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TECHNICAL REPORT

FINAL

DESIGN AND CONSTRUCTION OF A STORM WINDOW WITH INCREASED THERMAL EFFICIENCY WHICH OPENS TO ALLOW VENTILATION AS NEEDED

DISCLAIMER

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PREFACE

The significance of the Appropriate Technology Small Grants role, in addition to financial funding, should be acknowledged. The technical review of the project and suggested alternate constructions were valuable imputs. The program provided the opportunity, not available through small businesses, to develop a needed and energy-efficient product to potentially help revitalize the home building retrofit industry.

The market for the broad category of insulated, double and triple glazed windows has been relatively small in the South and a southern storm window a rarity. Certainly with the abundance of low cost fuel for heating and cooling, the incentive and the return on investment was minimal. These conditions are rapidly reversing. Currently, it is not only a matter of becoming energy efficient, but a case of National, Regional, and personal economics.

The market for storm windows, however is impeded by the fact that there are no large manufacturers of storm windows -- neither in the North nor in the South. Instead the industry is composed of small companies generally manufacturing custom made-to-order storm windows of varying quality and thermal efficiency. Original equipment manufacturers of windows

prefer to sell replacement windows rather than storm windows. There is, therefor, a need for education concerning the value of storm windows. A substantial amount of publicity, advertising, seminars for trade associations, and Energy Expos may be necessary to establish a market through storm window companies.

One market which appears to offer immediate acceptance is that of the handyman home-owner in the form of kits. Here again market analysis will be necessary to determine the preferable physical embodiment, price range, and size of the market. The text of this report covers some of the possibilities.

The basic concept of a storm window with increased thermal efficiency that mounts piggy-back ona window and opens with the window to allow ventilation can be extended to sliding glass doors and single and double hung windows in addition to awning type. Here too, market analysis and development will be necessary.

The argument for insulating the last 15% of the house --the windows -- for all seasons --is a strong one. The ultimate decision is economics. Time will prove this concept has a good return on investment.

1. FØWØRD

This project, Design and Construction of a Storm Window with Increased Thermal Efficiency which Opens to Allow Ventilation as Needed, was funded by the U.S. Department of Energy, Appropriate Technology Small Grants Program.

The project was limited in scope to retrofitting one awning type aluminum window. The preponderance of houses constructed with this type window in the Southeastern Region (Region IV) coupled with the inherent high energy loss of the awning type window, indicated a need for a storm window.

This report has been divided into the following catagories:

- Brief Summary
- Design
- Construction
- Operation
- Specifications and Drawings
- Summary and Conclusion

2. SUMMARY

The project as originally conceived and funded envisioned a conventional full - window - length storm sash mounted in the cement block window opening. Appropriate linkage would open the storm sash. This design proved to be a safety hazzard and physically undersirable (see quarterly report 12/31/80).

The design of the storm window sash was revised. Individual storm frames were to be mounted on each awning sash. Mechanical interferences with the storm sash occurred when a two inch air space was used. This was solved by reducing the air space to the optimum dimension of 3/4 inches.

The sizes and configuration of the awning type windows were studied to aid in cost effective and efficient design of the storm frame. (see SECTION 3.1 DESIGN). It was discovered that in all but the later (aluminum conserving) models, the window pane was recessed 3/4 inches. This serendipidous fact resulted in the design of a triple glazed window utilizing only one storm sash glazed on both sides. The resultant combination window and storm sash is estimated to give approximately R 3.9 to R 5.2 insulation value. (see SECTION 3.1 FRAME DESIGN).

Due to the high thermal conductivity of aluminum the storm frame material was changed to tubular 3/4 inch square, extruded, rigid polyvinylchloride plastic.

The selection and attaching of an insulating material to seal around the perimeter of the storm frame posed many formidable problems. Tearing, poor adhesion, insulating value, and high cost were solved by utilizing the appropriate glazing material as a seal. In a novel approach, the 16 mil flexible polyvinylchloride plastic sheet glazing was extended one inch beyond the perimeter of the storm frame. When the awning window is closed, the PVC on the inside and outside of the storm frame is pressed against the window sill, lintel and walls. This results in two sealed air spaces. (see SECTION 3.2 INSULATING SEAL).

Glazing materials were evaluated from manufacturers specification sheets and published literature. Samples were obtained.

Properties such as resistance to heat thermal expansion and conductivity, burning rate, effect of sun light, solar reflectance, clarity, and cost were evaluated.

The optimum compromise or trade-off of properties led to the specification of an inner clear .016 inch clear flexible PVC film (sheet) with an outer bronze tinted .016 inch transparent flexible PVC film.

Securing the PVC glazing to the PVC storm frame can be affected. by utilizing a solvent vinyl adhesive.

The storm sash may be anchored to the awning frame by either a structural adhesive or high strength double face vinyl foam tape. (see SECTION 3.3 GLAZING)

A display stand was designed and constructed and an aluminum awning window installed (see SECTION 3.4 DISPLAY STAND)

3. DESIGN

The original full - window - length design storm sash had many undesirable features. When the awning type window was opened fully, the storm sash would extend at least two feet beyond the awning window causing a severe safety hazzard. In addition the durability in wind was questionable. The appearance left much to be desired esthetically. Installation usually required drilling into a cement block wall with a masonry drill which is time consuming and difficult to maintain dimensional tolerances.

3.1 FRAME DESIGN

Attempts to redesign the original concept using linkage and alternate mounting led to the design shown in the Quaterly Report for the period ending March 31, 1981 (see SECTION 4.1 PROTOTYPE)

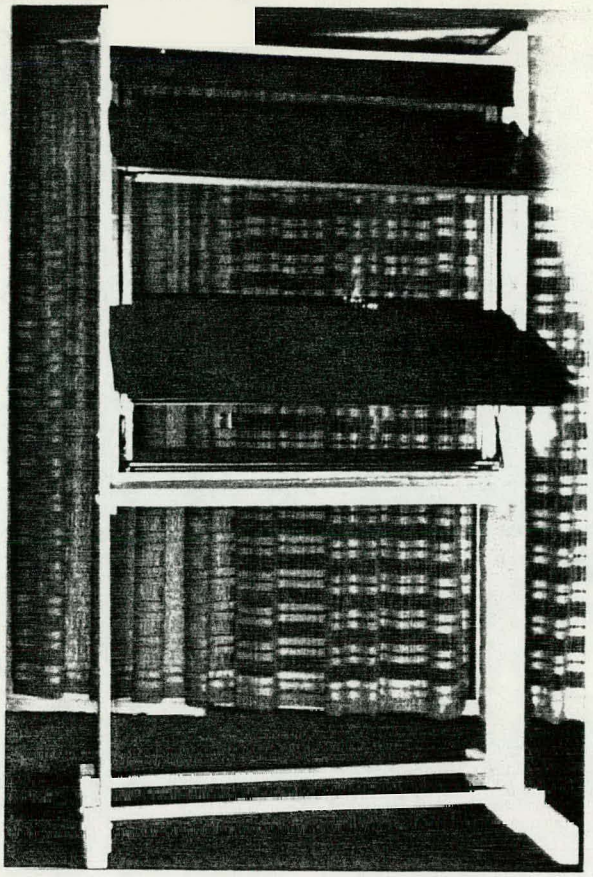


Illustration 1

Finalized storm window.
Mounted on awning window/
Installed in display stand.

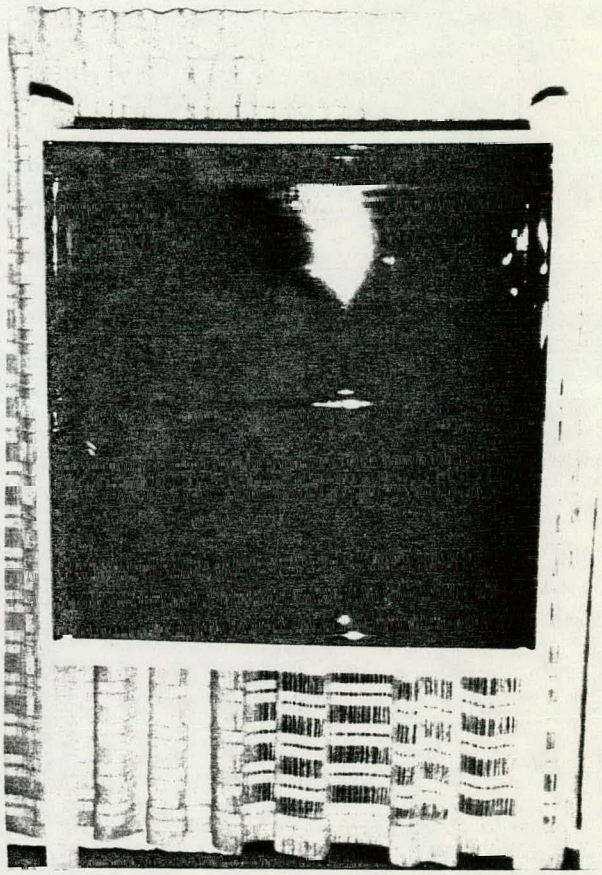


Illustration 2

Window closed shows
perimeter sealing.

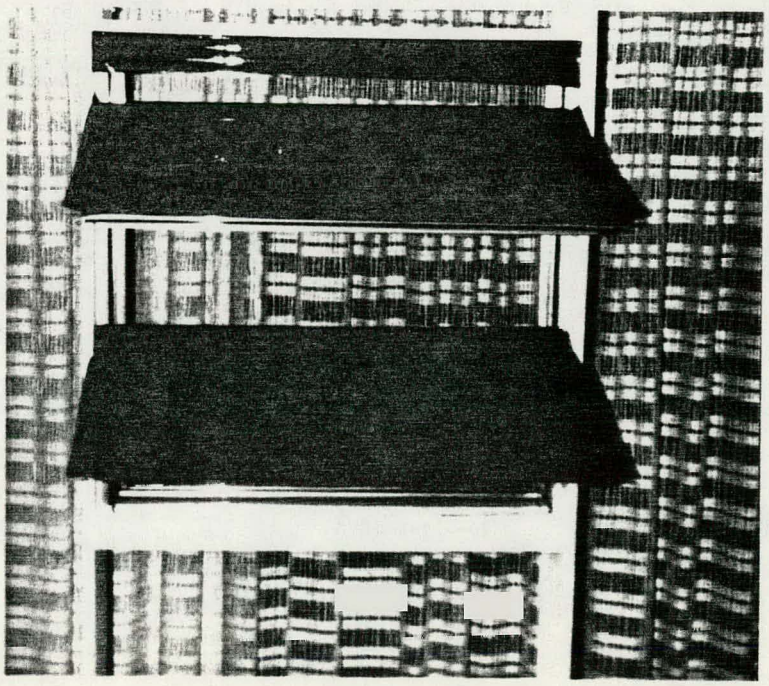


Illustration 3

Open window demonstrates
simple design and
operation.

This prototype also had severe deficiencies. When the awning type window was opened, it dropped down causing mechanical interference with the lower storm sash. The awning window opening was severely limited due to interference of the top storm sash with the awning window lintel. The problem could be helped somewhat by mounting the storm frames lower on the window sash. Mounting the upper storm sash in the window sash was another undesirable solution.

It became apparent that reducing the two inch insulating air space would solve the problem. It was originally believed that the optimum insulating air space between the window and the storm sash was 2 to 3 inches. A literature search was made to determine the optimum trapped air space. It was found that a 3/4 inch air space gives an R=2.6 value. Larger spaces have the same value, while spaces smaller than 3/4 inch gives a proportionately lower R value. (SECTION 8, REFERENCES 8.1)

In finalizing the design of the storm frame, the size, shape and material were determined. Since aluminum conducts 250 times as much heat as the same thickness of glass for the same period of time, a better insulator was found in the form of plastics. Structural foam plastics of the polyolefin, polystyrene, and rigid vinyl type were considered. (SECTION 8, REFERENCE 8.2)

However for low volume production at the beginning, this process and injection molded storm frames were ruled out in favor of an extruded 3/4 inch square tube of rigid PVC. (SECTION 8 REFERENCE 8.3). This has the advantage of low tooling cost as well as having a center air space. The square 3/4 inch tube has a 1/16 inch wall and can be fabricated to desired dimensions. This is important since there are sixteen different sizes of awning sash. Since the storm frames are the same size as the awning window frames and mounted directly on top of the latter, the lintel of the awning window will need to be insulated. A retangular tubular, extruded, rigid polyvinylchloride spacer or filler of required dimensions has been designed and built. It also has an insulating seal of .016 inches flexible PVC around the perimeter.

3.2 INSULATING SEAL

The first design specified a polyurethane foam or other suitable sealant material secured to the outer perimeter of the storm frame. Various materials were evaluated and some were purchased and tested on the first aluminum prototype storm sash. The following results were obtained:

a. Closed cell vinyl foam-good weatherability, moderate cost, tore when subjected to test-poor strength.

b. Integral skin polyurethane foam.
Poor weatherability, high cost, custom molded, not available for test.

c. Neoprene coated polyurathane foam and neoprene coated sponge rubber. Fair weatherability, high cost, special order only, not generally available.

d. Ionomer foam - same as "c".

e. Integral skin rubber foam. Acceptable weather-ability, high cost, black or dark color, abraded severely.

f. Medium durometer gasket rubber. Good weather-ability, moderate cost, good strength, abraded slightly, formed a fairly good seal.

g. PVC flexible vinyl weather stripping. Good weatherability, moderate cost, good strength, little abrasion, formed a fairly good seal when warm.

It was concluded that either medium gasket rubber or PVC flexible vinyl weather stripping type materials would give a satisfactory seal. Since the frame will be PVC, there appeared to be some advantage in solvent welding the PVC flexible weather stripping type material to the frame, however, adhesives and cements were investigated. (see APPENDIX C)

In the final design of the insulating seal, it was decided to use the glazing material - a .016 inch flexible PVC sheet-to form a double seal around the perimeter of the storm sash. This was done by extending the glazing material one inch beyond the sides and the bottom of each storm sash of both the inner and outer PVC glazing sheets. When the awning window is closed, the PVC sheet on the inside and outside of the lower storm frame seals against the walls at the sides and against the sill at the bottom. The upper storm frame simultaneously seals against the walls at the side and against the top of the lower storm frame. The seal at the top of the upper storm frame is provided by the lintel filler which also has a dual insulating seal similar to the storm frame. This results in two sealed air spaces around the perimeter of both storm frames and around the perimeter of the awning window lintel.

3.3 GLAZING

There are a multitude of standard materials, sizes and gauges (thickness) used for glazing. In addition, there are firms that will custom manufacture composite or laminated films to the purchasers specifications. Samples are generally not available and minimum orders of one roll of film are generally required at a cost ranging from about $50 to $300 a roll. Prices quoted vary with volume. The supply houses, such as Cadillac Plastic & Chemical Co. are jobbers rather than manufacturers and therefore their prices are wholesale, distributor or jobber rather than manufacturer's price. For this study, distributor or supply house prices have been used.

The following chart "Evaluation of Glazing Films" summarizes the most promising glazing materials. As indicated previously, the optimum compromise between material properties and cost led to the specification of an inner clear flexible PVC film and an outer bronze tinted flexible PVC film both .016 inches. While a solar reflective type glazing is far superior to a tinted film, a better solution is to shade the window from the sun with an awning (SECT. 8, REFERENCES 8.4) In evaluating the method of securing the glazing to the storm window, various adhesives were evaluated (see SECTION 8 REFERENCES 8.5, 8.6, 8.7). Utilizing a solvent vinyl adhesive is probably the best, fastest, and most economical.

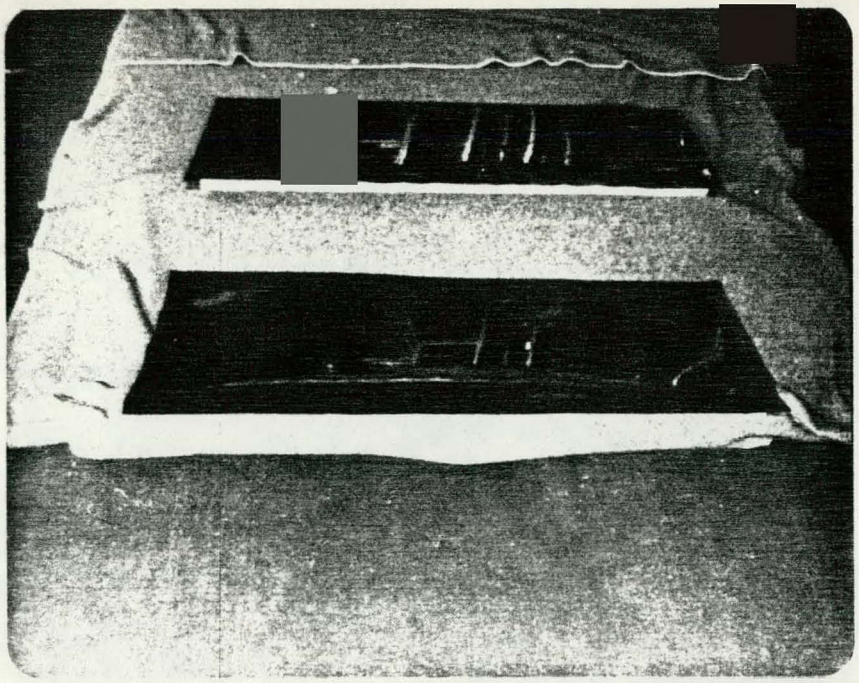


Illustration 4

View showes upper and lower frames with exterior tinted film extending beyond frame.

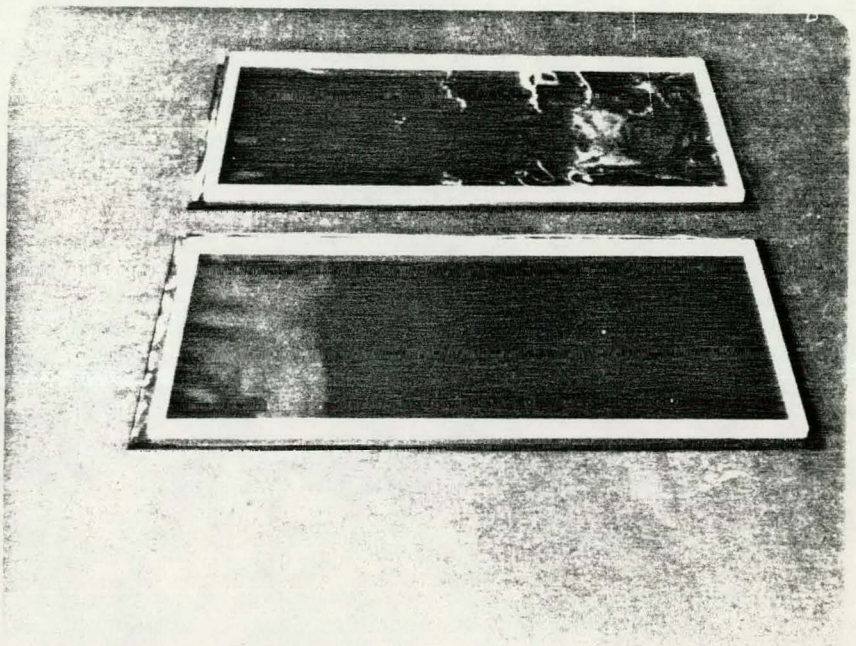


Illustration 5

View shows interior clear glazing film with tinted exterior film on other side of frame.
Both films extend 1" beyond frames.

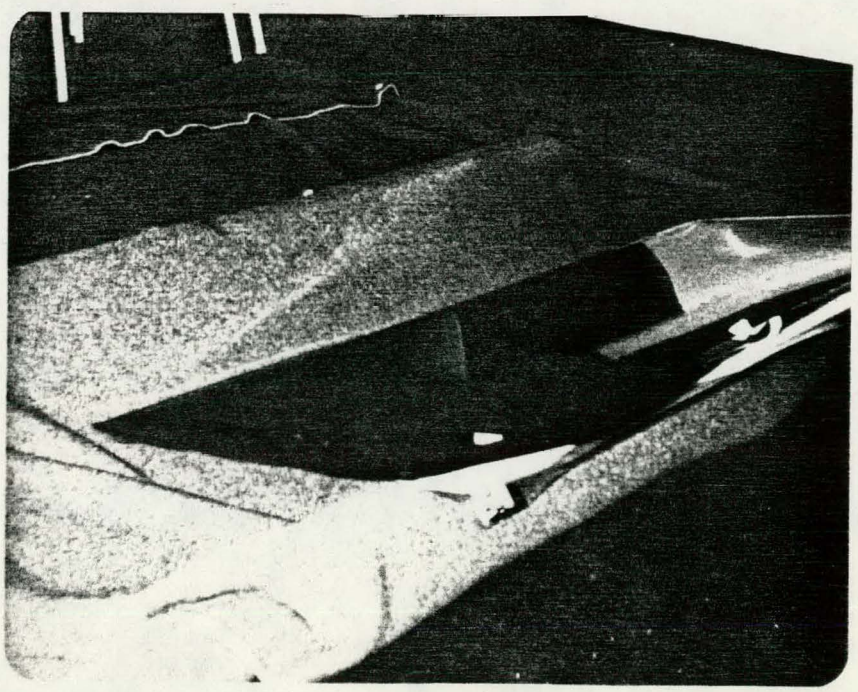


Illustration 6

Glazing films are taped open at perimeter to show sealing area.

EVALUATION OF GLAZING FILMS

	A	B	C	D	E	F	
GLAZING FILM	CAB	FLEXI-GARD	PET UVS	PET MET.	P.C.	PVC	
PROPERTIES							
THERMAL CONDUCTIVITY (1)	4.0-8.0	6	7	7	4.6	3-4	
RESISTANCE TO HEAT (2)	140-220	300	350	300	270	150-200	
THERMAL EXPANSION (3)	11-17	6	6	6	6.6	7	
FLAMMABILITY (4)	SLOW BURNING	SLOW BURNING	SLOW BURNING	SLOW BURNING	SELF EXTINGUISH-ING	SLOW TO SELF EXTINGUISHING	
EFFECT OF SUNLIGHT	SLIGHT G	VERY SLIGHT E	VERY SLIGHT E	VERY SLIGHT E	MODERATE M	SLIGHT G	
COST MIL (5)	22 7.5	38 7	46 5	75 5	15 5	7 6	26 16

See notes following page.

(1) 10^{-4} cal/sec/sq. cm/1 (°C/cm)

(2) °F continuous

(3) 10^{-5} /in/in/°C

(4) in/min.

(5) ¢/sq. ft.

A. Cellulose acetate butyrate - "UVEX," Eastman Chem. Products

B. "FLEXIGARD" composite acrylic and polyethylene terraphthalate, 3M

C. Polyethylene Terraphalate, Ultra-violet Stabilized "Llmar", Chemplast Inc.

D. .003 inch metallized PET bonded to .002 clear "Llmar" film-Chemplast

E. Polycarbonate, "Lexan", UVS, General Electric Co. "Mylar", duPont

F. Polyvinylchloride

3.4 DISPLAY STAND

The design of the display unit was thought at first to be quite simple. However, upon checking various builders houses, it was noted that while the window dimensions were standard, the wall dimensions varied widely. The sills sloped downward at angles from 8 to 15 degrees. The lintels likewise sloped upward at various angles. The vertical building walls of the window-opening varied the most. Some were perpendicular to the building walls; others tapered away from the window. The biggest variation occurred when the vertical window area was stuccoed. It was decided to design the stand to simulate the most difficult of conditions. This had to be an untapered opening. The stand was designed to be readily disassembled by bolting or screwing all the components together. The height of the window was kept at a workable dimension which also made it easy to see the operation. The overall size is such that it will fit in a station wagon.

4. CONSTRUCTION

This section will discuss the materials of construction and the cost, versus the properties of alternate materials and designs.

Storm windows can vary from the ultimate to the utilitarian. The storm window designed under this project falls somewhere in the middle. It will be examined first and the other extremities will be noted.

4.1 PROTOTYPE

The finalized prototype storm window is constructed of all-plastic materials. The 3/4 inch square tubular rigid PVC frame is easily sawed to dimension. This is important due to the large number of different sizes.(see APPENDIX C, MANUFACTURERS LITERATURE, 5) The following chart shows the standard window numbers and sizes with the corresponding storm sash dimensions.

STORM SASH SIZES

WINDOW NUMBER	WINDOW SIZE		STORM SASH SIZE		NUMBER OF STORM SASH/WINDOWS
	WIDTH	HEIGHT	WIDTH	HEIGHT	
12	19 1/8	26	18	12	2
13	19 1/8	38 3/8	18	18	3
14	19 1/8	50 5/8	18	16	3
15	19 1/8	63	18	15	4
½ 32	26 1/2	26	25	12	2
½ 33	26 1/2	38 3/8	25	18	3
½ 34	26 1/2	50 5/8	25	16	3
½ 35	26 1/2	63	25	15	4
22	37	26	36	12	2
23	37	38 3/8	36	18	3
24	37	50 5/8	36	16	3
25	37	63	36	15	4
32	53 1/8	26	52	12	2
33	53 1/8	38 3/8	52	18	3
34	53 1/8	50 5/8	52	16	3
36	53 1/8	63	52	15	4

The first prototype frame material was made from standard aluminum storm window - frame members and assembled with standard corner locks. Aluminum mounting brackets were fabricated and installed with self-tapping screws. The estimated material and construction cost was high and as discussed in the "Summary" was not insulation effective. It served the function, however, of establishing design parameters and mode of operation of the awning type window.

It is well understood that design determines to some degree the materials of construction, but to a larger degree cost of materials dictates the success in marketing the product. The following cost estimate will give some insight into the relative cost of materials.

STORM WINDOW COST ESTIMATE

a.	Outer film, 16 mil, PVC, Tinted. 9.5 sq. ft. x 26¢	2.47
b.	Inner film, 16 mil, PVC Clear 9.5 sq. ft. x 26¢	2.47
c.	Frame Material Upper and Lower Frame 3/4 in. square tube, rigid PVC 18 feet x 21¢	3.78
d.	Lintel Spacer Tubular, Rigid PVC 3 feet x 3/4" x 2" 3X 30¢	.90
	Sealing film, 2 sq. ft. x 26¢	.52
e.	Adhesive 1 oz. Solvent weld film to frame	.23
f.	Adhesive - or 3/8X#6 S.M. Screws Attach Storm Frames to Window	.90
	TOTAL Cost Of Materials	$11.27

Note: Cost is based on distributors price.

To this, the cost of labor as well as overhead and profit must be added. A guestimated manufacturer's price for the two assembled storm frames would be about $24.

Since retail price would be about another 50%, a $36 retail could be expected. This would be about the average cost of a triple track aluminum storm window, which of course, can be opened and closed for ventilation. The triple track windows however convert a window to a double glazed window, while the subject invention converts the window to triple glazing with optimum air space and insulating materials. Operational savings will be covered in section 5, but it is important to establish functional differences and similarities related to construction and economics.

Alternate materials of construction can increase or decrease the final price while still maintaining the basic design concept. For example a deluxe model storm window could be constructed of the following alternate and probably best of all materials of construction.

Alternate Deluxe Prototype Storm Window Cost

a.	Outer Film PET Reflective, Metallized 9 x 75¢	6.75
b.	Inner Film Flexigard 9 x 38¢	3.42
c.	Frame Material (see APPENDIX C, 1A) CPVC, Triextruded, Integral, Flexible seal 18ft. x 50¢ ft. (est.)	9.00
d.	LINTEL, PVC TRIEXTRUDED 3 ft. x 68¢ (est.)	2.25
e.	Adhesive - film (est.)	.50
f.	Adhesive - frame	.90
	Total material cost	$22.82

This translates into a retail price of about $68. Main advantages are longer life expectancy; probably 15 years vs. 7 years for vinyl. The insulation value would be greater and aesthetic appeal would be enhanced.

At the other end of the spectrum a single film would give the effect of double glazing. If one were seeking maximum economy, the storm frame could be eliminated by attaching the film directly to the aluminum awning window sash preferable with a double-sided adhesive closed-cell foam vinyl tape. The exterior stationary aluminum parts of the window could also be covered with the same type foam for insulation. The foam would provide a seal against the film which would extend to the window walls. If the glass in the awning window is recessed 3/4", an R value of about 2 could be expected. There would be an additional indeterminate saving through reduction for air infiltration. The estimated minimum cost follows:

Alternate Economy Prototype Storm Window Cost

(a)	Glazing film (one) PVC .004 9.5 sq. ft. x 4¢	.38
(b)	Double - sided adhesive vinyl C.S. foam tape 18 ft. x 10¢	1.80
(c)	Weather Strip 18 ft. x 6¢	1.08
	Total material cost	$3.18

This is obviously not a manufactured window, but it does represent the minimum that homeowners could install themselves.

The choice of materials was determined by the fact that they are currently in use and approved. Rigid vinyl storm frames for windows have been in use for many years and are manufactured by reputable companies (see APPENDIX C, 1A, 1B). PVC film has also been used for many years, especially in Florida to enclose screen porches with sliding vinyl glazed windows.

4.2 DISPLAY UNIT

The construction of the display unit is shown in drawing number B2 (see SECTION 6 DRAWINGS). It was constructed of spruce lumber, and bolted together. The bill of materials is also contained in Section 6.

5. OPERATION

Two aspects of the operation will be discussed. First the mechanical operation and then the functional operation.

The mechanical mode of operation is quite simple. The storm window sash is mounted permanently on the exterior of each awning window and automatically opens and closes integrally when the window sash is cranked open or closed.

The lower lip of the lintel has a rain drip guard that projects away from the window sash. This is very convenient because it also deflects the sealing (inner) film so that it does not get caught when the window is closed. Likewise, the bottom of the upper window also has a rain drip guard that projects away from the window. This prevents the sealing film from becoming caught between the upper and lower window sash when closing. The method of sealing the storm window has been discussed under section 3.2 Design, Insulating seal. (see Drawing #B7, page 39)

The functional operation relates to the performance of a product's intended use. The two functions of this storm window are:

(a) to open automatically to allow ventilation as needed and

(b) provide increased thermal efficiency.

The mechanical operation describes how the storm window opens automatically to allow ventilation. How well this function is performed is indicated by the fact that the prime awning window can be opened to the full limit. In addition, the obstruction to the flow of air between the window sashes is only 3/4 inches. This might well be negated by the fact that the aerodynamics of the window are improved in two ways. The surface of the window is now flat and minus the 3/4" recess for the glass. The smooth surface of plastic greatly reduces the friction or resistance to the flow of a gas or air. The functional operation related to ventilation should be rated excellent. The importance of ventilation has long been understood in relationship to the maintenance of desirable temperature and humidity. In the southeast, due to climate conditions, both seasonal and daily, there is a need to be able to control ventilation by opening or closing the windows.

Currently there is a realization that indoor air pollution is an emerging health problem (see SECTION 8 REFERENCES 8.9). One of the solutions is adequate ventilation. The subject storm windows open automatically with the windows to allow desirable ventilation.

The basic function of any storm window is to reduce heat loss or heat gain. This is done in two ways, that is, by reducing air infiltration and secondly by retarding the heat flow through the window. Air infiltration is the amount of air leakage between sash and frame.

Drafty and leaky, uncaulked and unweather-stripped windows have high air infiltration. The prime window should fit tight and seal when closed. With the addition of a tight fitting and sealed storm window air infiltration can be minimized.

The second aspect of reducing heat loss or gain is to slow the heat loss through the window by conduction. Conduction is the transmission of heat from warm air through the window to the cold air; outward during the winter and inward during the summer. The measurement of conducted heat loss is called the "U - value" of the window (or other surface or material). The lower the U-value the better. One method of reducing heat loss through the window is by adding multiple layers of glazing. Air films on the surface of the glazing provide most of the resistance to heat transfer. Since there is limited heat conduction through the air and each layer of glazing reradiates (radiates back) the heat, the heat loss is reduced. The glazing material is said to have little effect on preventing conductive heat loss in the thickness commonly used. Most plastics have a U value within 5 to 10% of glass. For example, glass has a U value of 1.13, while "Mylar" (PET) is 1.07. However, PVC has a thermal conductivity of just about one half that of PET. (see SECTION 3.3 GLAZING CHART "Evaluation of Glazing Films"). Obviously this will not make an order of magnititude difference since the plastic glazing only represents about 4% of the insulating area (2 glazing films @ .016 = .032 plus 0.750 air space = .782 therefore, .032/.782 = 4%).

Obviously the thermal conductivity of the air space is the major consideration. The thermal conductivity varies directly with the amount of convection of the air. As the air is heated up, it moves and in so doing transfers the heat to the next glazing which conducts the heat to the outside (and also reradiates it both to the inside and the outside). So, if air convection could be reduced between double glazing, better insulation would be obtained. One company has done this with the appropriately named "Heatmaze" window (see APPENDIX "C" MANUFACTURER'S LITERATURE, 6). The window consists of two panes of glass with horizontal strips of plastic every 3 inches to reduce convection heat loss. They claim an R 3.2 insulation factor.

In the article "Multi-layered Mylar Storm Windows", J. Stephenson uses a 3/4" air space (see SECTION 8 REFERENCES 8.1 and attachment). He has further disclosed in a sketch of the storm windows that a 3/4" air gap gives an R 2.6 value per 3/4" gap. He states that larger air gaps have the same R value (2.6) and that air gaps smaller than 3/4" proportionally lower R value. This is presumably verified by thermographic photography. This information is the basis of the improved thermally efficient storm window designed for this project. The double glazing of the storm window increases the thermal efficiency above that of a triple glazed window.

As a further test of thermal efficiency the conductive heat loss through the window can be calculated. This can then be compared to the calculated heat loss with the storm window installed.

Heat Loss/year = U x sq. ft. x 24 x 1000

(Btu/yr.) (Value) (window area) (hrs./day) (Heating degree days. Central Florida.)

Window/Single Glazed

Heat loss

Btu/yr. = 1.13 x 9 x 24 x 1000 = 244,080

Single Glazed Window

With double glazed storm R 3.9 = U.26(conservative estimate)

Heat Loss

Btu = 0.26 x 9 x 24 x 1000 = 56,160

Btu/yr. savings = 244,080-56,160 = 187,920

187,920 ÷ 244,080 = 77%

Houses lose heat through every square foot of exposed area and since windows represent only a small part of the whole house (15%), a 77% saving will not be realized in the heating bill even if storm windows are installed on all windows. In a 1400 sq. ft., one-story house with 15% windows-to-floor space ratio and 250 lineal ft. of crack in the windows, it is estimated a savings in window heat loss of 50% may reduce whole house heat loss about 25%.

Translating the window energy saving due to adding storm windows into dollars and pay back time is difficult to establish. It depends on many factors such as location, local temperatures, prevailing winds, weather and size, style, glazing system, number and type and condition of windows. Also the direction in which the house and largest window areas face. Of course, the type of fuel and utility or fuel rates. Even life style will influence the pay back period. If the windows are left open while the air conditioning is on, the storm windows won't prove much of a saving.

The arithmetical computation, is not difficult. The Btu/yr. savings can be translated into dollar savings if multiplied by the cost of fuel per Btu. If the fuel is electricity and the cost per KWH is $.08 including fuel adjustment, dividing by 3412 BTUH (= 1 KWH) gives the cost of fuel per BTU. Thus $.0000234 is the cost per BTU.

187,920 x $.0000234 = $4.40/yr/window
BTU/yr Savings COST/BTU

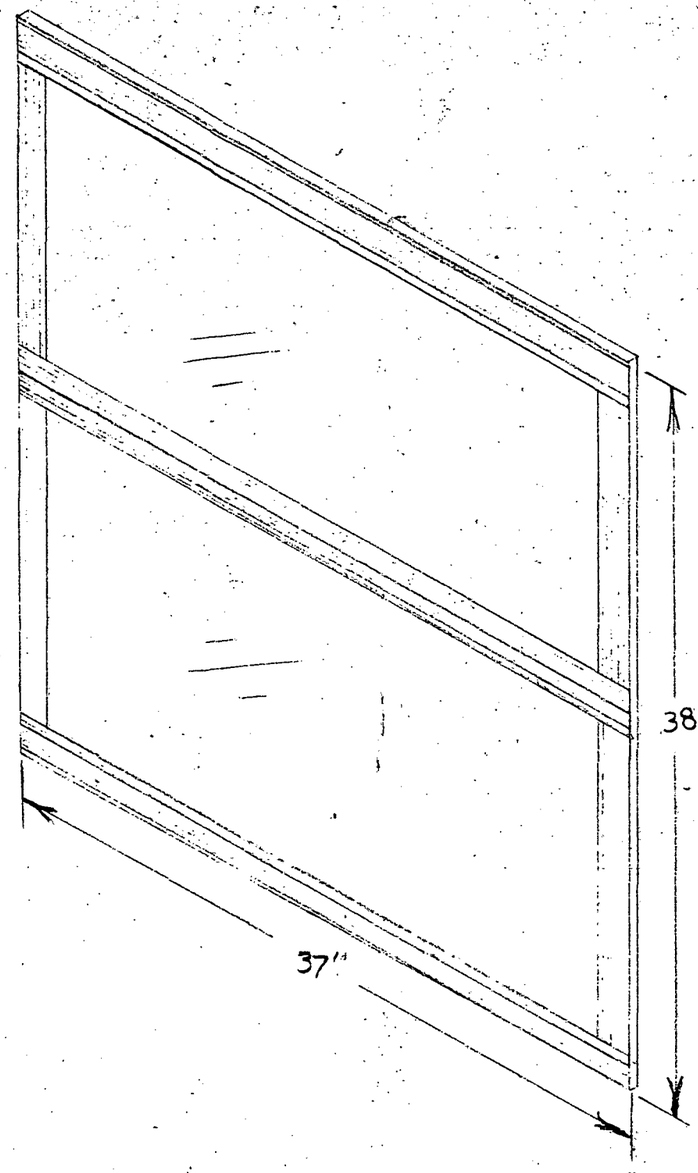
It should be noted that this saving is for heating only. The air conditioning energy saving can be calculated based on 3,500 cooling degree days in Central Florida area. This would amount to 3.5 x $4.42 = $15.47

Heating saving + 4.42

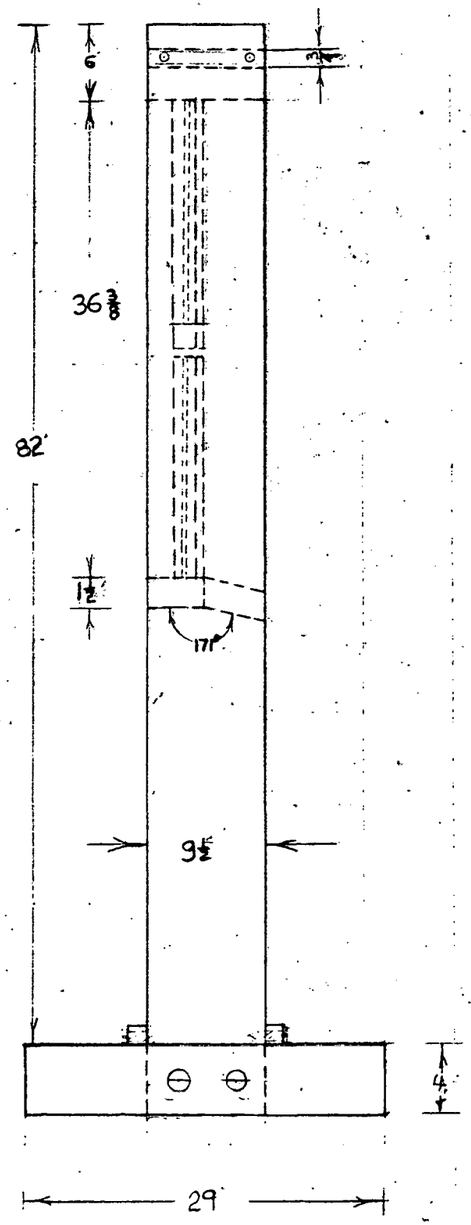
Heating and cooling saving = $19.89/yr.

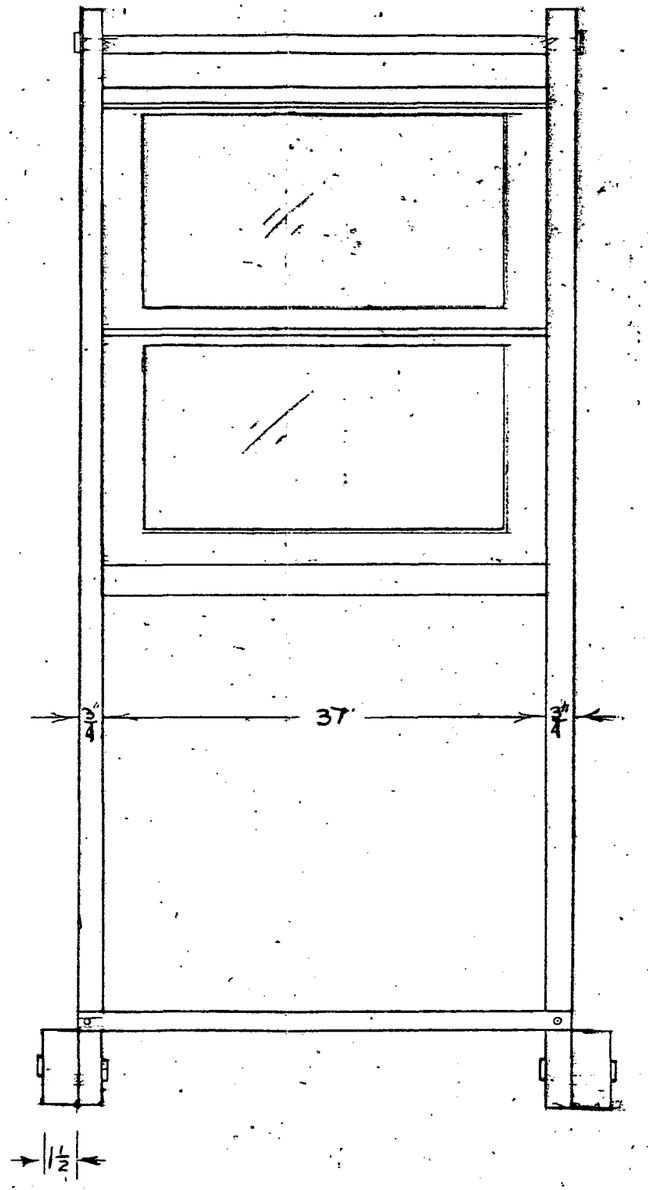
Using the 50% "whole house" heat loss factor gives $9.91 or approximately $1 per square foot of window area. In a 1000 square foot house with 15% window-to-floor space area there would be 150 sq. ft. of window area and the estimated saving per year at $1 per square foot would be $150 per year. This would appear reasonable based on some published estimates of storm windows saving 10 to 15% of utility bills, since the average all electric home of 1000 square feet expended $1,100 for electricity last year. Thus 10 - 15% would be 110 - $165/yr. The estimated retail price for a 3' x 3' foot storm window was $36 or $4 a square foot. Based on 150 sq. feet of window area the cost for storm windows would be $600 with a four year payback period. (see SECTION 8, REFERENCES 8.8)

6. SPECIFICATIONS AND DRAWINGS



NOTES: AAMA SPECS	DRAFTSMEN	A.R. LAMENDOLA	TITLE	NO. #23
	GRANTEE / PROJ. DIR.	F.S. TYRRELL		AWNING WINDOW
TOLERENCES: COMM.	MATERIAL: ALUMINUM	PROPOSAL NO. #	F 375	
		GRANT NO. #	DE-FG4480R910301.000	
	SCALE: NONE	DATE: 6/2/81	DWG NO #	B.1





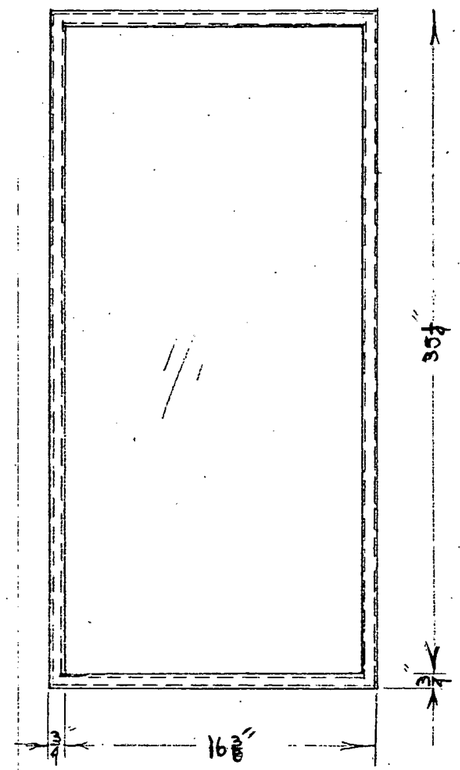
NOTES: SEE BILL OF MATERIAL B2	DRAFTER	A.R. LAMENDOLA	TITLE DISPLAY UNIT /
	GRANTEE/PROJ. DIR	F.S. TYRRELL	# 23 AWNING WINDOW
TOLERENCES: ± 1/16	MATERIAL SPRUCE	PROPOSAL NO: # GRANT NO #	E 375 DE-FG 4480R410 30 1.000
	SCALE: NONE	DATE 6/2/82	DWG NO. # B2

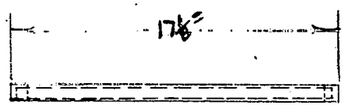
DWG. No.: B 2 TITLE: DISPLAY STAND/#23 AWNING WINDOW

BILL OF MATERIALS

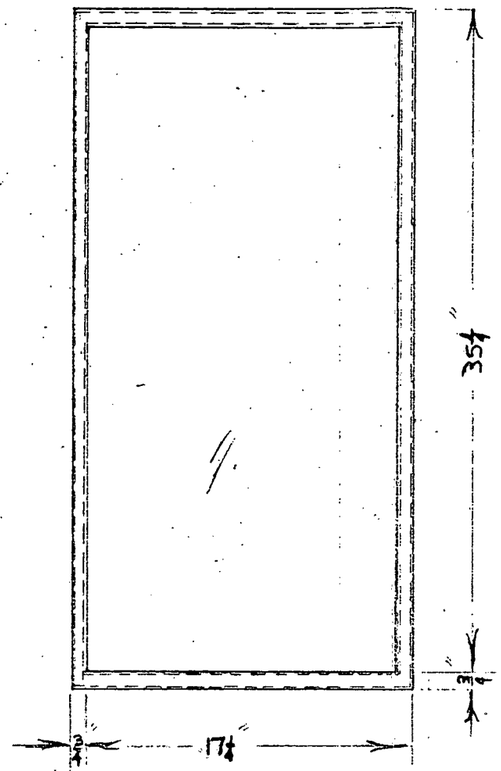
ITEM #	DESCRIPTION	SIZE	QUANTITY
1	LUMBER, SPRUCE	2 x 4 x 29	2
2	" "	2 x 4 x 37	1
3	" "	1 x 12 x 82	2
4	" "	1 x 12 x 37	1
5	" "	1 x 6¼ x 37	1
6	" "	1 x 2 x 37	2
7	BOLTS, PLATED	5/16 x 2 HEX. Hd	12
8	NUTS "	5/16	12
9	BOLTS "	3/16 x 1½ HEX. Hd	4
10	NUTS "	3/16	4
11	#23 AWNING WINDOW	37 x 38 3/8	1

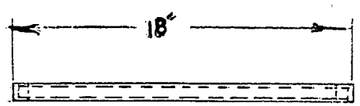
UPPER WINDOW SASH





LOWER WINDOW SASH



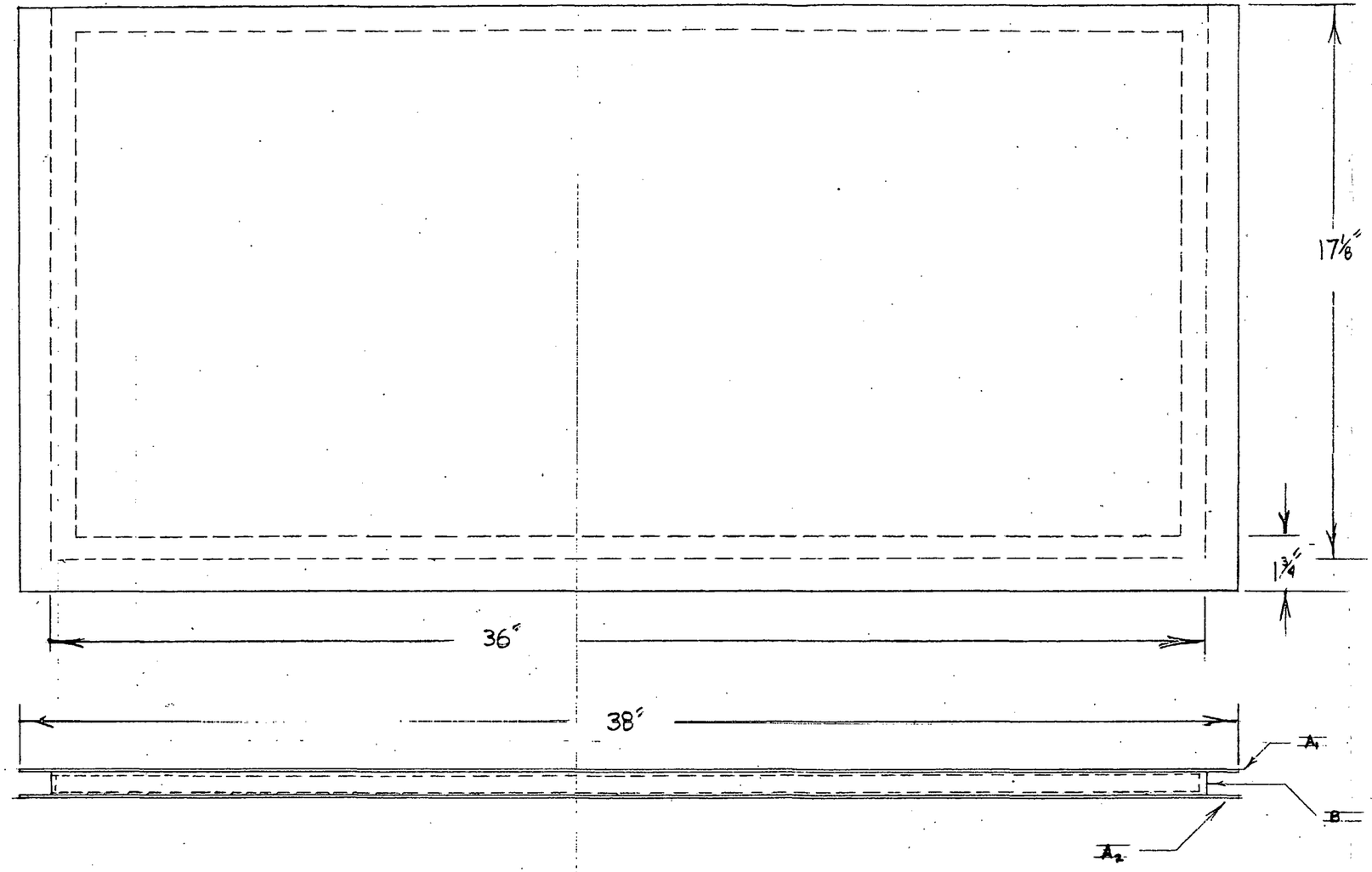


NOTES: SEE BILL MATERIALS B3	DRAFTER	A.R. LAMENDOLA	TITLE: STORM SASH FRAME
	GRANTEE / PROJ DIR	F.S. TYRRELL	
TOLERENCES: ± 1/32"	MATERIAL: RIGID PVC TUBE 3/4" SQUARE	PROPOSAL NO.#	F 375
		GRANT NO.#	DE-FG 4480R 410301
	SCALE: NONE	DATE: 6/2/81	DWG NO.# B3

DWG NO.: B 3 TITLE: STORM SASH FRAME

BILL OF MATERIAL

ITEM #	DESCRIPTION	SIZE	QUANTITY
	UPPER STORM SASH		
1	3/4 SQUARE TUBULAR RIGID PVC EXTRUDED	17 1/8	2
2	Same as 1	36	2
	LOWER STORM SASH		
3	Same as 1	18	2
4	Same as 1	36	2
5	PVC CEMENT		1 oz.



A1, A2 — SPECS

PVC .076" THICK

A1 = TINTED

A2 = CLEAR

B — SPECS

¾" SQUARE TUBULAR

RIGID PVC

NOTES: UPPER FRAME SEE B.M. B4	DRAFTSMAN -	A.R. LAMENDOLA	TITLE: STORM FRAME / FILM GLAZING
TOLERENCES: ± 1/32"	GRANTEE / PROJ. DIR.	F.S. TYRRELL	
	METERIAL: NOTED	PROPOSAL NO.#	F-375
		GRANT NO.#	DE-FG 44 80R 410301.000
	SCALE: NONE	DATE 6/2/81	DWG NO.# B4

DWG No.: B 4 TITLE STORM FRAME/FILM GLAZING

BILL OF MATERIALS

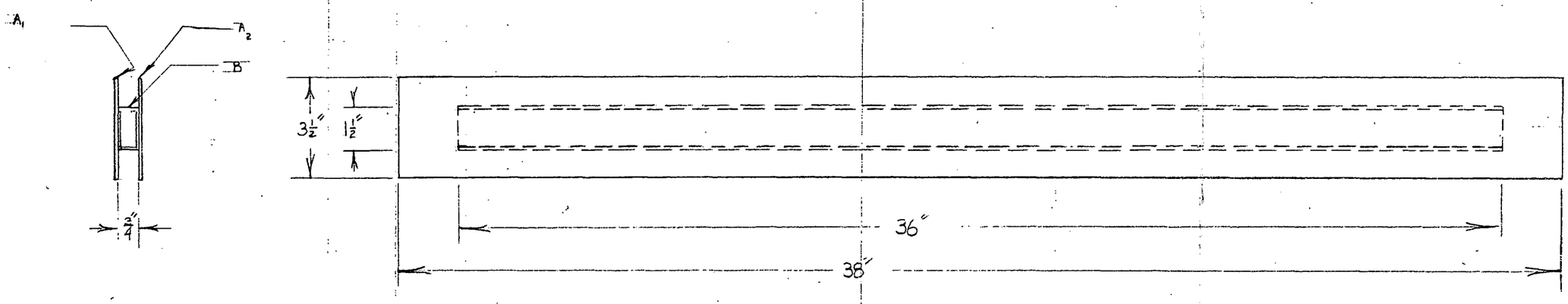
ITEM #	DESCRIPTION	SIZE	QUANTITY
1.	STORM SASH UPPER	PER DWG B3	1
2.	" " LOWER	" " "	1
3.	PVC FILM, CLEAR, POLISHED BOTH SIDES, U.V.S.	18 1/8 x 38 0.016 THICK	1
4.	PVC FILM, TINTED, POLISHED BOTH SIDES, U.V.S.	18 1/8 x 38 0.016 THICK	1
5.	PVC FILM, CLEAR POLISHED BOTH SIDES, U.V.S.	19 x 38 0.016 THICK	1
6.	PVC FILM, TINTED POLISHED BOTH SIDES U.V.S.	19 x 38 0.016 THICK	1
7.	PVC CEMENT		4 oz.

A_1, A_2

PVC .016" THICK
A_1 IS TINTED
A_2 IS CLEAR

B

3/4" x 1 1/2" TUBULAR
RIGID PVC



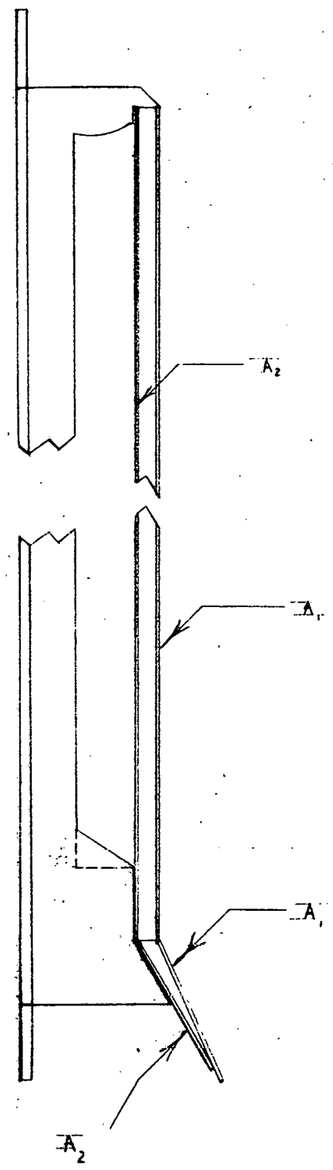
NOTES:	DRAFTED BY	A.R. LAMENDOLA	TITLE: STORM WINDOW
	GRANTEE / PROJ. DIRECTOR	F.S. TYRRELL	FILLER / SEAL
TOLERANCES: ± 1/32	MATERIAL: NOTED	PROPOSAL NO.#	F 375
		GRANT NO. #	DE-FG44BOR410301.000
	SCALE: NONE	DATE: 5/22/81	DWG NO.# B5

DWG No.: B 5 TITLE STORM WINDOW FILLER/SEAL

BILL OF MATERIALS

ITEM #	DESCRIPTION	SIZE	QUANTITY
1.	RECTANGULAR TUBULAR RIGID PVC EXTRUDED	1 1/2 x 3/4 x 36 1/16 WALL	1
2.	PVC FILM, CLEAR POLISHED BOTH SIDES, U.V.S.	3 1/2 x 36 0.016 THICK	1
3.	PVC FILM, TINTED POLISHED BOTH SIDES, U.V.S.	3 1/2 x 36 0.016 THICK	
4.	PVC CEMENT		1 oz.

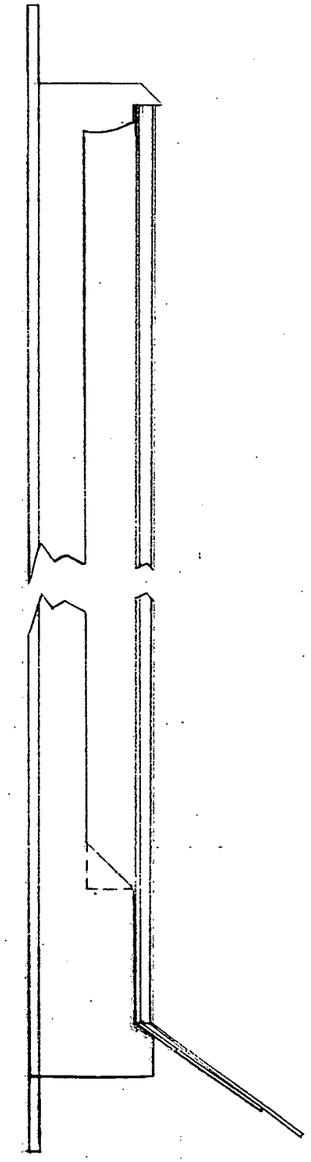
UPPER STORM WINDOW SASH INSTALLED



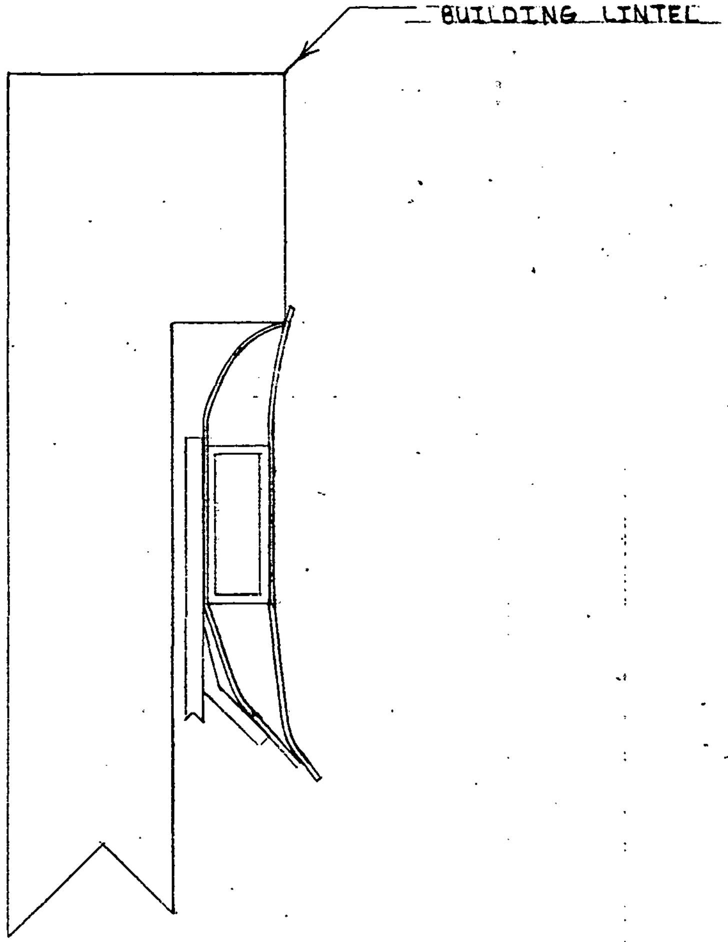
A1
PVC, .016 THICK,
TINTED

A2
PVC, .016 THICK,
CLEAR

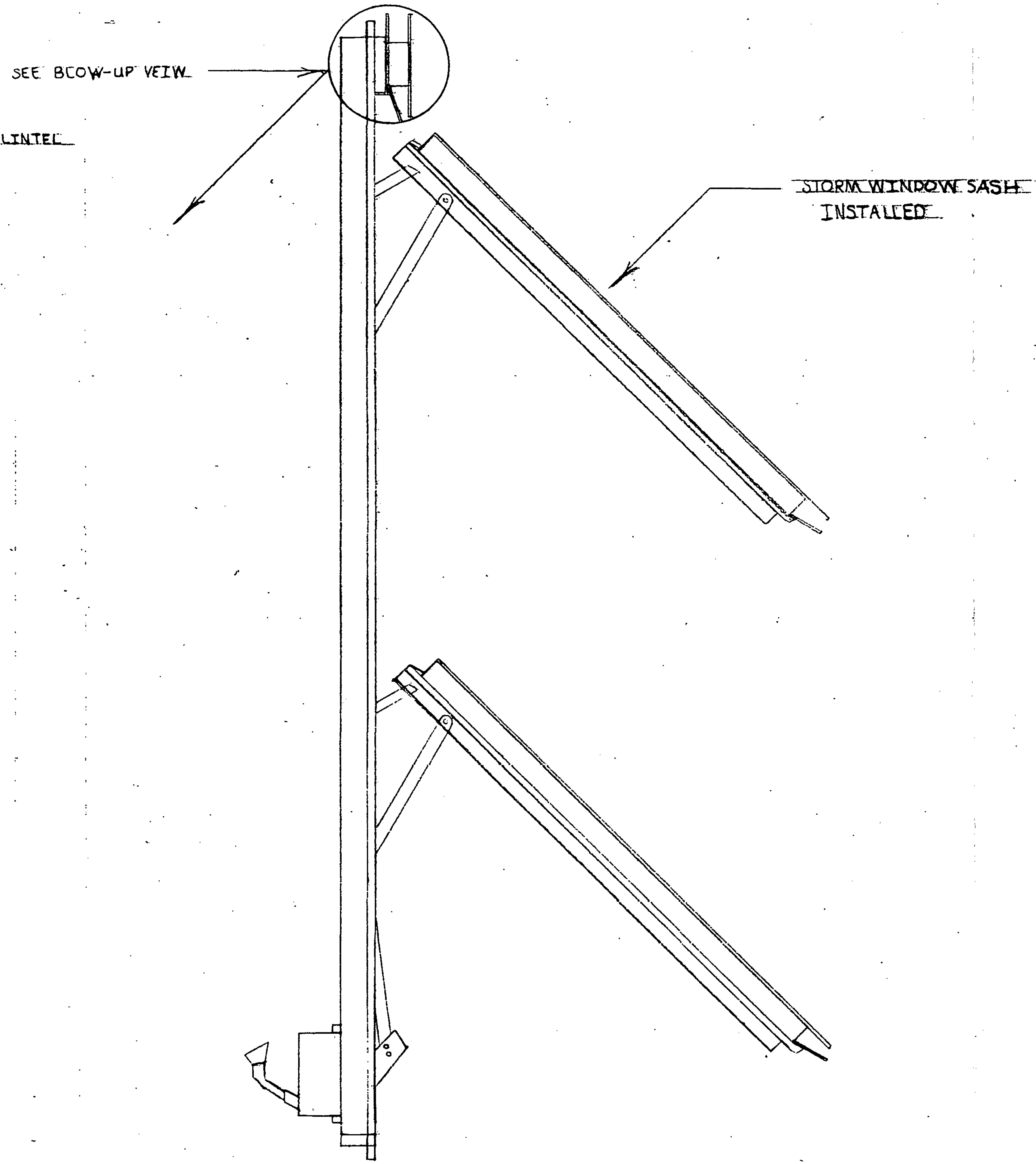
LOWER STORM WINDOW SASH INSTALLED



DRAFTER	A.R. LAMENDOLA	TITLE	STORM SASH WINDOW / AWNING DETAIL
GRANTEE / PROG. DIR.	F.S. TYRRELL		
MATERIAL: NOTED	PROPOSAL NO. #	F 375	
	GRANT NO. #	DE-F64RR4/10 301,000	
SCALE: NONE	DATE: 6/2/81	DWG NO. #	B 6
NOTES:	TOLERANCES:		



DETAIL OF FILLER SPACE
FOR STORM SASH



NOTES:	DRAFTER	A.R. LAMENDOLA	TITLE STORM SASH INST-ALLED ON AWNING WINDOW
	GRANTEE / PROJ. DIR.	F.S. TYRRELL	
TOLERENCES:	METERIAL:	PROPOSAL NO. #	E 375
		GRANT NO. #	DE-FG44-80R410301.000
		DATE: 6/2/81	DWG NO. # B7

7. SUMMARY AND CONCLUSIONS

The proposed storm window was redesigned in physical configuration and greatly improved in functional performance. Recently discovered technical information on the heat conductivity in multiple glazed windows has been incorporated in this storm window. This has resulted in at least a 50% increase in thermal efficiency. A novel method of double sealing was developed and adapted. The finalized storm window is light, structurally strong, weather resistant, easily installed, economic, thermally efficient and opens in conjunction with the window to allow ventilation. The storm window meets or exceeds all of the proposed specifications.

The scope of the funded proposal did not cover alternate manufacturing processes, independent lab testing, market investigation nor extended uses of the apparatus. The evolution of the product into an unconventional storm window design suggests the following should be explored:

a. other methods of fabrication

b. actual laboratory testing of thermal properties

c. investigation of the market potential for use with awning type windows and

d. extended uses such as sliding glass doors and single and double hung windows.

It is concluded that in the Southeast U.S. where ventilation is required throughout the year, this type of storm window is essential for energy efficiency. As the price of fossil fuel increases, storm windows will become an economic solution to energy conservation in both heating and cooling a building.

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8.6 "Construction Sealants" M.G. Kasperski, The Construction Specifier Oct. 78

8.7 "Silicone Sealants for Solar Energy Systems" S.A. Brady Adhesive Age Nov. 77

8.8 "Storm Windows," Cons. Rep. P. 562-65 Sept. '80

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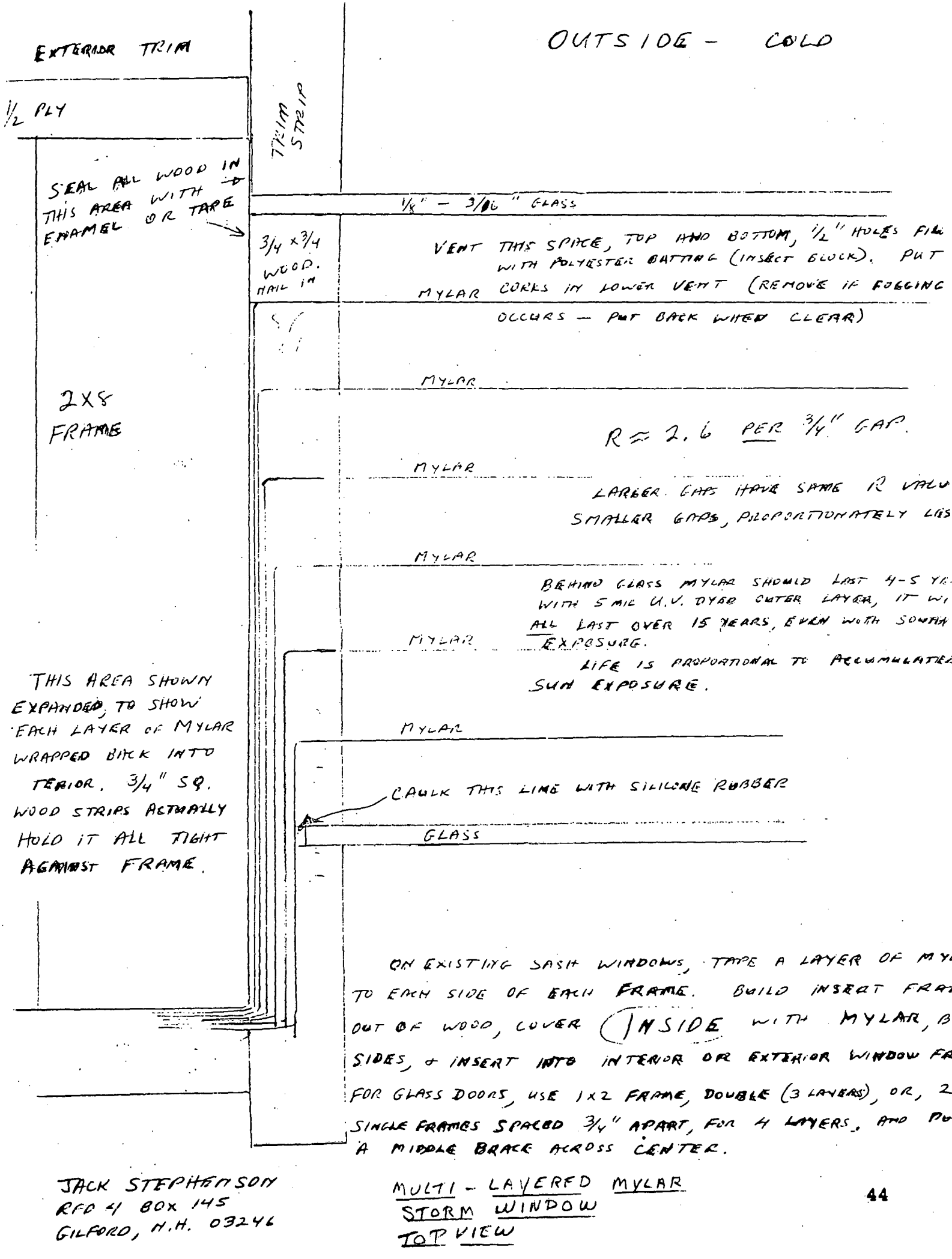

JACK STEPHENSON
RFD 4 BOX 145
GILFORD, N.H. 03246

MULTI - LAYERED MYLAR STORM WINDOW
TOP VIEW

APPENDIX A DEFINITIONS AND FORMULAE

AWNING WINDOW	See Windows, awning
BTU	British Thermal Unit Energy required raise one pound of water one degree Fahrenheit = 252 calories
BTUH	BTU Hour BTUH = 0.000293 KWH
CAB	Cellulose acetate butyerate a plant derived plastic compound. A thermoplastic material
CAL	Amount of heat required to raise temperature of one gram of water one degree Centigrade = 3.97×10^{-3} BTU
CASEMENT	See windows
CONDUCTION	Heat transfer within a material by passing thermal energy from one molecule to the next without movement of the material
CONVECTION	Transfer of heat from one place to another by actual motion of the air.
COOLING DEGREE DAYS	See DEGREE DAYS
CPVC	Chlorinated polyvinyl chloride Thermoplastic polymer made from acetylene, hydrochloric acid and chlorine.
DEGREE DAYS, COOLING	Measurement of probable cooling requirements. Average daily air temperature (F) minus 65 degrees plus the results for each day of the year.
DEGREE DAYS, HEATING	Measurement of probable heating requirements. Total number of degrees that the average daily outside temperature falls below 65°F each year

EXTRUDE	To shape by forcing a material through a forming die with pressure
FILM	A thin usually flexible material. .010 inches or less in thickness
FOAM	A material containing a mass of gas bubbles
FOAM, STRUCTURAL	A high strength foamed plastic manufactured under low or high pressure by forcing material into a mold
FRAME	A sash. A structure which encloses a border or holds or supports something
FRAME, STORM	A sash or structure which is added onto an existing building window
FRAME, WINDOW	That part of a window that contains the glass, usually movable.
GUAGE	The thickness of a material 100 Guage = 0.001" = 1 MIL
GLAZING	Originally glass or glass-like material. Glass or any glass-like material used in windows
GLAZING, DOUBLE	A structure containing two panes of glass (or equivalent) separated by an air space for insulation.
GLAZING, TRIPLE	A structure containing three panes of glass (or other material) each separated by an air space resulting in two insulating air spaces.
HEATING DEGREE DAYS	See DEGREE DAYS, HEATING
INFILTRATION, AIR	Air which passes through an interstice

INFILTRATION RATE, AIR	A measurement expressed in cubic feet of air per minute per lineal foot of sash crack when tested at a static air pressure of 1.56 pounds per square foot (Equivalent to 25 MPH wind velocity)
KW	Kilowatt(s) = 1000 WATTS
KWH	Kilowatt hours 1000 Watt hours = 3412 BTUH
LINTEL	A horizontal member spanning the upper opening of a window to carry the building weight.
METALLIZED	A reflective mirror-like finish made by sputtering molten metal (AL) in a vacuum onto a film or substrate.
MIL	One thousandth inch (0.001) = 100 Guage
PANE	A sheet of glass in a window frame
PC	Polycarbonate. A thermo-plastic polymer manu-factured from phosgene gas
PET	Polyethylene terraphthalate - A polyester. A thermoplastic material made from ethylene glycol and terephthalic acid "MYLAR" Tradename. duPont
PVC	Polyvinyl Chloride. A thermoplastic material made by polymerizing vinyl chloride gas with a catalyst.
PVC, FLEXIBLE	PVC with a modulus of elasticity of less than 60,000 psi

PVC, RIGID	PVC with a modulus of elasticity of 200,000 psi or above
R Value	Resistance to the flow of heat indicator. Thermal resistance expressed as $^{\circ}FFt^{2}/Btu$ the higher the R value the greater the insulating value $= \frac{1}{U \text{ value}}$, reciprocal of thermal conductance
RADIATION	The transfer of thermal energy by means of electromagnetic waves (infra red)
REFLECTANCE	A measure of the ability of a surface to reflect radiant energy
REFLECTIVE FILM	A plastic metalized or coated film having a high reflectance (coefficient of reflection)
SASH	See Frame
SHEET	Any film material in excess of .010 inches
SILL	The lower or bottom timber or stone on which a window rests.
THERMAL	RELATING TO HEAT
THERMAL EXPANSION	The change in length of a material for a unit change in temperature
TUBULAR	Consisting of a hollow cylinder of various shapes
TINTED	A transparent dye added to a plastic to impart color

U Value	A measurement of conducted heat loss (or gain), expressed as Btu/hr./°F/ft² the lower the U value the lower the conducted heat loss = $\frac{1}{R}$, reciprocal of thermal resistance
UVA,UV,UVS	UV light absorber UV light inhibitor UV light stabilizer A chemical agent added to a film to absorb or screen out radiation beyond the violet wavelength, to prevent degradation. eg sunlight.
VINYL	Commonly used for PVC
WEATHERABILITY	The ability of a material to withstand outdoor exposure
WELDING, SOLVENT	also Solvent bonding, solvent cementing. The process of joining plastic items by applying a solvent and pressing the softened surfaces together.
WINDOW, AWNING	Also Miami windows. A window of one or more panes which can be cranked open and resembles an awning by opening outward from the bottom
WINDOW, CASEMENT	A window hindged top and bottom and swings open like a door
WINDOW, DOUBLE-HUNG	A window that opens vertically both top and bottom
WINDOW, SINGLE-HUNG	Opens vertically. Only bottom sash opens. Top sash fixed.

WINDOW, STORM	An additional window placed outside the original building window for protection against severe weather.
WINDOW, STORM TRIPLE-TRACK	A storm window having three tracks which allows the storm window to be opened and a screen to be lowered into place.

APPENDIX B BIBLIOGRAPHY

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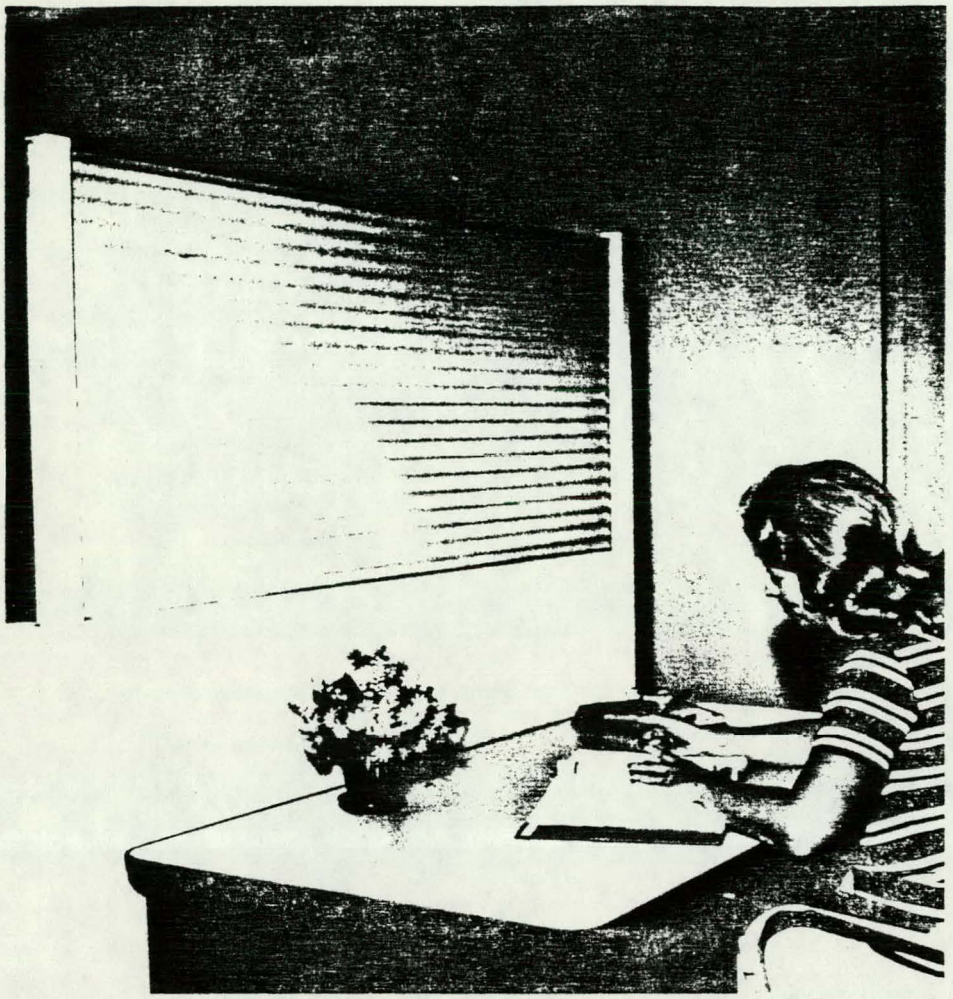
APPENDIX C MANUFACTURER'S LITERATURE

Chlorinated PVC (CPVC)



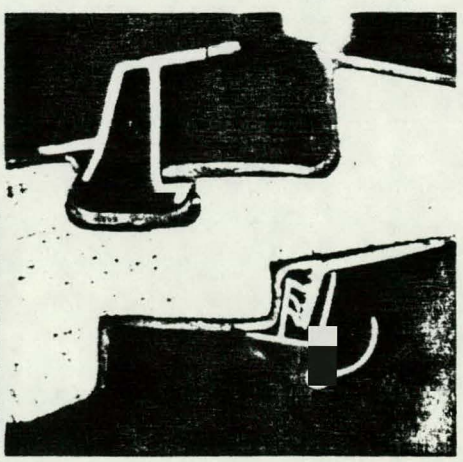
Relocatable office partitions, to establish and rearrange office spaces, are being made using sheet of Geon™ CPVC as the glazing material.

Geon™ CPVC performs at temperatures 60 F higher than ordinary vinyls and gives electrical resistance superior to rigid PVC. CPVC maintains the basic physical properties of PVC — impact resistance and tensile and flexural strength. It has exceptional resistance to most mineral acids and bases, paraffinic hydrocarbons and salt solutions. Molding and extruding techniques used for PVC can be used with CPVC.

For parts subjected to corrosive, high-temperature service in electrical, automotive or industrial equipment or other appliances, consider Geon™ CPVC.

CPVC pipe fittings and valves have been used extensively in hot and cold water piping for mobile homes, domestic plumbing systems and in chemical process, electroplating and metal-treatment plants. CPVC sheet is fabricated into protective covers and partitioning.

Geon™ CPVC can be coextruded with flexible and rigid vinyl compounds to generate parts which combine the outstanding properties of each of these materials. An example is a CPVC profile substrate being used in a window glazing bead application.



This tri-extruded cross-section of a vinyl-clad window shows the CPVC substrate, semi-rigid PVC capstock and flexible PVC edging

An important consideration or requirement for vinyl or thermoplastic material for outdoor use is good dimensional stability.

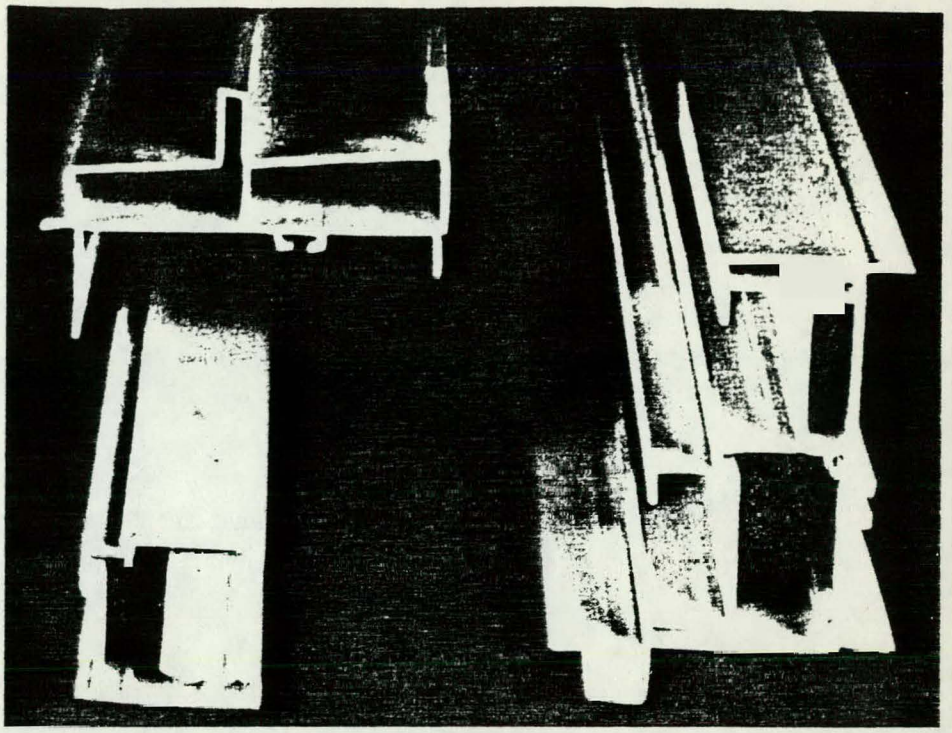
This characteristic depends greatly on heat buildup or energy absorption of a given colored vinyl or plastic material under exposure to the sun.

Therefore, the maximum temperature rise or heat buildup above ambient temperature for various colors exposed in the vertical position has been determined and is described below. Temperature buildup for a horizontal or inclined position would be approximately 20% higher.

To determine the temperature buildup on a vertical wall, the Δ°F for a given color should be added to the maximum air temperature for a specific geographical area. For example, if the ambient air temperature can rise to 43°C (110°F) in a certain area, then black, under the worst possible conditions, can reach 84°C (184°F) on a vertical wall.

TYPICAL SOLAR HEAT BUILD-UP, FOR SELECTED COLORS

Color	Δ°C (Δ°F)
Yellow	22 (40)
White	24 (43)
Light Green	24 (43)
Tan	24 (43)
Ivory	25 (45)
Gold	26 (47)
Light Brown	28 (50)
Light Gray	29 (52)
Medium Blue	30 (54)
Barn Red	30 (54)
Dark Brown	37 (67)
Black	41 (74)

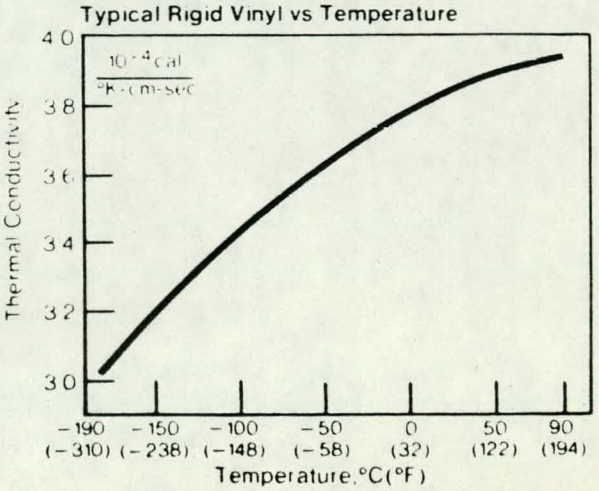


Rigid vinyl can be formed into widely varied extruded parts and provide a good thermal insulator as in these window profiles.

With a K factor or W m•K (BTU-in/h.ft²• F) of .19 (1.3) compared with .72-.86 (5-6) for glass, 44.92 (312) for steel and 203.90 (1416) for aluminum, rigid PVC is attractive in many applications because of its low heat transfer characteristics.

Figure 10 illustrates the thermal conductivity of typical rigid vinyl versus temperature.

Figure 10
Thermal Conductivity of Typical Rigid Vinyl vs Temperature

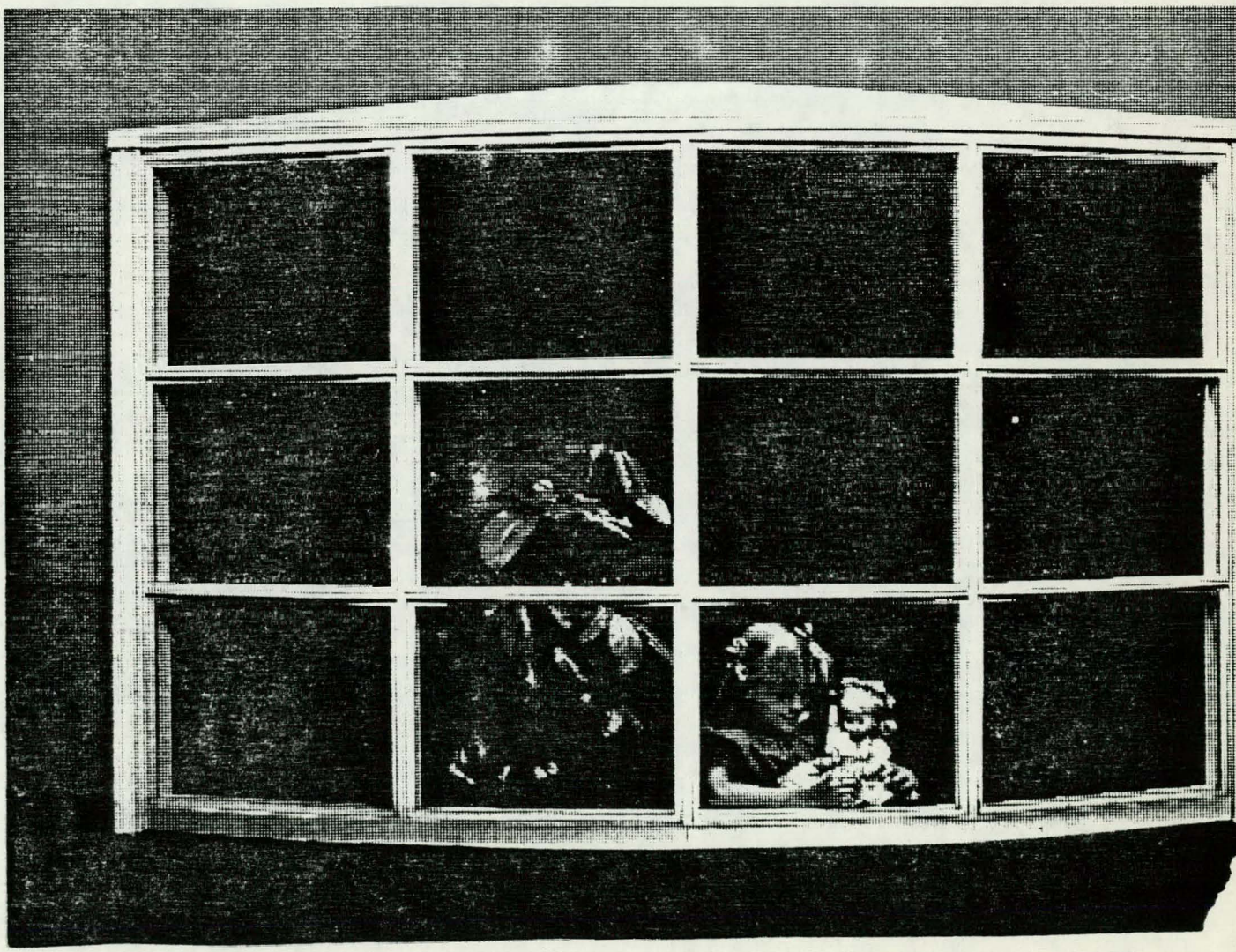


An oco 'deas make products wc ‹. Let them work for yo .

structural foam experience.

A prefabricated window frame manufacturer found an Amoco high-impact polystyrene to be an open-and-shut improvement over traditional materials. This structural foam resin matches expensive wood and finished aluminum for lasting good looks. The tough moistureproof polystyrene surface stands up to temperature and weather extremes; won't crack, rot, corrode or discolor. And a smaller number of parts can be molded, then snapped together without glueing, nailing or fastening. Result: fewer sub-assemblies and major production savings.

Write: Amoco Chemicals Corporation, Advertising Dept.-Plastics, 200 East Randolph Drive, Chicago, Illinois 60601.



Scotch-Weld
BRAND

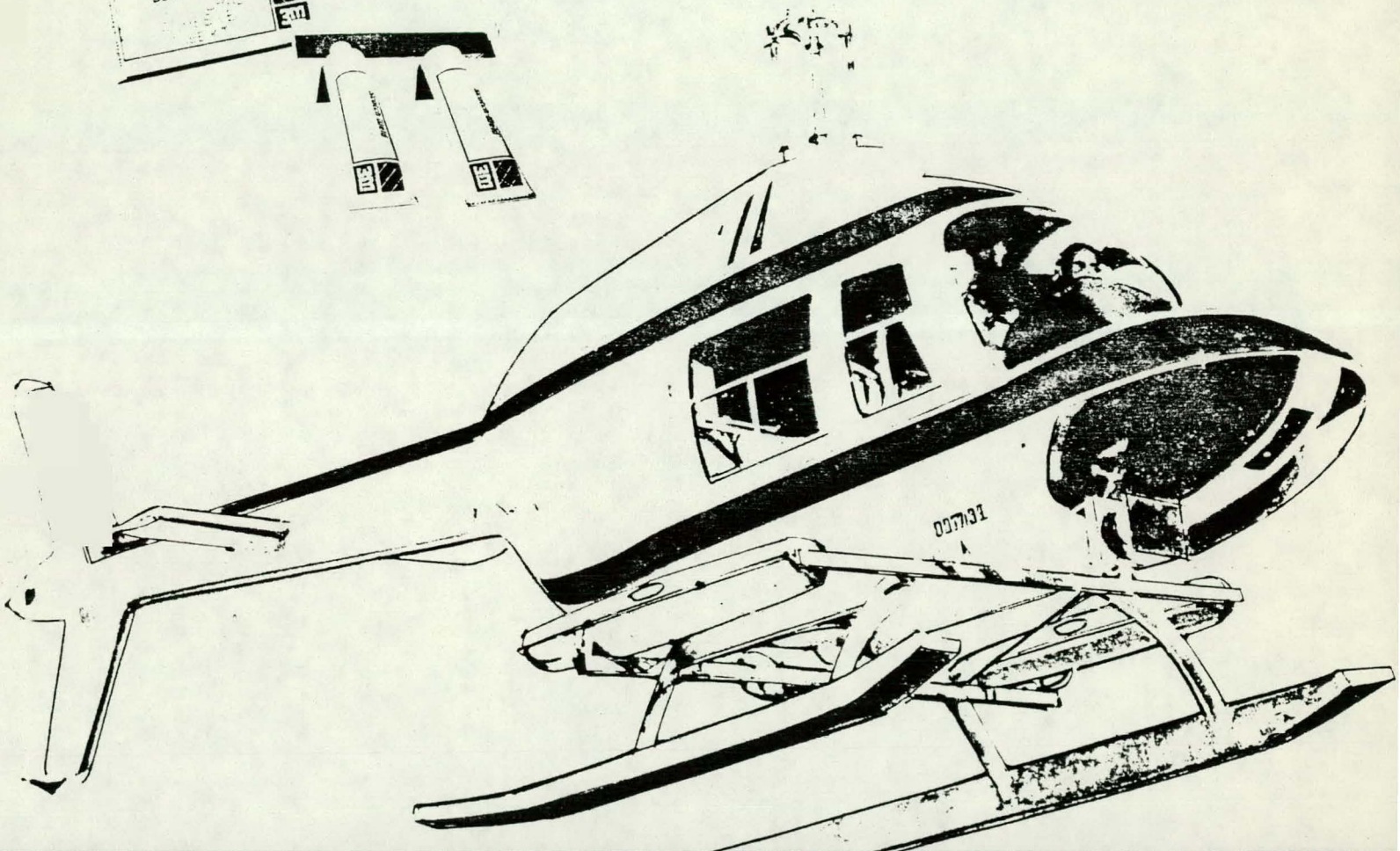
STRUCTURAL ADHESIVE

2216 B/A

"Scotch-Weld" Structural Adhesive 2216 B/A offers many advantages over ordinary "epoxy type" products or conventional fastening methods. It's a two-part, modified epoxy adhesive with high shear and peel strengths. Cures at room temperature to a highly flexible bond. Bond is often stronger than the parts being bonded. 2216 bonds numerous similar and dissimilar materials, including rubber, metal, wood, most plastics and masonry products.

2216 has been performance proven throughout industry in solving design problems and helping reduce the high cost of mechanical or fusion fastening. Consider it for product assembly applications wherever increased product performance is needed.

- CURES AT ROOM TEMPERATURE TO FORM STRONG, HIGHLY FLEXIBLE BONDS
- CURE CAN BE ACCELERATED WITH HEAT (e.g. TWO MINUTES AT 350°F).
- DEVELOPS EXCEPTIONALLY HIGH SHEAR AND PEEL STRENGTHS.
- LONG WORK LIFE – UP TO 90 MINUTES AFTER MIXING.
- BONDS RUBBER, METAL, WOOD, MOST PLASTICS AND MASONRY.
- EASY TO APPLY BY SPATULA, TROWEL OR FLOW EQUIPMENT.
- AVAILABLE IN GRAY OR CLEAR AMBER.



Guide Specifications

DOW CORNING

DOW CORNING® CONSTRUCTION SEALANTS

For caulking and sealing applications

GENERAL

The following guide specification is provided for the convenience of the architect/specification writer and is recommenced as a guide for the preparation of job specifications. It covers the general procedures necessary for proper installation of silicone construction sealants. Substantial deviations should be referred to the manufacturer for approval.

1.0 SCOPE

1.1 Furnish and install sealant work as specified herein. All joints and drawings required to be sealed and not noted, shall be the responsibility of the contractor to install the proper joint sealant.

2.0 MATERIALS

2.1 Materials shall be manufactured or supplied by Dow Corning Corporation, Midland, Michigan 48640, or its authorized distributor, and shall include the following Colors are to be selected by the architect Selection of the proper sealant for particular joints shall be in accordance with current recommendations as published by the manufacturer.

2.1.1 Dow Corning silicone rubber bathtub caulk (Part No. 8640) — white.

2.1.2 Dow Corning silicone rubber sealant (Part No. 732) — white, black, clear, aluminum, and bronze.

2.1.3 Dow Corning silicone rubber sealant, paintable (Part No. 8644) — white.

2.1.5 Dow Corning 790 building sealant — black, white, gray, natural stone, and bronze.

2.1.6 Dow Corning 1205 primer or Dow Corning 1200 prime coat — as specified or required, or other primers recommended by Dow Corning.

2.1.7 Ethafoam® SB brand sealant backer rod — manufactured by The Dow Chemical Company, Midland, Michigan, or polyurethane foam backer rod.

3.0 DELIVERY AND STORAGE

3.1 Materials shall be delivered in their original, tightly sealed containers or unopened packages, all clearly labeled with the manufacturer's name, product identification, and lot numbers where applicable

3.2 Materials shall be stored in strict accordance with the manufacturer's printed instructions, copies of which will be furnished to the architect.

4.0 JOINT SURFACE PREPARATION

4.1 All joint surfaces shall be clean and dry. They shall be free of dirt, dust, rust, release agents, lacquer, moisture and laitence.

4.2 Concrete shall be cured at least four (4) weeks and then cleaned by wire brushing, grinding, or sand blasting. Dust shall then be removed by blowing compressed air or vacuuming. For precast concrete, initial test joints shall be installed and adhesion checked and approved by the architect.

4.3 Nonporous surfaces shall be cleaned with methyl ethyl ketone solvent using a clean, white, oil-free, lint-free cloth. If the cloth becomes dirty, change to a clean cloth immediately.

4.4 Ethafoam brand SB sealant backer rod or polyurethane foam backer rod shall be of a diameter 25% greater than the joint width. Backer rod shall be installed with a blunt instrument and any punctured rod shall be removed and replaced with a new Ethafoam SB backer rod. Rod shall be installed so that sealant depth is one-half the joint width.

5.0 PRIMER APPLICATIONS

5.1 Primer selection shall be in accordance with manufacturer's written recommendations Primer shall be applied with a natural bristle brush; flooding of the surface with any primer shall be avoided

5.2 No primer is required on masonry, glass or ceramic surfaces to be sealed with Dow Corning construction sealant.

5.3 For all other surfaces the sealant manufacturer's recommendations shall be consulted and followed.

6.0 SEALANT APPLICATIONS

6.1 When applying a sealant, the depth shall be one-half (½) the joint width, with a minimum of one-fourth (¼) inch depth. The depth shall be measured to the crest of the round backer rod.

Be cautious about *overestimating* the cost of silicone. Generally, silicones should be applied in a 2/1 width to depth ratio (1/2" wide, 1/4" deep). The recommended practice for many other high performance sealants is a 1 to 1 ratio (1/2" wide, 1/2" deep). Some joint preparation is always required; priming is sometimes required. This depends upon the type of silicone and the application. Most silicones manufactured today are rather soft and are not recommended for foot traffic areas. High modulus sealants are used to seal aquariums, while most low modulus products are not recommended for below grade applications.

High Modulus Silicones

The original silicone sealant, and the most familiar, is the acid cure type, which emit the familiar vinegar odor during cure. Acid cure silicones in the U.S. have a high modulus and excellent adhesion to many substrates. This has led to use in a myriad of adhesive and sealing applications ranging from affixing information signs and lettering to structural glazing.

The high modulus silicone sealants are the only materials with the necessary adhesive and cohesive strength, durability, and weatherability to perform in structural glazing applications. The silicone sealant is used for the weather seal and the transfer of applied loads from the glass panel to its perimeter support.

Another major application for this sealant is as the structural seal in dual seal insulated glass units. A hot melt butyl sealant is used as the vapor barrier. The silicone gives the units strength along with exceptional ultraviolet and aging resistance. These silicones have a high moisture vapor transmission rate and cannot be used in an insulated glass as the only sealant of a single seal unit.

These sealants are also used to seal curtain walls where movement is within the material capability of ± 25 percent. It should not be used on masonry substrates because the acid released during cure weakens the concrete strate and adhesion is ruined.

These sealants cure very fast and are tack-free in less than 30 minutes. This is a mixed blessing in that it reduces dirt entrapment but it also requires tooling very soon after application (ideally within 5 minutes).

Low Modulus Silicones

A second type of silicone is a very low modulus sealant with a neutral cure. The most common is a one-package material that gives off an amide during cure. This material, with excellent adhesion to a variety of substrates including masonry, is especially suited for applications where a high degree of movement is expected.

The low modulus characteristics of this material is important because it reduces the stress at the bond/substrate interface. In a tensile bar configuration (as described in ASTM-D412), a force of 20 to 40 psi is required to extend the low modulus sealant by 150 percent. The high modulus acid cure sealant typically requires a force of 110 psi.

In addition to the low modulus, this sealant is also capable of very high extension. In the same ASTM configuration, low modulus silicones can be extended more than 1500 percent before failure occurs. In an actual simulated concrete joint, the sealants are capable of more than 650 percent extension—far beyond any normal requirements. This provides a significant safety factor.

Low modulus sealants also have the good recovery typical of silicone sealants, so they withstand repeated extension and compression. The cyclic movement capability of this material is rated at greater than ± 50 percent.

The high movement capability of the low modulus sealants make them ideal for such applications as expansion joints and curtain wall sealing. They are also being used in highway joint sealing. Use on highways requires installation slightly below the joint surface to prevent damage from traffic.

Because the movement capability of low modulus silicones is great, they lack strength and are considered too soft and pliable for use in structural glazing.

Medium Modulus Sealants

The third type of silicone sealant for construction uses is also a neutral-cure sealant. It is a medium modulus material that has sufficient strength to be used in many of the acid cure applications (95 psi at 150 percent elongation) and enough movement capability (± 40 percent in dynamic ASTM tests) for many of the low modulus applications. As with any relative term like "medium modulus", one should look at the fine print for a definition. Some sealant manufacturers define ± 40 percent as low modulus while others define it as medium. In general, a medium modulus sealant is a good general purpose construction sealant and can be used in many applications, but it is still not ideal for all uses. It doesn't provide the insurance factor of the truly low modulus silicones in problem joint applications. It isn't as high strength as the high modulus to give the insurance factor in the structural glazing applications. These sealants are satisfactory for normal, nonstructural glazing, and for most perimeter seals designed for less than ± 40 percent joint movement. They can be characterized as high performance, general purpose sealants possessing all of the typical silicone properties (long life, weatherability, and good recovery).

All neutral-cure silicones, low and medium modulus, offer good adhesion to a broad variety of substrates—broader than the other silicones. In most cases, no primer is required. Their cure rate is almost ideal for exterior construction, allowing 15 to 45 minutes after application for tooling and becoming tack-free in two to four hours. The neutral-cure products and low and medium modulus silicones, are not recommended for use in foot traffic joints or under conditions of total immersion.

MARTIN PROCESSING, INC.

P. O. BOX 5068
MARTINSVILLE, VA. 24112 - (703) 629-1711

Clear LLumar™ Polyester Films*

Summary of Typical Properties — .005" film

Property	Values	Test Method (*)
RESIDUAL SHRINKAGE	0.3% TD 0.7% MD	D-696-44 (30 min @ 150 C) (302 F)
ULTRA-VIOLET RESISTANCE (Weatherable Type UV-X)	10-15 years	Field Evaluations
SHADE VARIATION	± 5%	MacBeth Densitometer Type TD-504
SOLVENT RESISTANCE	Resists most chemical reagents, solvents and impregnants	Two months at room temperature
SERVICE TEMPERATURE	75° F to 350° F	—
TOTAL LUMINOUS TRANSMISSION	88 to 90%	D-1003-70
ULTIMATE TENSILE STRENGTH	25,000 psi	D-882-61T
TEAR STRENGTH	20 grams/mil	D-1004-61
IMPACT STRENGTH	6.0 kg-cm/mil	D-1709-62T
TENSILE MODULUS	550,000 psi	D-882-64T

(*) ASTM except where otherwise noted

Weatherability Performance

Polyester film normally has limited resistance to weathering due to ultraviolet degradation. By impregnating this film with an ultraviolet absorber, Martin has produced weather resistant polyester film called MARTIN LLumar™. MARTIN LLumar™ has virtually the same light transmission characteristics in the visible light spectrum as does ordinary window glass (see chart on back). It cuts off light transmission sharply at 0.4 microns and therefore transmits practically none of the ultraviolet region.

*Patent No. 3,843,105

CHEMPLAST SOLAR PRODUCTS

PRICE LIST 880
16 June 80

"LLUMAR" WEATHERIZED POLYESTER FILMS

FOR HIGH-PERFORMANCE APPLICATIONS

MADE BY MARTIN PROCESSING, INC.

CLEAR

Clear Films for Solar Collectors and Greenhouses

Product Code: 26500

"LLUMAR" Clear Weatherable Film	Thick-ness	Width	LENGTH (FT.) AND PRICE					
			50	100	150	200	250	300
500 Gauge	.005"	26"	$ 75.00	$115.00	$166.00	$212.00	$256.00	$294.00
	.005"	38"	106.00	168.00	243.00	312.00	378.00	437.00
	.005"	50"	139.00	222.00	320.00	409.00	499.00	574.00
	.005"	60"	168.00	266.00	383.00	490.00	598.00	688.00
700 Gauge	.007"	48"	188.00	301.00	432.00	554.00	675.00	775.00

METALLIZED

Fully reflective, metallized, mirror-like film for solar collectors and other specialized applications.

Product Code: 26501

"LLUMAR" Fully Reflective Weatherable Film	Thick-ness	Width	LENGTH (FT.) AND PRICE					
			50	100	150	200	250	300
500 Gauge*	.005"	48"	$219.00	$348.00	$500.00	$636.00	$779.00	$896.00

*Consists of a laminate of .003" fully reflective, metallized film bonded to .002" clear "LLumar" film with a high temperature adhesive.

"LLumar" Films are packaged in 50 ft. and 100 ft. rolls. Lengths listed above will be supplied in a combination of these standard roll lengths. Rolls in longer continuous lengths are available on special request. Other widths are also available.

PUT-UP:	3" I.D. Cores
DELIVERY:	1 week after receipt of order.
MINIMUM ORDER:	One 50 ft. roll per type and size.
TERMS:	Net 30 days. F.O.B. shipping point. All prices subject to change without notice.

LLumar®, Martin Processing, Inc., Reg. T.M.

Flexigard BRAND

7410
7415

Protective Film

Solar Collectors—Storm Windows—Greenhouses

November 1, 1980

General Description:

Flexigard Protective Film is an ideal replacement for glass in solar collectors, storm windows, and in small greenhouses. It has excellent thermal properties as a result of its laminated construction, making it particularly suitable for use on solar collectors. While very flexible and easy to handle, Flexigard Film remains strong and virtually shatterproof. It is easily trimmed to exact specifications, and can be adapted to fit any size window frame or collector surface. Holes or tears can be repaired while film remains tight.

Properties: 7410

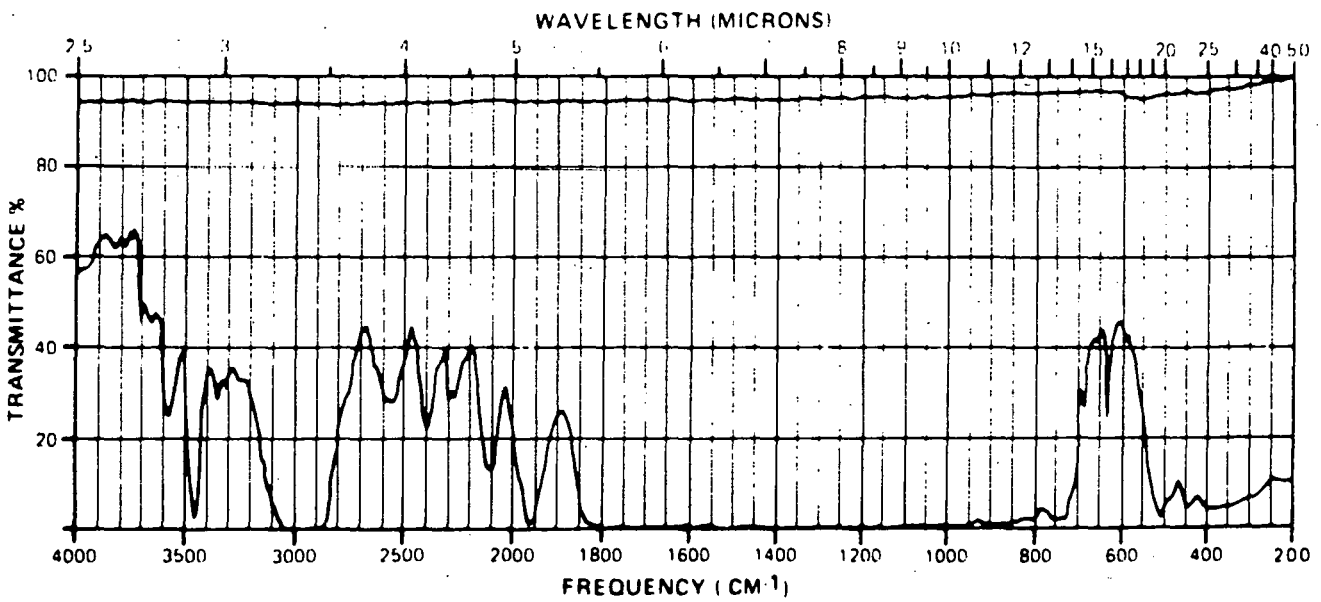
Thickness	Shrinkage	Break Resistance	Haze
.007" .18 mm	Over Operating Range .5%	Meets Impact Test 5.13 of ASSC	0.5%
Temperature			
Framed** operating range	275°F 135°C	Operating limit, product remains clear, colorless and tight.	

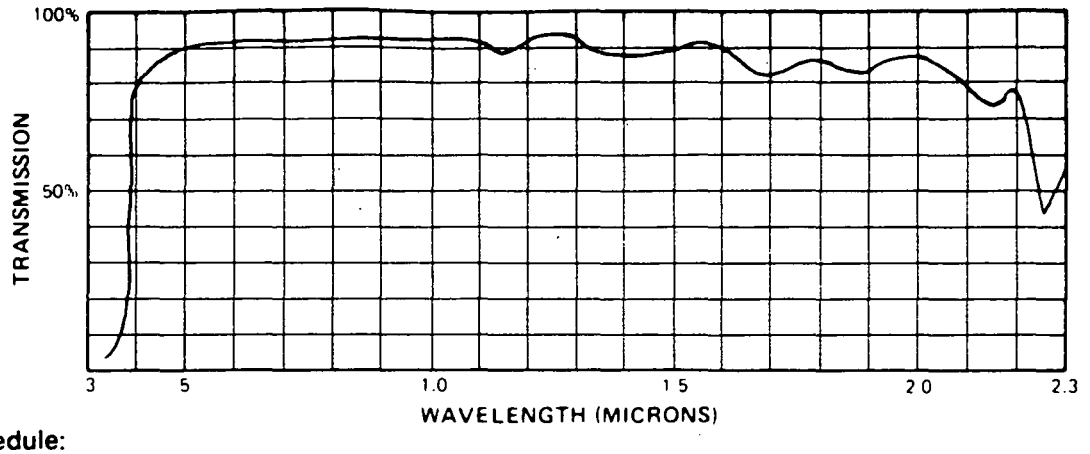
As temperature increases Flexigard Film retains its tension. Film does not sag.
*Elmendorf Tear Tester. **Framed with adhesive tape on top and bottom of film.

Properties: 7415

Thickness	Shrinkage	Break Resistance	Haze
.011" .28 mm	Over Operating Range .5%	Meets Impact Test 5.13 of ASSC	1.13-1.47% (error ± 0.2)
Temperature			
Framed** operating range	−60°F +271°F 133°C	Operating limit, product remains clear, colorless and tight.	

As temperature increases Flexigard Film retains its tension. Film does not sag.
**Framed with adhesive tape on top and bottom of film





Price Schedule:

Flexigard 7410 film available in 4' x 50 yds. roll at the following price:

Rolls	Sq. Ft.	Cost/Sq. Ft.	Cost Per Roll
1-9	600-5400	$.42	$250.00
10 and Up	6000	$.38	$228.00
4' x 20'	80 sq. ft.	$.65	$52.00

Flexigard 7415 film available in 4' x 25 yd., 4' x 50 yd. and 3' x 54 yd. rolls at the following price:

4' x 50 yd. Rolls	Sq. Ft.	Cost/Sq. Ft.	Cost Per Roll
1-9	600-5400	$.55	$330.00
10 and Up	6000	$.50	$300.00
4' x 25 yd. Rolls	**Sq. Ft.**	**Cost/Sq. Ft.**	**Cost Per Roll**
1-9	300-2700	$.61	$183.00
10 and Up	3000	$.55	$165.00
3' x 54 yd. Rolls	**Sq. Ft.**	**Cost/Sq. Ft.**	**Cost Per Roll**
1-9	486-4374	$.60	$291.60
10 and Up	4860	$.54	$262.44

Terms: Net 10 prox.

Transportation Charges: F.O.B. shipping point.

Shipment: 10 working days after receipt of order. 3M shall not be liable for delays in shipment which are due to causes beyond the reasonable control of 3M.

For information or to place an order call 612/733 0306 or write to Flexigard Film/3M, 223-2W 3M Center, St. Paul, Minnesota 55144.

Prices Subject to Change Without Notice.

Terms and Conditions of Sale

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, but the accuracy or completeness thereof is not guaranteed, and the following is made in lieu of all warranties, express or implied:

Seller's and manufacturer's only obligation shall be to replace such quantity of the product proved to be defective. Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct, incidental or consequential, arising out of the use of or the inability to use the product. Before using, user shall determine the suitability of the product for his intended use, and user assumes all risk and liability whatsoever in connection therewith.

Sale of these materials does not convey any rights under seller's patents relating to the use thereof, and seller does not warrant that use of these materials does not infringe patent rights of third parties.

Statements or recommendations not contained herein shall have no force or effect unless in an agreement signed by officers of seller and manufacturer.

L-FTB(100.5)R5 Litho in U.S.A.

Special Enterprises Department/3M
223-2W 3M Center
St. Paul, Minnesota 55144

Flexigard Protective Film
BRAND

3M

Insulating Windows

November 1, 1980

Features

- Energy/Fuel saver
- Weather resistant
- Lightweight
- Helps to eliminate cold air drafts
- ■ Seals entire window
- ■ Shatter proof
- ■ Long life
- ■ Transparent as glass
- ■ Easy to build/install
- ■ Inexpensive
- ■ Can be used inside or outside

Kits:

D.O.E. and H.U.D. Approved

Price List

Contents:

Each insulating window kit contains all the materials needed to build your own insulating windows on site. Kits come in three sizes. IWK-2 has enough material to build approximately 20 each 36" x 48" windows. IWK-3 has enough material to build approximately 37 each 36" x 48" windows. IWK-4 has enough material to build approximately 40 each 36" x 48" windows.

IWK-2

1 roll #7415 Film 4' x 25 yds.
58 ea. Alum. Frames, 6' length
80 ea. Plastic Corners
4 rolls #4508 Foam Tape
3 rolls #465 Double Coated Tape
60 ea. Plastic Keepers

Total Kit Cost — $263.00

IWK-3

1 roll #7415 Film 3' x 54 yds.
116 ea. Alum. Frames, 6' length
160 ea. Plastic Corners
8 rolls #4508 Foam Tape
6 rolls #465 Double Coated Tape
120 ea. Plastic Keepers

Total Kit Cost — $452.40

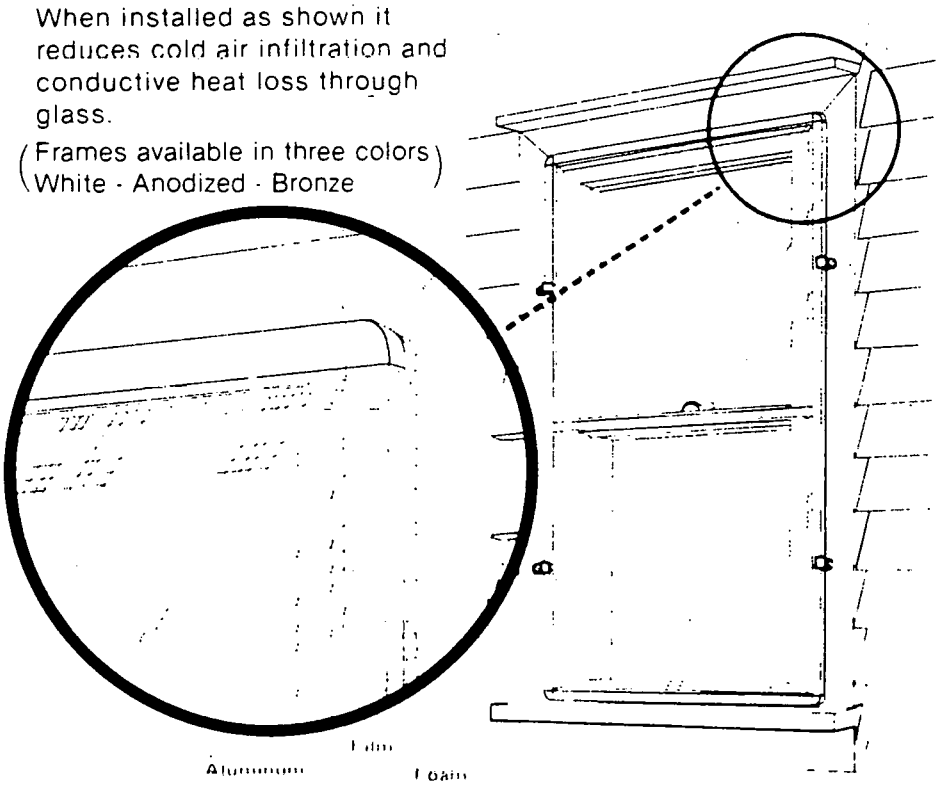
IWK-4

1 roll #7415 4' x 50 yds.
116 ea. Alum. Frames 6' length
160 ea. Plastic Corners
8 rolls #4508 Foam Tape
6 rolls #465 Double Coated Tape
120 ea. Plastic Keepers

Total Kit Cost — $478.06

When installed as shown it reduces cold air infiltration and conductive heat loss through glass.

(Frames available in three colors
White - Anodized - Bronze)



Terms: Net 10 prox.,

Transportation Charges: F.O.B. shipping point.

Shipment: 10 working days after receipt of order. 3M shall not be liable for delays in shipment which are due to causes beyond the reasonable control of 3M.

For information or to place an order call 612/733 0306 or write to Flexigard Film/3M, 223-2W 3M Center, St. Paul, Minnesota 55144.

Prices Subject to Change Without Notice

ALUMINUM WINDOWS

These quality windows will give you many years of dependable, trouble-free service. Manufacturers' factory service is always available on any CE or LOOK product sold by Scotty's. AAMA approved, meets FHA and VA requirements. Ask your Scotty's salesman about additional window styles available.

NOTE:

All windows and doors must be installed square and plumb for proper operation. Windows should be regularly maintained by applying a lubricant (i.e., WD-40) to all operating parts annually.

Window Size	ROUGH OPENINGS* Concrete Block Opening Width	Height	Finished Opening Width	Height
12	19⅞	26⅜	18⅛	25
13	19⅞	38¼	18⅛	37⅜
14	19⅞	51	18⅛	49⅝
15	19⅞	63⅜	18⅛	62
32½	27¼	26⅜	25½	25
33½	27¼	38¼	25½	37⅜
34½	27¼	51	25½	49⅝
35½	27¼	63⅜	25½	62
22	37¾	26⅜	36	25
23	37¾	38¼	36	37⅜
24	37¾	51	36	49⅝
25	37¾	63⅜	36	62
32	53⅞	26⅜	52⅛	25
33	53⅞	38¼	52⅛	37⅜
34	53⅞	51	52⅛	49⅝
35	53⅞	63⅜	52⅛	62
6068	71½	80½	70¾	79¾
SG DOOR				
8068	95½	80½	94¾	79¾
SG DOOR				

NOTICE: TALLAHASSEE, VALDOSTA, PANAMA CITY, FORT WALTON BEACH AND PENSACOLA RESIDENTS: Many of these window sizes are not available in these stores. Please ask your Scotty's salesman for a listing of the sizes available in your area.

Allow 1/8" additional width for each mull bar used.

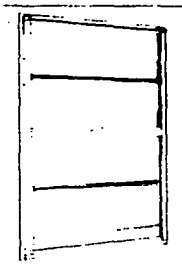
*These are **Minimum** recommended opening sizes. The actual opening depends on type of installation, and local building codes applicable.

SINGLE HUNG WINDOWS

Clear glass with screen

The simpler design of the prime aluminum single hung window allows it to be both less expensive and less likely to develop operational problems than other window types.

Single hung windows have a bottom moveable panel or sash which can be raised to allow room ventilation. The sash can be removed along with the drop-in interchangeable half screen for ease of cleaning. "Hard to open windows" or "windows that won't stay up" are corrected with an easy adjustment of the spiral balance. Single hung windows can be styled for a colonial look at any time.



MULL BARS

For joining windows of like size together.

26" — 2HI 2.29
38⅜" — 3HI 2.85
50⅝" — 4HI 3.39
63" — 5HI 3.98

16, ½36, 26 and 36 windows Special Order only. Half obscure and full obscure windows are Special Order only.

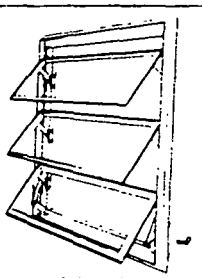
Outside dimensions shown below include 1/2" flange. Sizes are for concrete block construction.

No.	Width	Height	
12	19⅛"	26"	15.99*
13	19⅛"	38⅜"	22.49*
14	19⅛"	50⅝"	26.19*
15	19⅛"	63"	29.39*
½32	26½"	26"	18.59*
½33	26½"	38⅜"	23.35*
½34	26½"	50⅝"	26.09*
½35	26½"	63"	33.99*
22	37"	26"	21.89*
23	37"	38⅜"	26.79*
24	37"	50⅝"	30.35*
25	37"	63"	36.29*
32	53⅛"	26"	33.75*
33	53⅛"	38⅜"	34.55*
34	53⅛"	50⅝"	41.29*
35	53⅛"	63"	50.79*

AWNING TYPE WINDOWS

Clear glass with operator and screen

Prime aluminum awning windows are a long time Florida favorite because operable window vents open to provide full window ventilation. Awning windows come complete with a drop-in interchangeable screen for easy cleaning. A heavy duty operator eases window operation thus providing long life. Automatic vent locking devices engage when the window is fully closed to help protect your valuable property from intruders. All vents are weatherstripped with vinyl for a tight seal against rain



MULL BARS

For joining windows of like size together.

26" — 2HI 2.59
38⅜" — 3HI 3.35
50⅝" — 4HI 4.15
63" — 5HI 4.89

OPERATORS

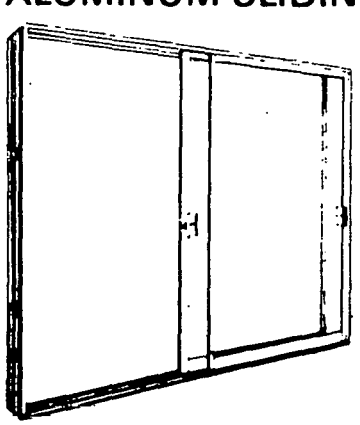
Right or Left Hand 9.79

Outside dimensions shown below include 1/2" flange. Sizes are for concrete block construction.

No.	Width	Height	
12	19⅛"	26"	27.29
13	19⅛"	38⅜"	31.49
14	19⅛"	50⅝"	38.79
15	19⅛"	63"	47.39*
½32	26½"	26"	30.85
½33	26½"	38⅜"	35.29
½34	26½"	50⅝"	43.35
½35	26½"	63"	52.59
22	37"	26"	33.99
23	37"	38⅜"	39.39
24	37"	50⅝"	46.75
25	37"	63"	57.79
32	53⅛"	26"	40.25
33	53⅛"	38⅜"	46.55
34	53⅛"	50⅝"	57.09
35	53⅛"	63"	71.29

ALUMINUM SLIDING GLASS DOORS

Mill finish and painted. Featuring tempered glass for safety.



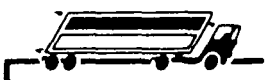
Our doors are specially designed with polyvinyl weatherstripping for draft-free sealing. They glide on ball bearings for smooth, quiet operation. Vertical adjustment of doors, if necessary, when installing is accomplished with a simple screwdriver operation. Screens and keylocks are available. Scotty's sliding glass doors can be simply adapted for a panel to move either left (OX) or right (XO) as necessary. ("X" is sliding panel, "O" is fixed panel.)

See your Scotty's salesman for availability and price of C. E. Morgan doors.

SLIDING GLASS DOORS	Mill Finish	Painted
B811 6'-0" OX-XO	118.19	140.49
B811 8'-0" OX-XO	140.49	163.89
INSULATED GLASS		
B821 6'-0" OX-XO	178.45	193.19
B821 8'-0" OX-XO	225.19	243.09
SCREENS for B811 or B821 Sliding Glass Doors		
3'-0"	20.09	23.79
4'-0"	22.38	26.49

HANDLES

6204-OX Keylock for right-hand opening door 3.99*
Deluxe handle 6.95

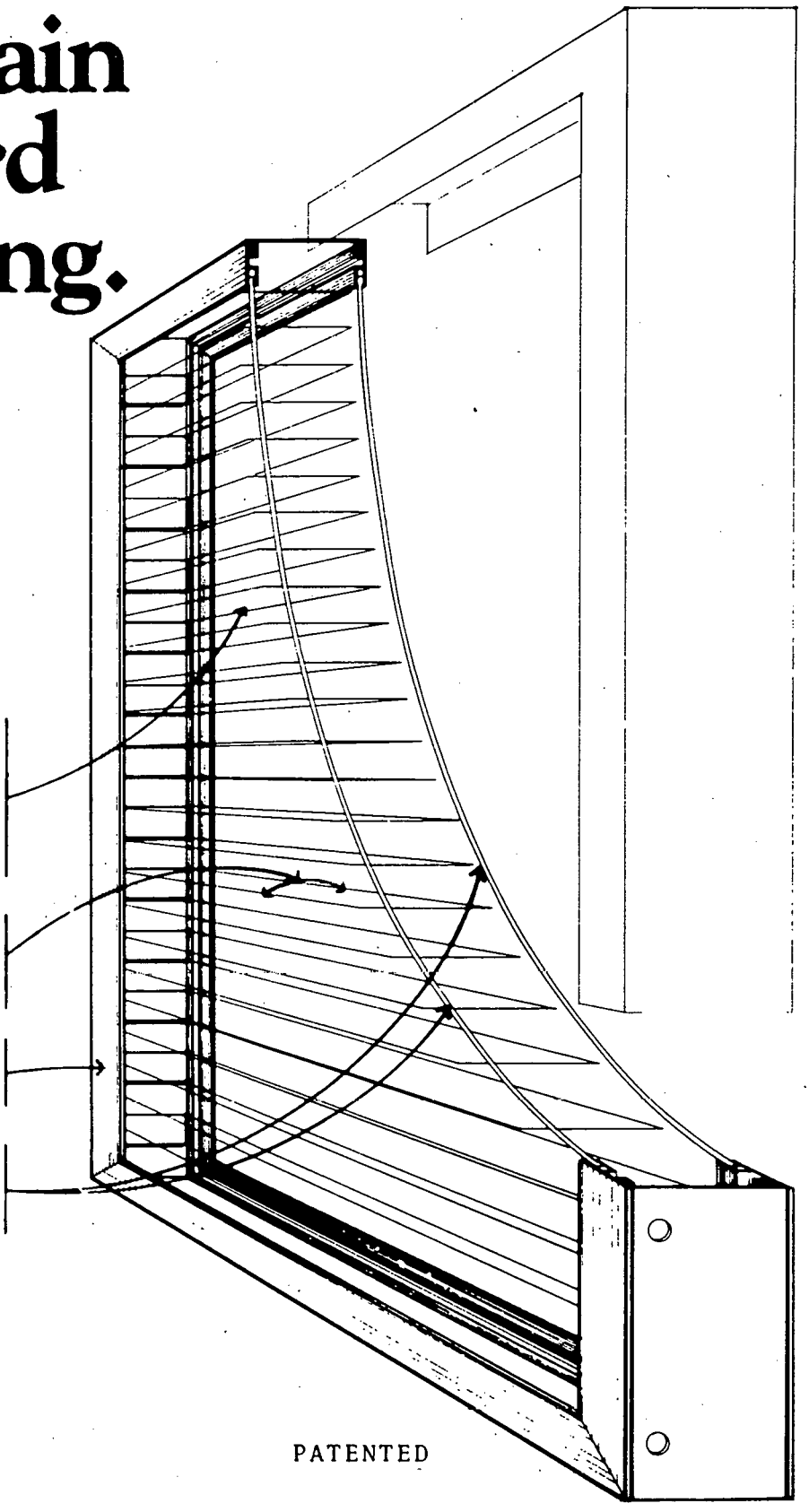


NOT STOCKED AT ALL STORES. Available at any store through the Winter Haven Warehouse.

Watershed

This new HeatMaze™ windo w delivers 85% more net energy gain than standard double glazing.

Computer projections of test results show Watershed's standard 35 1/4" x 77 1/4" HeatMaze window delivers a net heat gain of 1.3 million BTU's a year on south facing applications.



APPENDIX D PUBLICITY

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