does none of them well," separate banks of windows can be used to perform separated functions more efficiently. A "Sundow" system that uses a naturally activated insulating shutter is described and some applications are discussed.

Retrofitting Glass Windows For Energy Conservation

Roy K. Tsui, Leonardo M. Garcia (Vol. 2.2, p. 153)

A few glazing materials and combinations were monitored experimentally using a controlled environmental chamber. The design of the chamber, the effects of various heat transfer phenomena, and the effectiveness of some materials is presented. The study concentrates on solar control films and thermopane glass.

Space Heating With Indirect Sunlight

Raymond Auger (Vol. 2.2, p. 176)

This paper deals with some basic solutions to passive heating of structures in locations that have long overcast periods. The orientation and slope, number of glazing layers, and emissivity of interior surfaces are discussed as parameters that affect the thermal performance of windows.

Theory And Experiment Of The Performance Of The Pivotable Solar Heat Exchanger Window Wall

Robert A. Golobic, Stanley A. Mumma, Walter S. White (Vol. 2.2, p. 187)

This paper describes tests of the Pivotable Window Wall made at Arizona State University and the reasons for apparent differences between predicted and actual performance.

Passive Forms Of The Clearview Solar Collector

John F. Peck, T. Lewis Thompson, Helen J. Kessler (Vol. 2.2, p. 180)

The ClearView Solar Collector uses either dark venetian blinds or heat absorbing glass as an absorber plate located between two transparent glass plates. It is a vertical, wallmounted hot air collector. This paper describes the system, discusses its performance and design, presents an economic analysis, and discusses retrofit opportunities.

Glazing And The Trombe Wall

R. W. Pounder, R. W. Leigh (p. 192)

The marginal effect of additional glazing layers with regard to heat gain, energy savings, and total costs, on passive solar Trombe wall systems is evaluated in this paper. The study focuses on the dependence of reflectivity of each glazing pane on angle of incidence.

Introduction To Design: Nature's Lesson

W. Douglas Davis (Vol. 2.2, p. 257)

While the contents of this paper may not be directly concerned with window systems, it would be a shame to have the proceedings in your hand and not touch on this subject. The simple point of the paper is that several useful techniques of solar utilization have been used by the plant and animal kingdoms for millions of years. Many examples are used, including birds and monkeys who adopt specific postures in relation to the sun, and ants who in alternating groups heat their nests by sitting in the sun in large numbers and then take their hot bodies down into the nest.

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PROCEEDINGS OF THE 3rd NATIONAL PASSIVE SOLAR CONFERENCE, JANUARY 10-13, 1979, SAN JOSE, CALIFORNIA (Available from the American Section/International Solar Energy Society, P.O. Box 1416, Killeen, TX 76541, 943 pp.)

Glass — An Essential Component In Passive Heating Systems

John I. Yellott (p. 95)

This paper summarizes the methods of estimating solar heat gains and conduction heat losses, through any glazing material in any location, that have been developed by the Fenestration Committee of the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). Since the paper addresses passive solar applications, it concentrates upon ¼" clear float glass which must be used to sustain wind loads in relatively large windows. The reader is referred to the *ASHRAE Handbook of Fundamentals*, 1977 ed., for discussions of other glazing materials.

Daylighting And Passive Solar Buildings

Stephen E. Selkowitz (p. 271)

This paper discusses the role of lighting systems as major energy consumers in commercial buildings and suggests some approaches to reducing lighting energy consumption. Several techniques for solar daylighting are discussed as well as some of the barriers to their use (including thermal vs. illumination trade-offs). Lighting controls, and their interface with daylighting, are included. The issue of cost effectiveness and economics is treated by presenting reduced peak power demand charges, energy savings, and failure tolerance as evaluation criteria.

Designing For Daylight: A New Prediction Technique

Marietta S. Millet, James R. Bedrick, Guy S. Spencer, Gordon B. Varey (p. 121)

A simplified daylighting prediction technique, based on simulations done by the computer program UWLIGHT which, in turn, is based on the C.I.E. Daylight Factor, is described in this paper. The technique is a graphic design aid that requires no technical expertise or calculations. A sample procedure is included to illustrate the use of the technique.

A Simplified Daylighting Design Methodology For Clear Skies

Harvey J. Bryan (p. 114)

Graphs and tables are developed to determine sky components, externally reflected components, and internally reflected components of the daylight reaching the point under consideration. The work reported in this paper allows the daylight factor method to be used with clear, as well as overcast, skies.

Determining The Optimum Design Of The Solar Modulator

Ralph M. Lebens (p. 100)

The solar modulator is a reflective louver that is used in the new MIT Solar Building 5 to reflect solar radiation onto ceiling tiles that contain phase change materials for heat storage. The louvers resemble inverted venetian blind louvers and are located between the panes of the south glazing. The paper deals with the determination of the size, spacing, and curvature of the slats within a series of design constraints.

Solar-5, An Interactive Computer Aided Passive Solar Building Design System

Murray Milne, Shin Yoshikawa (p. 129)

This simplified design system uses an interactive computer program to allow an architect to see the resultant thermal effects of changes in building geometry and type of construction in the form of a 3-dimensional graph of heating and cooling loads. The program is quick and easy to use and is based on standard ASHRAE algorithms. Some of the operating principles are discussed and some sample output is included.

A Preliminary Study Of Passive Solar Heating Performance And Visual Clarity For A Transwall Structure

J. F. McClelland, R. Fuchs (p. 107)

The Transwall system consists of three glazing layers, the middle layer being a semi-transparent absorber plate, between which a water-based storage medium is contained. A baffle structure is used to quench convective heat transfer. The benefits of a direct gain system free from glare and photodegradation problems and of a thermal storage wall that allows reasonably good visual transmission are combined in a Transwall. The thermal performance of the Transwall was compared by computer simulation with other passive heating systems, and its visual performance was tested. The results of these preliminary analyses are reported.

Recent Design & Performance Data For The Hybrid Clearview Solar Collector System

John F. Peck, T. Lewis Thompson, Helen J. Kessler, Carl N. Hodges (p. 597)

Experience derived from installation of hybrid ClearView collectors in two new houses and three existing houses in Tucson, Arizona is presented in this paper, preceded by a description of construction details.

Window Insulation: A Neighborhood Demonstration Project

A. B. LaVigne (p. 900)

This paper describes a slide show and workshop series held to demonstrate the construction of simple insulating window covers. The scope of the project, which included a retrofit demonstration house, and some of the results are presented.

Cost And Thermal Performance Comparisons For Wall Systems As Applied To Passive Solar Buildings

Robert D. Taylor (p. 905)

Various wall systems, including several glass wall configurations (with Trombe walls, watertubes, insulating shades and shutters, and some clerestory configurations) are compared to a standard wall on the basis of cost and heat transfer characteristics.

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ASHRAE SEMI-ANNUAL MEETING, JANUARY 28-FEBRUARY 1, 1979, PHILADELPHIA, PENNSYLVANIA (Papers may be ordered from ASHRAE Publications Sales Dept., 345 E. 47th St., NY 10017, $4.00 each)

From Symposium PH-79-6:

Windows Usage at the National Bureau of Standards — Venetian Blinds as a Potential Energy Saver

A. I. Rubin, B. I. Collins, R. I. Tibbott

In conjunction with a research program monitoring energy use at the National Bureau of Standards, a study of the use of internal shading devices was undertaken. Although many energy conservation measures for buildings require the active participation of the occupant, little information is available about this participation, even in simple cases such as the efficient use of window shading devices. This study was designed with four goals in mind: (1) To determine whether the office occupants of the general purpose laboratories of NBS manipulate their window blinds, and if so, how frequently this occurs; (2) To test the effects of a number of external variables, and determine their influence on window usage as measured by venetian blind position; (3) To determine the feasibility of energy-saving operations that depend on the manipulation of venetian blinds by building occupants; (4) To develop and refine a methodology applicable to a variety of field investigations of building use by occupants. Venetian blinds are a particularly versatile shading device, allowing selective control over window characteristics by means of adjusting blind height and the angle of the slats. Proper blind usage offers the possibility of significant energy savings if ways can be found to encourage the cooperation of room occupants or maintenance personnel.

U-Value Testing of Windows Using a Modified Guarded Hot Box Technique

S. J. Rennekamp

This paper describes a recently developed technique for determining the U-value of windows by tests using modified hot box facilities and procedures. When used to test for the thermal properties of windows, conventional methods for determining the thermal conductance and transmittance of building sections have proven to be unsatisfactory. This is primarily due to the irregularities and non-uniform cross sections which exist in a typical window and the manner in which the surface film coefficients are handled. This modified approach uses a facility which applies a direct 15-mph air flow perpendicular to the unit and uses procedures that pre-determine the surface film coefficients to conform to standard ASHRAE values. Tests of more than 150 different window products using this technique have yielded accurate, consistent, and reproducible results.

Thermal Performance of Wood Window And Doors

J. F. Lowinski

The National Woodwork Manufacturers Association conducted controlled thermal testing of modern, wood window and door designs, mostly of woodframed construction, to verify their calculated performance and to explore the effects of various testing techniques and construction details not specifically covered by general engineering calculation methods. The results of the study form an overall view of the thermal performance capabilities of these window and door designs. The various units and tests conducted in this study are evaluated and compared to the design performance data contained in the 1977 Fundamentals Volume of the *ASHRAE Handbook*. The report shows that a close relationship exists between the calculated performance values and the actual test results when the tests are conducted in conformance to ASTM C236 "Guarded Hot Box Tests." It also discusses modifications of that test method, specifically in applying an exterior wind during the test.

From The Third Technical Session:

Roller Shade System Effectiveness in Space Heating Energy Conservation

N. M. Grosso, D. R. Buchanan

The effectiveness in conserving space heating energy of several commercial and experimental roller shade systems (as measured with a full-size guarded hot plate) depends mainly on the thickness and emissivity of the shade fabric and the geometry of mounting the shade in the window. It is particularly important to seal at least three sides of the shade to the window frame, thereby reducing convective heat losses. For the same reason, using a shade-to-glass distance of 25.4 mm (1 in.) proved to be significantly more effective than using larger distances. Finally, multiple layers of shade fabric are more effective than a single fabric layer, especially if they are separated by no more than 12.7 mm (½ in.).

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ASHRAE SYMPOSIUM, "WINDOW MANAGEMENT AS IT AFFECTS ENERGY CONSERVATION IN BUILDINGS," JUNE 1979, Detroit, MI. Published in ASHRAE Transactions, Vol. 85, Part 2. (Papers may be ordered from ASHRAE Publications Sales Dept., 345 E. 47th St., NY 10017, $4.00 each)

Window Management: An Overview

Dr. Belinda Collins (Paper DE-79-5, No. 1)

Window management has been defined as the selective alteration of a window's thermal and light transmission properties. In this paper the use of window management to alter window properties is discussed in terms of the need for energy conservation in buildings. Initially, a brief review of the psychological reaction to windows is given. Then thermal calculations of the energy balance at the window are given in terms of the use of daylight and window management. Finally, several studies on actual window management practices are reviewed. These include the use of natural ventilation, natural light, and venetian blinds. In conclusion, the need for further research into the factors that affect the use of window management is suggested, along with the urgent requirement to evaluate the window as a total system.

Energy Conservation with
Natural Air Flow through Windows

Benjamin H. Evans (Paper DE-79-5, No. 2)

The need for optimizing energy use in buildings is drawing designers back to some of the basics of natural environmental control. Of the principal elements that govern human comfort — air temperature, humidity, and air movement — only the latter can be significantly controlled without substantial energy use. Windows are primary vehicles for getting air into and out of buildings. They are only part of a system of air-controlling features that must be used to enhance air movement through the "living zone" of a building where it can cool occupants. The paper discusses the effect of window size location and type on natural ventilation and reviews the influence of other design elements such as overhangs, landscaping screens, trees and shrubs.

The Phoenix Fenestration Tests of
1977 — Thermal Aspects

John I. Yellott, P.E.; P.V.R. Schuyler, III; R. D. Timmons (Paper DE-79-5, No. 3)

Six identical west-facing office spaces in a high-rise building in Phoenix, Arizona, were used for an extensive series of tests to determine sun-control capabilities of various glazing materials with internal shading devices. For the test program, the original bronze float glass was replaced in five rooms with other types of glass. Thermal and illumination tests were then run on approximately forty different types of roller shades, films and Venetian blinds.

Measurements were made of exterior and interior total solar and visible radiation; temperatures of outdoor and indoor air, glazing and shade materials; indoor and outdoor air velocities. Subjective evaluations of human comfort were also made and both total illumination and ESI were determined at selected locations. The objective of the tests was to determine the ability of the various glazing combinations to admit daylight and to admit or exclude solar radiation.

Daylight and Energy Conscious Design

James W. Griffith, P.E. (Paper DE-79-5, No. 4)

Daylight, the primary light source in commercial and institutional buildings before the advent of cheap electric energy and air conditioning, is rediscovered as a replacement for nonrenewable energy. A review of the development of techniques for evaluating alternative daylight schemes to permit trade-offs between the HVAC and lighting subsystems leads to life cycle cost-benefit analysis as a desirable energy conservation criterion. Additional energy conservation could be accomplished by using daylight to reduce peak loads on electric utilities.

Thermal Performance of Insulating Window Systems

Stephen E. Selkowitz (Paper DE-79-5, No. 5)

Energy efficient windows coupled with window management strategies can alter the role of windows from that of an energy drain to a net supplier of energy to the building. This will require effective utilization of winter solar gain and daylight, coupled with reductions in thermal losses. Thermal losses of conventional double glazing are less than those of single glass but fall far short of the lower loss rate of other building elements. This paper reviews several improvements in window design that show promise of reducing the window U value to as low as .5 W/m^2-K (.1 Btu/hr-ft^2-°F). These include the use of convection suppression in double glazed windows using low conductivity fill gases, with vertical and horizontal partitions; partial evacuation of the air space; transparent heat mirror coatings on glass and on plastic interlayers; movable insulating devices; and air flow windows. Thermal comfort, cost effectiveness and other non-energy related performance issues are discussed briefly relative to several of the proposed designs.

In keeping with our policy of reader participation please help us improve the following tables by:

- Informing us of corrections and omissions.
- Sending information on new products.

METRIC CONVERSIONS* FOR WINDOW DESIGN AND CONSTRUCTION

LENGTH

1 m	= 1.09361 yd	(0.9144)
	= 3.28084 ft	(0.3048)
1 cm	= 0.3937 in	(2.54)
1 mile	= 1.6093 km	(0.6214)

AREA

1 m^2	= 1.19591 yd^2	(0.8362)
	= 10.7636 ft^2	(0.0929)
1 cm^2	= 0.155 in^2	(6.4516)
1 hectare	= 2.47 acres	(0.4049)
1 acre	= 43,560 ft^2	(2.2957×10^{-5})

VOLUME

1 m^3	= 1.30795 yd^3	(0.7646)
	= 35.3147 ft^3	(0.0283)
1 cm^3	= 0.061 in^3	(16.3934)
1 liter	= 0.0354 ft^3	(28.3170)
	= 0.2642 gal	(3.7854)
1 barrel (bb1)	= 42 gal	(0.0238)

MASS

1 kg	= 2.2046 lb	(0.4536)

TEMPERATURE

t °C	= 0.556 (t °F-32)	
t °F	= 1.8 t °C + 32	
Δ°F	= 1.8 Δ°C	(0.5556)
T °K	= t °C + 273	
T °R	= t °F + 460	

DENSITY

1 kg/m^3	= 0.0624 lb/ft^3	(16.0256)

ENERGY, HEAT

1 MJ	= 0.2778 kWh	(3.600)
1 kJ	= 0.9478 Btu	(1.0551)
1 J	= 0.7376 ft-lbf	(1.3557)
1 kWh	= 3412.4 Btu	(2.93×10^{-4})

FLOW

1 liter/s	= 2.1189 ft^3/min (CFM)	(0.4719)

HEAT STORAGE

1 KJ/°C	= 0.5269 Btu/°F	(1.8979)	Thermal Mass
1 Wh/°C	= 1.8969 Btu/°F	(0.5272)	Thermal Mass
1 kJ/m^2-°C	= 0.04895×10^{-3} Btu/ft^2-°F	(20.4290)	
1 kJ/kg-°C	= 0.2390 Btu/lb-°F	(4.1841)	Specific Heat

HEAT TRANSFER

1 W/m-°C	= 0.5782 Btu-ft/hr-ft^2-°F	(1.7295)	Conductivity
	= 6.9380 Btu-in/hr-ft^2-°F	(0.1441)	Conductivity
1 W/m^2-°C	= 0.1762 Btu/hr-ft^2-°F	(5.6745)	Transfer Coefficient
1 W/°C	= 1.8956 Btu/hr-°F	(0.5275)	Conductance
1 W/m^2	= 0.3172 Btu/hr-ft^2	(3.1526)	Heat Flux

POWER

1 W	= 3.4144 Btu/hr	(0.2929)
	= 0.7380 ft-lbf/sec	(1.3550)
1 kW	= 1.3423 hp	(0.7450)

PRESSURE

1 Pascal	= 0.1450×10^{-3} psi	(6894.759)
	= 0.0040 in. water	(250.00)

VELOCITY

1 m/s	= 196.85 ft/min	(0.0051)
	= 2.2369 mph	(0.4470)

BUILDING HEAT LOSS

1 Wh/DD $_{(°C)}$	= 3.600 kJ/DD$_{(°C)}$
	= 1.896 Btu/DD$_{(°F)}$
1 Wh/m^2-DD $_{(°C)}$	= 3.6 kJ/m^2-DD$_{(°C)}$
	= 20.4 Btu/ft^2-DD$_{(°F)}$

ILLUMINANCE

1 lux	= 0.0929 lm/ft^2 (footcandle)

PROPERTIES OF COMMON MATERIALS

Property (Typical Values)	Specific Heat (Btu/lb-°F)	Density (lb/ft^3)	Thermal Conductivity (Btu-ft/hr-ft^2-°F)
Air	0.24	0.076	0.015
Aluminum	0.214	171	128
Concrete	0.156	144	0.54
Hardwood	0.55	50	0.1
Water	1.0	62.3	0.348

MISCELLANEOUS CONVERSIONS & EQUIVALENTS

(Note: Many are rough approximations, as indicated by use of ≐)

1 Quad = 10^{15} Btu ≐ 1.05×10^{18} Joules ≐ 2.9×10^{11} kWh
≐ 180×10^6 bbl oil ≐ 10^{12} ft^3 gas ≐ 44×10^6 short tons coal
1 Therm = 10^5 Btu
1 bbl crude oil = 5.8×10^6 Btu (1 bbl = 42 gal)
1 ft^3 natural gas ≐ 1050 Btu
1 lb bituminous coal ≐ 12,500 Btu
1 lb hardwood (dry) ≐ 8,600 Btu
1 kWh (electric) ≐ 11,000 Btu (thermal)
Solar constant (above atmosphere) = 1353 W/m^2
Average solar noon intensity (at Earth's surface) = 900 W/m^2

Total U.S. Energy Consumption	100%	75 Quads
Building sector consumption	38%	28 Quads
Building sector: heating/cooling	20%	15.2 Quads
Attributable to windows	5%	3.8 Quads

*Use the figure in parenthesis to make the inverse conversion of units. For example, since 1m = 1.09361 yd, it is true that 1 yd = 1/1.09361 m, and 1/1.09361 = 0.9144, the figure in parenthesis.

A Comparison Matrix of Window Thermal Barriers

The numerical performance data in the table have been assembled from calculations and test data reported in manufacturers literature, calculations based upon standard ASHRAE methods (primarily chapter 26, *Handbook of Fundamentals*), and data collected from other sources. Due to the variety of sources, **these values should be used with caution,** even for comparative analysis. Existing window conditions, installation details, air leakage characteristics, and product variations will add further uncertainty to calculations of installed product performance.

Product characteristics checked off in the matrix are suggestive but not definitive judgments. Footnotes are provided where possible to indicate the source of the data. Short product descriptions and sketches are provided in the "Products" section of this publication. A more detailed analysis of the thermal performance of each product is available as a separate publication, "Thermal Barrier Performance: Notes and Analysis."

a: reduces S.C. of prime window by 0.1 - 0.15

b: Nominal value, ½" air space, uncoated glass, no sash, frame

c: U value

d: based upon reported emissivity of 0.2 - 0.3

e: assumes 11/16" polystyrene

f: assumes air tight fit to window

g: assumes 1" beadboard

h: assumes 5/64" air gap between glass and panel

i: assumes tight fitting shade

j: single shade U = 0.85, double shade U = 0.68, double shade, metallized U = 0.60

k: lower range for exterior application

m: all three layers deployed

NOTE

Product descriptions, performance claims and data are reproduced from information supplied by the manufacturers. No claims are made concerning the validity or completeness of any product descriptions. The mention of certain company names or brand-name products is not intended as a recommendation of them over other companies or similar products on the market. Before purchasing or ordering any materials, it is sound practice to contact the manufacturer directly (or appropriate distributors and retailers) for complete information regarding a proposed application. Inclusion in this document does not constitute endorsement by the Lawrence Berkeley Laboratory, The University of California, or the U.S. Department of Energy.

A Comparison Matrix of Window Thermal Barriers

Calendar

This section provides information on upcoming conferences, meetings, exposition workshops, and other learning opportunities concerning windows and related energy conservation and solar matters. Please inform us of future events which might be included in the Calendar Section. We have included meetings that have already occurred so that the reader may obtain conference proceedings or other written records.

Aug. 27-Sept. 2: **1st International Symposium on Non-Conventional Energy.** Miramare-Trieste, Italy. Sponsors: Italian National Research Council; ISES, Italian Section, Italian National Energy Authority; Ministry for Scientific and Technological Research. Contact: International Centre for Theoretical Physics, P.O. Box 586, 1-34100, Trieste, Italy.

Aug. 29-31: **A Critical Look at Solar Energy Applications Presently Useful in the Design of Buildings, a Symposium.** Sydney, Australia. Contact: The Symposium Organizer, Department of Architectural Science, University of Sydney, Sydney, N.S.W. 2006, Australia.

Sept. 9-13: **Flat Glass Marketing Association Pacific Coast Section.** Inn at Pebble Beach, Pebble Beach, CA. Contact: FGMA, 3310 Harrison, White Lakes Professional Bldg., Topeka, KS 66611. (913) 266-7014.

Sept. 14-16: **National Energy Expo '79.** Baltimore Convention Center, Baltimore, MD. Sponsor: Society for Energy Awareness. Contact: EMI, Inc., 51 Monroe St., Suite 104, Rockville, MD 20850. (301) 424-3660.

Sept. 16-19: **National Energy Economics III.** Houston, TX. Contact: Charles F. O'Connor, Council for Energy Studies, P.O. Box 7374, Tulsa, OK 74105.

Sept. 23-27: **18th International Meeting of Comples-Solar Energy, New Perspectives.** Milan, Italy. Sponsor: Comples. Contact: Secretariat Comples, Via di Propaganda, 27 00187 Rome, Italy.

Sept. 24-28: **Design Installation, and Operation Criteria for Solar Energy Systems Symposium.** Illinois Institute of Technology, Chicago, IL. Contact: Institute of Gas Technology, 3424 South State St., IIT Center, Chicago, IL 60616. (312) 567-3719.

Sept. 26-29: **Flat Glass Marketing Association Southeastern and Southwestern Sections.** Contemporary Resort Hotel Disney World, Orlando, FL. Contact: FGMA, 3310 Harrison, White Lakes Professional Building, Topeka, KS 66611. (913) 266-7014.

Sept. 28-30: **Glassexpo '79.** Holiday Inn O'Hare, Chicago, IL. Contact: National Glass Dealers Association, 1000 Connecticut Ave., N.W. #802, Washington, D.C. 20036. (202) 296-1662.

Oct. 3-5: **Fourth National Passive Solar Conference.** Kansas City, MO. Conference will cover passive and hybrid HC, performance and economics on existing data, regionally appropriate designs, natural cooling, commercial and multifamily buildings, industrial and agricultural applications, integrated homesteads, simulation techniques, and more.

Contact: Fourth National Passive Solar Conference, P.O. Box 1643, Jefferson City, MO. 65102.

Oct. 6-10: **Solar Energy Industries Association (SEIA), 5th Annual Meeting and Product Exhibit.** Denver, CO. Contact: SEIA, Suite 800, 1001 Connecticut Avenue N.W., Washington, D.C. 20036. (202) 293-2981.

Oct. 9-11: **Energy Management.** Birmingham, England. Contact: Conference '79, Energy Conservation Division, Department of Energy, Room 1685, Thomas House South, Millbank, London, England SW 1P 40J. (01) 211-3000.

Oct. 16-18: **Build Expo '79.** McCormick Place, Chicago, Illinois. Commercial, industrial and institutional products for construction projects. Contact: Build Expo '79, 331 Madison Avenue, New York, NY 10017. (212) 682-4802.

Oct. 16-22: **Flat Glass Marketing Association, Eastern, MidWestern and Pacific Coast Sections, Fall Meetings.** Hyatt Regency Hotel, Cambridge, MA. Contact: FGMA, 3310 Harrison, White Lakes Professional Building, Topeka, KS 66611. (913) 266-7014.

Oct. 18-24: **Sealed Insulating Glass Manufacturers Association Summer Meeting.** Hyatt Regency Hotel, Cambridge, MA. Contact: SIGMA, 111 E. Wacker, Chicago, IL. (312) 644-6610.

Oct. 19-21: **The Glass Show '79, 6th Annual Regional Trade Show.** John B. Hyres Auditorium, Boston, MA. Contact Corinne Dame, 51 Church St., Boston, MA 02116. (617) 482-9380.

Oct. 19-21: **Inter GLASS Metal '79, 2nd Biennial International Industrial Exhibition.** John B. Hyres Auditorium, Boston, MA. Contact: Corinne Dame, 51 Church St., Boston, MA 02116. (617) 482-9380.

Oct. 22-26: **International Conference on Energy Use Management (ICEUM-II).** Los Angeles, CA. Sponsors: U.S. Department of Energy, University of Arizona, Alliance to Save Energy. Contact: Craig Smith, Energy Use Management Conference, P.O. Box 64360, Los Angeles, CA.

Oct. 22-Nov. 9: **Solutions to the National Use of Energy in Buildings.** London, England. Contact: RIBA, Portland Place, London, England.

Oct. 24-26: **Congress International Solaire (International Solar Energy Symposium).** Nice, France. Sponsor/Contact: M. Ferard Maurel, Directeur du Congres Energie Solaire 1979, Jeune Chambre Economique De Nice-Cote D'Azur, 24 boulevard Stalingrad, 06300 Nice, France.

Oct. 24 - Nov. 1: **Energy Conservation Materials and Applications Exhibition.** London, England. Contact: Judith Stammers, Solar Trade Association Limited, c/o the Building Centre, 26 Store Street, London, WCIE 7BT, England.

Nov. 1-2: **Conference and Exhibition on Energy Conservation for Small Business and Home Owners.** Charlotte, N. C. Sponsor: North Carolina Department of Energy. Contact: Forrest Collier, 8 Hickory Ridge Court, Clover, SC 29710. (803) 831-1595.

Nov. 2-4: **Energy Fair '79.** Los Angeles, CA. This fourth annual fair will feature a session on Solar Energy — Issues and Pointers. One focal point is Solar/Wind Energy Management Systems. Contact: Randy Roash, Charles B. Slack, Inc., Los Angeles World Trade Center, 350 South Figueroa St., Los Angeles, CA 90071. (213) 485-1182.

Calendar *Continued*

Nov. 7–9: **Synergy in the Building Science.** Pittsburg, PA. Topics Include: Structural System Design, Material Selection, Computer A-Ideal Design, Human Factors in Physical Planning, and Energy Conservation. Contact: Pat Markenson, Advanced Building Studies Program, Schenley Park, Pittsburgh, PA 15213. (412) 578-2350.

Nov. 9-10: **First Passive Residential Design Competition Displays.** Merritt Island, FLA. Winning Designs of Florida's competition. Sponsor: Florida Solar Energy Center, 300 State Road 401, Cape Canaveral, FL 42920. (305) 783-0300.

Nov. 11–14: **Glass Tempering Association Fall Meeting.** Hotel Del Coronado, Coronado, CA. Contact: Glass Tempering Association, 3310 Harrison, White Lakes Professional Building, Topeka, KS. (913) 266-7014.

Nov. 14–16: **Laminators Safety Glass Association Fall Meeting.** Hotel Del Coronado, Coronado, CA. Contact: Laminators Safety Glass Association.

Nov. 15-29: **New Products Exhibition.** London, England. Contact: Judith Stammers, Solar Trade Association Limited, c/o The Building Centre, 26 Store Street, London, WC1E 7BT, England.

Nov. 16–18: **Energy Futures Exhibition.** New York Hilton Hotel, New York. Contact: National Energy Foundation, 366 Madison Avenue, New York, N.Y. 10017.

Nov. 16-21: **Sixth International Heating, Refrigerating and Air Conditioning Exhibit.** Paris, France. Contact: Judith Stammers, Solar Trade Association Limited, c/o The Building Centre, 26 Store Street, London, WC1E 7BT, England.

Nov. 28-30: **Second Annual Solar Heating and Cooling System Operational Results Conference.** Colorado Springs, CO. Sponsor: DOE/SERI. Contact: Vicki Curry, Conferences Group, Solar Energy Research Institute, 1536 Cole Blvd., Golden, CO 80401. (303) 231-1000.

Nov. 29-30: **Solar Energy Products Markets in Europe.** London, England. Contact: Frost & Sullivan, 104-112 Marylebane Lane, London, W1M 5FU, England.

Dec. 2-8: **Interbuild.** Birmingham, England. Contact: Judith Stammers, Solar Trade Association Limited, c/o The Building Centre, 26 Store Street, London, WC1E 7BT, England.

Dec. 3–5: **Thermal Performance of the Exterior Envelopes of Buildings.** Orlando, FL. Sponsors: U.S. Department of Energy and the American Society of Heating Refrigeration and Air Conditioning Engineers. Contact: Ralph Burkowsky, Meetings Manager, ASHRAE, 345 East 47th Street, New York, NY 10017. (212) 644-7950.

Dec. 10–12: **Second Miami International Conference on Alternative Energy Sources:** Miami, FL. Conference will cover solar, ocean, wind, breeder and fusion energies, and synthetic fuels. Contact: Clean Energy Research Institute, School of Engineering and Architecture, University of Miami, Box 248294. Coral Gables, FL 33124.

Jan. 20–26, 1980: **Third Middle East Construction Exhibition and Conference.** Jeddah, Saudi Arabia. Contact: William J. Mason, Director, International Sales, Cahners Exposition Group, 331 Madison Avenue, New York, N.Y. 10017. (212) 682-4802.

Feb. 3-7, 1980: **Energy Sources and Technology Conference and Exhibition.** New Orleans, LA. Sponsor: American Society of Mechanical Engineers (ASME); National Association of Corrosion Engineers (NACE); Institute of Electrical and Electronics Engineers (IEEE). Contact: F. C. Demarest, Demarest Public Relations, 10517 Countess Dr., Dallas, TX 75229. (214) 351-1042.

Feb. 3-7, 1980: **ASHRAE 1980 Semi-Annual Meeting.** Los Angeles, CA. Sponsor: American Society of Heating, Refrigerating, and Air-Conditioning Engineers. Contact: Ralph Burkowsky, Meetings Manager, ASHRAE, 345 East 47th Street, New York, NY 10017. (212) 644-7950.

Mar. 24-26, 1980: **7th Energy Technology Conference and Exposition.** Washington, DC. Sponsor: American Gas Association; Electric Power Research Institute; National Coal Association. Contact: Lauren Unzelman, Energy Technology Conference, 4733 Bethesda Avenue, Washington, DC 20014. (301) 656-1090.

Apr. 16-20, 1980: **Energy and Home Improvement Fair.** Arlington Heights, IL. Sponsor: Energy Wisely Committee of Greater Chicago. Contact: Carleton Rogers, Expo Management, Inc., The Apparel Center, Suite 1073, Chicago, IL 60654. (312) 329-1191.

May 6-8, 1980: **25th National SAMPE Symposium and Exhibition.** San Diego, CA. Sponsor: San Diego Chapter/Society for the Advancement of Material and Process Engineering. Contact: Marge Smith, SAMPE, Box 613, Azusa, CA 91702. (213) 334-1810.

Jun. 1-5, 1980: **Annual AS/ISES Conference.** Phoenix, AZ. Sponsor: American Section/International Solar Energy Society. Contact: AS/ISES, c/o American Technological University, P.O. Box 1416, Killeen, TX 76541. (817) 526-1300.

June 22-26, 1980: **ASHRAE 1980 Annual Meeting.** Denver, CO. Sponsor: American Society of Heating, Refrigeration, and Air-Conditioning Engineers. Contact: Ralph Burkowsky, Meeting Manager, ASHRAE, 345 East 47th Street, New York, NY 10017. (212) 644-7950.

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