

[54] SAFETY PANES

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1970, abandoned, which is a continuation-in-part of
Ser. No. 754,269, Aug. 21, 1968, abandoned, which
is a continuation-in-part of Ser. No. 360,749, April
17, 1964, abandoned.

[30] **Foreign Application Priority Data**

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[58] **Field of Search** 161/183, 193, 206, 208,
161/165, 44, 404, 147; 117/138.8 R, 138.8
UA, 124 A; 156/99, 106, 107

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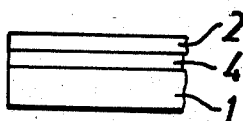
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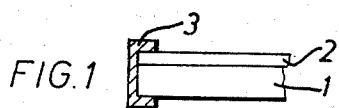
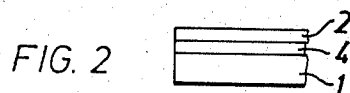
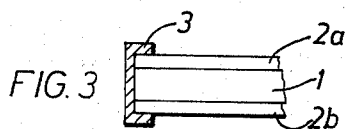
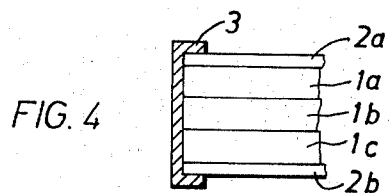
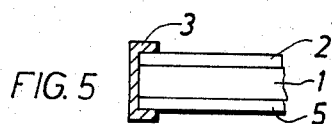
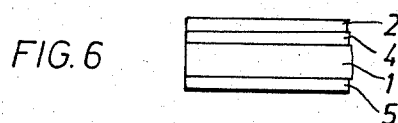
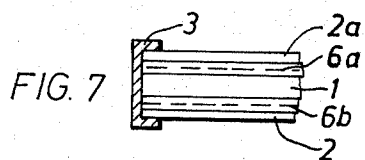
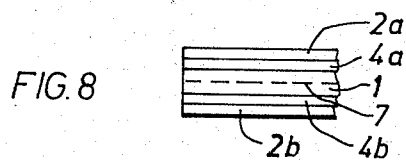
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[57] **ABSTRACT**

A polycarbonate sheet and a glass sheet slidably
mounted one on the other in face to face relationship.

1 Claim, 8 Drawing Figures





SAFETY PANES

This invention relates generally to safety panes and, more particularly, to an improved pane of that type, and is a continuation-in-part of copending U.S. Pat. application Ser. No. 55,256 filed July 15, 1970, now abandoned, which in turn is a continuation-in-part of U.S. Pat. application Ser. No. 754,269 filed Aug. 21, 1968, now abandoned, which in turn is a continuation-in-part of U.S. Pat. application Ser. No. 360,749 filed Apr. 17, 1964, now abandoned.

It has been the practice heretofore to provide window panes and the like made from glass, or if a pane which is resistant to breaking is required, a laminated pane of glass and synthetic resin are often used. Because glass breaks so easily and shatters when breaking, panes of glass cannot be used for many purposes and the laminates have been adopted; however, such laminates are not entirely satisfactory because they often break upon impact and sometimes become discolored because the laminates pull apart and the resin darkens.

It is, therefore, an object of this invention to provide an improved window pane or the like having a high impact resistance, high rigidity and low light absorption in the visible light range.

Still another object of the invention is to provide an improved safety pane for use in vehicles, store windows, and the like.

A further object of the invention is to provide a substantially rigid pane having a high impact strength and a substantially scratch-resistant surface.

The foregoing objects and others which will become apparent from the following description are accomplished in accordance with this invention, generally speaking, by providing a safety pane having a polycarbonate sheet and a glass sheet slidably mounted one on the other in face to face relationship.

Any suitable polycarbonate may be used in preparing the laminates of this invention. For example, some such suitable polycarbonates are prepared by reacting di(monohydroxyaryl) alkanes with derivatives of carbonic acid such as carbonic acid diesters, phosgene, or bischlorocarbonic acid esters of di(monohydroxyaryl) alkanes. A process for making substantially linear aromatic polycarbonates of the type contemplated is disclosed in U.S. Pat. No. 3,028,365. Some other suitable polycarbonate materials and processes for their preparation are described in U.S. Pat. Nos. 2,999,846; 2,970,131; 2,991,273; 2,999,835; 3,014,891; 3,248,414 and the like as well as in Canadian Pat. Nos. 578,585; 578,795; 594,805; and those referred to in *Chemistry and Physics of Polycarbonates* by Schnell and *Polycarbonates* by Christopher and Fox.

It has been found that polycarbonate sheets are unexpectedly advantageous for making safety panes of all kinds because of their especially high rigidity (the E-modulus ranges, in general, between about 22 to 25,000 kp/cm²) in combination with an impact strength which is so high that test bodies do not break under the usual measuring methods, and stability under load at temperatures from well below -100° C. to as high as 150° C. and higher. Furthermore, it has been found that there is very little visible light absorption by the polycarbonate layer of the safety pane (the optical density of a 3 mm. thick sheet is lower than 0.05 measured as diffuse density according to ISO R5), but high ultraviolet

let light absorption of all rays having a wave length lower than 360 nm and infrared radiation absorption of rays having a wave length longer than 2 microns.

Because polycarbonates possess the unique combination of properties discussed above, it is now possible for the first time to prepare safety panes which satisfy not only the ordinary requirements of a safety pane but also permit the fabrication of safety panes which are far superior to those known heretofore, especially the safety panes of the compound glass type or of the pre-stressed glasses.

Further, when polycarbonates are utilized in accordance with the instant invention, safety panes having impact strengths much greater than those of prior art safety panes are obtained. Thus, even those polycarbonate sheets having a thickness as low as about 2 mm. cannot be broken with the hand and panes of polycarbonate which are 4 to 6 mm. thick even withstand hard blows with tools such as hammers, axes and the like. Polycarbonate panes having a thickness of about 25 mm. can be regarded as bullet-proof since even steel bullets of 9 mm. caliber shot from the most favorable distance and impinging at right angles, are not able to penetrate such panes. However, if for some reason it should happen that a pane breaks, no sharp broken edges or splinters result so that injuries by cutting are excluded.

On the other hand, the resilience of such panes is so high that the danger of breaking bones, for example, by bumping against such panes, is considerably reduced. If the deformation stress tolerated is taken as a measure for the resilience of the panes, than the latter is more than seven times as high as that of the known compound glasses.

As a result of the already-mentioned favorable absorption behavior of polycarbonates with respect to light rays, practically no absorption losses in the visible spectrum occur even in the case of very thick panes, while the usually undesired ultraviolet and infrared radiations are almost completely blocked out, even in the case of thin panes.

In addition, there is, in many cases, the advantageous saving of weight in comparison with safety panes made of glass since polycarbonate safety panes are frequently thinner than corresponding panes of glass and since the specific weight of the new panes is scarcely half as great as that of glass.

Finally, polycarbonate safety panes provide good heat insulation which is mainly the reason that the new panes are less readily misted than glass panes with varying temperatures.

The safety panes of this invention can be flat or bent. They can be transparent or they can be made translucent with opacifiers or by matting their surfaces, or they may be colored as desired.

In general, thicker polycarbonate sheets will be chosen with increasing size of the panes but even for display windows a thickness of 5 to 8 mm. will suffice as a rule. However, for special purposes, such as, for example, bullet-proof glazing, the polycarbonate sheets can also be considerably thicker. It is preferred, however, to use two or more thinner polycarbonate sheets mounted together in face to face relationship to form a thicker one either by framing or cementing the sheets together. In order to achieve special effects, threads or fabrics, for example, of metal wire or glass, can be

placed between the individual panes or can also be molded into the panes themselves.

In a preferred embodiment of this invention, a bullet-proof safety pane is prepared by assembling three spaced polycarbonate sheets in face to face relationship, each sheet preferably having a thickness of 4 mm., and mounting one external glass sheet on each side of the construction. When impacted by a bullet, the polycarbonate sheets stretch and absorb the shock of the bullet and, even in the event that one sheet of polycarbonate is penetrated, the next sheets will stretch with the impact and prevent the complete penetration of the missile. It has been found that one sheet three times as thick will not operate as efficiently in the construction of a bullet proof pane since one thick sheet alone is not elastic enough to adequately absorb the shock of the impacting bullet in most cases.

In preparing the laminates of this invention, it is necessary that the polycarbonate pane or panes and the glass sheet or sheets are slidably connected to one another since glass and polycarbonate expand at different degrees with heat (about 1 to 10). Hence, if the polycarbonate and the glass sheet or sheets are too rigidly connected to one another, the valuable mechanical properties of the polycarbonate, especially its impact strength would be lost. If, on the other hand, the covering sheet or sheets of glass are slidably connected with the polycarbonate pane the laminate does not lose its properties when exposed to heat and upon impact the polycarbonate is able to resist the force with its full impact strength even though the glass sheet or sheets might break.

The glass sheets with which the polycarbonate sheets can be covered according to the present invention may have any desired thickness from the thinnest technically producible ones of about 0.5 mm. upwards, since the main function of the glass is merely to render the surfaces of the polycarbonate panes scratch-resistant. For economic reasons, however, the cheaper glass sheets with a thickness of about 1-3 mm. are usually preferred.

Since polycarbonate sheet or sheets account for a substantial or even the preponderant part of the total mass of the safety panes of this invention, such panes as a whole can be thinner than panes of glass alone and have a comparatively low weight. At varying temperatures the safety panes of this invention also have a much smaller tendency to become misted than do corresponding glass panes.

In general, clear-transparent, possibly transparently colored polycarbonate and/or glass sheets will be used. If desired, however, the polycarbonate sheets and/or the glass sheets can also be patterned, cloudy, or matted on one or both sides. In order to achieve definite effects, threads or fabrics, for example, of metal wire or glass, can be inserted between the polycarbonate sheet and the glass sheets and/or possibly between several polycarbonate sheets laid on top of one another, or they can also be molded into the polycarbonate sheet itself.

In order to meet the requirement that the sheets are slidably connected with one another, the simplest method of construction is to place the sheets one upon another in face to face relationship without cementing them together with a binding agent, but merely to achieve their connection by framing; this is the most preferred embodiment of the invention. Any suitable

framing means may be employed in this embodiment including a window frame. In such a case, the polycarbonate sheet and the glass sheet are mounted one on the other in face to face relationship and inserted into the window frame without any cementing or adhering agent while the window frame alone holds the laminate together.

Care must be taken, however, to exclude air or moisture between the sheets thus avoiding optical faults, viz., the so-called Newton's rings. In general, however, because of the difficulty involved in avoiding such optical faults, when the panes are to be clear-transparent it is often preferred to cement the sheets together with a binding agent which remains soft and thus insures a sufficient degree of slidability between the sheets when they are mounted one on the other in face to face relationship. The E-modulus of such cements or binders should be lower than 5,000 kp/cm² and preferably between about 200 and about 2,000 kp/cm² and they should be able to withstand temperatures as high as about 50° to about 60° C. or as low as -25° C. Further, the cement or binder must be able to adhere both to the polycarbonate and to the glass and it must be able to stretch under the influence of heat to a degree commensurate with the expansion of polycarbonate which is about 10 times that of glass without permitting the pane to break due to the disproportionate degrees of stretching of the components thereof. Hence, a suitable binder is generally a liquid or a paste; some examples of such suitable binding agents or cements include silicone rubbers, hardenable polyester-styrene mixtures, preferably those in which the mixture ratio of unsaturated polyester of the maleinate type containing small amounts of unsaturated acid radicals to styrene amounts to at least about 4:1, further, soft epoxy resins, polyvinyl butyral containing phosphate softening agents, soft polyurethanes, polyisobutylenes and soft copolymerizates of acrylic acid esters. The thickness of the adhesive binding or cementing layer should not be less than about 0.1 mm. and preferably ranges from about 0.2 to about 0.5 mm. in thickness.

In another embodiment of this invention wherein the polycarbonate sheet or sheets are used without glass covering sheets, the surface hardness of the polycarbonate alone is generally not sufficient to resist mechanical damage, for example due to scratching, so that some scratch-resistant covering must be applied to the polycarbonate surface. One method of protecting the polycarbonate surface in a safety pane is to coat the surface of the polycarbonate sheet with a thin layer of SiO_x, wherein x is from 1 to 2. It has been discovered that a silicon oxide layer can be deposited onto the surface of the polycarbonate by evaporation in an atmosphere of oxygen, such as, for example, by the process disclosed in German Pat. specification No. 1,104,283. In such a process, visually-undetectable and abrasion-resistant coatings on transparent substrates which are distinguished by especially high mechanical and chemical resistance on the one hand and by especially high transparency on the other hand can be prepared. Such compositions, which are especially suitable as optical elements, can be obtained by evaporating a suitable metal compound such as, inter alia, silicon dioxide, or a subcompound thereof or a mixture of said compounds with the corresponding metal in a vacuum in proximity to the substrate and in the presence of an atmosphere of reactive gas such as oxygen, whereby the

pressure of the gas is more than 3×10^{-5} mmHg (= 0.03 micron). In the case of the evaporation of a silicon oxide, an oxygen-pressure of about 5×10^{-5} mmHg (= 0.05 micron) is preferred. According to the U.S. Pat. No. 3,010,839, for example, silicon monoxide is a suitable sub-compound of silicone to be evaporated. In a preferred embodiment of the German patent, the reactive gas such as oxygen is activated by ionization, for example, by passing the gas between two electrodes which are loaded with several thousand volts before or during the entrance into the reaction zone.

It is pointed out that, in the absence of, for example, the oxygen atmosphere in the evaporating zone the metal oxide coating such as the silicon oxide layer deposited on the surface of an element consists of a sub-compound such as SiO_x wherein x is remarkably lower than 2, for example 1, and that such a coating is colored and absorbs a remarkable portion of light. The presence of the oxygen atmosphere, however, avoids this disadvantage. The coating deposited on the surface of the substrate under this condition consists substantially of SiO_2 which is colorless and visually undetectable and absorbs only minor portions of light. As mentioned above, this process is also suitable for the production of a scratch-resistant surface of the polycarbonate safety panes which also may be used as optical elements, such as glazings for motor vehicles. Contrary to experiences with other synthetic resins, the silicon oxide layer will form an adhered coating to the polycarbonate which is so resistant to wiping and scratching that such surface coated panes satisfy almost all scratch resistant requirements. These surface coatings also offer outstanding protection against attack by solvents and overcome the inherent and undesirable tendency of polycarbonate surfaces to pick up a static charge.

In addition, if it is desired, this embodiment may be combined with that in which the polycarbonate surface is covered with a glass sheet so that the polycarbonate sheet or sheets have one surface thereof covered with a layer of SiO_x wherein x is 1 to 2 while the other surface is covered with a glass sheet slidably mounted on the polycarbonate sheet either by framing or by means of some suitable cement or binder.

As a result of their numerous advantageous properties, the new composite panes of this invention are capable of being used in various ways. Thus, for example, they can be used with special advantage in vehicle construction, especially in motor vehicles and railway vehicles, as front, side, push-out, or rear panes, as well as for skylights or cupolas of omnibuses and the like. The laminates of this invention can also be used in boat and ship building, as well as for airplanes, especially for the glazing of airplane cockpits of very fast flying airplanes. They can also be used for the glazing of display cases, display windows, as well as windows in general, of light wells and the like in house building, for the production of glazing on doors and so on. Further possible applications are, for example, the glazing of rooms which are exposed to increased or reduced pressure such as airplane cabins, as well as of rooms endangered by explosion or implosion, as protective panes for television screens and technical devices and apparatus of all kinds, for the protection of bank counters and as bank windows, the pane behind taxi drivers and, in general, for all types of bullet-proof glazing. Thus, the above-mentioned types of glazing function as protective cov-

erings for the underlying surfaces to which they are respectively bonded.

The invention is further illustrated but not limited by the following example, in which parts are by weight unless otherwise specified.

EXAMPLE

For the production of a motor car pane, a pane of polycarbonate of bisphenol A having a relative viscosity of 1.32, measured in a 0.5 percent methylene chloride solution at 20° C., of 3-4 mm. thickness, according to the size of the pane, is vaporized in a vacuum with a scratch-resistant layer of silicon dioxide.

There is subsequently poured over the untreated side of the polycarbonate pane, a prepared, bubble-free synthetic resin mass, for example, a silicone rubber mass which has previously been de-gassed, and to this liquid adhesive layer, a glass pane is applied, previously cut to the right size, in such a manner that no bubbles can form. In order to achieve a uniform layer of about 0.2 mm., the glass sheet is provided on the edges with spacing pieces of corresponding thickness, made of metal, glass or paper. The excess adhesive mass is allowed to run out by lifting one side of the pane. Depending on the nature of the adhesive agent used, the pane can subsequently be subjected to a heat treatment in a drying cabinet (about 50° C. for about 30 minutes) for acceleration of the hardening.

The finished pane can be molded directly into the rubber or metal mounting support of the vehicle with a silicone rubber mass (glass side on the outside).

A pane produced in this manner is unbreakable and takes up about 30 times as much deformation stress as a safety pane of prestressed glass.

For large panes such as windscreens of larger vehicles like private motor vehicles of the 2-liter class, it is recommended to use a polycarbonate sheet of from about 5-6 mm. thickness. The thickness of the glass sheet can amount to up to about 1.5 mm. for reasons of easier production and working up of the glass.

The invention is further illustrated by the drawings.

FIG. 1 shows a safety pane consisting of a polycarbonate plastic sheet (1) and a glass sheet (2) slidably held together by means of a frame about the edges thereof (3).

FIG. 2 shows a similar safety pane consisting of a polycarbonate plastic sheet (1) and a glass sheet (2), however, slidably held together by means of an elastic cement layer (4).

FIG. 3 shows a safety pane consisting of a polycarbonate plastic sheet (1) and 2 glass sheets (2a and 2b) slidably held together by means of a frame about the edges thereof (3).

FIG. 4 shows a safety pane consisting of 3 polycarbonate plastic sheets (1a, 1b and 1c) combined with 2 glass sheets (2a and 2b), these 5 sheets being slidably held together by means of a frame about the edges thereof (3).

FIG. 5 shows a safety pane consisting of a polycarbonate plastic sheet (1) and a glass sheet (2) slidably held together by means of a frame about the edges thereof (3), whereby the other surface of the polycarbonate plastic sheet is covered by a thin SiO_2 layer (5).

FIG. 6 shows a safety pane consisting of a polycarbonate plastic sheet (1) and a glass sheet (2) slidably

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held together by means of an elastic cement layer (4), whereby the other surface of the polycarbonate plastic sheet is covered by a thin SiO_2 layer (5).

FIG. 7 shows a safety pane consisting of a polycarbonate plastic sheet (1), 2 glass sheets (2a and 2b) slidably held together by means of a frame about the edges thereof (3), whereby a reinforcing agent (6a and 6b) is placed between the polycarbonate plastic sheet (1) and the glass sheets (2a and 2b) respectively.

FIG. 8 shows a safety pane consisting of a polycarbonate plastic sheet (1), 2 glass sheets (2a and 2b) slidably held together by means of elastic cement layers (4a and 4b), whereby in the polycarbonate plastic sheet (1) a reinforcing agent (7) is embedded.

It is to be understood that any of the components and conditions mentioned as suitable herein can be substituted

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for its counterpart in the foregoing examples and that although the invention has been described in considerable detail in the foregoing, such detail is solely for the purpose of illustration. Variations can be made in the invention by those skilled in the art without departing from the spirit and scope of the invention except as is set forth in the claims.

What is claimed is:

1. A safety pane comprising a sheet of polycarbonate having a coating on at least one side thereof of SiO_x wherein x is from 1 to 2, and having at least one sheet of glass mounted in face to face relationship adjacent one surface of the polycarbonate sheet and in slidable relationship thereto.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,821,071

DATED : June 28, 1974

INVENTOR(S) : KARL DIETZEL, GUNTER PEILSTOCKER, KARL-HEINRICH
MEYER AND HUGO STREIB

It is certified that error appears in the above-identified patent and that said Letters Patent
are hereby corrected as shown below:

On the cover page, Section [75], Inventors, correct the address
of the inventor Karl Dietzel to --Krefeld-Uerdingen--;

same page, Section [30] Foreign Application Priority Data, add
the following six applications:

-- July 31, 1963 Germany 40381
June 20, 1963 Germany 40067
June 20, 1963 Germany 40069
June 20, 1963 Germany 40071
June 20, 1963 Germany 40073
June 14, 1963 Germany 39990 --

to the listing of foreign priority applications

Signed and Sealed this

Twentieth Day of July 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks