March 18, 1958 P. GRAHAM 2,826,788

CURVED BARRIER

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FIG. 1

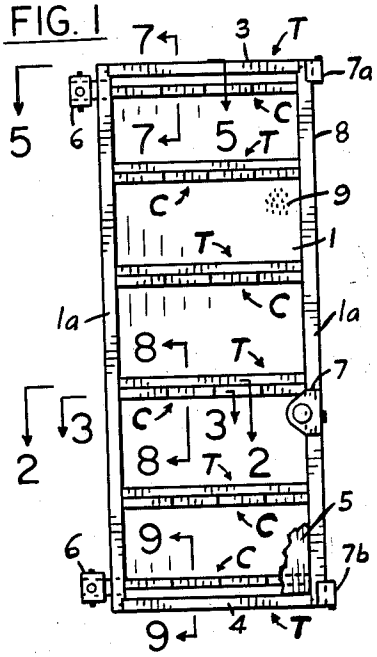


FIG. 6A

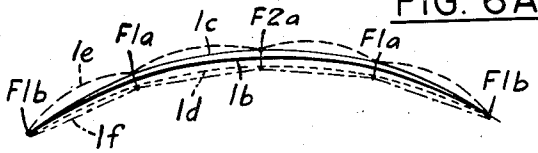


FIG. 6B

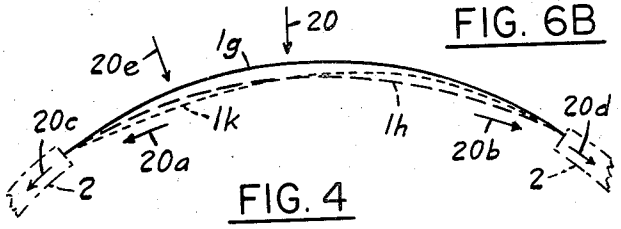


FIG. 4

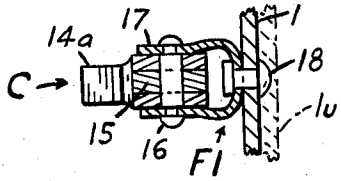


FIG. 7

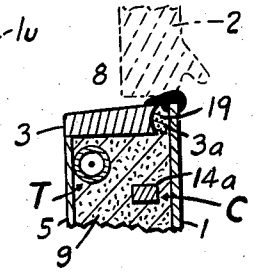


FIG. 2

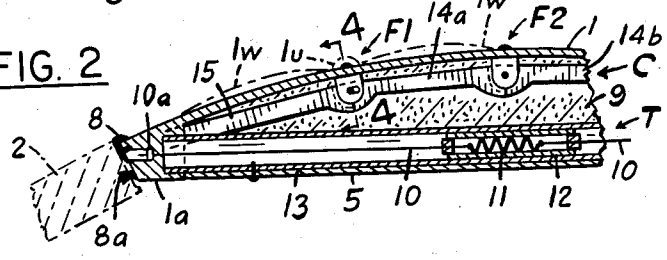


FIG. 8

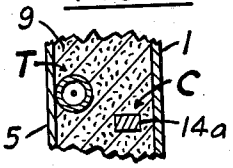


FIG. 3

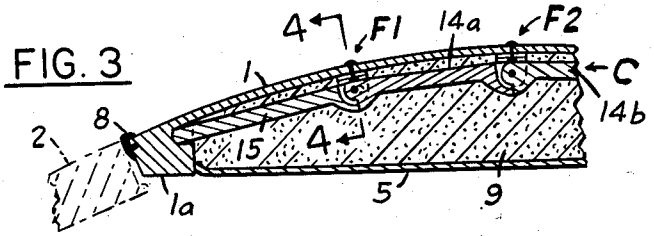


FIG. 9

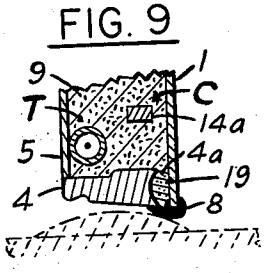
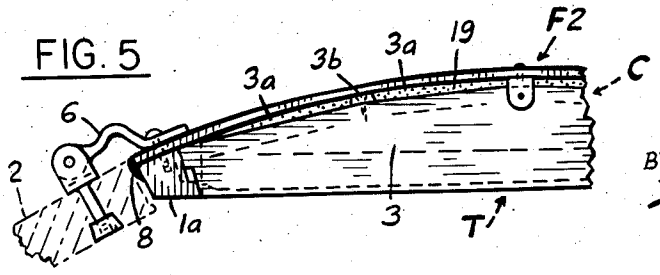


FIG. 5



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FIG. 10

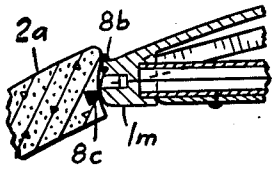


FIG. 11

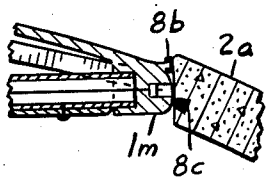


FIG. 17

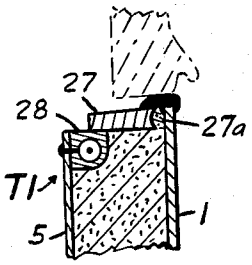


FIG. 12

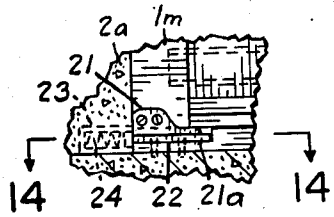


FIG. 13

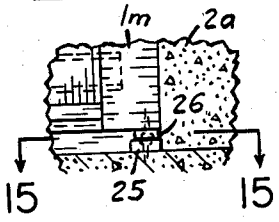


FIG. 18

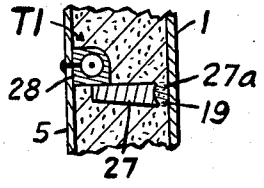


FIG. 14

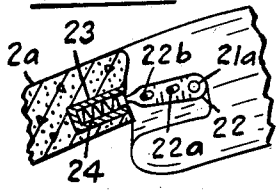


FIG. 15

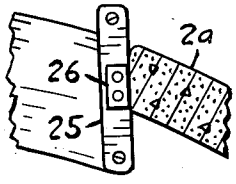


FIG. 19

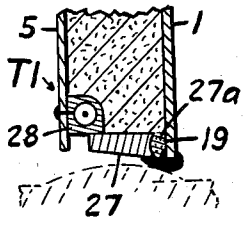
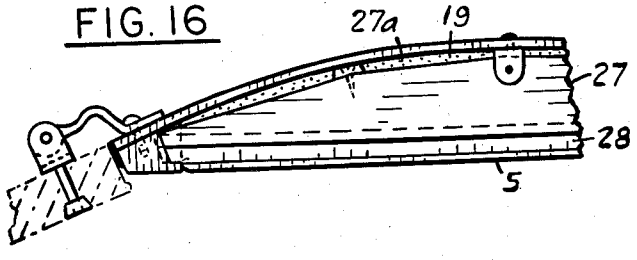


FIG. 16



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FIG. 20

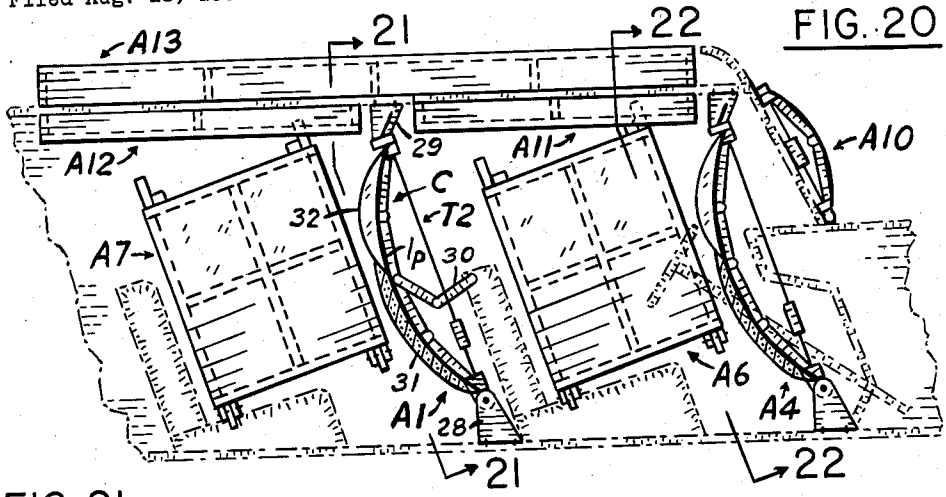


FIG. 21

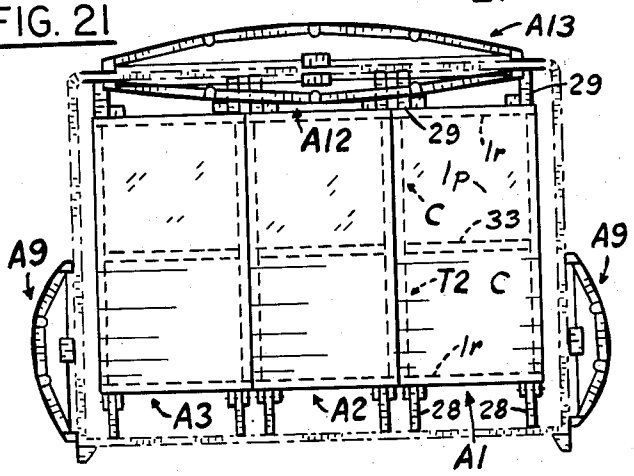


FIG. 23

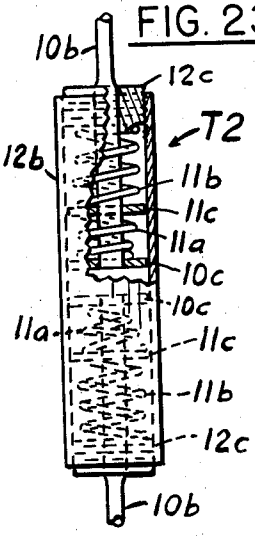
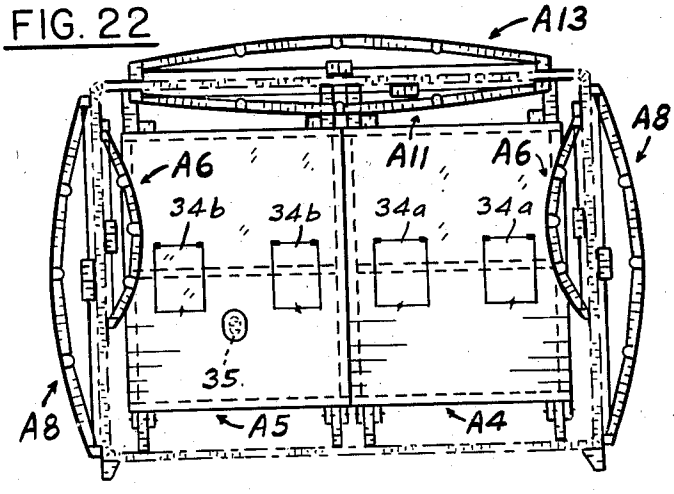


FIG. 22



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United States Patent Office 2,826,788 Patented Mar. 18, 1958

2,826,788

CURVED BARRIER

Phillip Graham, Pittsburgh, Pa.

Application August 13, 1954, Serial No. 449,695

25 Claims. (Cl. 20—35)

This invention relates to a barrier in the form of a closure or shield, such as a door, shutter, or a barricade section, which is curved, light in weight, resilient, and strong, also which is surrounded by a cushion-seal to make a tight fit with a frame. The door embodying the present invention is of such construction as to maintain a true bearing edge with the door opening and prevent warping which occurs in many common flat doors. This invention is a continuation-in-part of my co-pending applications, Serial No. 265,465, now Patent No. 2,770,850, filed January 8, 1952, entitled Curved Closure Device and Serial No. 363,867, filed June 24, 1953, entitled Curved Closure Device.

A barrier embodying the principles of this invention offers protection against the effects of violent forces that may be thrust against it. A small amount of relatively low cost material is shaped for optimum use to provide a safety barrier that can offer security against possible fatal injury and property damage from violent forces. In general the parts are confined and forced to work efficiently. Doors and shutters of this type provide protection from explosions, including protection in the enormous critical fringe areas of atomic-H-blasts, and hurricane-like winds. Automobiles may be equipped with safety barriers, or closure elements to provide safety cushioning or restraining means which will yieldably slow down and check the momentum of the occupants, when a sudden stoppage during a collision would otherwise tend to hurl the occupants forwardly against rigid framing causing injury. The closure-shields may also be attached to the outside of automobiles, to enclose or partially enclose the auomobtiles, to provide cushioning and restraining means to check momentum of autos when they collide, to lessen or prevent injury to occupants and to lessen or prevent property damage.

An object of my invention is to provide a low-cost, strong, durable, attractive door, or the like, to yieldingly resist and cushion violent impacts and restrain these forces, and which will resist deterioration from the elements.

Other objects of my invention will become more apparent from the following description, taken with the accompanying drawings wherein:

Figure 1 is an elevational view of a curved door;

Figure 2 is an enlarged, fragmentary, sectional view taken along line 2—2 of Figure 1;

Figure 3 is an enlarged, fragmentary, sectional view taken along line 3—3 of Figure 1;

Figure 4 is an enlarged, fragmentary, sectional view taken along line 4—4 of Figures 2 and 3;

Figure 5 is an enlarged, fragmentary, sectional view taken along line 5—5 of Figure 1;

Figure 6A is a schematic diagram, showing the control of distortion along the width of the door shell caused by expansion and contraction;

Figure 6B is a schematic diagram, showing the distortion along the width of the door shell caused by exterior thrusts;

Figure 7 is an enlarged, fragmentary, sectional elevational view taken along line 7—7 of Figure 1;

Figure 8 is an enlarged, fragmentary, sectional view taken along line 8—8 of Figure 1;

Figure 9 is an enlarged, fragmentary, sectional view taken along line 9—9 of Figure 1;

Figures 10 and 11 are fragmentary, sectional plan views, similar to Figure 2, taken through a modified door that swings two ways;

Figures 12 and 13 are fragmentary elevational views showing the lower corners of the door shown in Figures 10 and 11;

Figure 14 is a fragmentary, sectional view taken along line 14—14 of Figure 12;

Figure 15 is a fragmentary, sectional view taken along line 15—15 of Figure 13;

Figure 16 is a fragmentary, sectional view similar to Figure 5 taken through a further modified door;

Figure 17 is a fragmentary, sectional elevation similar to Figure 7, taken through the modified door shown in Figure 16;

Figure 18 is a fragmentary, sectional elevation similar to Figure 8, taken through the modified door shown in Figure 16;

Figure 19 is a fragmentary, sectional elevation similar to Figure 9, taken through the modified door shown in Figure 16;

Figure 20 is a fragmentary, sectional elevation taken through an automobile showing some uses of closures and shields;

Figure 21 is a fragmentary, sectional elevation taken along line 21—21 of Figure 20;

Figure 22 is a fragmentary, sectional elevation taken along line 22—22 of Figure 20; and

Figure 23 is an enlarged detail showing a yieldable and restraining link for the tie rods in the closure.

The door shown in Figures 1 to 9 inclusive is illustrated as an exterior door. Its arched curved shell 1 is bowed out in width to the exterior to allow it to resist violent exterior forces. The door is shown positioned in an opening in a curved thin shell concrete wall 2. It may be used with straight walls whose edges are beveled at the door opening. The door is symmetrical about its vertical axis except for the hinges and latching means. This bowed shape is strong, and greatly resists pressure on the convex side of the arched shell. The bowed shape allows the door to yield slightly under heavy loads to cushion the force and to divert the thrust into the direction of the arch. Thus an exterior thrust against the curved shell 1 is arcuately transmitted effectively through the shell to the curved wall 2. The bowed shape of the shell 1 allows it to yield for expansion and contraction without objectionable warping or cracking. The curved shell 1 has a shape that resists forces that tend to cause it to bend lengthwise.

The door is illustrated and described, in general, as being made of plastic.

Since possible loads on the convex surface of an arched shell effect compression in the arch, a door shell may be constructed of materials that are strong in resisting compression, such as plastics, wood, metal, concrete, glass or laminations of these and/or other suitable materials. A door, if made of plastic, and similar materials, may be reinforced with fiber glass, metal or other suitable reinforcing, impregnated in the door material. A concrete shell may have expanded mica, known in the trade as vermiculite, in its aggregate to lighten the weight and for insulation. A strong shell may have relatively weak materials laminated to it for appearance and for insulation.

Referring to Figures 1 to 9 inclusive, sides 1a of the shell 1 are shaped to stiffen the sides of the door and to

form a trim. Ties T may be used to span the chord of the arched shell 1 and connect to the sides 1*a*. The chain ribs C may be used as stiffeners. They may be connected to the shell 1 with fasteners F1 and F2. The ends of the ribs C fit into sockets in the sides 1*a*.

Figures 5 and 7 show a top rib 3 and Figure 9 shows a similar rib 4 at the bottom of the door. Ribs 3 and 4 act as closures in addition to stiffening the door. A flat cover 5 may be used to cover the inner or chord face of the door. Resilient hinges 6 are shown in Figures 1 and 5. A latch 7 is shown in Figure 1.

A seal-cushion 8 may be fitted onto the edging around the door perimeter. It acts as a seal, a cushion, an insulator, and a trim. The seal 8 may be colored to make an attractive trim. The seal 8 prevents ice from forming on the side edges of wall 2. The seal 8 yields to strip away from ice that may form around its edge and thus the ice may be sheared off as the door is opened. The seal 8 may be stretched onto the door and be cemented to it. A door without a seal 8 may be made to bear against a seal around the door opening such as the seal 8*a* shown in Figure 2.

Insulation 9 may be placed in the space between the shell 1 and cover 5. The cover 5 may be a stiff or a relatively weak covering. It may be a mirror or it may be an insulating cover. A stiff cover 5 may be hinged (not shown) to form a closet space in the door.

As shown in Figure 2, a tie T has two pieces of tie wire 10 which are linked together by the spring 11. An end of each wire 10 is threaded to engage a nut 10*a*. There are holes through sides 1*a* for the wires 10. Sockets in the sides 1*a* provide anchorage for the nuts 10*a*, and thus the wires 10. A limit link tube 12 may have threaded adjustable ends. The link 12 may be used to straddle the spring 11 to limit the yielding of the spring 11. A tube 13 may be used to cover the wires 10, the spring 11 and the link 12. The tube 13 fits into sockets in the sides 1*a*. Nuts 10*a* are turned to adjust the tension of the spring 11. The limit links 12 prevents violent pressures on the concave side of the shell 1 from tending to flatten and then collapse the shell outwardly. Such violent pressures could be from interior explosions, partial vacuum outside of the building caused by a hurricane eye, or a gust of wind when the door is in an opened position. The limit link 12 may have its effecive length shortened by adjusting an end, to restrain the shell 1 from flattening more than slightly after it yields to cushion a load on its convex surface, when weak walls cannot absorb the whole thrust from the shell 1. Thus the hinges 6 and the latches 7*a* and 7*b* carry the load onto the stronger floor and ceiling. The tube 13 besides being a cover, acts as a strut to restrain the shell 1 from tending to bow in from the tension of spring 11 and from forces on the concave side of the shell. When the cover 5 is omitted from the door, the tubes 13 may be used as hangers for articles, as well as to make attractive covers for the tie wires and spring. The tubes 13 may be omitted when loading conditions and the like do not warrant their use. Modified ties (not shown) may have spring washers under nuts 10*a*, thus omitting the springs 11 and the links 12.

As shown in Figures 2, 3 and 4, chain ribs C have intermediate links 14*a* and 14*b* and end links 15. Pins 16 connect the links. Fasteners F1 and F2 have clevises 17 and rivets 18 to couple the links 14*a*, 14*b* and 15 to the shell 1. The clevises 17 for fasteners F1 may be slotted to allow limited independent side movements of the shell 1 with respect to the ribs. Fasteners F2 are not slotted as they are at fixed anchor points between the shell 1 and the ribs C. Clevises 17 may have a bowed resilient diaphragm, and thus have gaps between the rivets 18 and the links, 14*a*, 14*b* and 15, to allow slight outward and inward movement of the shell 1. Thus slight expansion and contraction in the width of the shell 1 would be allowed without abruptly distorting the shell curvature

at the fasteners F1 and F2. Therefore, a highly brittle shell 1 would not have to bend as sharply and it would have less tendency to crack.

Clevises 17 may be made non-resilient, if preferred, to prevent the slight bowing.

Modified doors (not shown) may have the links 14*a*, 14*b* and 15 bearing directly against the shell 1 without being attached to it. Suitable pads or wearing plates may be placed at the contact surfaces. Such an arrangement would be less effective for strength and for controlling distortion.

Ribs 3 and 4 may be attached to the shell 1 with fasteners F2. The ends of ribs 3 and 4 are not fastened to the shell 1. They are held in alignment by tongue and groove bearing surfaces with the sides 1*a*. The ends of ribs 3 and 4 may be tongued to fit grooves in sides 1*a*. The ribs 3 and 4 may have resilient separators 3*b* attached midway between their ends and centers. The separators 3*b* have bearing contact with the shell 1, but are not a tying means. Resilient separators 3*b* allow the shell 1 to bow in and out slightly from the effects of expansion and contraction while contact is maintained. The ribs 3 and 4 are cut back from the contour of the shell 1 between the fasteners F2 and the separators 3*b*, also between the rib ends and separators 3*b* to form gaps 3*a* and 4*a*. There are similar gaps between the intermediate parts of links 14*a*, 14*b* and 15 and the shell 1. The gaps allow further local flattening during the contraction of the shell 1. The gaps 3*a* and 4*a* may be left open between the shell 1 and the ribs; or, if desired, an elastic filler 19, such as one made of foam rubber, may be used as a gap filler. To hold the filler 19, the edges on the ribs 3 and 4 are grooved slightly for keying the filler 19 to the ribs.

The ties T allow the use of a thin shell 1, as they restrain the shell from objectionably flattening and spreading in width, particularly when the door is in an opened position. The ribs 3, 4 and C with their fasteners F1 and F2 and separators 3*b* bear against the shell 1 to maintain a substantially true arched curvature. When the door is closed and seated to the jambs of wall 2, the chain ribs C may yield and flatten slightly when a strong pressure on the convex side of the shell 1 causes the shell 1 to deflect, the ties T yielding from the effects of the same force. While the ribs C are yielding, they are also restraining the shell 1 from buckling, so as to keep it confined or trapped to force it to act as an arch to divert the strong forces into the arch and thus into the edges of the curved wall 2.

The ribs C may yield to an extent under an impact on a local area of the shell 1, thus the ribs C would cushion the shock allowing it to be distributed over a larger area so that it can be checked and its force diverted to the side edges of the wall 2. The ribs C cannot bow outwardly past the normal position because the ends of links 14*a*, 14*b* and 15 toward the chord line have offset bearing surfaces contacting each other. The slotted holes in the clevises 17 of fasteners F1 allow the shell 1 to spread sideways slightly when it is flattened slightly. Ribs C act as pin connected arches to absorb some of the load against the shell 1, and divert it into the sides 1*a* and thus into the edges of the wall 2. Since in general the ends only of the links 14*a*, 14*b* and 15 contact and thus take thrusts from the shell 1, the ribs C do not act as beams under localized impact loads as would ribs of conventional ribbed curved doors.

The ribs 3 and 4 act similarly to ribs C, as they may yield inwardly and restrain the shell 1 from buckling or from bulging objectionably from non-uniform pressure on the shell 1. The sloping ends of ribs 3 and 4 bear and slide against the sides 1*a* when they are yielding. These sliding contact edges may be waxed to prevent binding action. Thus the ribs 3 and 4 with sloping ends act as wedges to divert loads on the ribs into the sides 1*a* and thus into the edges of the wall 2. Offsets on the ends of ribs 3 and 4 and on the engaging edges of sides

1*a* limit the movements of the rib ends to prevent excessive movement at an end. The non-connecting separators 3*b* allow the shell 1 to spread sideways slightly when the shell 1 flattens slightly.

The curved straps of the hinges 6 yield to allow the shell 1 to carry the arched thrust directly into the wall 2. The seal-cushion 8 along the door side edges would yield under the arched thrust and it would thus make a tighter seal and a continuous bearing surface.

The latches 7, 7*a* and 7*b* engage suitable slotted catches on the door opening to allow the door to spread to bear tighter against the wall when outside pressure is increased. The latch 7 would be sufficient latching means where the wall edge adjacent the latching side of door is strong enough to take the thrust from the door edge. Latches 7*a* and 7*b* may be used in general when the thrust must be transmitted to supports adjacent the ends of side 1*a*.

When cover 5 is omitted on a door, ribs 3 and 4 may be omitted, or if preferred, when loads are light, ribs 3 and 4 may be used and the adjacent ribs C may be omitted. Both types of ribs may be used on a door, particularly when less sturdy ribs 3 and 4 are primarily used to close the ends of the door.

A very thin plastic shell, such as shell 1, may be used effectively to carry a greater thrust, by incorporating longitudinal ribs 1*u* in line with the fasteners F1 and F2. Only one such rib 1*u* is shown and is indicated by the dot-dashed outline in Figures 2 and 4. Such ribs may be used on either or both shell surfaces. Another means to effectively use a very thin plastic shell, such as shell 1, to effectively yield and resist a greater thrust, is to have local corrugations 1*w* between the fasteners F1 and F2, and between fasteners F1 and the sides 1*a*, to prevent excessive buckling. Corrugations 1*w* are indicated by the dot-dashed outlines on Figure 2.

Modified doors of limited strength but sufficient for use as closet doors and the like, may be made without ribs, the shell 1 being sprung to the required shape with ties T. The shell may be corrugated in width (not shown).

Another modification for doors of limited strength embodies only two ribs. If such door is to have a cover 5 and/or insulation 9, the ribs 3 and 4 would be most suitable.

Modified doors (not shown) may have the cover 5 or the tubes 13 yieldably connected to sides 1*a*, to act as yieldable ties and struts, thus omitting the tie wire 10.

The door, with its yieldable means to allow diverting of the abnormal thrusts on the door shell 1 into the edges of the wall 2, allows the use of less sturdy walls as the thrust is made in the direction that the wall 2 is strongest. Flat doors, and to an extent non-yielding curved doors, tend to cause shear and bending at the door jambs.

Figure 6A is a schematic diagram showing the distortion of the door shell 1 along its width, which results from expansion and contraction. The heavy solid curved line 1*b* indicates the normal contour of the door shell. When resilient clevises 17 are used with gaps between the shell 1 and the ribs to allow for expansion and contraction, the expansion gaps at clevises 17 allow the shell 1 to expand slightly to a bowed shape indicated by the thin line contour 1*c*. The gaps at clevises 17 also allow the shell 1 to contract to a flatter bowed shape indicated by the light dotted line 1*d*. There are fixed points F2*a* at fasteners F2. There are semi-fixed points F1*a* and F1*b*, which are located at the ends of the ribs, at the fasteners F1 and F2 and at the separators 3*b*.

The points F1*a*, F1*b* and F2*a*, divide the shell bending area into four incremental areas or zones.

In modifications there may be more or fewer bending zones (not shown) than four. Bending zones allow considerable unobjectionable bending in the arched shell 1, without causing undesirable warping of the door. The door shell 1 bends locally in width and the strong curved shape restrains it from bending lengthwise. The door shell is restrained from spreading or objectionable bulging by the ribs, ties, and door jambs. When the door shell 1 expands due to increased temperature or increased moisture, if absorbent material is used, such as wood, it takes on the bulging contour in the bending zones between points shown by dashed line 1*e*. The cooling of all doors, and drying out in wooden doors, causes contraction which, without this localization of bending, causes undesirable wraping and cracking. The curved shell 1 allows the curved width to flatten out locally in the bending zones for contraction. When the door shell 1 shrinks, it assumes the contour indicated by dot-dash line 1*f*, which flattens between points.

Figure 6B is a schematic diagram showing the distortion of the door shell 1, which results from heavy pressures on the convex side of the shell. The heavy solid line 1*g* indicates the normal contour of the door shell. When the shell is under an evenly distributed load 20, it compresses, yields and flattens to the dashed contour line 1*h*. The direction of the load 20 is diverted into the arch to convert it into forces 20*a* and 20*b* and thus to forces 20*c* and 20*d* in the wall 2. When a concentrated impact load 20*e* strikes a local area of the shell, the shell yields to the dotted contour line 1*k*. In yielding, the shell distributes the impact load over a greater shell area, which can resist the tendency of the impact to shear through or puncture the shell. The thrust would be diverted into the shell and wall 2.

In general, the door or closure device shown in Figures 1 to 9 inclusive is light-weight, very strong, and durable. It is relatively low in cost to build, install, and maintain. The curved door is strikingly different from conventional building doors; and it is pleasingly attractive in appearance, since the curved effect gives the impression of strength and beauty. This curved door would require less material than would common flat doors or other curved doors of equal strength. This would be an exceptionally efficient door and wall arrangement that would make optimum use of the stress carrying characteristics of the door and wall materials, so as to make the arrangement capable of resisting forces from abnormal conditions, such as exterior explosions and the like. The continuous, resilient, sealed cushion around the edge of the door prevents the passage of air, moisture, insects, rodents, dirt, fumes or odors, sound, light, heat, cold, smoke, flood waters. And, since it retards the progress of fire, it is a fire seal. It seals in air for air-conditioning. In wartime, the seal would prevent the passage of warfare types of poisonous gas, smoke, bacteria, and radioactive dust or mist from an atomic blast. The seal will yield to break away from ice that forms around the door. A door equipped with an edge cushioned-seal closes with little noise even when slammed hard. The seal-cushion would also yield to take up the slack caused by discrepancies in the door or door opening. Thus, a less accurate door and door opening are required; therefore, an accurate costly door frame or door opening is unnecessary. There would evolve no future door trouble caused by slight settling of the building and untrued door openings due to the settling. Since the seal compensates for minor discrepancies in the door opening, it would allow more tolerance in hanging the door than is possible with ordinary flat doors. The present door can be more easily and quickly erected.

The doors being light in weight may easily be handled and erected even by a person frail in build. The light-weight doors may be shipped at low cost and would require smaller hinges and supports for the hinges compared with conventional heavier doors of equal strength. Light-weight plastic storm doors or shutters may be stored in quantities in a small space without overloading a floor. Plastic doors would not require paint. Doors may be made of attractive colored plastic. Plastic doors

may be transparent, translucent or opaque. Plastic is not affected by atmospheric moisture which causes wooden doors to warp and unprotected steel doors to rust. Plastic doors can be readily cleaned with water. A plastic door would be resistant to damage by rodents, vermin, and the like. Plastic would be particularly suitable for closure devices such as those in warm climates where destructive elements are prevalent.

A mail slot (not shown) with a resilient seal frame may be placed in the curved shell.

A window (not shown) with a resilient frame may be placed in the curved shell. Resilient frames would allow for bending in the shell and still maintain a seal. Jalousies (not shown) may be placed in an opening in the door shell.

While I have shown a door in Figures 1 to 9 inclusive that is suitable for plastic construction, a door with the same principles, such as the bowed shell, yieldable ribs and yieldable ties, may be made with other materials, such as wood, metal, glass, concrete and the like, similar to the means described in this application and in my co-pending applications Serial No. 265,465, filed January 8, 1952, entitled Curved Closure Device and Serial No. 363,867, filed June 24, 1953, entitled Curved Closure Device.

Figures 10 to 15 inclusive show a modification of the door shown in Figures 1 to 9 inclusive. This modified door may swing in and out in addition to its being similar in its characteristics to the door previously described. The differences are in the modified shell sides **1***m*, the modified edges of the wall **2***a*, the modified seal-cushions **8***b* and **8***c*, and principally in the hinging system. Hinge plates **21** are attached to the bottom and top of the door. A hinge pin **21***a* is attached to the end of hinge plate **21**. The pin **21***a* engages a hole in the sliding plate **22**. Plates **22** are attached to the floor and ceiling with dowel pins **22***a* and **22***b*. Tubes **23** are imbedded in the wall **2***a*. Springs **24** are positioned in tubes **23**. Plate **22** is threaded and it has an adjusting nut attached. The nut or plate **22** bears against the spring **24**, so that the spring tends to force the plate **22** away from the door jamb and thus tend to keep the door from sagging and binding to the door jamb. When an abnormal pressure on the convex side of the door spreads the door in width, the springs **24** yield to allow the hinges to slide.

A tapered aligning plate **25** is fastened to the floor on the non-hinged side of the door opening, which tapers at the top from the center to the ends. A wearing plate **26** is attached above it to the door side **1***m*. The plate **25** engages the plate **26** to raise and align the door as it closes, thus correcting any inaccuracy of positioning not accomplished by the spring **24**. The hinges and latching are strong enough to hold the door in position while it yields in width under loads on its convex surface. The yielding causes the sides **1***m* to bind to the edges of wall **2***a* and then the forces on the door are diverted to the wall edges. Although this modified door is not as effective as the door shown in Figures 1 to 9 inclusive, it is useful where a door is needed that swings in and out and yet must resist violent exterior pressures. This door can be used to swing in only, with its shell bowed to the exterior to resist violent forces.

Figures 16, 17, 18 and 19 illustrate a modified closure that is similar to the door shown in Figures 1 to 9 inclusive. This modification has ribs **27** rather than ribs **3**, **4** and C. Ribs **27** are similar to ribs **3** and **4**. They differ by being narrower in width. The narrow width allows the ribs **27** to yield under loads without fouling the cover **5**. Modified ties **T1** are similar to ties T. They have tubes **28** that are similar to tubes **13** except that they are shaped to have a sliding fit with ribs **27** to help close the cross area of the door. The ribs **27** are shaped to form gaps **27***a* similar to gaps **3***a* between their edge and the shell **1**. Elastic filler **19** may be inserted in these gaps **27***a*. If preferred, for appearance and as a covering, a rib **3** may be used at the top in place of a rib **27**. When a fixed cover **5** is not used, the intermediate ribs and bottom ribs **27** may be used as shelves, when slats (not shown) are placed above the ribs to keep articles from falling off.

Figures 20, 21 and 22 show how thin curved shell barriers or closure-shields A1 to A13 inclusive may be used in and on automobiles and the like, to enclose, shield or separate non-compatible elements to effectively act during auto accidents, to prevent injury and death to the people in the accidents and to prevent property damage. These closure-shields act similar to the door shown in Figures 1 to 9 inclusive. The door shown in Figure 1 would yield and then restrain, without much harm, a would-be intruder who hurls his weight against the door. The closure-shields inside an auto provide cushioning and restraining means which slow down and check the momentum of the occupants of an auto when it is stopped suddenly, such as the stoppage during a collision. The momentum tends to hurl the occupants forwardly until they strike rigid framing. The safety barriers or closure-shields catch the occupants being thrown by the momentum, and ease their movement to a stop, thus preventing or lessening injury. These inside closure-shields would also cushion and stop the flight movement of objects such as luggage being transported on the rear seat. These barriers may be used on the outside of automobiles to contact, cushion and bounce pedestrians and autos that are struck, to lessen injury to the pedestrians and to prevent property damage.

The arrangements shown allows means to adapt these barriers to existing autos, modified arrangements (not shown) may be incorporated into new designs for autos.

The closure-shields A1, A2 and A3 shown in Figures 20 and 21, are alike in general. They have curved shells **1***p* which are bowed in height, chain ribs C and ties T2. The modified yieldable tie T2 shown in detail in Figure 23, is similar to tie T shown in Figure 2. It may be used for the closure-shields as well as for the doors such as previously described. The ties T2 take most of the reaction from the arched thrust from the ends of the sides **1***r*. The tie T2 has heavy wires or rods **10***b*, with anchor disks **10***c* attached to the ends shown. Light springs **11***a* and heavy spring **11***b* are enclosed and trapped by the limit tube **12***b* and the adjustable tube ends **12***c*. The tube **12***b* with its ends **12***c* restrain the ties **10***b* from yielding after the springs **11***a* and **11***b* have reached their depressed limit. Washers **11***c* separate adjacent springs **11***a* and **11***b*. The weaker springs **11***a* allow readily yielding of the bowed shell **1***p* to cushion and slow up the initial impact, before the heavy springs **11***b* increase the resistance against the thrust on the shell **1***p*. The limit tube **12***b* with its ends **12***c* prevent excessive yielding. Excessive yield would allow the shell **1***p* to flatten and then buckle and collapse. Springs **11***b* and **11***c* may be combined if preferred.

These closures A1, A2 and A3 are shown as being mounted to the rear of the front seats of a two-door sedan. They also may be mounted behind the front seats of a four-door sedan and the like. Since access to the rear seats of a two-door sedan is by tilting the backs of the front seats to allow access space, the safety barrier or closure-shield arrangement is sectionalized rather than being similar to the single closure shown in Figure 1. The closure-shields A1, A2 and A3 are hinged at the bottom to supports 28. The tops are latched to slotted catch plates **29**. Supports 28 and plates **29** are securely attached to the strong members of the auto framework. Linkage 30 may be used to connect the closure-shield A1 to the top of the hinged backing of the front seat. The closure A3 may also be linked to a back of a front seat section. Closures A1 and A3 may be unlatched, then tilted with the back sections of the front seats to allow access to and from the rear seats. When the closures

A1 and A3 are in their latched position, they restrain, with linkage 30, the backs of the front seat from folding during a sudden stop. The closures may be mounted high enough above the auto floor to allow space below them for feet of the passengers. A gap is left above the closures to allow the closures to spread as they yield and flatten under impacts. The slotted plates 29 allow this expanding movement. With the arrangement shown, the sides 1*r* transmit the arch thrust of shells 1*p* to the hinges and latches, as was described for the door shown in Figure 1, when it was to be mounted in a weak wall. The closure-shields, such as A1, are most effective to prevent injury when they yield considerably, since they slow down a person's body that has been hurled against it. Therefore more yielding movement is allowed for in these closure-shields than in the door shown in Figure 1. Deeper bows to the shells 1*p* make them more useful.

The closure-shields A1, A2 and A3 are positioned so that the middle ordinate of the bow of the shell, that is the deepest part of the bow, is centered where the force of the thrust is greatest from the midsection of a person's body striking it. This is an advantage as the bowed shell can yield a further distance in this vicinity. Thus it can more effectively ease the person to a stop. The arch of the shell is strongest when the thrust against it is the greatest. As the shell yields and resists the thrust against it, it flattens to a degree. Thus the shell spends its strong shape as it slows down and reacts against the force of the person bearing against it. The slots in plates 29 are sloped to allow forward yielding movement. The legs and feet of people weigh much less than the torso, thus the forward forces of legs and feet can be restrained with less yielding of the shell 1*p* where they bear.

The shell 1*p* may be one piece or it may be two or more pieces that are fastened together. The shell 1*p* would be most useful if at least the upper part has a transparent area to allow all of the occupants of the car to see through it. The protective characteristics of the closure-shields A1, A2 and A3 may be increased by adding padding 31, such as that made of foam rubber, with suitable covering. The padding 31 may be fastened to the non-transparent convex surfaces of the shells 1*p*. A slightly yieldable transparent curved plastic shell or blister 32 may be fastened to the shell 1*p*. The shell 32 would yield to an extent to a person's facial features to more effectively cushion the face to prevent or lessen injury as the face is forced by momentum to bear against the shell. The shell or blister 32 may have slightly yieldable closed ends to make an air-filled cushion that would be more effective in reducing injury. The air-filled blister 32 may be filled with dry compressed air or gas to add to its effectiveness. The non-transparent part of the shell 1*p* may be made of stronger material than can be used for the yieldable transparent areas. Reinforced plastic may be used, or metal may be used for the lower part of shell 1*p*. A metal part of a shell may have straight ribs fastened to it for strengthening it. When such ribs are on the convex side of the shell, they would be covered with padding 31. Since the shell 1*p* would have a tendency to buckle under the impact of a person's body against it, a tubular strut 33 may be fastened between the ribs C to reduce the buckling tendency. The strut 33 would allow the use of a thinner, more yieldable shell 1*p*. The adjacent ribs C of the adjacent closure-shields may be doweled or latched together to make them act together, to distribute the impacts.

The closure-shields A1, A2 and A3 act together as a diaphragm at the center of an automobile to resist the buckling effects of a side thrust from a car colliding into its side.

The forward interior part of the auto has closure-shields A4 and A5, which are similar to closure-shields A1, A2 and A3. There may be curved doors 34*a* and 35*b* in the closure-shields A4 and A5. The doors 34*a* may be opaque and they may be padded. These doors allow access for cleaning the windshield and access to the glove compartment, radio, heater controls and the like. The doors 34*b* may be transparent to allow the driver to view the instrument panel indicators. The doors 34*b* also allow access for cleaning the windshield and such. The steering wheel column 35 may pass through a slot in the shell of the closure-shield A5. The two closures A4 and A5 allow the opaque ribs and splices to be at the center where they are not highly objectionable. A single closure as large as closures A4 and A5 combined may be used.

Side closure-shields or barriers A6 may be built into the doors to protect the occupants when an auto skids broadside and collides or rolls over in that direction. The rear closure-shields A7 would be similar to shields A6, except that on a two-door sedan they would be attached to the auto body. The closure-shields or barriers A8 on the exterior of the auto doors act to protect the occupants as these closures cushion and resist impacts on their convex surfaces during collisions and roll-overs. The closure-shields A6 and A8 are shown as they may be made for attaching to existing autos and for future autos, these closure-shields may be combined to form double bowed yieldable auto doors that are capable of yielding and then resisting violent thrusts on both sides.

The barriers A9 may be fastened to the sides of the auto, also at the ends. They may cover only the lower parts of the auto or they may be made larger to cover more surface such as do the closures A8.

A closure-shield A10 may be used instead of or along with a conventional windshield. It would project the occupants of the auto against missile-like objects that may be hurled against the exterior of the closure. During collisions, objects are torn loose from the opposing auto and hurled by the momentum to the other car. Such a closure as A10 would be useful in times of riots and warfare to resist the forces of missiles thrown against it manually or by the force of explosions and the like.

Barriers A11 and A12 would offer protection for the occupants of convertible type autos as well as those with strong tops. These barriers would cushion and restrain persons who are hurled against the ceiling during roll-overs, collisions and when bumps in the roadway cause them to hit the ceiling. The floors of autos may also have these barriers for protection during roll-overs.

The barrier A13 along the exterior topside of a vehicle would cushion and absorb most of the impact from roll-overs, thus preventing serious injury to the passengers and preventing serious damage to the auto.

Barriers such as A11, A12 and A13 may be used effectively when they have both side edges of the shells slidably latched, with the ties T2 anchored to the auto body.

Convertible autos with the tops retracted may use vertical barriers or closures similar to A1 to A10 inclusive by rigging the closure tops to the auto body with wires and struts (not shown).

Thus barriers may be attached in and on autos and the like, to prevent people from being maimed and killed and to prevent property damage. The steering wheel and column are the only non-shielded objects that are likely to cause injury and death. There are known means to make these yield during collisions.

Thus it will be seen that I have provided an efficient and strong curved safety barrier or closure element, in the form of a door, shutter, barricade or the like, which provides optimum strength for a given weight, and which, by curvature of panel and yieldable ribs and ties makes it possible to cushion and stop violent forces; also, I have provided novel ribs for such closure element which have spaced anchoring points across the width of the closure element, and between which anchoring points a small space is provided between the curved panel of the door and ribs so as to permit free outward or inward bowing of the panel portions, such as caused

by temperature or humidity changes, thereby providing uniform distribution across the width of the closure element of such bowing. Additionally, I have provided a closure element which may be made of plastic or other suitable materials and which may be provided with a resilient sealing material about its perimeter and the interior of which may be filled with insulating material.

While I have illustrated and described several specific embodiments of my invention, it will be understood that these are by way of illustration only, and that various changes and modifications may be made within the contemplation of my invention and within the scope of the following claims.

I claim:

1. A yieldable barrier comprising an outwardly curved thin panel, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, to permit said device to expand in width when pressure is applied to its convex surface; and a plurality of stiffening members extending transversely across said panel along arcuate paths immediately adjacent the inner surface of said panel, said stiffening members each comprising a plurality of elements disposed in end-to-end pivotal relationship.

2. A yieldable barrier comprising an outwardly curved thin panel, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, to permit said device to expand in width when pressure is applied to its convex surface, stiffening members extending transversely across said panel along arcuate paths adjacent the inner surface of said panel, said stiffening members each comprising a plurality of links pivotally connected together in end-to-end relationship, to allow yieldable stiffening and maintenance of an arc shape by said panel.

3. A yieldable barrier comprising an outwardly curved panel, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, to permit said device to expand in width when pressure is applied to its convex surface, a plurality of transversely extending stiffening members secured to said panel in spaced parallel relationship, each of said stiffening members comprising a plurality of pivotally interconnected links, said links having projecting portions normally in abutment to limit abnormal outward movements of said links and permitting inward movement of said links when said panel is flexed inwardly.

4. A yieldable barrier comprising a thin, outwardly bowed panel of substantially rectangular shape and bowed across the width of the panel, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, to permit said device to expand in width when pressure is applied to its convex surface, stiffening members comprising a plurality of pivotally interconnected links, said links having projecting end portions normally in abutment to limit abnormal outward movements of said links and permitting inward movement of said links when said panel is flexed inwardly, said stiffening members being connected to said panel in at least one intermediate point.

5. A yieldable barrier comprising an outwardly bowed panel, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, to permit said device to expand in width when pressure is applied to its convex surface, a plurality of stiffening members extending transversely across said panel along arcuate paths adjacent the inner surface of said panel, said stiffening members each comprising a plurality of links pivotally connected together in end-to-end relationship, to allow yieldable stiffening and maintenance of an arc shape by said panel, and a flat panel spanning the concaved face of said panel.

6. A yieldable barrier comprising an outwardly curved thin panel, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, to permit said device to expand in width when pressure is applied to its convex surface, a plurality of stiffening members extending transversely across said panel along arcuate paths adjacent the inner surface of said panel, said stiffening members each comprising a plurality of links pivotally connected together in end-to-end relationship, to allow yieldable stiffening and maintenance of an arc shape by said panel, and a strip of resilient material surrounding the perimeter of said outwardly curved panel.

7. A yieldable barrier as recited in claim 1 wherein said panel has a transparent portion.

8. A yieldable barrier as recited in claim 2 wherein said panel is of plastic material.

9. A yieldable barrier as recited in claim 5 wherein insulating material is provided in the space between said flat panel and said outwardly bowed panel.

10. A yieldable barrier as recited in claim 2, together with a pair of hinges of yieldable material for hinging said barrier to an opening in a building wall so as to allow an edge of the barrier to bear against an edge of said opening.

11. A yieldable barrier as recited in claim 1 together with an outer layer of padding on said panel.

12. A yieldable barrier as recited in claim 2 together with a second outwardly curved thin panel of smaller radius than, and disposed on the outer surface of, said first mentioned panel.

13. A yieldable barrier as recited in claim 12 wherein said second panel and the confronting portion of said first panel are of transparent material.

14. In a vehicle having a body enclosing a compartment for occupants, a safety cushioning device secured to said body having a yieldable barrier comprising a curved thin panel in confronting relationship with said compartment, a yieldable tie whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, said body including spaced bearing means for said panel extremities, at least one of which allows relative sliding movement with one of said panel extremities to permit said device to expand in width when pressure is applied to its convex surface; and a stiffening member extending transversely across said panel along an arcuate path adjacent the inner surface of said panel, said stiffening member comprising a plurality of elements disposed in end-to-end pivotal relationship.

15. In combination with a body portion of a motor driven vehicle including driver and passenger compartments, a safety cushion device disposed immediately in front of an exposed portion of one of said compartments and comprising a yieldable barrier having an inwardly curved thin panel disposed so that its convex portion confronts said last mentioned compartment, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, said body having substantially vertically spaced bearing means for said extremities, at least one of which bearing means allows relative, substantially vertical sliding movement with one of said extremities to permit said device to expand in width when pressure is applied to its convex surface, stiffening members extending transversely across said panel along arcuate paths adjacent the inner surface of said panel, said stiffening members each comprising a plurality of links pivotally connected together in end-to-end relationship, to allow yieldable stiffening and maintenance of an arc shape by said panel.

16. In an automotive vehicle, a body portion in combination with a yieldable barrier secured to the exterior of said body portion and having an outwardly curved thin panel mounted on said body portion in confronting relationship with a compartment for occupants, a plurality of yieldable tie elements whose extremities are

fastened adjacent the extremities of said panel on opposite sides thereof, said body including spaced bearing means for said panel extremities, at least one of which bearing means allows relative sliding movement with one of said panel extremities to permit said device to expand in width when pressure is applied to its convex surface; and a plurality of stiffening members extending transversely across said panel along arcuate paths immediately adjacent the inner surface of said panel, said stiffening members each comprising a plurality of yieldable elements disposed in end-to-end pivotal relationship.

17. In combination with an automobile having driver and passenger compartments separated by a yieldable barrier mounted on said body and located rearwardly of the driver's seat and comprising an outwardly curved thin panel extending in a rearward direction, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, to permit said device to expand in width when pressure is applied to its convex surface; and a plurality of stiffening members extending transversely across said panel along arcuate paths immediately adjacent the inner surface of said panel, said stiffening members each comprising a plurality of links disposed in end-to-end pivotal relationship.

18. A closure element consisting of a yieldable barrier comprising an outwardly curved thin panel, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, to permit said device to expand in width when pressure is applied to its convex surface; and a plurality of stiffening members extending transversely across said panel along arcuate paths immediately adjacent the inner surface of said panel, said stiffening members each comprising a plurality of elements disposed in end-to-end pivotal relationship.

19. A door comprising an outwardly curved thin panel, a plurality of yieldable tie elements whose extremities are fastened adjacent the extremities of said panel on opposite sides thereof, to permit said device to expand in width when pressure is applied to its convex surface stiffening members extending transversely across said panel along arcuate paths adjacent the inner surface of said panel, said stiffening members each comprising a plurality of links pivotally connected together in end-to-end relationship, to allow yieldable stiffening and maintenance of an arc shape by said panel.

20. A yieldable barrier comprising an outwardly curved thin panel, yieldable means cooperable with an extremity of said panel to permit said barrier to yieldably expand in width when pressure is applied to its convex surface; and stiffening means extending transversely across said panel along an arcuate path immediately adjacent the inner surface of said panel, said stiffening means comprising a plurality of portions disposed in end-to-end pivotal relationship.

21. A yieldable barrier for mounting on a conveyance body for protecting occupants in a compartment thereof, comprising a thin panel of convex shape, yieldable means at one of the extremities of said panel to permit said panel to yieldably expand in width when pressure is applied to its convex surface, and stiffening means comprising a plurality of yieldable support points in spaced relationship transversely across said panel on the concave side thereof and positioned to limit the extent of radially inward movement of portions of said panel, whereby the panel is prevented from collapsing and the substantially convex curvature of the panel is maintained even after collision of an object against the convex surface.

22. A yieldable barrier as recited in claim 21 wherein at least a portion of said barrier is of transparent material to permit viewing therethrough.

23. A yieldable barrier as recited in claim 21 wherein said convex surface confronts the interior of said compartment and wherein said conveyance body includes bearing means for engaging said one of the extremities of said panel to permit relative movement therebetween and so as to maintain said substantially convex curvature of said panel even during said collision.

24. A yieldable barrier as recited in claim 21 wherein said convex surface projects outwardly of said compartment and wherein said conveyance body includes bearing means for engaging said one of the extremities of said panel to permit relative movement therebetween and so as to maintain said substantially convex curvature of said panel even during said collision.

25. A yieldable barrier as recited in claim 21 wherein said conveyance body includes bearing means adjacent the roof of said compartment against which said one of said extremities of said panel is slidable in a substantially vertical direction, the other of the extremities of said panel being rigidly secured to a point near and above the floor of said compartment, said convex surface confronting the interior of said compartment, whereby occupants will be thrown thereagainst in the event of a collision but without substantially altering said convex curvature.

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