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WINDOWS

For Energy Efficient Buildings

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Contents **Page**

Statement of Intent 1
Research and Development 2
Demonstrations and Applications 5
Contracts 6
New Products, Materials, and Components 8
Patents 20
Legislation 24
Literature, Publications, Reports 25

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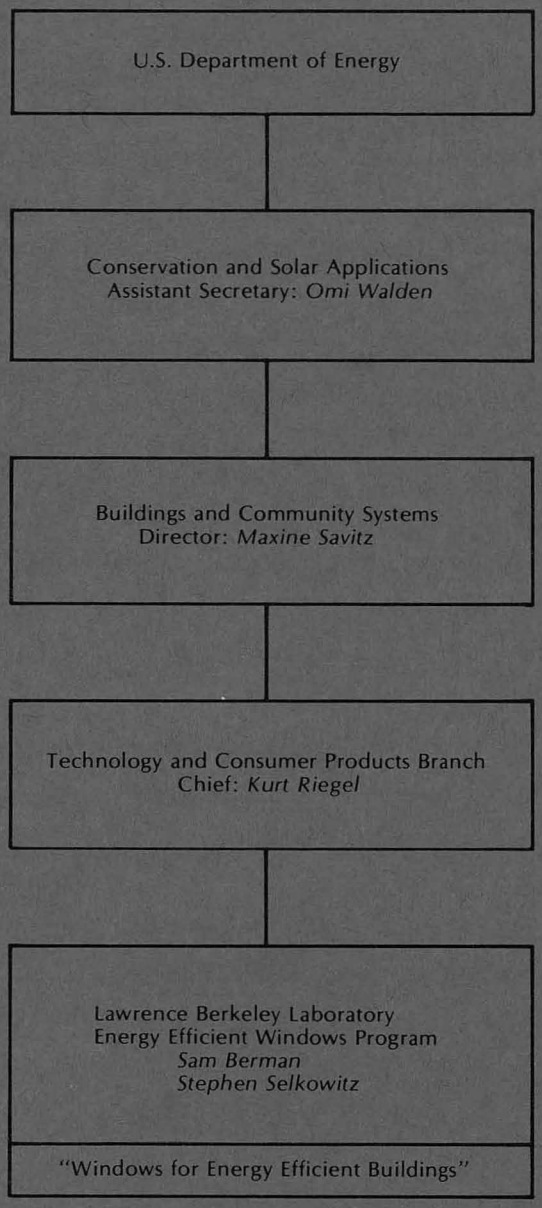
United States
Department of Energy

Prepared by the Lawrence Berkeley Laboratory for the Assistant Secretary for Conservation and Solar Applications, Division of Buildings and Community Systems under Contract W-7405-ENG-48



Windows for Energy Efficient Buildings is prepared at the Lawrence Berkeley Laboratory (LBL) for the U.S. Department of Energy, and 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. The Energy-Efficient Windows Program at LBL is directed by Samuel Berman and Stephen Selkowitz. DOE and LBL accept no responsibility for any damage that may result from the use of any information contained herein. Use of trade names and publication of performance data do not constitute endorsement of the product or claims by DOE, LBL, or the University of California.

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S a emen 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: a) bringing together inventors and manufacturers, b) bringing new products and research results to the attention of architects and engineers, and c) 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. In addition to topics included in this issue, future issues will feature a review of window testing standards, a compilation of independent testing laboratories and their test capabilities, product information on moveable insulating devices, and a listing of professional and trade organizations with window-related interests or activites.

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 & Developmen

Research and deveopment (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.

WEATHER RESISTANT SELECTIVE REFLECTANCE SOLAR CONTROL COATINGS

Research Organization:
Dr. William King
Kinetic Coatings Incorporated
P.O. Box 416
Burlington, Massachusetts

Support: Division of Buildings and Community Systems, Technology and Consumer Products Branch, DOE, Lawrence Berkeley Laboratory

Status: In progress

In many buildings, undesired solar heat gain substantially increases cooling loads. Reflective and tinted glazing and solar control plastic films provide desired control, but often at the expense of natural lighting. Approximately 45% of incident solar radiation is received in the infrared portion of the spectrum (beyond the visible range) under average conditions. This fraction of incident energy could be rejected without the loss of daylighting potential. The slight unavoidable increase in visible reflectivity can be turned to advantage through color control to improve the external appearance of the building.

This project supports the development of a glazing unit which contains an external thin film layer to selectively reject short wave IR while exhibiting high transmissivity to visible light. The film is applied and protected in such a manner that it will maintain its optical properties under prolonged exposure in an outdoor environment. The deposition process, called Ion beam sputtering, is adaptable for use with almost any standard coating material applied to glass. In addition, it is suitable for use with some plastic substrates. Plastic samples were made and tested for consideration as retrofits.

A secondary program objective has been to produce heat mirror samples for residential use, in addition to the solar control films for office buildings. A longer cut-off wavelength for these films allows most of the incoming solar radiation to pass the window (see figure 1).

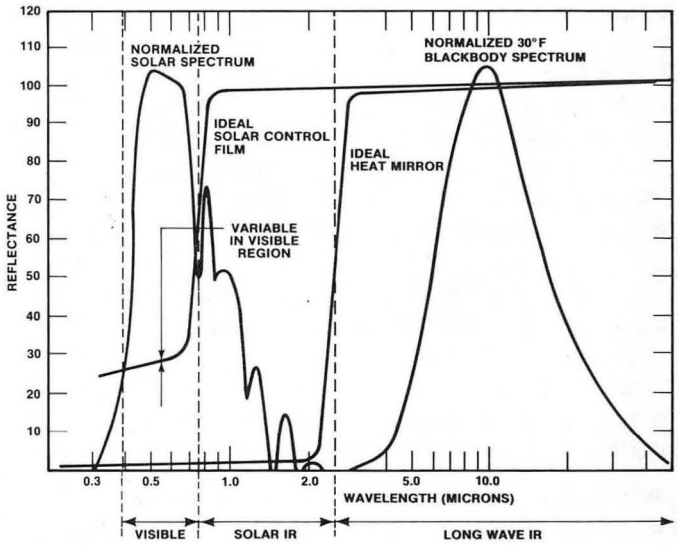


Fig. 1. Comparison of Ideal Properties—Heat Mirror vs. Solar Control Film.

Desirable optical properties and adequate coating durability have been demonstrated; work is now in progress to determine if the deposition process can provide adequate uniformity and reproducibility in a scaled up configuration.

HEAT MIRROR FILM: PERFORMANCE, PRODUCTION PROCESS, AND COST ESTIMATES

Research Organization:
B. P. Levin
Sierracin Corporation
12780 San Fernando Road
Sylmar, California 91342

Support: Division of Buildings and Community Systems, Technology and Consumer Products Branch, DOE, Lawrence Berkeley Laboratory

Status: Completed

Sierracin currently manufactures a transparent, electrically conductive plastic film in commercial quantities. The product was developed originally for applications requiring transparent heating devices, but it has performance characteristics that suggest it would

function well as a heat mirror. For its original purpose the film did not need more visible transmittance than was required to see through it clearly. In order to improve solar gains, antireflection coatings (oxide and polymer) were applied and found to increase solar transmission significantly. Overall, the U-value of a pane of glass was reduced by a factor of 2. The thin metallic layer is vacuum evaporated on plastic film using a speed and tension controlled transport system as pictured in figure 2.

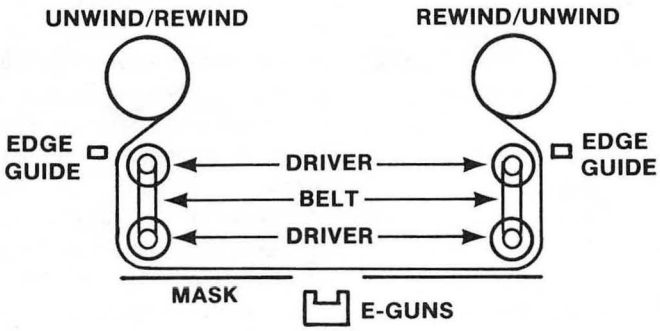


Fig. 2. Film Transport System.

The mechanism is reversible so that the sheet can be glow-discharge cleaned in one run and the metal film deposited on the way back. The AR coating is chemically deposited using a dip roller apparatus, with thickness adjusted through solution concentration, and roller speed. Besides improving transmission by about 10%, this coating also provides some mechanical protection. Thicker, low absorption polymer topcoats were studied from the standpoint of abrasion-corrosion resistance.

Optical and thermal performance of several film types were studied and production rates and costs were projected over a range of production volumes. Despite the high cost of the gold evaporant, it appears the film might be a cost effective heat mirror.

HEAT MIRROR AND OPTICAL SHUTTER RETROFIT PACKAGE

Research Organization:
Melvin Hodge
Suntek Research Associates
500 Tamal Vista Blvd. No. 506
Corte Madera, California 94925

Support: Division of Buildings and Community Systems, Technology and Consumer Products Branch, DOE, Lawrence Berkeley Laboratory

Status: Completed

The goal of this project was to perfect a retrofit window package which includes a heat mirror deposited on a plastic substrate and an optical shutter sandwiched between glass layers.

The heat mirror reflects long wave-length infrared radiation from interior room surfaces, thereby reducing heat losses in winter. At the same time, it passes the solar spectrum, including visible light, for heat gain and exterior visibility. To avoid summer overheating, incoming sunlight should be blocked when the temperature of the room and window is too high. This is accomplished by the optical shutter, a thermoactive chemical gel whose transparency changes from 92% to 20% rather abruptly at the transition temperature, thus providing an automatic sunshade. This feature might have an advantage over an architectural overhang, since the seasonal temperatures do not behave as planned. By creating a dead air space, the retrofit would drop the nominal window U-value from 1.1 to about 0.32 Btu/ft^2-hr-°F.

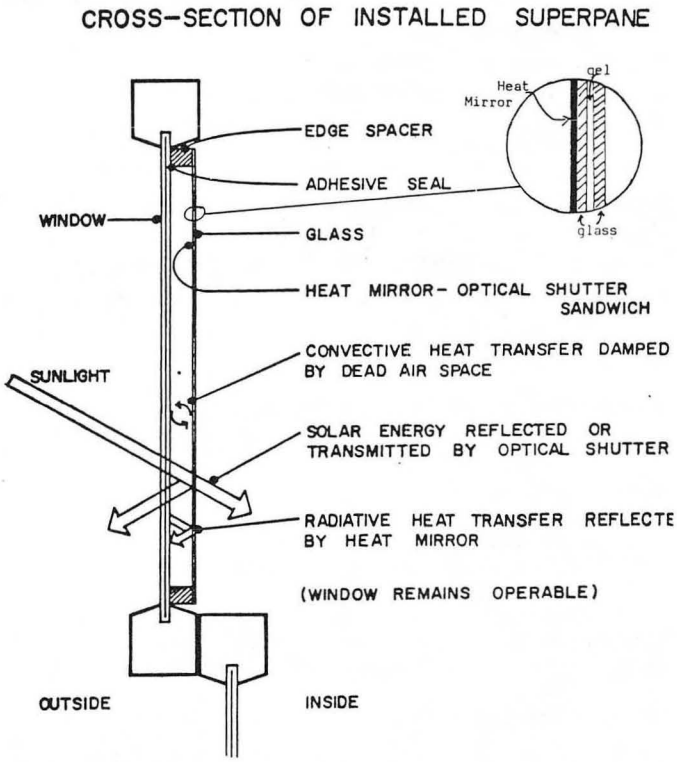


Fig. 3. Superpane Construction and Operation.

Prototypes of each component have been produced and tested and perform well. A retrofit package was developed for the heat mirror film alone as the optical shutter appears not to be cost effective in its present configuration. Configurations were studied for a range of existing windows, using adhesives or magnetic clips. Figure 3 displays the essential features of the retrofit. Production processes for the heat mirror were developed, along with a commercialization plan based on market research and cost/benefit analysis. The final element of this program will be the development of abrasion and corrosion resistant coatings to improve the lifetime and applicability of the heat mirror.

OPTIMIZATION OF COATINGS FOR FLAT PLATE SOLAR COLLECTORS, PHASE II

Research Organization:
Henry Y.B. Mar
Honeywell Systems Research Center
Aerospace and Defense Group
2600 Ridgeway Parkway
Minneapolis, Minnesota 55413

Support: Division of Solar Energy, Research and Development Branch, DOE

Status: Completed

The overall objective of this study is to continue development of low-cost coatings to enhance the performance and therefore the cost effectiveness of flat-plate solar collectors. The initial study explored three main areas:

- Selectively absorbing paints
- Selectively absorbing electro-chemical coatings
- Anti-reflection coatings for glazing materials

The present program will concentrate on improving the long-term stability and reproducibility of the most promising coatings identified in the initial study. A proposed continuation would investigate the feasibility of scaling the coating process to large panels and high production volumes. An outdoor durability test program is also proposed.

ABRASION AND CORROSION RESISTANT COATINGS FOR HEAT MIRRORS

Research Organization:
Melvin Hodge
Suntek Research Associates
500 Tamal Vista Blvd. No. 506
Corte Madera, California 94925

Support: Division of Buildings and Community Systems, Technology and Consumer Products Branch, DOE, Lawrence Berkeley Laboratory

Status: Completed

Heat mirror coatings must maintain their high infrared reflectivity in many window applications that expose the coatings to abrasive and corrosive stresses. This project identified a number of overcoating materials that can be applied to heat mirrors on rigid and flexible substrates without adversely affecting emissivity. Candidate materials were tested for resistance to mechanical abrasion, chemical corrosion, temperature cycling, and short-wave solar radiation. The degradation of the heat mirror alone and in combination with the polymer topcoats was determined through electrical resistance and direct emissivity measurements as well as examination by electron microscopy. Several promising protective materials have been identified.

EXPOSURE TESTING AND EVALUATION OF SOLAR COLLECTOR MATERIALS

Research Organization:
J. Gilligan
IIT Research Institute
10 West 35th Street
Chicago, Illinois 60616

Support: Division of Solar Energy, Research and Development Branch, DOE

Status: In progress

The program will establish comprehensive objective criteria for the test and evaluation of materials that are candidates for use in solar collectors. Relevant properties of these materials, before and after outdoor weathering will be determined. Appropriate data for the selection of cost-effective materials will be provided and longterm weathering performance will be predicted. Materials to be tested include different types of collector covers, absorber plates, and mirrors. Antireflection coatings and white paints will also be studied.

NCAT WINDOW TEST PROGRAM

Research Organization:

Blair Hamilton
National Center for Appropriate Technology
P.O. Box 3838
Butte, Montana 59701
406/723-5475

Support: National Center for Appropriate Technology
Status: In progress

The National Center for Appropriate Technology (NCAT) is funded by the U.S. Community Services Administration and addresses the need for small scale technologies as solutions to energy and resource related problems. Located in Butte, Montana, NCAT has initiated a demonstration, monitoring, and evaluation program to produce credible performance data and quantitative design guidelines for cost effective conservation and solar devices. One set of test cells has been built to assist in evaluating the performance of windows and their accessories, and a second is designed to simulate the performance of a variety of passive solar heating systems.

NCAT is particularly interested in identifying and evaluating low-cost thermal shutters designed to reduce nightime window thermal losses. The window test cell is o perated as a calorimeter and window performance is measured by metering the quantity of electric heat required to maintain constant internal room temperature against approximately steady state nightime outdoor air temperature.

A low-cost mechanism for operating and closing

large thermal shutters has been developed and is under test. "Window box" thermosiphone air collectors have also been built and tested as part of the NCAT low cost, solar device performance evaluation.

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 and accessories.

MIT PASSIVE SOLAR BUILDING

Construction was completed recently on a passive solar heated building at the Massachusetts Institute of Technology. A vital element in the overall design is windows incorporating heat mirror films produced by Suntek of Corte Madera, California. The prototype heat mirror increases the thermal resistivity of the double glazed windows from R2 to approximately R6 without drastically reducing the transmissivity at shorter solar wavelengths. Thus, the windows retain their potential for providing solar heat gain. Sunlight passing through the windows is reflected onto the ceiling with louvered, mirror-finish blinds, made by Rolscreen Company of Pella, Iowa. The solar gain is then absorbed and stored as heat in special polymer concrete tiles with a phasechange core. The louvers need only a small amount of manual adjustment for sun tracking; otherwise the system has no moving parts.

The MIT structure is one story with 900 square feet of space. It has a projected market cost of $28,000. The payback period is estimated at five to ten years for the special energy management components whose cost is estimated at $1500. Additional savings might be obtained through reduction of electric lighting in favor of daylighting; the large south windows and reflecting blinds lend themselves well to this secondary purpose.

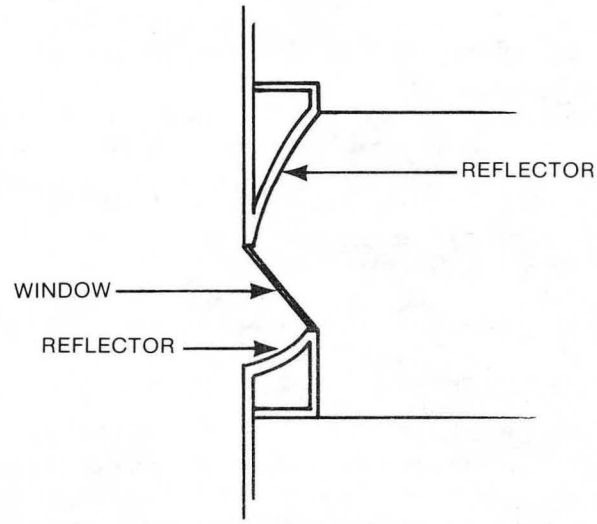
The project has been a cooperative effort between MIT and the manufacturers of the various components, over the last five years. For further information, contact:

Timothy Johnson
Department of Architecture
MIT
Cambridge, Massachusetts

IBM OFFICE BUILDING, SOUTHFIELD, MICHIGAN

The windows of this 14-story building are clear glass rather than the reflecting or absorbing glass often found in large commercial structures when solar gains are unwanted throughout much of the year. Energy conservation features are incorporated in the design of the windows rather than in the window materials.

An unusally small fraction of the exterior surface area is glass (20%). This feature combined with a well insulated exterior curtain wall results in a low composite U-value of 0.2. Tilting the panes outward reduces the direct rays of the sun still further and causes some self shading.



Curved stainless steel reflectors bounce sunlight onto internal diffuse reflectors above the window, reducing the lighting requirements.

The designers emphasize that this is a functional office building not a "corporate palace," and that their goals were met on a medium size budget. The clients anticipate savings of about $21,000 per year in operating costs.

For further information contact the architects:

Gunnar Birkerts and Associates
292 Harmon Street
Birmingham, Michigan 48009

DAYLIGHTING/ELECTRONIC BALLAST DEMONSTRATION

The realization of full daylighting potential in buildings is severely hampered by the lack of cost

effective lighting hardware which is designed to respond effectively to changing ambient natural lighting conditions. Commercialization of a new generation of energy-efficient electronic ballasts is now being supported by the DOE/LBL Energy Efficient Lighting Program. These ballasts have the potential of providing excellent dimming and control capabilities which makes them a strong candidate for use in daylighted buildings.

A demonstration is now under way in the Pacific Gas and Electric Building in San Francisco to show the energy saving potential of high-frequency electronic ballasts. A major element in this demonstration is the use of dimmable ballasts, connected to light sensing devices in offices with windows. Among the experiments to be performed are: the effect of sensor placement on energy savings; the effects of automatic vs. step or continuous dimming; the effects of room orientation and sun control devices on daylighting savings; and user response to daylit offices. Rooftop sensors will record simultaneous illumination and solar radiation to allow refinement and validation of computer models of daylight availability.

The overall demonstration is planned and managed by the LBL lighting program staff with assistance from Pacific Gas and Electric. Electronic ballasts are supplied by Iota Engineering/Excel Inc. and by Stevens Luminoptics. Additional information can be obtained from:

Energy Efficient Lighting Program
Lawrence Berkeley Laboratory
Bldg. 90, Rm. 3111
Berkeley, California 94720

INSULATING REFLECTION WINDOW FILM DEMONSTRATION

A new insulating solar control film has been used to retrofit the windows of two utility company office buildings in California. The new window insulation film, P19, is made by the 3M Company and combines a traditional solar control capability with a low emissivity surface which reduces the winter U value to about 0.68 Btu/ft^2-hr-°F. The addition of this film, which is glued to the interior window surface, should provide heating load reductions approximately equal to those achieved with storm windows. All windows in both buildings have been retrofit—clear glazing in an older, 11-story building in Fresno, California and tinted glass in a new eight story building in San Jose. Energy consumption in both buildings has been monitored for several years providing a control period against which the winter fuel consumption can be compared.

For information contact:

Stan Blois
Pacific Gas & Electric
Room 740
215 Market Street
San Francisco, California 94106

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.

INNOVATIVE WINDOW SYSTEMS: REQUEST FOR PROPOSALS (RFP)

Support: Consumer Products and Technology Branch, DOE/LBL

Status: Proposals due June 9, 1978

This RFP will support testing, development and/or demonstration of near-term, low-risk, energy-efficient window systems. The emphasis is on innovative designs which have the potential of being rapidly commercialized and widely specified and utilized by consumers and design professionals. Proposals will be accepted for units which fall into one or more of the following categories: thermal barriers, solar control devices, passive solar applications, skylights, and infiltration barriers.

The following awards have been made:

INSULATING SHADE DEMONSTRATION

Organization: Thomas Hopper
Insulating Shade Company
17 Water Street
Guilford, Connecticut 06437

This project is a demonstration of the energy savings resulting from the use of a multilayer roll-up insulating shade under development by the Insulating Shade Company. When the shade is unrolled at night, the thermal resistance of the single glazed windows is increased from R1 to approximately R8. Two hundred windows in a college dormitory will be retrofit with the shades and resultant energy savings will be monitored in the building.

LOW SHADING-COEFFICIENT VENETIAN BLINDS

Organization: Thomas Konen
Davidson Laboratory
Stevens Institute of Technology
Hoboken, New Jersey

Venetian blinds are well known window accessories used for control of light and heat as well as to provide privacy. In conjunction with a blind manufacturer, Davidson Laboratory will analyze and test the solar control properties of a new class of highly reflective venetian blinds with shading coefficients less than .2.

LIGHT SWITCHING AND CONTROLS: RFP

Support: Divisionof Buildings and Community Systems, Technology and Consumer Products Branch, DOE, Lawrence Berkeley Laboratory

Status: One contract awarded, others in negotiation.

After decades of neglect, daylighting has been "rediscovered" as a method of energy conservation in buildings. Use of daylighting has been frustrated by lack of (1) daylighting availability data; (2) widely accepted, simplified design methods; and (3) methods to assess annual energy savings, and (4) by uncertainty about how to use daylighting along with conventional lighting hardware.

Switching and controls demonstrations supported by this RFP are intended to provide hard performance data about the daylighting/artificial lighting integration problem. The following award has been made:

DIMMABLE FLUORESCENT LIGHTING SYSTEM

Organization: Honeywell, Inc.
2600 Ridgway Parkway
Minneapolis, Minnesota 55413

A new dimmable fluorescent lighting system will be demonstrated in a typical office environment. A variety of sensors and control systems will be studied with the dimmable system, to investigate the most effective strategies for reducing annual energy consumption.

SOLAR COLLECTOR MATERIALS DEVELOPMENT

Support: Division of Solar Energy, DOE
Status: Underway or in negotiation

Nineteen organizations have been selected by DOE for negotiations for research and development activities on new types of materials and fluids for use in solar collectors. The goal is to assist in developing lower cost collector systems with improved durability, reliability, and performance. Projects that involve glazing, glazing systems, and surface coatings are listed below.

The projects were chosen in response to a Program Research and Development Announcement (PRDA E6 77-D-20-003) that was issued in April.

Altas Corporation. Santa Clara, California, "Development of Cost Effective Techniques and Concepts for the Protection of Glazing Against Breakage Caused by Hail, Vandals, or Thermal Stresses".

Honeywell Systems and Research Center. Minneapolis, Minnesota, "Selective IR Reflective Coatings Development".

Honeywell Systems and Research Center. Minneapolis, Minnesota, "Low Cost Solar Anti-Reflection Coatings".

Hughes Aircraft Company. Culver City, California, "Non-Glass Glazings and Surface Coatings".

Research Triangle Institute. Research Triangle Park, North Carolina, "Non Glass Glazings".

TELIC Corporation. Santa Monica, California, "Development of Selective Surfaces".

Tufts University. Medford, Massachusetts, "Studies for Predictably Modifying the Optical Constants of Doped Indium Oxide Films for Solar Energy Applications".

The University of Wisconsin at Madison. Madison, Wisconsin, "Polymer Surface Coatings for Downconversion of UV Radiation and Inhibition".

PASSIVE SOLAR RESIDENTIAL DESIGN COMPETITION

Support: U.S. Department of Housing and Urban Development (HUD)

Status: Applications closed

Passive designs for both new and existing houses are eligible, but the project details and awards differ:

New Houses. Designs for new single family projects can be for private owners or for builders who plan to sell them on the open market. All projects must be planned for construction; conceptual designs for imaginary projects are not eligible in this category.

Existing Houses. Designs for using passive solar energy techniques in existing houses may be for projects which are planned for construction, or for conceptual projects. In either case, the design must be based on an existing house.

If the project construction was begun on or after March 17, 1978, (the date this program was announced at the Second National Passive Solar Conference), it will be eligible for a design award in either category. The award for each new passive solar house design will be $5,000.

Each selected design for passive solar applications to an existing house will be awarded $2,000, In addition to the awards, all designs selected will receive national publicity through inclusion in a special HUD publication highlighting practical passive solar applications.

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 solar control 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 and future issues 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.

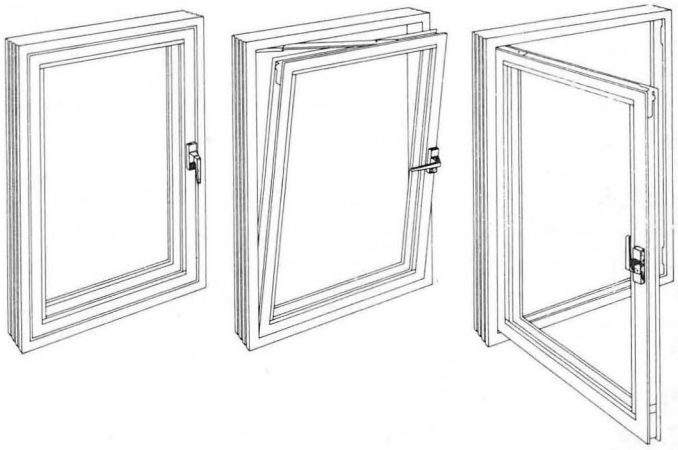
We solicit comments regarding the format and content of this section and suggestions for the content of future issues.

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.

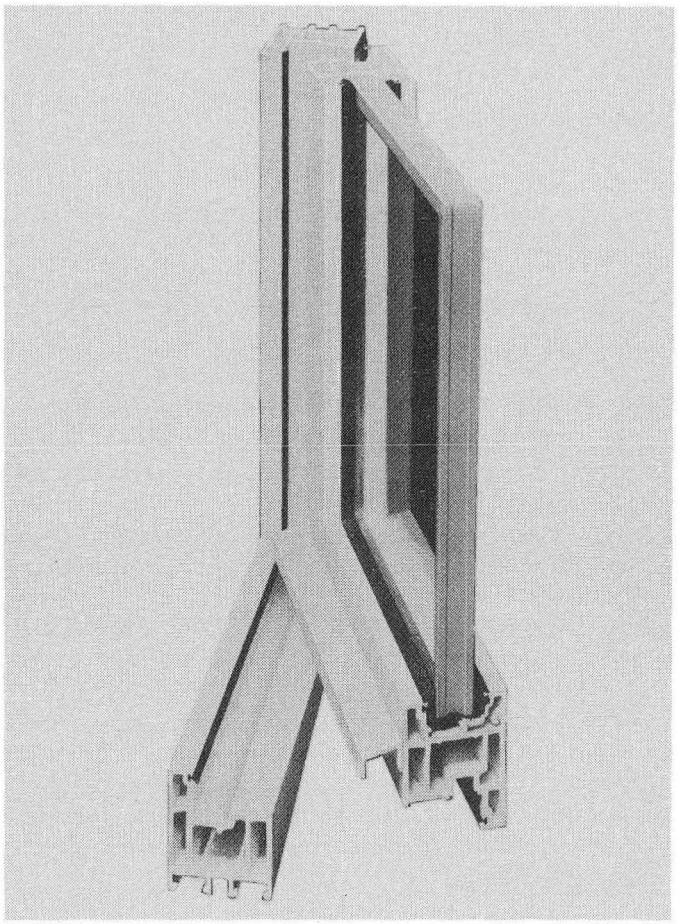
WINDOWS

Ventilating Window. Bottom hinged, top-venting action for ventilation and an inswinging casement mode to facilitate window cleaning. Energy conservation options include: double glazing, insulating glass, a thermal break incorporated in the aluminum frame, solar screens, and built-in venetian blinds. The weather seal is of the metal-overlap, compression type for reduced infiltration and long life.



(Versa Vent, Flour City Architectural Metals, 175 Sea Cliff Avenue, Glen Cove, New York 11542, 516/759-1010)

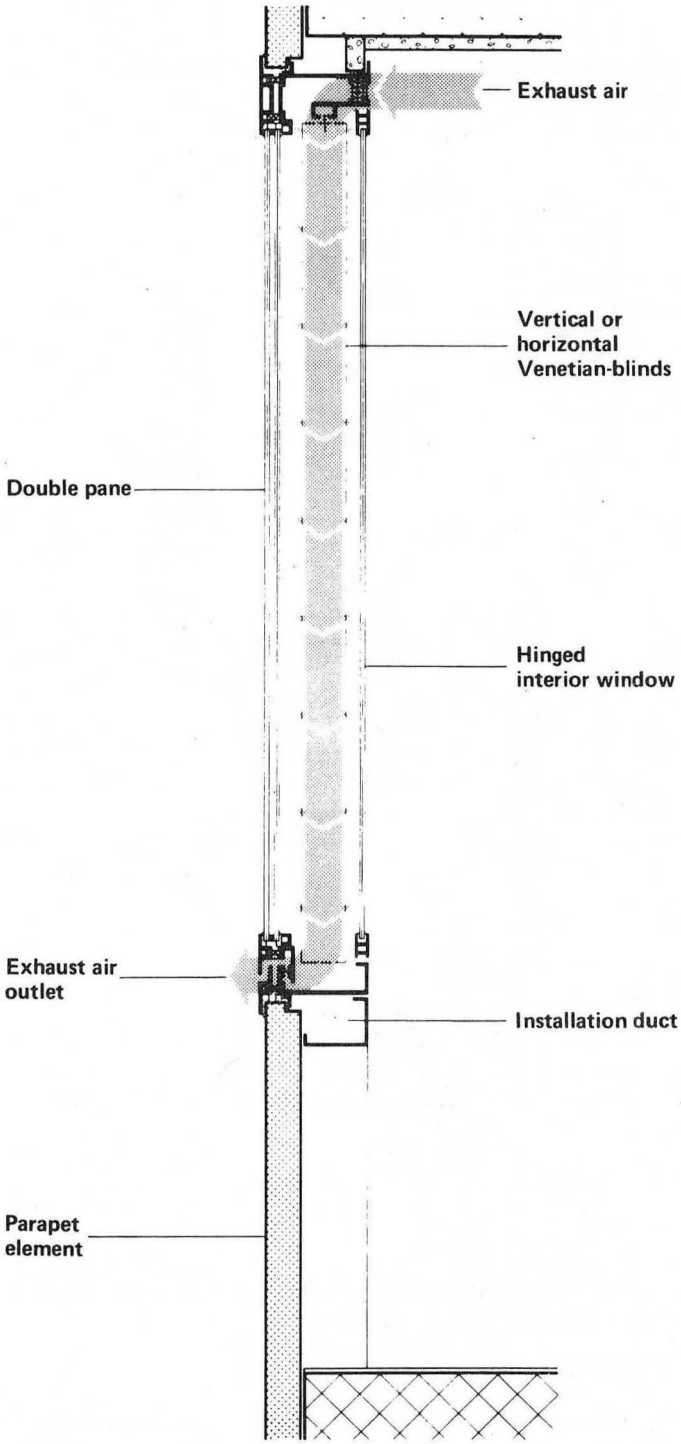
Multichambered PVC Window Systems. Air spaces in insulating plastic frames provide a calculated U value of 0.312 Btu/hr.ft.^{2} °F and a condensation resistance factor of 74. Swings inward on side hinges for cleaning or on bottom hinges for ventilation.



(Trocal Window Systems, Dynamit Nobel of America Inc., 105 Stonehurst Court, Northvale, New Jersey 07646, 201/767-1660)

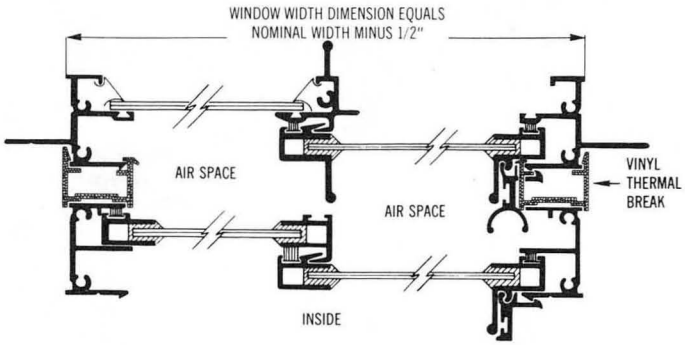
Air Flow Window. An outer double-glazed unit (or single glazed for milder climates) and an inner single pane serve as a channel for exhaust air. At the top of the window a connection is made to the main exhaust or recirculation duct of the air conditioning system. The slight overpressure inside the building causes the movement of air through the window. In winter or summer, this moderates the temperatures of the window surfaces and effectively lowers the U-value of the window to 0.3 to 0.6 k cal/m^2. hr.°C. The built-in blinds provide additional solar heat and lighting control.

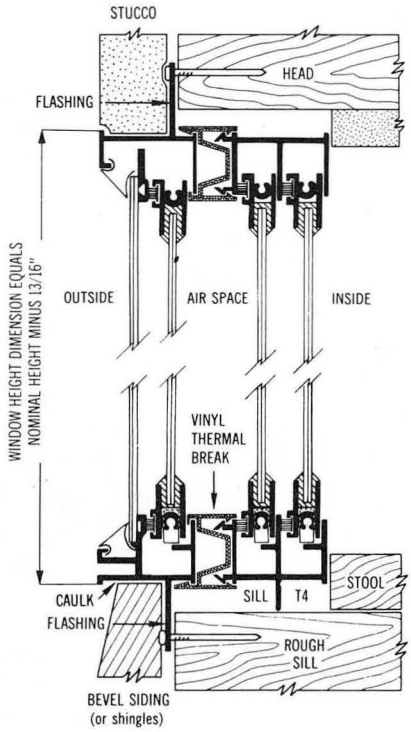
protecta-sol air conditioning façade-section



(Protecta Sol, George Capsis, 69 Charles Street, New York, New York 10014, 212/ 924-5718)

Four-Track, Thermal Break Window. Four-track, aluminum, horizontal sliding window for residential construction incorporates a vinyl thermal break and a 1.5-inch air gap for a condensation resistance factor of 62 and a U value of 0.56. Outside unit may take insulating glass to provide a triple-glazed window.

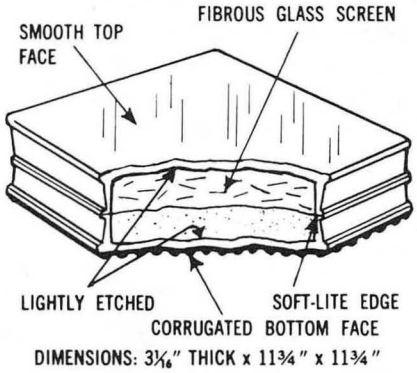




(Rylock Company, Ltd., P.O. Box 766, Union City, California 94587, 415/ 471-1400)

SKYLIGHTS

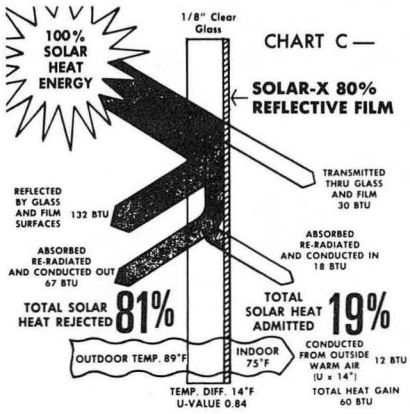
Prefabricated Glass-Block Skylights. Hollow evacuated glass blocks, mounted and sealed in insulated aluminum grids, have a low overall U value, reducing night and winter heat losses, and lowering the probability of condensation. Prismatic elements in the glass provide uniform transmission of daylight and rejection of some solar heat for summer.



(Solarwhite Toplighting Panels, Circle Redmont Corporation, 819 East Main Street, Stamford, Connecticut 06902, 203/323-2103)

SOLAR CONTROL

Solar Control Films. A range of tinted and reflective polyester films are available to adhere to inner window surfaces to provide solar control for existing clear glazing. Films are typically two-or three-layer laminates composed of metalized, transparent and/or tinted layers. Films are available with a wide range of solar and visible light transmittance values, resulting in shading coefficients as low as 0.24. Most films are adhered with precoated pressure sensitive adhesives. Reflective films will reduce winter U values by about 20%. (Note that a new solar control film, which provides a U value of 0.68, is described in the Thermal Barrier Section B.) Films adhered to glass improve the shatter resistance of glazing and reduce transmission, thus reducing fading of furnishings. Major manufacturers of solar control films are listed below:

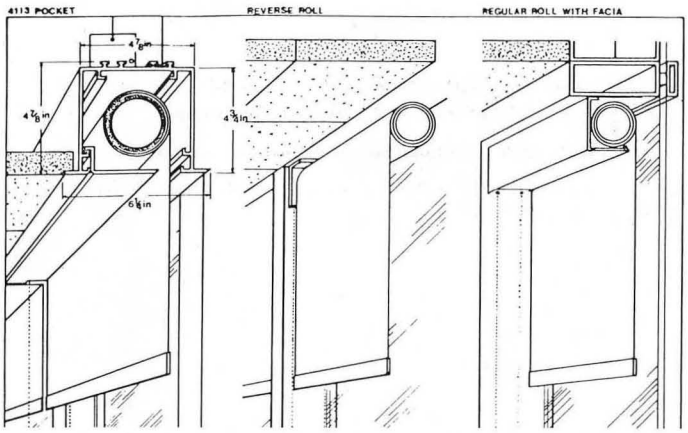


(3M Company, Energy Control Products, 3M Center, Saint Paul, Minnesota 55101, 612/733-1110 • Madico, 64 New Industrial Parkway, Woburn, Massachusetts 01801, 617/935-7850 • Solar-X Corporation, 25 Needham Street, Newton, Massachusetts 02161, 617/244-8686 • National metallizing Division, Solar Control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

Fiber Glass Solar Control Screens. Solar control screen provides sun and glare control as well as some reduction in winter heat loss. Screens are woven from vinyl-coated glass strands and are available in a variety of colors. Depending on color and weave, shading coefficients of 0.3-0.5 are achieved. Screens are durable, maintenance free, and provide impact resistance. They are usually applied on the exterior of windows and may (1) be attached to mounting rails and stretched over windows, (2) mounted in rigid frames and installed over windows, or (3) made into roller shades which can be retracted and stored as desired. Names of local distributors, installers, and retailers may be obtained by writing to major fabric manufacturers.

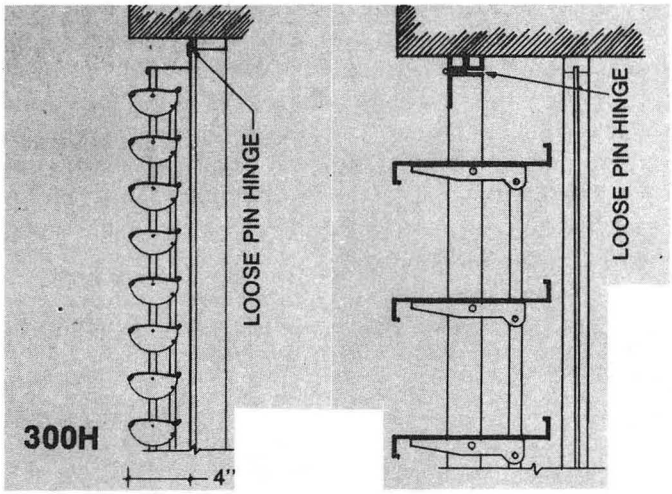
(Phifer Wire Products Company, Box 1700, Tuscaloosa, Alabama 35401, 205/345-2120 ● J.P. Stevens & Co., Inc., Box 1138, Walterboro, S.C. 29488, 803/538-8041 ● Chicopee Manufacturing Co., Box 47520, Atlanta, Georgia 30362, 404/455-3754)

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 gauged and operated locally or from a master station. Automatic photoelectric controls are available that (1) monitor sun intensity and angle and adjust shade position to provide solar control and (2) employ an internal light sensor and provide a preset level of internal ambient light.



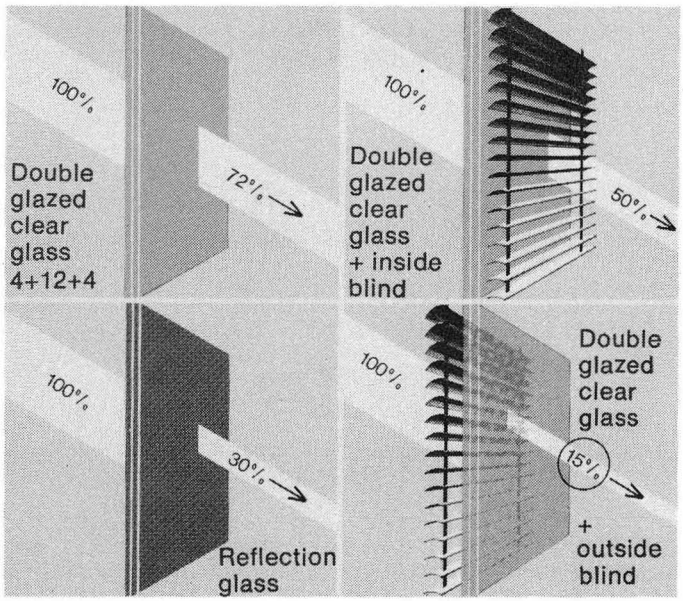
(Electro Shade System, Joel Berman Associates, Inc., 102 Prince Street, New York, New York 10012, 212/226-2050)

Exterior Sun Control Louvers. Operable external horizontal and vertical louver systems are offered for a variety of building sun control applications. Louvers are hinged together and can be rotated in unison to provide the desired degree of shading for any sun position. Operation may be manual or electric; electrical operation may be initiated by manual switches, time clock, or sun sensors. Louvers may be closed to reduce night thermal losses. Sun control elements are available in several basic shapes and in a wide range of sizes.



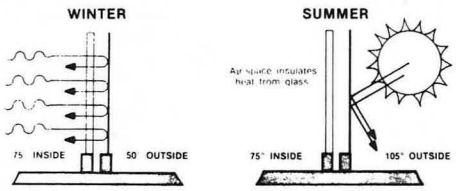
(Brown Manufacturing Company, P.O. Box 14546, Oklahoma City, Oklahoma 73114, 405/751-1323)

External Venetian Blinds. Externally mounted, all weather, venetian blinds may be manually operated from within a building or electrically operated and controlled by means of automatic sun sensors, time controls, manual switches, etc. Aluminum slats are held in position with side guides and controlled by weatherproof lifting tapes. Slats can be tilted to modulate solar gain, closed completely, or restricted to admit full light and heat. Blinds have been in use in Europe for many years and have been tested for resistance to storms and high winds.



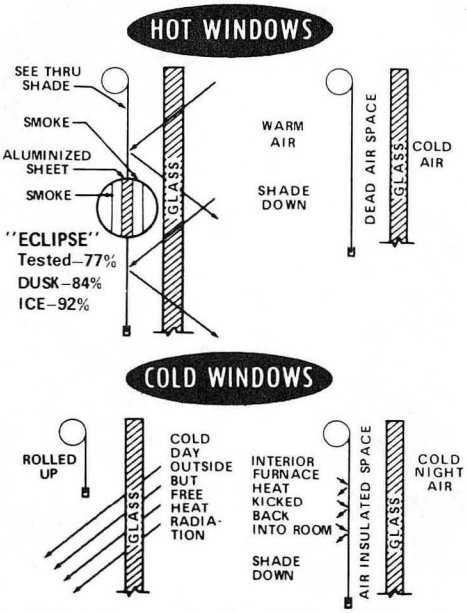
(Exterior "L" Type Venetian Blind (Lamellenstoren), Swiss Blinds Division, Richard Goder Associates, Inc., Box 1264, Rosemount, Illinois 60018, 312/ 297-6420)

Reflective, Perforated Solar Control Laminate. Laminate of metalized weatherable polyester film and black vinyl which is then perforated with 225 holes/ in^2, providing 36% open area. Available in a variety of metallized and non metallized colors, the shading coefficients vary from 0.30 to 0.35 for externally mounted screens and 0.37 to 0.45 for the material adhered to the inner glass surface. The laminate is typically mounted in aluminum screen frames which are hung externally, several inches from the window; it can also be utilized in a roll-up form. Some reduction in winter U value can be expected with external applications.



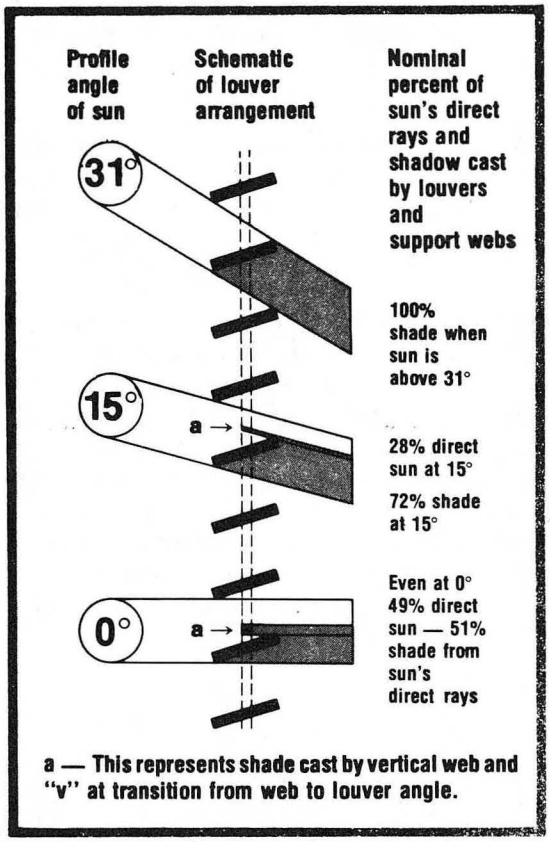
(Reflect-O-Screen Incorporated, 7521 East Second Street, P.O. Box 147, Scottsdale, Arizona 85252, 602/9940317)

Semi-Transparent Window Shades. Roll-up window shades made from a variety of tinted or reflective solar control film laminates. These shades provide most of the benefits of solar control film applied directly to glass but provide additional flexibility and may be retracted on overcast days or when solar heat gain is desired. Shades available with spring operated and gravity (cord and reel) operated rollers as well as motorized options. Shading coefficients as low as 0.13 are achieved and a tight fitting shade provides an additional air space and thus reduced U-value.



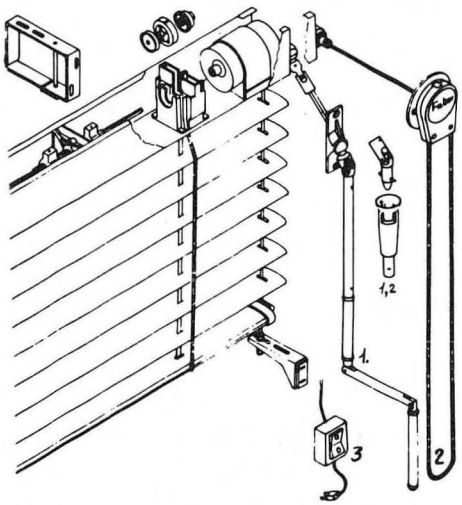
(Plastic View Transparent Shades, Incorporated, 15468 Cabrito Road, Van Nuys, California 91408, 213/786-2801)

Louvered Metal Solar Screens. Solar screen consists of an array of tiny louvers which are formed from a sheet of thin aluminum. The louvered aluminum sheet is then installed in conventional screen frames and may be mounted against a window in place of a regular insect screen or mounted away from the building to provide free air circulation around the window. View to the outside is maintained while substantially reducing solar gain. Available in a light green or black finish with shading coefficients of 0.21 or 0.15, respectively.



(ShadeScreen, Kaiser Aluminum, 300 Lakeshore Drive, Oakland, California 94643)

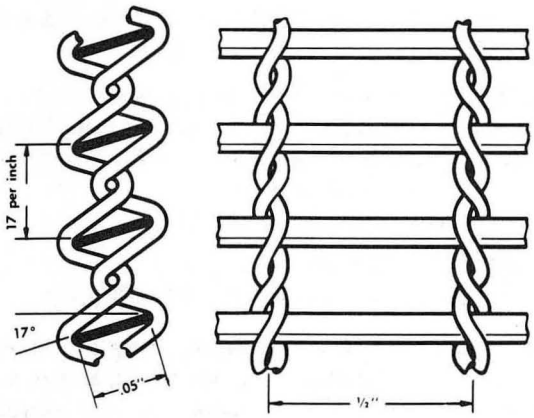
Operable External Louvre Blinds. Solar control louvre blinds, mounted on the building exterior, can be controlled manually or automatically by sun and wind sensors. Slats can be tilted to modulate light, closed completely, or retracted to admit full light and heat. Developed and used extensively in Europe, they provide summer sun control, control of natural light, and reduction of winter heat loss.



(Joseph C. Maillard Enterprises, 1233 East Ramsey Street, Banning, California 92220, 714/849-3141)

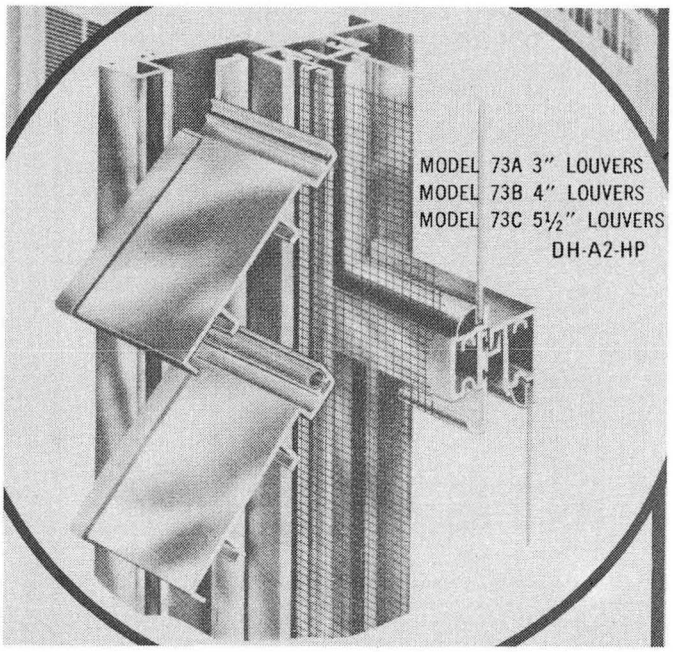
Louvered Metal Solar Screens. Solar screen consists of an array of tiny fixed horizontal louvers which are woven in place. Louvers are titled at 17° to provide sun control. Screen material is set in metal frames which may be permanently installed in a variety of configurations or designed for removal. Installed screens have considerable wind and impact resistance. Standard product (17 louvers/inch) has a shading coefficient of 0.23 ; low sun angle variant (23 louvers/inch) has a shading coefficient of 0.15. Modest reductions in winter U value have been measured.

(MAGNIFIED VIEW)



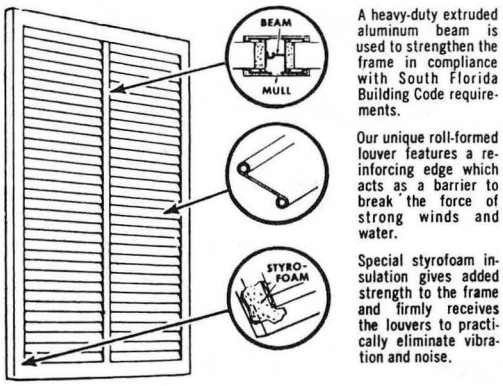
(Koolshade Corporation, 722 Genevieve Street, P.O. Box 210, Solana Beach, California 92075, 714/755-5126)

Adjustable Louvered Windows. Windows incorporating adjustable external louvered shading devices. Louvers are extruded aluminum or redwood, 3 to 5 inches wide, and are manually controlled. Louvers may be specified on double-hung, hinged, or louvered-glass windows. When open, the louvers provide control of solar gain and glare; when closed, they provide privacy and security.



(SolarShade Windows, Clearview Corporation, 3987 Pacific Boulevard, San Mateo, California 94403)

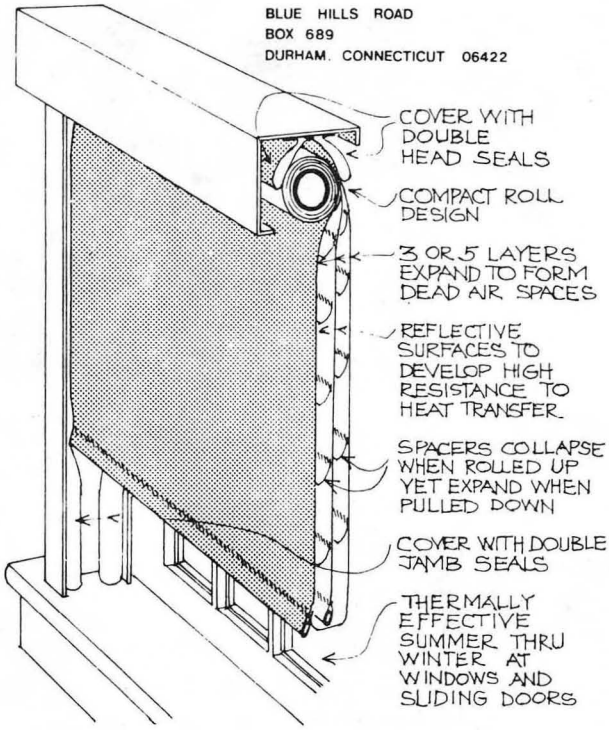
Solar Shutters. Shutter is composed of an array of aluminum slats set at 45° or 22½° from the vertical to block direct sunlight. Shutters are designed for external application and may be mounted vertically in front of window or projected outward from the bottom of the window. Other rolling and hinged shutters are stored beside the window and roll or swing into place for sun control, privacy, or security.



(Willard Shutter Company, Incorporated, 4420 Northwest 35th Court, Miami, Florida 33142, 305/6330162)

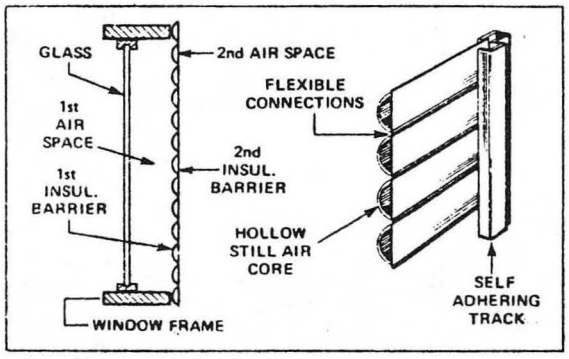
THERMAL BARRIERS

Multilayer, Roll-up Insulating Window Shade. A multilayer window shade which stores in compact roll and utilizes spacers to separate the aluminized plastic layers in the deployed position, thereby creating a series of dead air spaces. Five-layer shade combined with insulated glass provides R8 thermal resistance.



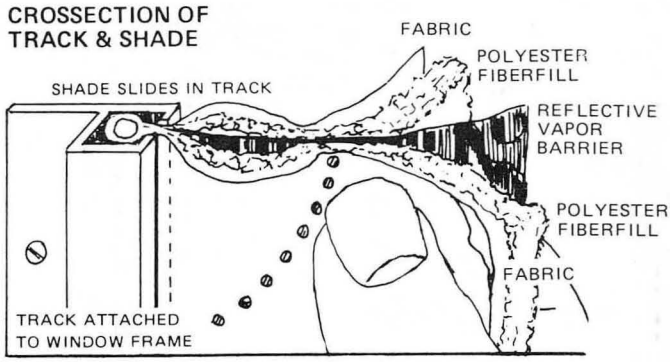
(High "R" Shade Insulating Shade Company, 17 Water Street, Guilford, Connecticut 06437, 203/453-9334)

Insulating Window Shade. ThermoShade thermal barrier is a roll-up shade composed of hollow, lensshaped, rigid white PVC slats with virtually no air leakage through connecting joints. Side tracking system reduces window infiltration. Designed for interior installation and manual or automatic operation.



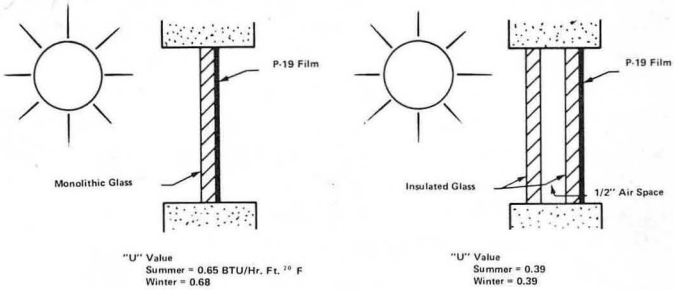
(Thermo Shade, Solar Energy Construction Company (SECO), Box 718, Valley Forge, Pennsylvania 19481, 215/783-7735)

Insulating Window Shade. When added to a window, roll-up insulating shade provides R4.5 for single-glazed window or R5.5 for double-glazed window. Quilt is composed of fabric outer surfaces and two polyester fiberfill layers sandwiched around a reflective vapor barrier. Quilt layers are ultrasonically welded. Shade edges are enclosed in a side track to reduce infiltration.



(Window Quilt, Appropriate Technology Corporation, P.O. Box 975, Brattleboro, Vermont 05301)

Insulating Solar Control Film. A modifed solar control film designed to be adhered to the interior of windows provides conventional solar control function and has greatly improved insulating properties. Film emissivity is 0.23-0.25 resulting in a U value of 0.68 Btu/ft.^{2}hr-°F under winter conditions, compared to 0.87 for conventional solar control films and 1.1 for typical single-glazed windows.



(Energy Control Products, 3M Company, 3M Center, Building 207, St. Paul, Minnesota 55101)

Interior Storm window. Low cost, do-it-yourself interior storm window with a rigid plastic glazing panel. Glazing panel may be removed for cleaning or summer storage. Reduces infiltration losses as well as conductive/convective heat transfer.

(The In-Sider, Plaskolite Incorporated, 1770 Joyce Avenue, Columbus, Ohio 43216, 215/563-7600)

Retrofit Insulating Glass System. Single glazing is converted to double glazing by attaching an extra pane of glass with neoprene sealant. A dessicant-filled aluminum spacer absorbs moisture between the panes. An electric resistance wire embedded in the neoprene is

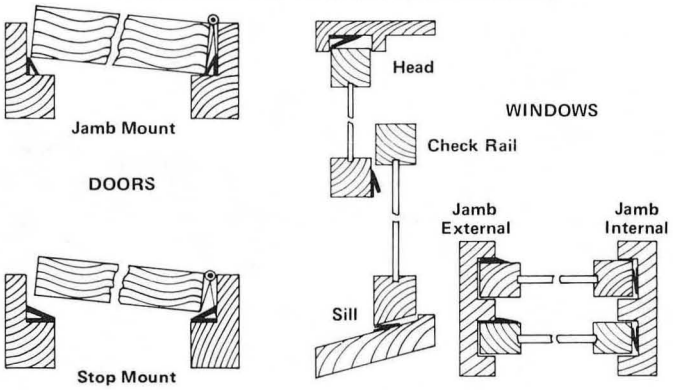
heated with a special power source. This hermetically seals the window. New molding can then be applied if desired.

(Energy Sealants, 1611 Borel Place, Suite 240, San Mateo, California 94402)

INFILTRATION

Weather-Strip Tape. A polypropylene film scored along its centerline so that it can be easily formed into a "V" shape. It has a pressure sensitive adhesive on one leg of the "V" for application to seal cracks around doors and windows. On an average fitting, double-hung window it will reduce infiltration by over 70%. It can be applied to rough or smooth surfaces.

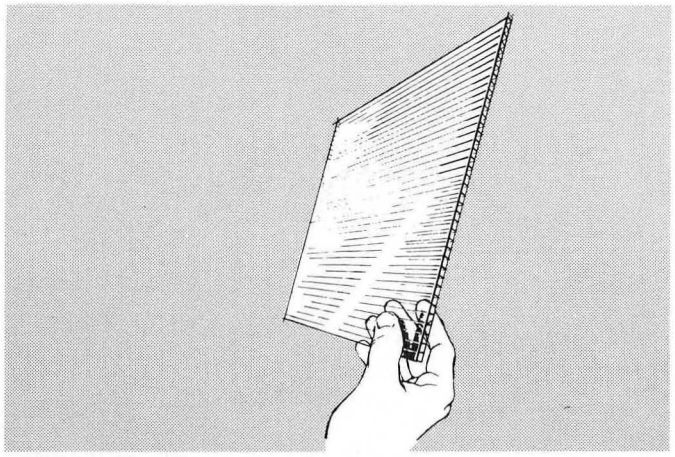
TYPICAL WEATHERSTRIP APPLICATIONS



(Scotch Brand Weatherstrip, 3M Company, Energy Control Products, 3M Center, St. Paul, Minnesota 55101, 612/ 733-1110)

GLAZING MATERIALS

Polycarbonate and Acrylic Single Sheets. Abrasion resistant polycarbonate sheet with a durable clear coating significantly improves abrasion resistance without changing optical properties. High impact resistance.



(Tuffak CM, ROHM and HAAS Company, Philadelphia, Pennsylvania 19105)

Polycarbonate and Acrylic Single Sheets. Single-sheet acrylic or polycarbonate glazing. The polycarbonate has one-third the U-value of glass and is highly impact resistant. Available in stock and custom colors as well as decorator designs.

(Sheffield Poly-619Z, Division of Sheffield Plastics Inc., Sheffield, Massachusetts 01257, 413/229-8543, Telex 455346)

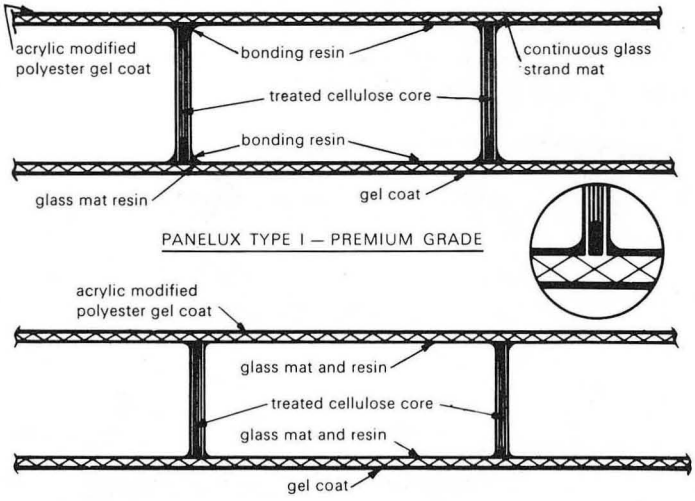
Polycarbonate and Acrylic Single Sheets. Acrylic structural sheets, reinforced with fiber glass. Clear and "frosted" both transmit light well, for lighting, glazing, and solar energy.

(Lumasite, American Acrylic Corporation, 173 Marine Street, Farmingdale, Long Island, New York 11735, 516/249-1129)

Polycarbonate and Acrylic Single Sheets. Impact resistant, cast acrylic glazing. Specialized options for applications requiring abrasion resistance or high impact strength. Incorporates anti-reflecting layer for excellent visibility.

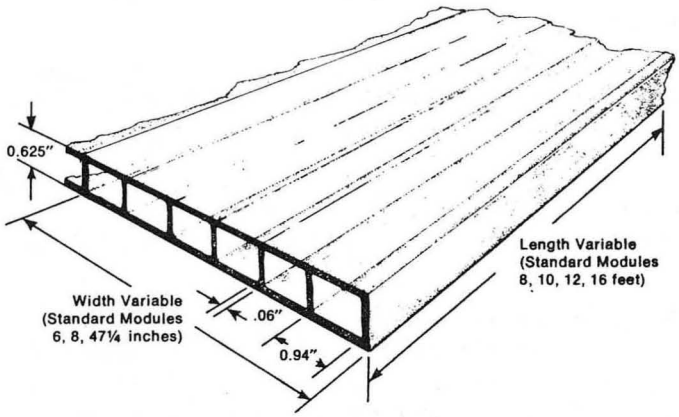
(Acrivue, Swedlow Incorporated, 12122 Western Avenue, Garden Grove, California 92645, 714/893-7531, Telex 678457)

Decorative Double Wall Sheets. Decorative translucent panels made of fiber glass reinforced acrylic face sheets with a honeycomb core. The core of the sandwich may be made from a variety of materials selected for decorative or utilitarian purposes. They are light in weight, impact resistant, much better thermal insulators than glass, and transmit enough light to be used as exterior windows and skylights as well as indoor partitions.



(Cemcel Corporation, 49 Industrial Way, Greenbrae, California 94904, 415/ 924-4554)

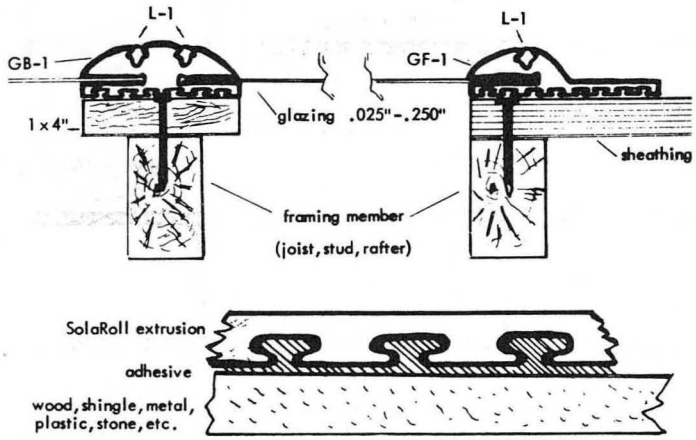
Double Wall Sheets. Acrylic or impact resistant polycarbonate for windows, skylights, and partitions; clear or tinted translucent shades provide visible transmission up to 83%; U-values of approximately 0.57 Btu ft.^{2}-hr.°F. Some specialized hardware available although the panes can be used with standard 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)

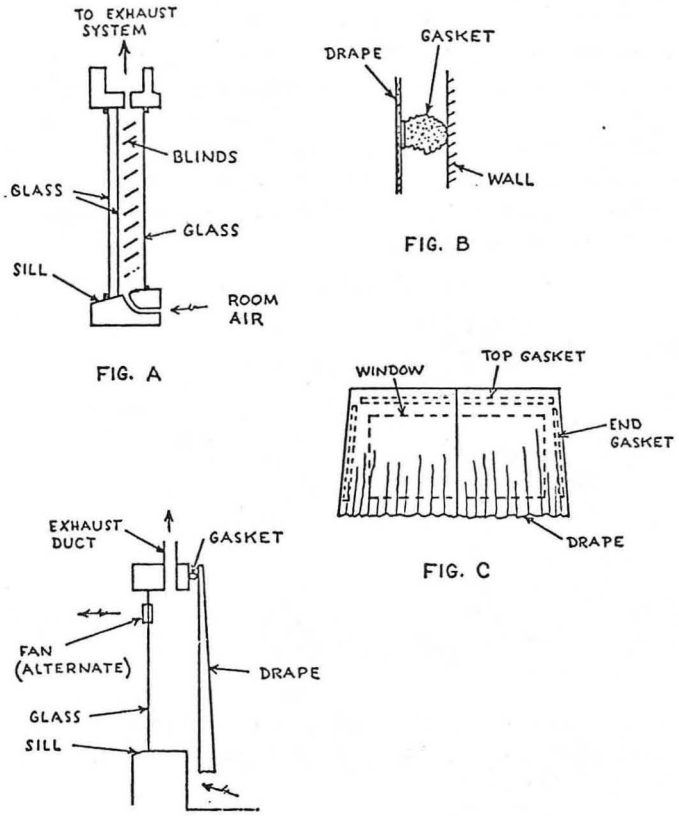
COMPONENTS

Architectural Extrusions for Glazing Systems. Flexible plastic (EPDM) extrusions in a variety of cross sections for collectors, greenhouses, skylights, window walls, and storm windows. A thermo-setting mastic adhesive is supplied which will stick to wood, metal, plastic, stone, or asphalt shingle. For heavy jobs, reinforcement can be provided with nails, staples, or screws. Inwardly diverging recesses were designed in the extrusions to promote their adhesion to the mastic. Glazings from 0.025 to 0.250 in. can be fitted and secured using a locking strip which slides into a groove in the extrusion and exerts pressure on the glazing.



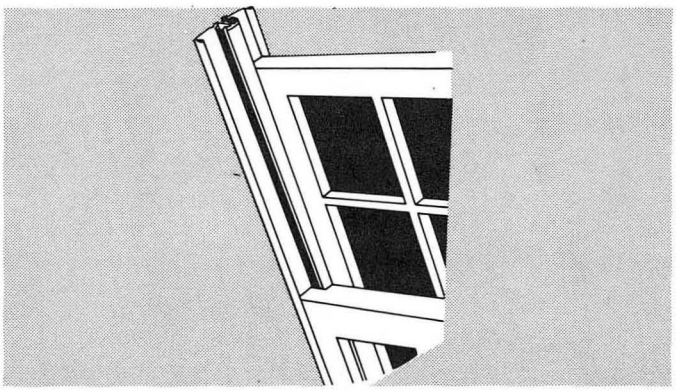
(Solaroll, Bio-Energy Systems, Mountaindale Road, Spring Glenn, New York 12483, 914/434-7858)

Window Drapery Gasket. A "fluff" gasket which attaches to draperies forms a drapery-to-wall air seal when the drapes are closed. Reduces downdrafts in winter and traps heat between windows and draperies in summer, thereby increasing heat rejection to the outside.



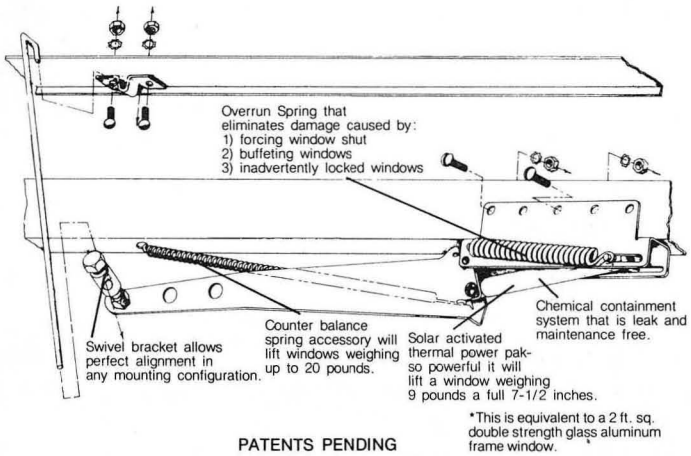
(David E. Russell, Consulting Engineer, 110 Riverside Avenue, Jacksonville, Florida 32202, 904/356-2654)

Replacement Window Channels. Do-it-yourself replacement window channels to reduce infiltration around windows and to stop rattling. Standard sizes or cut them to fit.



(Quaker Window Channel, Quaker City Manufacturing Company, 701 Chester Pike, Sharon Hill, Pennsylvania 19079, 215/586-4770)

Thermal Window Operator. A self-contained power unit which extends its length in response to rising temperature. Force is provided using a confined chemical which expands when it melts at a predetermined temperature. Life expectancy is in excess of 20,000 cycles. Operator may be used for opening and closing windows, skylights, ventilators, shutters, curtains, etc.



(Solarvent, Dalen Products, 201 Sherlake Drive, Knoxville, Tennessee 37922, 615/ 690-0050)

Black Solar Absorber Fabric. Fiber glass fabric with black silicone rubber coating is lightweight, flexible, dimensionally stable, and may be suitable for applications requiring solar heat absorbing layers.

PHYSICAL PROPERTY DATA

STYLE #8267-CD

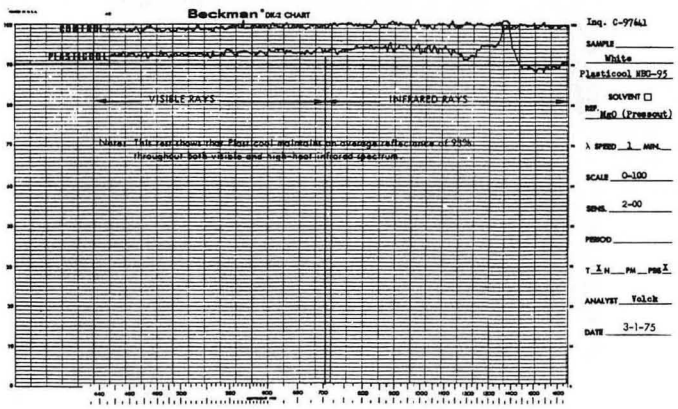
Base Fabric		Fiber Glass
Weave		Plain
Coating		Special Black Silicone Rubber
Total Weight (sq.yd) ASTM-64, Method 39		10.29 oz.
Thickness - ASTM D1777-64, Method 39		.0104 in.
Tensile strength	Warp	279 lbs.
ASTM D579-66	Filling	228 lbs.
Mullen Burst - FTM-191-5122.2		455+ lbs.
Trapezoid Tear Test	Warp	42.0 lbs.
FTM-191-5136	Filling	39.0 lbs.
Cracked Tensile	Warp	267 lbs.
There is no ASTM test	Filling	219 lbs.

The information and data contained herein are based on information we believe reliable. You should thoroughly test any application, and independently conclude satisfactory performance before commercialization. Suggestions of uses should not be taken as inducements to infringe any particular patent.

(Otto Solar Collector Fabric, Style #8267-CD, Otto Fabric Inc., P.O. Box 18361, Wichita, Kansas 67218, 316/2625183)

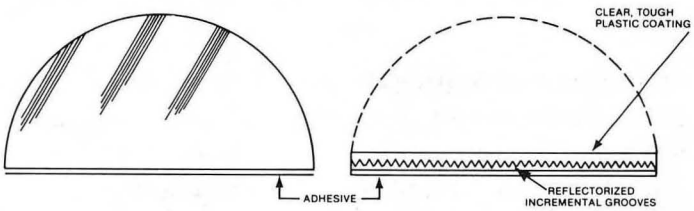
Solar Reflective Coating. White reflective paint with a minimum reflectance of 92% in the visible and near IR. Applied by spray or brush methods to exterior building surfaces, the paint will minimize surface temperature rise due to sunlight.

PLASTICOOL REFLECTANCE CHART



(Plasticool, Coating Laboratories, 505 South Quaker, Tulsa, Okalahoma 74120, 918/582-4156)

Plastic Fresnel Reflector. A flat plastic with reflectorized incremental grooves, "Optically Shaped Film" is designed primarily as a decorative molding to provide the illusion of depth or bulk from a flat, lightweight surface. However, the product may be used for a variety of light control applications. Convex, concave, and other special effects can be achieved.



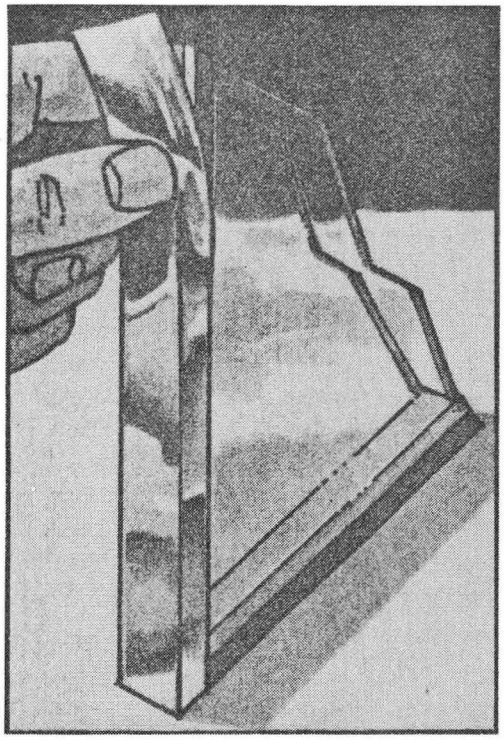
STANDARD MOLDING **OSF MOLDING**

(Optically Shaped Film, 3M Company, Visual Products Division, 3M Center, St. Paul, Minnesota 55101, 612/7330128)

Extruded Sealants. Extruded sealants are preformed, pressure sensitive, and stable in storage. They are made in standard and custom sizes and shapes for window applications. Waste of material is minimized and simplicity of application reduces labor costs.

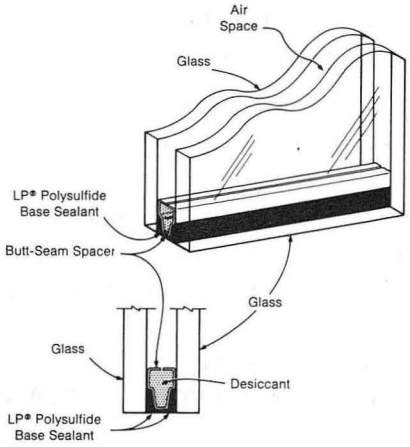
(General Sealants Corporation, 15428 E. Proctor Avenue, City of Industry, California 91744, 213/330-3118)

Sealant Tape. Aluminum foil tape for double pane windows. Forms moisture barrier and provides additional structural strength. For use with polysulfide and hot butyl sealants.



(Scotch Aluminum Foil Tape, 3M Company, Industrial Tape Division, 3M Center, St. Paul, Minnesota 55101, Dept. IBU-38)

Polysulfide Base Sealants. Polysulfide base sealants used in the manufacture of insulating glass units have good resistance to aging, ozone, oxidation, weathering, solvents, and oils, as well as good flexibility and adhesive properties.



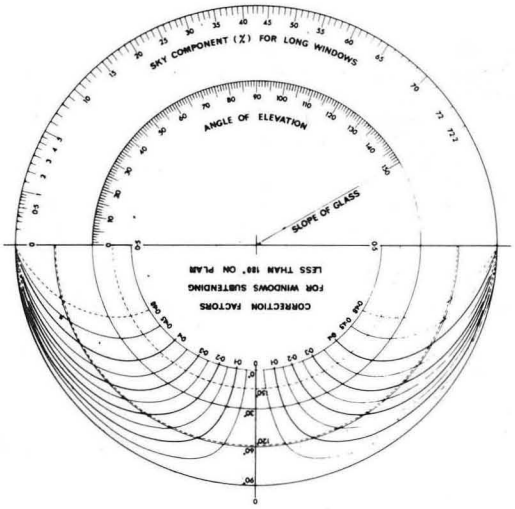
(LP Polysulfide Base Sealants, Thiokol Chemical Division, P.O. Box 1296, Trenton, New Jersey 08607, 609/396-4001)

DESIGN AIDS

Solar Shadow Mapper. Performs shadow surveys which determine the time, date, and duration of shadows at a specific geographic location. Measures the angle of inclination of the sun's ray on horizontal, inclined, and vertical surfaces. Measures sun altitude and azimuth angles. Measures the directional orientation of objects such as walls, roofs, windows, and collector panels etc. Measures elevation and azimuth angles of nearby objects.

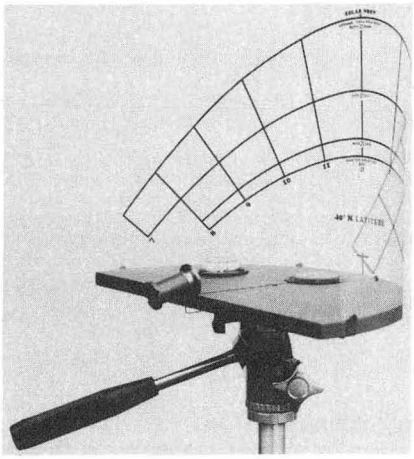
(Solar Shadow Mapper, Campbell Engineering, 1302 Toney Drive Southeast, Huntsville, Alabama 35802, 205/883-9866)

Daylighting Graphical Aids. The British Research Establishment (BRE) has produced a set of 10 daylight protractors and an accompanying test to allow building designers to predict the influence of window size and placement on natural illumination loads. Protractors provide sky components of daylight factor for a variety of window and skylight conditions, both glazed and unglazed for uniform and CIE overcast sky conditions.



(Pendragon House, Inc., 2595 East Bayshore Road, Palo Alto, California 94303)

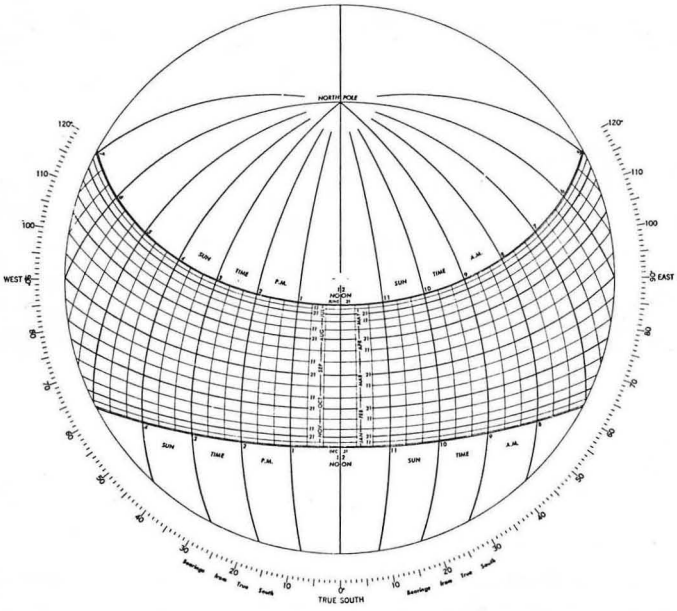
Solar Site Selector. Aids in determining potential for solar energy or daylighting by optically superimposing the trajectory of the sun and hour segments on the area of interest. Built-in compass and level for proper orientation.



(Solar Site Selector, Don Lewis Associates, P.O. Box 6, Sutter Creek, California 95685, 916/272-2077)

Daylighting, Solar Heat Gain Design Aids. The sun angle calculator, developed in 1951 is once again available to assist building designers in solving solar heat gain and daylighting problems. The sun angle calculator consists of sun-path projections which allow determination of solar altitude and azimuth for any hour throughout the year. Overlays allow determination of angle of incidence and profile angle for a vertical surface of arbitrary orientation. The "heat gain calculator" is a slide chart which provides hourly and monthly clear-day solar heat gain values. "How to Predict Interior Daylight Illumination" is based on standard IES methods developed by J.W. Griffith.

32° SUN CHART
(32° N. Lat.)



(Libbey Owens Ford Company, Merchandising Department P-1, 811 Madison Avenue, Toledo, Ohio 43695)

INSTRUMENTATION

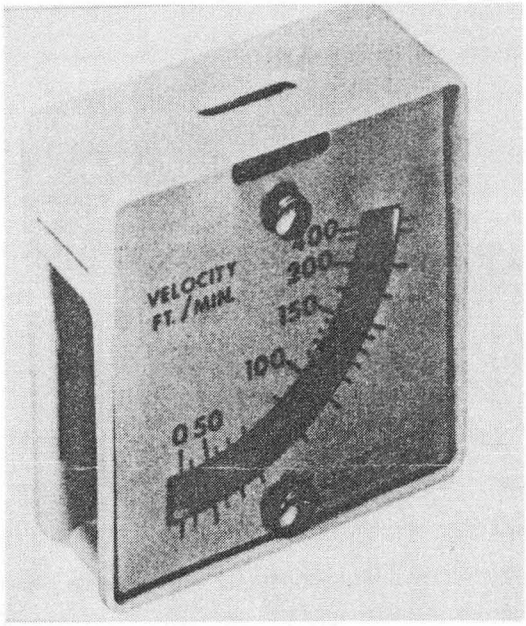
Solar Heat Meter. A hand-held solar intensity meter used to measure direct and diffused solar radiation. The meter sensor is placed directly against the surface to be measured. Solar heat transmission is read directly in Btu hr/ft^2. The meter was designed principally to measure the energy savings to be realized with the use of glass shading devices such as solar control films, screens, window shades, etc.

(Sun-Gard Solar Heat Meter, Metallized Products, 2544 Terminal Drive South, St. Petersburg, Florida 33712)

Portable Infiltration Tester. This device is designed to facilitate field measurements of air leakage through windows. The suitcase-size portable package contains a reversible blower, manometer, flow meter, valves, and assorted tubing to allow both infiltration and exfiltration characteristics to be measured. A large plastic sheet is taped over a window, the resultant air space is pressurized to the desired pressure, and air leakage is measured.

(Devac, Incorporated, 10130 State Highway 55, Minneapolis, Minnesota 55441)

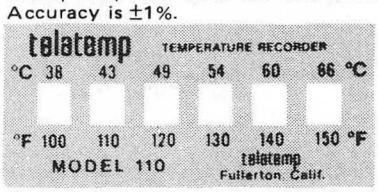
Low-Cost Air Velocity Gauge. Measures indoor air flow from 25 to 400 ft/min. Portable or fixed mount.



(Vanometer Air Velocity Gauge, Lab Safety Supply Company, P.O. Box 1363, 10 South Locust, Janesville, Wisconsin 53545)

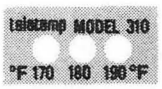
Temperature-Indicating Pigments. Paints and crayons undergo pronounced color changes at predetermined temperatures. Useful for visualizing the surface temperature gradients over extended surfaces or for quick indications to aid in manual operation of windows.

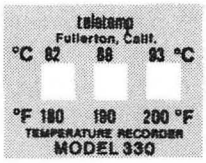
For low cost, accurate, permanent records of surface temperatures. Telatemp Temperature Recorders contain one or more sealed temperature sensitive silver-colored increments. Each increment has a rated value in °F and/or °C. As each finely calibrated increment is exposed to its rated value, it turns permanently black, Response time for this reaction is less than one second. Accuracy is ±1%.



MODEL 110 — Wide range, general purpose, with six increments for a range of 50°F. "Brackets" the temperature involved quickly. Several Model 110's, with overlapping values, extend this range simply and economically. Rated values are given in both °F and °C. 1¾"W x ¾"H.

MODEL 310 — Compact, 20°F range, for applications where a range of temperature is needed and where small size is also helpful. Three increments, °F only. ¾"W x 3/8"H.





MODEL 330 — Medium size, three increments covering a 20°F range, °F and °C. 1"W x ¾"H.

HOT SPOT — Tiny, single increment, only 3/16" in diameter. Use to locate potential trouble points in hard-to-reach locations in all types of products and equipment. Ideal for product warranty protection. Provides proof of the temperature to which your product was subjected.

(Thermocolor/Thermochrom, Teletemp Corporation, P.O. Box 5160, Fullerton, California 92635, 714/879-2901)

WINDOWS

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 unsoluble 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.

Complete documentation for patents may be obtained at a nominal fee by writing to:

Commerce Dept.
Patent and Trademark Office
2021 Jefferson Davis Hwy.
Washington, D.C. 20231

3,925,945
HEAT EXCHANGER WINDOW

Inventor: *Walter S. White*
833 Old Dutch Mill Road
Colorado Springs, Colorado 80904

Filed: November 23, 1973

Appl. No.: 418,606

A transparent insulating building panel reversibly mounted for positioning commensurate with the outside temperature, comprising:

- A frame pivotally mounted in the plane of a wall of said building.

- A pane of tinted heat absorbing glass mounted within said frame.
- A pair of spaced apart glass panes mounted within said frame and in air tight engagement therewith, said pair of panes mounted in spaced relation and parallel to said pane of heat absorbing glass, and
- Aperture means in said frame providing an unrestricted path of air flow through the space between the heat absorbing glass and the said pair of panes.

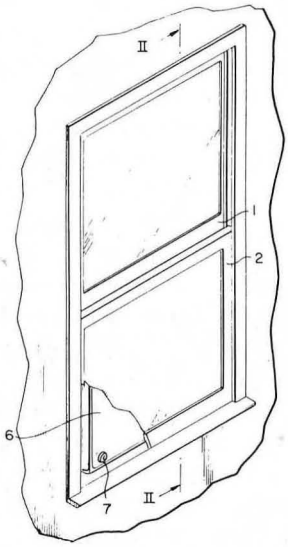
3,918,512
WINDOW ARRANGEMENT

Inventor: *David W. Kuneman*
Box No. 55
Dewittville, New York 14728

Filed: November 22, 1974

App. No.: 526,415

A modification to virtually eliminate air leakage (in a window arrangement which has both a double-hung inner window and an outer storm window, but considerable leakage). The modification adds a flexible clear plastic bag between the inner and outer window, inflated to enough pressure to make the bag firmly contact the trim between the windows.



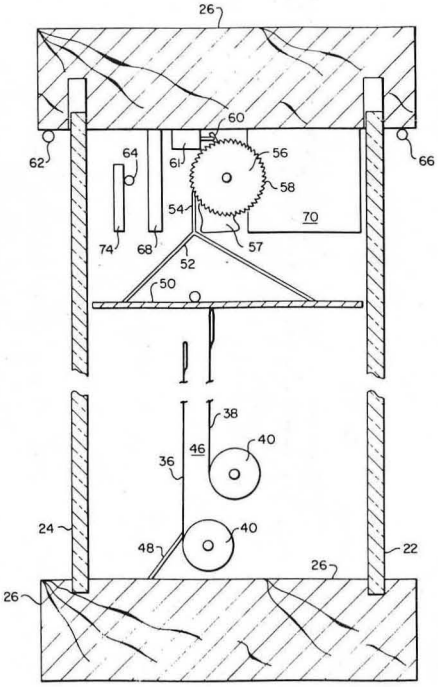
3,952,947
HEATING AND VENTILATION SYSTEM

Inventor: *Norman B. Saunders*
15 Ellis Road
Weston, Massachusetts 02193

Filed: December 3, 1974

Appl. No.: 529,235

A system for controlling the air and radiant temperatures, ventilation, illumination and humidity within an enclosed building is described. The system comprises a double glazed window which is transmissive to light and heat energy mounted in the wall of the building. Means are provided for measuring the net energy flow through the window and for automatically adjusting the energy flow through the window responsively to seasonal as well as weather conditions. A heat sink is thermally coupled to the building for storing some of the insulation received so that it can be released as the temperature drops in the building. The system can also include an auxiliary roof heating system. Also ventilation and humidification means for circulating and humidifying exterior air drawn into the building are provided.



3,903,665
HEAT ENERGY TRANSMISSION CONTROL PANEL

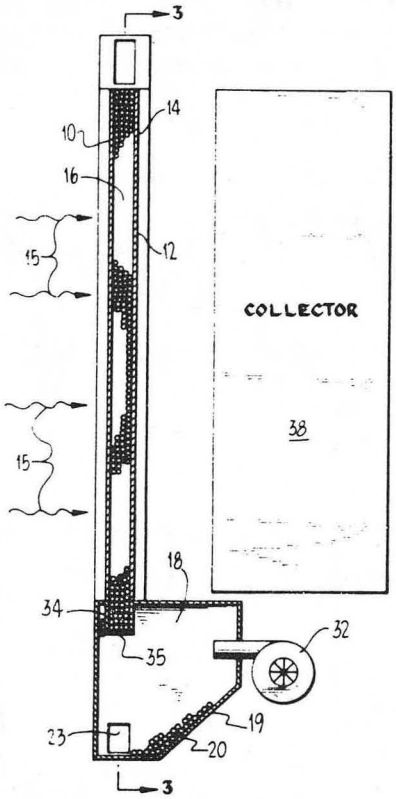
Inventor: *David Carl Harrison*
2726 Monterey Street
Albuquerque, New Mexico
87106

Filed: November 28, 1973

Appl. No.: 419,589

A panel for providing controlled transmission of heat energy there-through. A chamber having sidewalls defined by a pair of laterally spaced thermally transmissive windows is coupled via a transport duct to

the outlet of a storage bin. The bin contains a quantity of thermal insulative granular material sufficient to fill the chamber and an air blower for propelling the material from the bin to the chamber. A valved outlet at the bottom of the chamber permits selective return of material from the chamber to the bin. The amount of material in the chamber determines the thermal transmissivity of the panel. The present invention can be used in place of a conventional window to control solar heating of a building during the day and heat loss at night. The invention could also be used to control the energy input to a conventional energy collector.



3,681,179
MOISTURE RESISTANT SOLAR CONTROL FILM

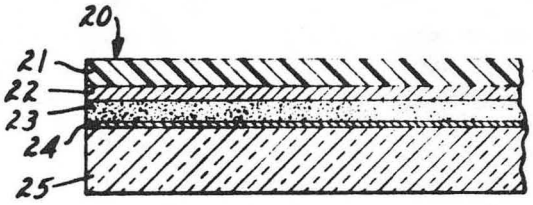
Inventor: *Donald R. Theissen*
St. Paul, Minnesota

Assignee: Minnesota Mining & Manufacturing Company
St. Paul, Minnesota

Filed: July 20, 1970

Appl. No.: 56,379

Solar control film having a water-activatable adhesive system comprising a normally tacky and pressure-sensitive adhesive coating which is covered by a thin tack-free continuous water-soluble layer. The product which does not require a liner, can be moistened and installed on a windowpane, the water-soluble layer providing lubrication during positioning and the pressure-sensitive adhesive providing the primary bonding to the glass.



3,775,226
SOLAR CONTROL FILM

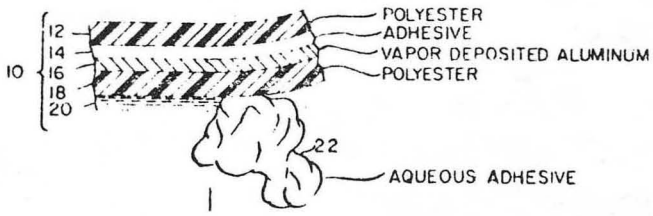
Inventor: *Michael E. Windorf*
Malden, Massachusetts

Assignee: Material, Distributors Corp.
Woburn, Massachusetts

Filed: February 8, 1971

Appl. No.: 113,426

The primary object of the present invention is to provide a solar control film comprising a vapor deposited aluminum coat, which is of a thickness characterized by a light transmission of 5 to 50 percent, interposed between a pair of moisture permeable polymeric strata, each of which ranges in thickness from 0.25 to 1 mil so as to be individually self-supporting. It has been found that the self-supporting strata eliminate physical and chemical degradation that typically occur at the vapor-deposited aluminum coat in prior systems. In one modification of the solar control film, an optional integral outer coat or one of the polymeric strata is composed of a pressure-sensitive adhesive in association with a discrete silicone release sheet. In another modification, an optional integral outer coat on the other side of the polymeric strata is composed of a silicone release agent. In such modifications, storage in roll forms is permitted by the incompatibility of the pressure-sensitive adhesive and the silicone release agent, application to the window glass is enabled by a water compatible detackifier which is applied to the pressure-sensitive adhesive, and permanent implacement is achieved by permeation of the water compatible detackifier through the film and via the edges.



3,921,359
MULTIPLE-PANE GLAZINGS

Inventors: *Edgard Brichard,* Jumet; *Michel Lambert,* Brussels, both of Belgium

Assignee: Glaverbel S.A. Secretariat Technique, Brussels, Belgium

Filed: November 17, 1971

Appl. No.: 199,652

In a multiple glazing composed of two or more transparent sheets joined together by a soldered connecting strip, a spacing member is mounted between sheets adjacent the strip to support deforming compression forces between the sheets and preserve the seal provided around the peripheral region between the sheets.

3,514,175

STRUCTURAL CLOSURE MEMBERS WITH ABSORPTION AND REFLECTION FILMS

Inventor: *Weston H. Jenkins* Corning, New York

Assignee: Corning Glass Works Corning, New York

Filed: June 24, 1966

Appl. No.: 565,032

A structural closure member for absorbing a substantial amount of solar radiation, particularly in the near infra red portion of the solar spectrum. It comprises a first body, which is a substantially transparent sheet of heat absorbing glass or a glass bearing a heat absorbing material on the outer surface exposed to solar radiation, the first body absorbing solar radiation at one wave length and emitting secondary radiation of a longer wavelength, and a substantially transparent second body on the side of the first glass sheet body which faces in toward the enclosure, the second body being preferably a film of a metal oxide having a lower emissivity for secondary radiation than the surface of the first glass sheet body which is directly exposed to solar radiation.

This invention relates to structural closure members that are adapted to absorb a substantial amount of solar radiation, particularly in the near infrared portion of the solar spectrum. It is especially concerned with an improvement in such closure members whereby secondary radiant energy resulting from such absorption is selectively emitted and transfer of solar thermal energy into the structure is thus further reduced.

A basic function of any closure member is to permit transmission of visible radiations, thereby providing both visibility and illumination. It is common experience, however, that conventional glass closures may be a source of considerable physical discomfort on a sunny day. Thus, a sharp rise in ambient temperature may occur in a room or vehicle interior. Also, glare or brightness may occasion visual discomfort.

There is then a well recognized problem of effectively and economically minimizing the undesirable effects of solar radiation while still utilizing it as a means of providing adequate visibility and illumination. The present invention is directly concerned with all aspects of this problem, but especially the thermal aspect which becomes of major significance in the building and vehicle fields. Recent design trends in both of these fields have been in the direction of larger glass closures. This, of course, accentuates the solar control problem and has intensified the search for a satisfactory means of coping with it.

3,637,416
METHOD OF TREATING SYNTHETIC PLASTIC AND ELASTOMERIC MATERIALS AND ARTICLES PRODUCED THEREBY

Inventors: *Robert D. Mioch;* *Donald A. Dana* Both of Chicago, Illinois

Assignee: MBT Corporation, Chicago, Illinois

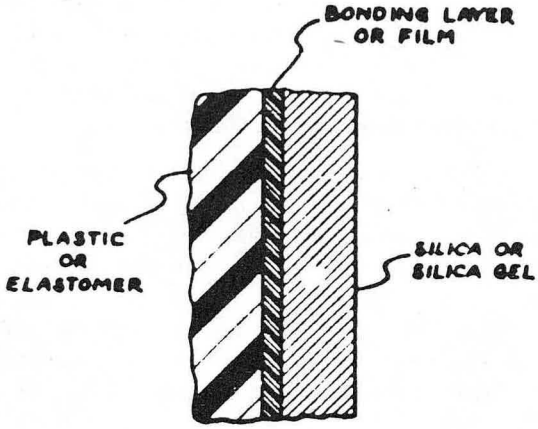
Filed: February 4, 1970

Appl. No.: 8,530

A method of improving the surface characteristics of plastics and elastomers which in its preferred aspects includes the steps of forming a bonding or coupling film of an organic silicon compound on the surface of a plastic or elastomerid material and thereafter contacting the film with a compound or mixture of compounds, or a solution thereof, capable of forming a deposit or coating silica gel thereon, and articles produced in accordance with the method.

Plastic articles such as plastic lenses and "plexiglas" windows, and the like, treated by the method are provided with surfaces which are harder and far more resistant to scratching than the plastic of which they are made. The surfaces, moreover, are substantially

permanent in character and, in many instances, can improve the light transmission properties thereof by acting as antireflection coatings.



3,920,402
THERMALLY OPACIFIABLE GLASSES

Inventors: *James E. Flannery; Dale R. Wexell,* both of Corning, New York

Assignee: Corning Glass Works Corning, New York

Filed: February 3, 1974

Appl. No.: 439,077

This invention relates to thermally opacifiable glasses which exhibit uniformly dense opacity, that do not require the presence of lead or lithium, and contain as the primary opacifying phase a crystal selected from the group consisting of sodium molybdate, sodium tungstate, barium molybdate, barium tungstate, and mixtures thereof. The glasses consist essentially, by weight on the oxide basis, of about 64-80% SiO^2, 2-12% Al^2O^3, 9-16% R^2O, wherein R^2O consists of 9-15% Na^2O and 0-5% K^2O, 1.2-4% RO^3, wherein RO^3 consists of 1.24% MoO^3, or 1.6-4% WO^3, or mixtures thereof in amounts equivalent to at least 1.2% MoO^3, 0.5-3% F, and preferably, up to 4% BaO.

3,922,440
PROCESS FOR CHANGING THE TINT OF A PHOTOCHROMIC MATERIAL AND MATERIAL FORMED THEREBY

Inventor: *Robert A. Simms* 449 Ithica Road Horseheads, New York

Filed: February 1, 1974

Appl. No.: 438,835

The tint of a photochromic material is changed without degradation in photochromic properties by heating the material in a reducing atmosphere and, while the photochromic material is at an elevated temperature, irradiating it with ultraviolet irradiation. While the heating in a reducing atmosphere itself causes a change in the tint of the photochromic material, the subsequent ultraviolet irradiation further emphasizes this change, generally yielding darker and deeper tints. The resulting material is also described.

WINDOWS

Legislation

To reduce energy consumption in new and existing buildings, national, state, and local legislation is being discussed and enacted, including both prescriptive design standards and energy performance standards. Any standard affects the use of windows in buildings.

Prescriptive standards, such as ASHRAE 90-75R, tend to favor restrictions or reductions in glazed area by setting an upper limit for the overall heat loss rate of the building envelope. This approach tends to ignore the potential benefits from windows of winter solar gain and the use of natural lighting. Credits for passive solar gain and daylighting may be taken if additional calculations are completed to support performance claims.

Performance standards, based on energy budgets or other measures of net building energy consumption, allow greater freedom in the selection and use of individual building elements, while requiring compliance with an overall annual energy consumption for the entire building. Given an adequate method for determining the annual energy consumption of a complex building at the design stage, the performance approach allows a fair assessment of annual energy losses and gains through windows.

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.

BUILDING STANDARDS

With the energy crisis, both federal and state governments have shown a growing interest in reducing

wasteful energy use in buildings. There is considerable debate as to the most effective approach for achieving this end. One approach receiving increased attention is energy standards for new buildings.

Building standards can be of two types: (1) performance standards simply refer to the total energy budget of the building, and (2) prescriptive standards specify how the building's components will be designed to meet this budget.

One of the earliest efforts at developing a set of standards for new buildings was made by ASHRAE. ASHRAE 90-75 (A 90-75), published in 1975, has provided the technical criteria for most standards programs. ASHRAE is now revising A 90-75 in response to criticism from outside reviewers.

In 1976, DOE funded the National Conference of States on Building Codes and Standards to develop a Model Energy Conservation Code, based on the technical criteria of A 90-75, which they hoped would be acceptable to all concerned code groups and in a language compatible with current building codes.

On a second front, as part of the Energy Conservation Standards for New Buildings Act of 1976, Congress mandated DOE and HUD jointly to develop and implement energy performance standards for new construction. HUD and DOE contracted with the American Institute of Architects Research Corporation (AIARC) to perform the research. By January 1978, baseline data on current energy performance in a group of 3- to 5-year-old residential and non-residential buildings throughout the country had been developed. AIARC is now assessing how much less energy these buildings can reasonably be designed to use, and developing trial standards. By August 1979, the trial standards will be tested and revised, before they are accepted as national energy performance standards.

Not suprisingly, states have varied in implementing standards for new buildings. About half of the states still do not have legislative power to create statewide energy building codes. Details of various state approaches to developing building energy standards will be presented in future issues.

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.

Future editions will contain in depth literature reviews and bibliographies which focus on specific subject matter or issues such as daylighting, solar control, economics, and thermal transfer. We solicit your opinion as to which subject areas would be of greatest interest to readers.

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.

SOLAR AND TERRESTRIAL RADIATION
Coulson, Kinsell L.
Academic Press
New York, 1975

A comprehensive source book for information on the characteristics of solar radiation and methods of analysis and measurement. Instrumentation (both old and new) for measurement of direct and diffuse solar radiation, illumination, sky polarization, sunshine duration, and long wave radiation is described.

The book emphasizes empirical data, although theoretical analysis is presented where appropriate. Extensive references are provided. Useful for those involved

in analysis and measurement of window thermal and illuminating characteristics.

ENERGY CONSERVATION AND WINDOW SYSTEMS

Berman, S.M. and Silverstein, S.D., Editors
American Institute of Physics Conference Proceedings
American Physical Society, 1975

Meaningful suggestions on ways to improve the energy performance of window systems are presented. The suggestions apply to the full spectrum of technology from research and development through manufacturing, marketing, and consumer utilization. Thermal heat transfer is discussed and the results of detailed window calculations for variable window geometries, construction materials, and weather factors are given. The potential solar heat gain through architectural windows is also discussed. The presently available selective surface materials are reviewed and the problems of bonding both semiconductor and metallic films to transparent plastic materials are dealt with. The basic physics of selective infrared reflecting wide-band-gap semiconductors is discussed.

WINDOWS AND PEOPLE: A LITERATURE SURVEY
Collins, B.L.
Building Science Series 70
National Bureau of Standards
Washington, D.C., June 1975

The current need for energy conservation has forced some fundamental re-evaluation of building design. One aspect that has come under much review is that of building fenestration. Although windows provide daylight and ventilation, they also can allow undesirable heat gain and loss.

In the past, the provision of light and fresh air were essential functions of windows. A building was uninhabitable without windows. Now however, these functions can be fulfilled by artificial lighting and mechanical ventilation. As a result, a number of people have suggested that a substantial reduction in the size of windows, or their complete elimination is desirable in order to reduce excessive energy consumption. Nevertheless, even though a windowless building might be the best solution for eliminating energy loss through windows, there is considerable evidence that this may not be very desirable for the people in the building.

In an attempt to delineate some of the functions of windows, the literature on the reaction to both the presence and the absence of windows was surveyed. In the first section, the psychological reaction to windowless buildings is examined to determine if the absence of windows in a building exerts any noticeable effect upon the occupants' behavior or attitudes. In the second section, the various characteristics of windows are reviewed to define some of their functions and benefits. (123 references) (from introduction)

WINDOW DESIGN STRATEGIES TO CONSERVE ENERGY
Hastings, S.R. and Crenshaw, R.W.
Building Science Series 104
National Bureau of Standards
Washington, D.C., June 1977

A multitude of design strategies are available to achieve energy efficient windows. Opportunities for improving window performance fall into six groups: site, exterior appendages, frame, glazing, interior accessories, and building interior. Design strategies within these groups can improve one or more of the six energy functions of windows: solar heating, daylighting, shading, insulation, air tightness, and ventilation.

Included in this report are 33 strategies; an explanation of the physical phenomena responsible for each strategy's energy performance, summarized energy and non-energy advantages and disadvantages; aesthetic considerations; cost approximations; example installations, laboratory studies, or calculations by the authors; and references. Intended readers include professional designers, leasors and owners of commercial space, home buyers and owners, window component manufacturers, and researchers. The report's purpose is to draw attention to the wide range of options currently available to conserve energy with windows.

WINDOWS AND ENVIRONMENT
Turner, D.P., Editor
McCorquodale and Co., Ltd., publishers for
Pilkington Brothers, Ltd.
England, 1969

This book was produced by staff of the Environmental Advisory Service of Pilkington Brothers, Ltd. in response to a need for a comprehensive publication to examine the relationship between the window and the internal environment that it helps to produce. The brief for the production of 'Windows and Environment' derived directly from that need. It was: to collect into one work the window physics needed as part of the overall design of an internal environment: to publish the design techniques developed by the Environmental Advisory Service and to co-ordinate them with existing methods: to present the information in a readily usable form. This last is achieved by the extensive use of graphic techniques .

The book examines the physical facts of the lighting, heating and acoustic components of the environment and the ways that they are affected by the window. These factual analyses are preceded by a dissertation, mainly pictorial, on the less tangible features of window design—the requirements of view and contact, the effects of form and symbolism.

These analyses are utilized to present window selections for a variety of building types and discuss them with an annotated bibliography. Extensive charts and overlays are provided as working tools.

SOLAR CONTROL AND SHADING DEVICES,

Olgyay, Aladar and Olgyay, Victor
Princeton University Press, Princeton, New Jersey, 1957, 1976

This classic text on solar control has been recently republished in paperback. The book combines theoretical and technical aspects of the design of solar control devices in a profusely illustrated text showing design tools and techniques as well as numerous architectural solutions to a variety of sun control problems.

The material is divided into four parts: the role of shading devices as architectural elements; technical considerations involved in the design of solar protection; practical applications of the shading design method; and architectural examples of shading solutions with photographs, device cross sections and sun-path diagrams showing the effectiveness of each device. The design method stresses Olgyay's bioclimatic approach, wherein design strategies are developed based on an assessment of requirements for thermal comfort, local climatic conditions, and properties of building materials.

WINDOW SHADES AND ENERGY CONSERVATION

Dix, Rollin C. and Laran, Zalman
Illinois Institute of Technology, Chicago, 1974

This report describes a study of the effectiveness of roller shades in conserving energy in residential heating and cooling systems. The study was conducted at the Illinois Institute of Technology with support provided by the Window Shade Manufacturers Association.

Summer and winter temperatures and solar radiation were simulated in controlled chambers. Window shades were hung inside a window frame with 0.25-in. clearance along vertical edges. Under typical summer conditions heat gain through light-colored, opaque shades was reduced by about 50% and through translucent shades by 44%, compared to unshaded glass. Under winter temperature conditions, thermal losses were reduced 24 to 41 percent. Shade hanging arrangements and room air flow were found to be critical parameters in determining shade thermal performance.

SUN PROTECTION, AN INTERNATIONAL ARCHITECTURAL SURVEY

Frederick A. Pragers,Publishers, New York 1967

A complete and visually interesting collection of solutions to sun control problems for a variety of building types in a range of climates. The book presumes that the reader understands the fundamentals of solar control, sun paths, etc. that are carefully laid out in Olgyays book. As its title suggests this is a survey of sun protection devices and methods. They are divided into fixed vs. moveable devices and then futher illustrated in sections focusing on sunshade from trees, protecting roof, balconies, shades and blinds, shutters, sun control glazing, screen, and internal shading devices.

RECOMMENDED PRACTICE FOR THE USE OF METRIC (SI) UNITS IN BUILDING DESIGN AND CONSTRUCTION

Milton, Hans J
National Bureau of Standards Technical Note 938
U.S. Department of Commerce, 1977

Conversion to metric by the construction community will require the early availability of comprehensive and authoritative national standards on the selection and use of metric (SI) units. This technical note was prepared as a draft standard for ASTM and the Construction Industries Coordinating Committee of the American National Metric Council. It describes the structure of the International System of Units (SI); recommendations for units and symbols; numerical conversion factors; and special considerations in the selection and use of SI units in design and construction. Available from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-003-01761-2.

ASHRAE METRIC GUIDE FOR HEATING, REFRIGERATING, VENTILATING, AND AIR CONDITIONING

ASHRAE Metric Committee, 1977

This booklet contains conversion data for applications primarily in the fields of heating, ventilating, air conditioning, and refrigerating applications. Convenient approximations are given for many of the standard values used routinely in load and sizing calculations. Note that all ASHRAE publications now require at least the use of dual units and that the 1981 Handbook of Fundamentals will either be all metric or dual units. ASHRAE, 345 East 47th St., New york, NY 10017

SOLAR RADIATION CONSIDERATIONS IN BUILDING PLANNING AND DESIGN

Committee on Solar Heating in the Heating and Cooling of Buildings, BRAB, National Research Council, National Academy of Sciences, Washington, D.C. 1976

This publication is an update of the 1963 Building Research Institute publication, *Solar Effects on Buidling Design*. It contains 15 papers divided into five sections: urban development, human satisfaction, available solar data, building costs, and architectural design for optimum solar effects. Individual papers deal with building envelope design, reducing solar gain, design of windows and skylights to utilize natural illumination, planning for energy conservation cost benefit analysis, solar radiation data, human response to sunlight, and access to sunlight.

SURVEY OF PASSIVE SOLAR BUILDINGS

AIA Research Corporation
1735 New York Avenue NW,
Washington, D.C. 20006

This publication describes 98 passive solar heated and cooled buildings in the United States. Each project surveyed includes the following information: the building location; a summary of climatological data; a physical description and diagram; a short explanation of the energy transfer and control mechanisms involved; backup systems used; and a capsule performance evaluation; and references.

The buildings listed in this survey incorporate a variety of energy efficient window designs, in the following categories: standard insulating windows and skylights, with suitable orientation and overhangs to block summer solar heat gain; moveable insulation, shading, reflecting, and concentrating components, both manually and automatically controlled; and a variety of devices for improving daylighting.

A DISCUSSION OF HEAT MIRROR FILM: PERFORMANCE, PRODUTION PROCESS AND COST ESTIMATES
Levin, B.P. and Schumacher, P.E.
LBL-7812
Lawrence Berkeley Laboratory
Berkeley, CA, October 1977

A unique, transparent, electrically conductive plastic film is produced in commercial quantities by the Sierracin Corporation. This film is designated by the trade name Intrex® and has been commercially available for several years. It was originally developed as a component in electrically heatable, transparent products such as de-icing windshields for aircraft, locomotives, and the like, but has potential use as a transparent heat mirror film for window applications.

This report reviews the solar and long wave IR properties of a variety of Intrex films, utilizing a gold metallic coating as well as semiconductor type coatings, and discusses the effects of protective dielectric overcoats applied to the films. The roll coating production system is described and high volume production costs for heat mirror films are derived.

HIGH PERFORMANCE SOLAR CONTROL OFFICE WINDOWS
King, W.J.
LBL-7825
Lawrence Berkeley Laboratory
Berkeley, CA, December 1977

This report describes initial investigations on the use of ion beam sputtering methods for the fabrication of solar control windows for energy conservation. Principal emphasis was placed on colored, reflecting, heat rejecting, office building windows for reducing air conditioning loads and to aid in the design of energy conserving buildings. The coating techniques were developed primarily for use with conventional absorbing plate glass, but were also demonstrated on plastic substrates for retrofit applications. Extensive material investigations were conducted to determine the optimum obtainable characteristics, with associated weathering studies as appropriate, aimed at achieving a 20 year minimum life.

A secondary program was carried out to modify the techniques to yield heat mirror films for thermal control windows for residential applications. These windows were designed to provide a high heat retention capability without seriously affecting their transmission of incident solar radiation, thereby enhancing the greenhouse effect. Films with good performance were successfully deposited on glass and plastic substrates with only slight coloring effects. Optical and thermal performance of these films are described.

TRANSPARENT HEAT MIRRORS FOR PASSIVE SOLAR HEATING APPLICATIONS
Selkowitz, S.E.
LBL-7829
Lawrence Berkeley Laboratory
Berkeley, CA, March 1979

Transparent heat mirrors are long-wave IR reflecting coatings that transmit solar radiation. Applied to windows or used in related passive solar heating applications, they substantially reduce winter thermal losses from windows, while admitting beneficial solar gain.

This paper summarizes recent progress in the development and commercialization of heat mirror coatings. Existing heat mirror applications are reviewed and projected performance in window systems is discussed. Additional development work being supported by the DOE/LBL windows program is reviewed. Several window product configurations incorporating heat mirrors are described, and results of cost-benefit calculations are presented. Heat mirrors are compared to other window insulation devices on the basis of cost, performance, durability, and consumer acceptance.

METRIC CONVERSIONS FOR WINDOW DESIGN AND CONSTRUCTION*

Conversion factors are taken to *six* significant figures, where appropriate.

METRIC TO U.S. CUSTOMARY		U.S. CUSTOMARY TO METRIC	
Length			
1 m	= 1.09361 yd	1 yd	= 0.9144 m
	= 3.28084 ft	1 ft	= 0.3048 m
1 cm	= 0.3937 in	1 in	= 2.54 cm
Area			
1 m^2	= 1.19591 yd^2	1 yd^2	= 0.836127 m^2
	= 10.7636 ft^2	1 ft^2	= 0.092703 m^2
1 cm^2	= 0.155 in^2	1 in^2	= 6.4516 cm^2
Volume			
1 m^3	= 1.30795 yd^3	1 yd^3	= 0.764555 m^3
	= 35.3147 ft^3	1 ft^3	= 0.0283108 m^3
1 cm^3	= 0.061 in^3	1 in^3	= 16.38706 cm^3
Temperature			
t(°C)	= t(°K) - 273.15 = 5/9(t°F)-32)		
t(°F)	= 9.5t(°C) + 32		
Work, Energy, Heat (1 J (Joule) = 1 N × m = 1 W × s)			
1 MJ	= 0.277778 kWh	1 kWh	= 3.6 MJ
1 kJ	= 0.947817 Btu	1 Btu	= 1.05506 kJ = 1055.06 J
1 J	= 0.737562 ft × lbf	1 ft × lbf	= 1.35582 J
Power, Heat Flow Rate			
1 kW	= 1.34102 hp (horsepower)	1 hp	= 0.745700 kW
1 W	= 3.41214 Btu/h		= 745.700 W
	= 0.737562 ft × lbf/s	1 Btu/h	= 0.293071 W
		1 ft × lbf/s	= 1.35582 W
Coefficient of Heat Transfer			
1 W/(m^2 × °C) = 0.176110 Btu/(ft^2 × h × °F)		1 Btu/(ft^2 × h × °F)	= 5.67826 W/(m^2 × °C)
Illuminance			
1 lx (lux)	= 0.092903 lm/ft^2 (footcandle)	1 lm/ft^2 (ft. cndl)	= 10.7639 lx(lux)

From National Bureau of Standards Technical Note 938, Recommended Practice for the Use of Metric (SI) Units in Buidling Design and Construction, April, 1977, Hank J. Milton.

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.

Nov. 21-Dec. 1, 1978: **National Vacuum Symposium.** San Francisco, CA. Presentations on optics and coatings for energy conservation and solar applications. Sponsor: American Vacuum Society, 335 East 45th St., New York, NY 10017.

Nov. 30-Dec. 1: **Second Annual International Conference on Energy.** Washington, DC. This conference, aimed at bringing together energy and technical management, energy decisionmakers, planners, government reps, will generate practical information for producers, suppliers, and users of energy producing and using devices. Contact: Energy Magazine, Dept. C8, PO Box 2070C, Stamford, CT 06906.

Dec. 11-13: **Commercialization of Solar and Conservation Technologies Symposium-Workshops.** Miami Beach, FL. Contact: Dr. T. Nejat Veziroglu, Clean Energy Research Institute, University of Miami, P.O. Box 248294, Coral Gables, FL 33124.

Jan. 11-13, 1979: **Third National Passive Solar Conference.** San Jose, CA. Sponsor: American Section, International Solar Energy Society. Preconference Tutorials and Workshop; post conference bus tours to local passive buildings. American Technological University, P.O. Box 1416, Killeen, TX 76541. Phone: 817/526-1300.

Jan. 20-23: **National Association of Home Builders Annual Convention and Exposition.** Las Vegas Convention Center, Las Vegas, NV.

Jan. 22-26: **Third National Conference and Exposition on Technology for Energy Conservation.** Tucson, AZ. Conference and exhibition sponsored by DOE, Mojave County Solar Energy Commission, University of New Mexico, others. Contact: TEC-III, c/o Information Transfer, Inc., Suite 202, 1160 Rockville Pike, Rockville, MD 20852. 301/379-7969.

Jan. 28-Feb. 1: **ASHRAE 1979 Semiannual Meeting.** Philadelphia, PA.

Jan. 29-31. **ASHRAE and ARI, 1979 International Air-Conditioning, Heating, Refrigerating Exposition.** Philadelphia, PA.

Feb. 21-23: **WATTec '79 Energy Conference & Exhibition.** Knoxville, TN.

Feb. 26-28: **Sixth Energy Technology Conference.** Washington, DC. Contact: Martin Heavner, Energy Technology Conference, 4733 Bethesda Ave., N.W., Washington, D.C. 20014. 301/656-1090.

March 16-19: **Kansas City Energy Exposition.** Kansas City, MO. Contact: Pat Kelley, president, Energy Exposition '79, 3009 Main Street, Kansas City, MO 64108. 816/561-1070.

March 27-30: **Technology Resource Exchange Fair.** Sydney, Australia. International exhibition for manufacturers, marketers, R&D and service organizations. Contact: Australian Innovation Corp. Ltd., 150 Queen Street, Melbourne, Victoria, Australia 3000 or Australian Government Trade Commission, 636 Fifth Ave., New York, NY 10020.

April 3-6. **Second International Week on New Source of Energy: ENERGY 79, Paris, France.** Contact: Technoexpo S.A., 8 rue de la Michodiere, 75002.

April 18-22. **Energy & Home Improvement Fair** TM. Chicago, IL. Contact: Expo Management Inc., The Apparel Center, Suite 1073, Chicago, IL 60654. 312/329-1191.

April 30-May 2: **1979 Institute of Environmental Sciences Meeting.** Seattle, WN. Topics include testing, evaluation, ecology, biosciences, contamination control, energy education, management. Further specifications available from: Institute of Environmental Sciences, 940 E. Northwest Highway, Mt. Prospect, IL 60056.

May 28-June 1: **International Solar Energy Society (ISES) 1979 International Conference.** Georgia World Congress Center, Atlanta, GA.

May 28-June 1: **International Council for Building Research Studies & Documentation (CIB) Working Commission W67, Symposium on Energy Conservation in the Built Environment.** Copenhagen, Denmark.

June 24-28: **ASHRAE 1979 Annual Meeting.** Detroit, MI

Windows
C/O Steve Selkowitz
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