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3,358,408

INSULATED LIGHT TRANSMITTING PANEL

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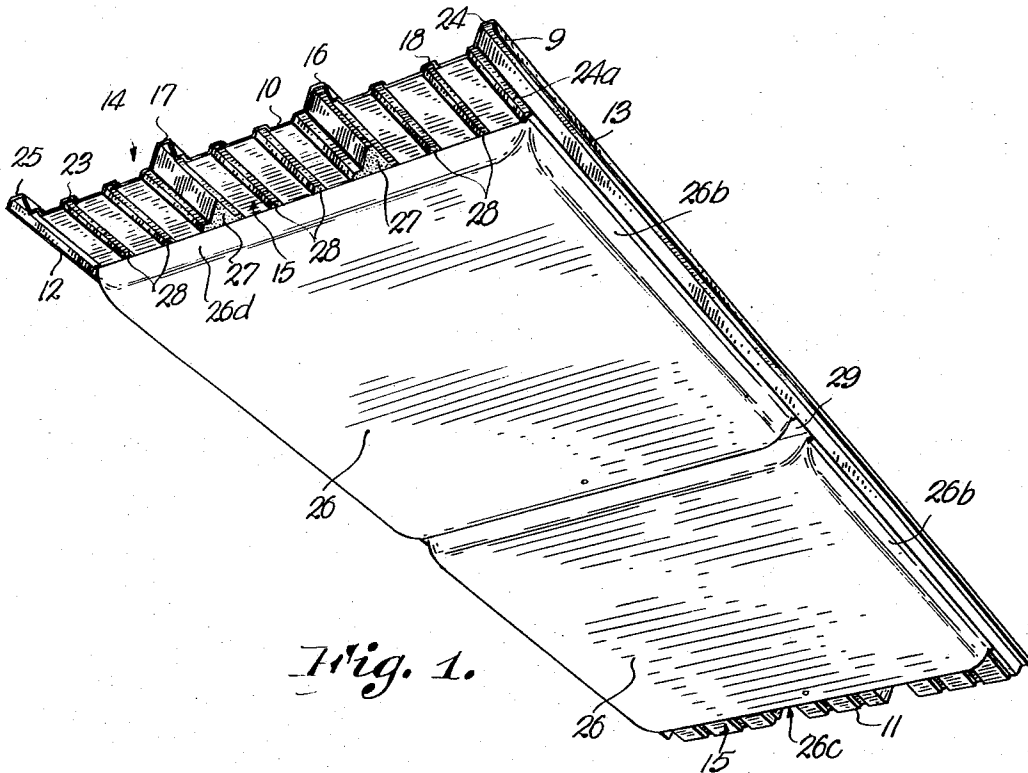


Fig. 1.

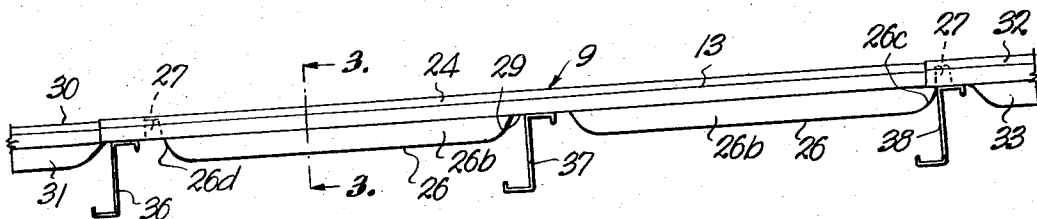


Fig. 2.

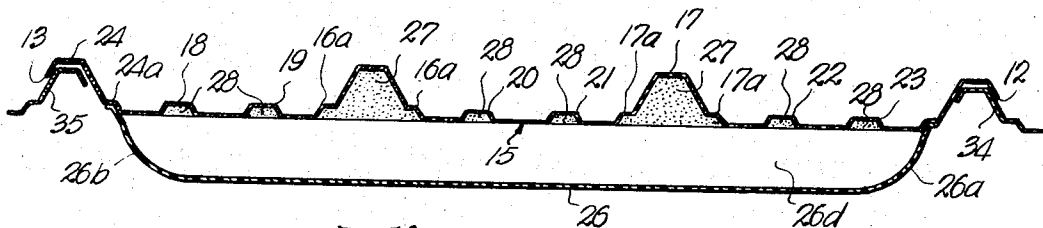


Fig. 3.

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**INSULATED LIGHT TRANSMITTING PANEL**  
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## ABSTRACT OF THE DISCLOSURE

A light transmitting, heat insulating panel construction for use in buildings employing a first, outer, light transmitting plastic sheet having partial major corrugations in the side edges thereof which permit side edge engagement of the sheet with the side edges of building panel sheets of like configuration, and an inner, second, light transmitting plastic sheet also substantially rectangular in shape, the second sheet of both lesser length and width than the first sheet, with upwardly dished side and end edges thereon, the upper extremities of the side and end edges of the second sheet bonded to the under surface of the first sheet in substantially continuous manner, the side edges bonded closely adjacent or within the inner margins of the partial side edge corrugations of the outer sheet and the end edges bonded inwardly spaced of the end edges of the outer sheet.

This invention relates to improvements in fiber reinforced plastic panels usable for various structural purposes such as skylights, partitions, awnings, canopies, wall and ceiling elements, etc., and refers more particularly to such panels having integral therewith means for insulating portions or substantially the entirety thereof.

The Hungerford et al. application Ser. No. 146,479, filed Oct. 20, 1961, now Patent No. 3,265,556, "Fiber Reinforced Plastic Panel and Manner of Making Same," discloses a typical glass fiber reinforced thermosetting resin panel to which the instant invention is particularly adaptable.

It is well known to provide double layer windows, windshields, glazing units, storm windows, observation ports, skylights, heat and sound insulating units, and the like. Such structures may be opaque, in whole or in part, translucent in whole or in part, transparent in whole or in part or combinations thereof.

In the patents to Hield et al. 2,815,831, issued Dec. 10, 1957, "Column and Rafter Assembly for Rigid Frame Buildings," and Simpson et al. 2,871,997, issued Feb. 3, 1959, "Low Pitch Rigid Frame Building," there may be seen the manner of mounting, in rigid frame buildings, roof and side wall panels on the structural framework.

It has become quite common to substitute, for one or more lengths of panel members of such roof or side wall panels or panel arrays, one or more longitudinal, transverse or both, like configured translucent or transparent skylight or light transmitting panels (like configured to the panels with which they mesh) such skylight or light transmitting panels typically of reinforced plastic of the type disclosed in the Hungerford et al. application, supra.

However, in such use, and particularly in roof applications for skylights, when the outside atmosphere is relatively cold and the inside atmosphere of the building is relatively warm, there arises the problem of condensation on the inner faces of the panels with concurrent and consequent sweating and dripping therefrom. Condensation within a building, thus takes place when the temperature of the inside surface of a given panel arrives at the dew point within the building, which means that the outside cold has passed or crept through the single layer panel.

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Thus, there arises the situation, typically and very commonly, in a building of the type described, namely, one utilizing interleaved or overlapping flat metal panels for roof panels, of a single, series, set or array of skylight panels being interleaved in the roof panels to give greater light, same not having the conventional glass fiber insulation or the like thereunder whereby the warm air of the interior of the building strikes directly against the chilled panel, thus resulting in condensation, dripping, sweating, etc. When one corrects this by insulating the underside of the panel as may be done with the metal panels by using conventional insulation with a vapor barrier, naturally, all skylight and illumination effects desired will be lost.

To obviate this, that is, to obtain the benefits of insulation, while retaining the advantages of skylight light transmission, it has become common to insert "sky domes" in such metal panel roofs. A typical such dome may be seen in Bettcher 2,918,023. In such construction, a curbing is inserted into an opening in the roof which is then topped off with a multiple layer translucent or transparent level of glass, plastic sheet, or the like. Difficulties with this construction in general involve the undesirability of breaking the roof line, the extra work, time, materials, special parts, etc., required to insert such sky domes, the loss of the well-known advantages of panel edge-to-panel edge juncture in the regular manner of the metal panel-to-panel connections, both laterally and longitudinally of the roof, the fact that, when one breaks the roof line and provides a number of seams, both vertically and horizontally, additional leak problems arise, additional problems of insulation, that is, heat loss from the interior of the building, etc.

## Summary of the invention

An improved plastic panel for wall and roof construction, particularly in skylight use in rigid frame buildings. An insulated translucent or transparent plastic panel configuration particularly utilizable as a skylight in buildings having interleaved metal panels for side and end walls and roofs, which light transmitting panels are of the same configuration as the panels they are used in conjunction therewith, whereby to retain the wall or roof line. Means for insulating the interior surface of roof and wall translucent and transparent plastic panels to avoid condensation, sweating and dripping with respect to same due to temperature differences between the outside and inside of the building. A light transmitting roof panel construction utilizing two separate spaced translucent and/or transparent panels wherein improved light dispersion is achieved, together with insulation of the outer of the two of said panels.

An object of the invention is to provide an improved plastic panel used for wall and roof construction, particularly in rigid frame buildings, and most particularly in skylight use.

Another object of the invention is to provide an insulated translucent or transparent plastic panel particularly usable for skylight construction, which panel retains all of the advantages of a noninsulated plastic panel for skylight purposes, while offering additional advantages with respect to avoidance of interior condensation, sweating and dripping.

Another object of the invention is to provide an insulated, configured, fiber-reinforced plastic panel particularly utilizable as a skylight in buildings having interleaved metal panels for side and end walls and roofs, which light transmitting panels are of the same configuration as the panels they are used in conjunction therewith whereby to retain the wall or roof line, yet such panels obtaining and providing many and complete benefits of

insulation without losing the majority of their benefits of light transmission.

Another object of the invention is to provide such an insulated light transmitting panel for use in panel walled buildings wherein the side edges and end edges of a configured translucent or transparent plastic panel are left free for interleaving or interengagement with other like light transmitting configured panels or metal panels, the central portions thereof fully and completely insulated whereas to eliminate condensation, sweating and dripping thereon.

Another object of the invention is to provide means, products and methods for insulating the interior surfaces of roof and wall translucent and transparent plastic panels whereby to avoid condensation, sweating and dripping with respect to same due to temperature differences between the outside and inside of the building, such products, methods of manufacture and structures simple, inexpensive, easily obtained, yet dependable and long lived in use, application, etc.

Yet another object of the invention is to provide such insulated light transmitting panels wherein end and side edge portions and central portions thereof may be left in condition for engagement with other like panels or interleaving metal panels of a side or end wall or ceiling array of building skin panels, while retaining the desired flexibility for support by interior building structurals, connection to the other panels, etc.

Another object of the invention is to provide a light transmitting roof panel construction utilizing two separate spaced translucent and/or transparent panels wherein improved light dispersion is achieved because the double panel breaks up, diffuses or disperses light rays to a greater extent than a single panel construction.

Other and further objects of the invention will appear in the course of the following description thereof.

In the drawings, which form a part of the instant specification and are to be read in conjunction therewith, an embodiment of the invention is shown and, in the various views, like numerals are employed to indicate like parts.

FIG. 1 is a three-quarter perspective view from below of a corrugated plastic light-transmitting panel having the inventive improvement on the underside thereof.

FIG. 2 is a side elevation of a roof construction showing the panel of FIG. 1 supported on transverse roof purlins and engaging with the ends thereof the ends of conventional insulated metal roof panels.

FIG. 3 is a view taken along the line 3—3 of FIG. 2 in the direction of the arrows.

Characterizing the panel of the drawings, that is, the basic translucent or transparent glass fiber reinforced plastic corrugated panel, its cross-sectional form is typically that of the U.S. Field Design Patent 178,659, issued Sept. 4, 1956, or Field Design Patent 178,605, issued Aug. 28, 1956, "Building Panel." The form actually shown is the latter. This comprises an elongate rectangular panel 9 having end edges 10 and 11 and side edges 12 and 13. The upper or outer side of the panel 14 is opposed by the lower or inner side of the panel 15. The panel is configured in transverse cross section to have a pair of complete major corrugations 16 and 17 extending upwardly therefrom with stepped bases 16a and 17a. Elongate minor corrugations 18—23, inclusive, are positioned in pairs between the major corrugations 16 and 17 and the latter and partial side edge corrugations 24 and 25. The latter fit over like partial major corrugations to make a side edge connection with a like sheet of either metal of plastic (preferably metal). It is important to note that the side edge partial major corrugations 24 and 25 have a stepped base 24a and 25a, respectively. It is contemplated that the minor corrugations 18—23, inclusive, are not essential for the practice of the instant invention, indeed, they are added complications thereto, but elongate corrugation of the nature of corrugations 16

and 17 would be generally expected in building panels for strength and rigidity, while the presence of the partial side edge corrugations 24 and 25 with their stepped bases 24a and 25a are well nigh essential to the instant invention.

General requirements of corrugated plastic panels of this type as used for skylights would be that both surfaces thereof should be smooth and free of wrinkles and other defects. The panels should conform to the shapes, dimensions and tolerances as shown on applicable product drawings. The primary use of such plastic panels should be for flush-mounted installation on roofs of prefabricated metal buildings, as seen in FIG. 2, the function of the panels being to permit the entrance of light into the building. Such panels would typically be used in conjunction with galvanized steel, aluminized steel or aluminum panels of the same configuration to form a weather-tight covering. Such panels may be used on side walls and end walls of the buildings and must be able to function in any position.

With respect to mechanical, chemical and other basic property requirements, typically, the material would be a translucent, light stabilized, thermosetting, acrylic modified, polyester resin with a thoroughly impregnated glass fiber reinforcement. A typical resin composition (100 parts total) would constitute no less than 15 parts methyl methacrylate monomer and no more than 25 parts styrene monomer with polyester accordingly. The glass fiber reinforcement, with a nominal weight of two ounces per square foot of panel, would constitute at least 25 percent of the combined total weight of the resin and glass fiber reinforcement. The panels typically would weight eight ounces plus or minus 10 percent per square foot. The color of the panel typically would be the standard skylight green. Color would be consistent not only within a shipment, but from any one shipment to any other shipment. The minimum visible light transmission would be 82 percent (air 100 percent) when measured in accordance with Federal specification LP 406B Method 3021. The maximum infra-red transmission would be approximately 60 percent (air 100 percent) and ultra violet transmission shall be 3 percent or under. The panels should not in any way react with metal panels to produce discoloration, corrosion or any other unsightly condition. The resin coating over the glass fibers shall typically be capable of withstanding no less than 1500 hours of weatherometer testing (ASTM D-22 Method) without evidence of glass fiber blooming, loss of surface gloss, or any other type of detrimental deterioration.

The panel typically is fabricated as a fiber-reinforced resin panel including a moisture impermeable corrosion resistant, extremely tough surfaced layer which is permanently bonded to the panel and remains an integral part thereof throughout the life of the panel. Such surface layer has an uninterrupted bond with the underlying resin body and its smooth, glossy exposed face. To obtain this surface layer, there is placed upon at least one surface of a sheet-like web, made up of a collection of reinforcing fibrous resin, a thin preformed film-like body of polyvinyl fluoride while the resin is still in liquid state, that is, before polymerization thereof has progressed to any appreciable degree. Such film-like body has a web contacting face treated to promote adhesion with the resin as the latter is cured and further is laterally heat shrinkable to substantially the same extent as the potential lateral shrinkage of the resin impregnated web during polymerization of the resin under the temperatures utilized in the curing of the panel. The composite uncured structures are then subjected to heat while maintaining the film-like body in firm but low pressure contact with the web throughout substantially the entire area covered by the film-like body. During the cure, the resin polymerizes and permanently bonds to the film-like body and at the same time the film-like body contracts to the same extent as the resin impregnated web.

The panel is typically formed from a bulk roll from which is unwound a continuous web of glass or other reinforced fibers. Such web is composed of loosely interconnected or matted fibers and is highly porous. Such web typically has an uncompressed air thickness of approximately 0.048 and 0.139 inch, the fibers having an average diameter on the order of 10 microns and a length of 2 to 3 inches. The density weight of the web is between  $\frac{3}{4}$  and 3 ounces per square foot. The width of the web is determined by the width to be given to the final product and is selected in accordance therewith.

As such web is unwound, it is passed into an impregnating trough where it is immersed in a body of liquid resin to thoroughly impregnate same. Typical commercially available unsaturated polyester resins modified with vinyl aromatic (styrene) or acrylic and vinyl aromatic monomers are employed. If desired, various catalysts can be employed to aid in curing the resin, such as catalysts of the organic peroxide type such as methyl, ethyl, ketone peroxide, benzoyl peroxide, and tertiary butyl perbenzoate. For speed in manufacturing, a resin composition which polymerizes to a hard, strong and solid mass within 20 to 60 minutes when subjected to temperatures of the order from 150° to 300° F. is employed.

Pigments or dyes, relatively light, fast and unaffected by the catalysts, may be included in the resin trough to impart the desired tint or color to the vinyl product.

Once the resin impregnated web has left the trough, it is fed directly into the nip of a pair of squeeze rolls which serve not only to squeeze excess resin from the impregnated web, but also to firmly contact with the opposite faces of the advancing, but still uncured web, a continuous layer in the form of a preformed, thin (0.5 to 5 mils) film of polyvinyl fluoride, known more familiarly under the Du Pont Company trademark "Tedlar." Such film is drawn in continuous fashion from bulk rolls, passing from each roll into the nip of the squeeze rolls where it is merged with the confronting face of the impregnated web.

The film body must be substantially uniform in thickness and have a potential lateral shrinkability when subjected to the resin curing temperatures and during the period of cure, substantially equal to the lateral shrinkability of the web. To promote adhesion between the film body and the web, the web contacting face of the film is provided with a bond-promoting surface, such as by incorporating in said face, during manufacture of the film, microscopic irregularities into which the resin will reach or, alternatively, forming a thin coating on said face of titanium (IV) oxide by treatment with alkyl titanates and subsequent controlled hydrolysis thereof. Such polyvinyl fluoride films as described are readily available from the manufacturer.

Subsequent to the contacting of the film bodies with the web through the squeeze roll, the laminated wet layup is passed to a conveyor or table through shear blades where same is cut to desired lengths. Air bubbles or creases in the layup may be removed by manually wiping the laminate with wire squeegees in a direction to expel air at the edges of the layup and smooth out the films.

Lengths of uncured layup are then placed in stacked arrangement between upper and lower light-weight caul plates with each length between a pair of said plates to form a stack assembly. Such plates impart to the wet layup the final cross-sectional configuration desired, such as seen in the Hield design patents, supra, and obviously may be flat or in any configuration. The stack assembly is then placed on an oven conveyor and passed through the curing oven. While the speed of the oven conveyor and the temperatures in the oven may be varied according to particular resins employed, the range in a typical process is from a low of 150° to a high of 300° F. through a period of from 15 to 60 minutes in the oven. As a particular example, using a web of the characteristics set forth earlier with an acrylic-modified polyester and a one-

mil polyvinyl fluoride film, the temperature ranged from 200° F. to 300° F. with a curing time of 30 minutes.

Pressure may be applied in known fashion to the layup during the cure, but only sufficient pressure is required as to insure that the film material will be maintained in continuous contact with the web during the cure so that it will conform closely to the web. Maximum pressure should be no more than 10 p.s.i. and preferably is much less, ranging from zero to 5 p.s.i. When the stack emerges from the curing oven, the plates are separated from the cured articles and the latter are now ready for use except as for such edge trimming as may be required to neaten the appearance and provide uniform edges.

In the completed construction of FIGS. 1 and 3, the bottom panel 26, as fixed to the upper panel 9, comprises a unitary structure which may be described as follows. The upper panel 9 is rectangular in shape, as previously described, and has major and minor corrugations therein the length thereof intermediate the side edges thereof, with partial edge corrugations 24 and 25 bounding same. The lower integral panel 26 comprises a molded elongate rectangular sheet formed into two substantially rectangular bubbles. These bubbles have elongate side edges 26a and 26b which are attached at their upper extremities into the stepped base portions 25a and 24a of partial edge corrugations 25 and 24 of upper panel 9. The end faces or extremities of the bottom panel 26, that is, the end faces of the two bubbles made up thereof, comprise elongate end panels 26c and 26d, respectively. These are bonded at their upper extremities directly to the underside 15 of panel 9 between corrugations, major and minor. Polyethylene closures or plugs 27 are sealed into the major corrugations 16 and 17, including their stepped bases 16a and 17a, surrounded by a suitable adhesive or sealing substance of conventional type which bonds plug 27 to the upper panel 9 and the end walls 26c and 26d. The said sealing substance is worked into the minor corrugations 18-23 as small plugs to effect a seal between the upper panel 9 and lower panel 26. These minor corrugation seal points are seen at 28 in FIGS. 1-3.

The central connection as at 29 (FIG. 2) between the upper panel 9 and the lower panel 26 is effected by a cross beam in the mold in which the lower panel is formed and effects a panel-panel seal at sanded upper panel under surface zones between the major and minor corrugations.

There is thus effected a circumferential upper panel 9-lower panel 26 connection which is continuous along the side edges of the lower panel on the underside of upper panel portions 24a and 25a and intermittent at the ends 26c and 26d save for sealing substance inserts 28 and plugs 27. There is only a partial seal between the upper and lower panels along the center portion 29.

The view of FIG. 2 shows a typical roof panel assembly wherein the inventive panel overlies with its lower end the upper end of a metal panel 30 of like configuration to upper panel 9 and having on the underside thereof as at 31, conventional glass fiber insulation with conventional facing material underlying same, the latter operating to provide a vapor seal and give a pleasing ceiling appearance. Likewise, to the right in FIG. 2, there is shown the lower end of a metal panel 32 which overlies the upper end of panel 9 and has at 33 like conventional insulation and facing. Suitable conventional fasteners are employed at the upper and lower end overlaps of panel 9 and panels 30 and 32.

To the right and left in FIG. 3 there are shown the partial edge corrugations of like configured metal panels 34 and 35 underlying edge partial corrugations 25 and 24 of panel 9, respectively, in the roof panel array. Suitable conventional fasteners are again employed through the crowns of the partial corrugations to connect adjacent roof panels to one another.

Referring again to FIG. 2, transverse roof purlins 36, 37 and 38 underlie and support panels 9, 30 and 32 with

purlins 36 and 38 underlying the end overlaps and purlin 37 underlying the central bubble dividing area 29 of under panel 26. The purlins 36-38, inclusive, are carried in conventional fashion on rafter beams or members of the type clearly seen in U.S. Hield Patent 2,815,831, and Simpson Patent 2,871,997.

In the process of application of the glass fiber bubbles or lower surfaces 26 to the upper panel 10, the following steps are employed:

(a) The bottom panel 26 mold, the upper receiving surface of which is configured to the desired shape (here a two bubble construction), is placed adjacent a curing oven or on a conveyor feeding a curing oven.

(b) After removing a top protective film, an uncured resin impregnated glass fiber composite is draped over the mold. A bottom film sheet, preferably of acetate, remains, against the mold face. However, this film could be cellophane, Mylar, Tedlar or others.

(c) The pre-formed and pre-cured plastic top panel 10 which has previously been sanded at points of contact (ends, side edges and centrally) with the wet layup placed on top thereof.

(d) A fixture which holds the plastic panels in position is then placed on top and the entire assembly is processed through the curing oven where heat and a small amount of pressure are applied, whereby to cure the lower panel.

(e) After leaving the oven, the top assembly is removed and the composite panel structure according to the teachings of FIGS. 1-3, inclusive, is taken out of the mold and cleaned.

(f) Closures, preferably of polyethylene or the like (with a sealing substance or plastic glue on the top and bottom thereof) are installed in the major corrugations at each end of the panels. The sealing substance is worked by hand into the openings at the minor corrugations at each end of the panel.

For the central bubble-panel seal, the pre-formed plastic top panel is bonded directly to the bubble in the flat areas. This bond is accomplished during the curing operation. Communication is thus established to or between the separate bubbles through the major and minor corrugations. With respect to the edge seal, the sides of the bubble are bonded directly to the pre-sanded top panel during the curing operation. The resin in the uncured bubble layup acts as an adhesive.

The composition of the bubble or lower panel 20 is the same as the upper plastic panel. The surface is preferably crinkle but can be smooth with or without use of a facing plastic sheet such as Tedlar, Mylar or the like. For fabrication of the bubble, see the step-by-step process given above. The thickness of the lower panel is preferably approximately 0.035 inch, but can be varied. Glass fiber reinforcements are employed and the resin is preferably polyester but can be other plastic substances. Air bleed holes are provided at suitable locations. One such air bleed hole may be seen in each panel bubble of FIG. 1 at the lower right center of each.

Various types of sealants may be employed, but a typical example would have as a base, 30 percent minimum, a blend of polybutylene, butyl and/or equal suitable compatible ingredients. Asphalt or asphalt derivatives would preferably not be employed. As fillers, a 70 percent maximum, asbestos and other inert pigments would be employed.

Tedlar is a Du Pont trade name for polyvinyl fluoride. Mylar is a trade name for polyester.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth together with other advantages which are obvious and which are inherent to the structure.

It will be understood that certain features and sub-combinations are of utility and may be employed without

reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described our invention, we claim:

1. A light transmitting heat insulating panel construction for use in buildings comprising a first outer light transmitting plastic sheet, said outer sheet substantially rectangular in shape with elongate parallel side edges and parallel end edges extending normal thereto, the side edges of the said outer sheet having partial major corrugations therein and therealong whereby to permit side edge end engagement of said sheet with the side and end edges of building panel sheets of like configuration, the said outer sheet partial edge corrugations each having an inner, stepped, base portion, and an inner second light transmitting plastic sheet also substantially rectangular in shape, said second sheet of both lesser length and width than said first sheet and having upwardly dished side and end edges thereon, the upper extremities of said side and end edges of said second sheet bonded to the undersurface of said first sheet in substantially continuous manner, the longitudinal side edges of said inner sheet integrally bonded to the inner, stepped base portion of the said outer sheet partial edge corrugations, and the end edges of the second sheet inwardly spaced from the end edges of the first sheet whereby to permit end edge overlap engagement with like outer sheets.

2. A construction as in claim 1 wherein said inner second sheet is sealingly bonded transversely thereof to the underside of said first sheet intermediate the ends of the latter.

3. A light transmitting heat insulating panel construction for use in panel wall and roof buildings comprising a pair of light transmitting plastic sheets of substantially rectangular form, the outside of said sheets having inwardly stepped partial side edge corrugations adapting same for side edge and longitudinally aligned end edge overlap engagement of other like outside sheets, said outside sheet also multiply and longitudinally corrugated inwardly of said side edge partial corrugations thereof, the inner of said pair of sheets dished centrally and sealingly connected at its side edges to the inwardly stepped portions of the partial side edge corrugations of said outer sheet and at the end edges thereof substantially inwardly of the end edges of said outer sheet, that said outer sheet free end edge portions may overlap like end edges of like outer sheets for connection therewith, whereby to provide a double walled sheet construction over a substantial portion of the inner face of said outer sheet, the air space between said two sheets substantially air tight.

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