

March 13, 1962

W. W. BIRD

3,024,796

AIR SUPPORTED STRUCTURES

Filed April 18, 1958

2 Sheets-Sheet 1

FIG. 1

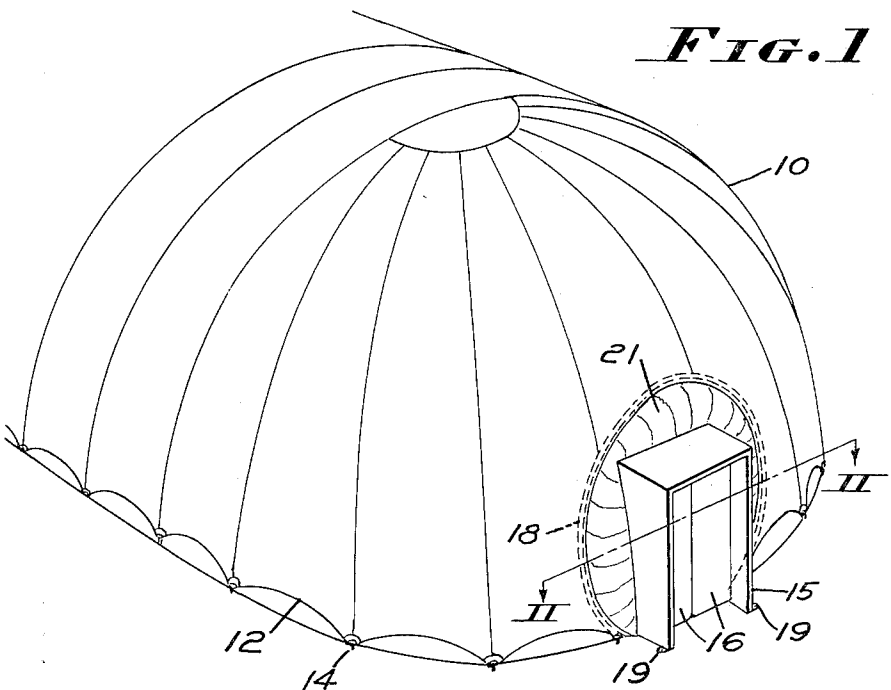


FIG. 2

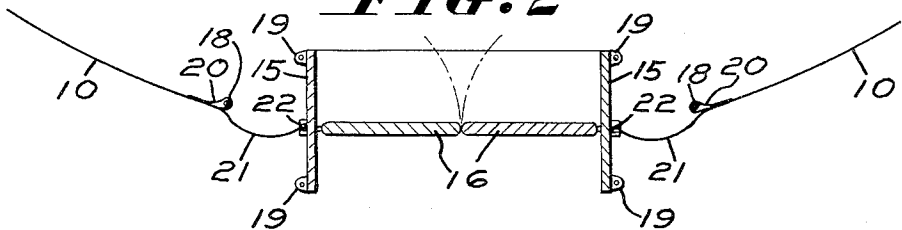
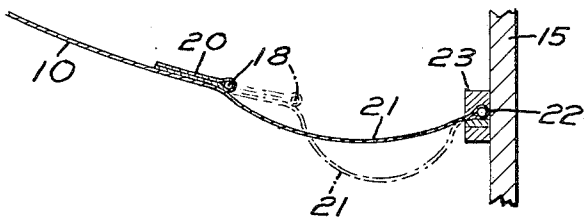


FIG. 3



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FIG. 4

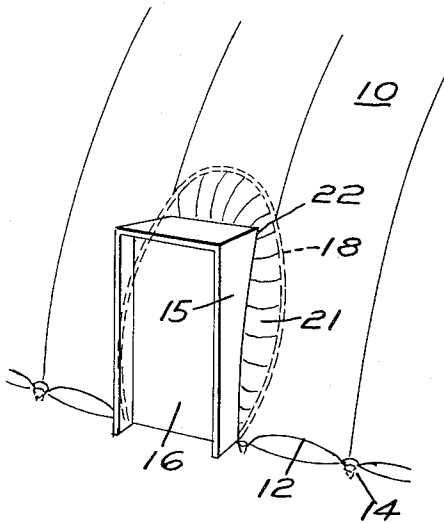


FIG. 6

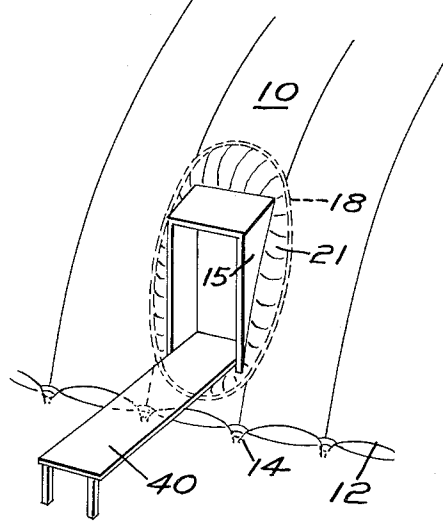


FIG. 5

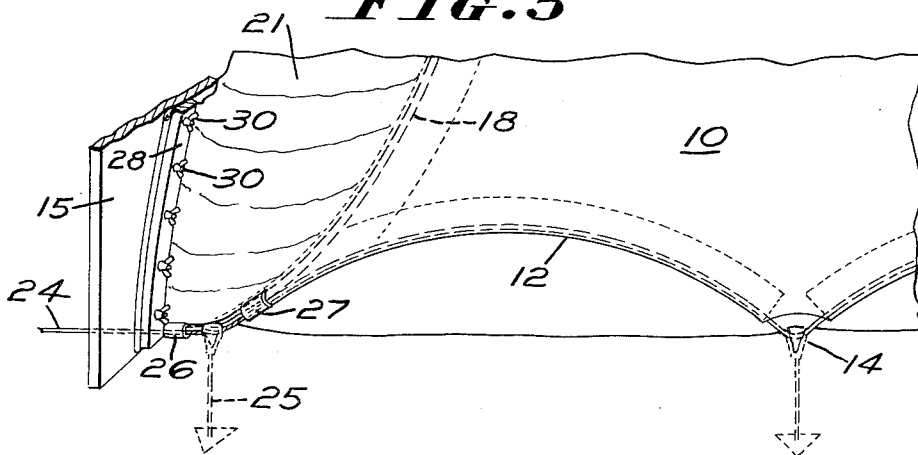


FIG. 7

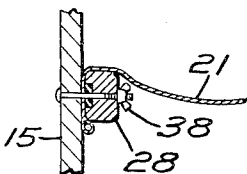


FIG. 8

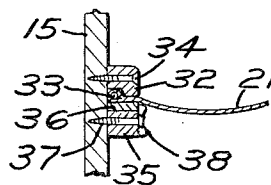
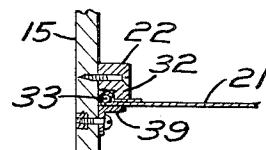


FIG. 9



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AIR SUPPORTED STRUCTURES

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4 Claims. (Cl. 135-1)

This invention relates to air supported and other types of portable structures constructed of flexible fabric or similar material, and more particularly to an improved doorway or other opening arrangement.

A primary object, for example, is to provide improved means for reinforcing a flexible envelope adjacent to an opening, such as around a doorway or other cutouts, in such manner as to prevent stress concentrations in the envelope material due to distortion of the envelope form. A further object is to provide improved means for relieving loads transferred to a rigid door frame or the like as a result of movements of the flexible envelope, for example, under windy conditions. A further objective is to provide an extremely simple, portable, air and water tight installation unit which is applicable as a standard item to an inflated structure, and which is adapted to accommodate a wide variety of door sizes and configurations; and which will permit installation and disassembly and transport of the structure in minimum time. Other objects and advantages of this invention will appear in the specifications hereinafter wherein the accompanying drawings are identified as follows:

FIG. 1 is a perspective view showing a typical installation of a door in accord with subject invention, in a spherical wall portion of an air supported building;

FIG. 2 is a fragmentary section on enlarged scale as along line II—II of FIG. 1;

FIG. 3 is an enlarged detail of FIG. 2 diagrammatically illustrating how the envelope structure can distort without applying appreciable load to the door frame;

FIG. 4 illustrates a similar installation of a door in a cylindrical sidewall section of an air supported building;

FIG. 5 is a fragmentary perspective view showing door arrangement details;

FIG. 6 is a view similar to FIG. 4, but of a modified arrangement;

FIGS. 7, 8, 9, illustrate several possible methods of attaching the closing skirt to the door frame in order to provide an air and weather tight connection.

Because air inflated structures distort under wind loads, it is desirable that attachments of such structures to stationary or rigid objects, such as at entrance ways or interconnecting structures, be made in such manner as to avoid concentrations of load which would damage the fabric or the connecting structures and possibly result in destruction of the building. It is particularly important that such distortion of the structure be allowed for in making such attachments. Because such distortions are minimum in any spherical wall portion of a building, this is the preferred location for doors and other cutouts. However, even in this section, the structure may distort appreciably in high winds and such distortions have previously resulted in excessive concentrations of load both on the envelope and on the rigid structure to which it is attached. The cylindrical side sections of an air supported structure will tend to distort a great deal more than do the spherical ends and therefore it is of even greater importance to provide redistribution of load, to avoid stress concentrations in this area.

The present invention provides a means of collecting and redistributing the loads in the envelope of an air supported structure in a simple but effective manner by employing a cable or other relatively strong, flexible, load carrying member to reinforce the opening in the

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envelope in a manner such that the normal fabric loads can be picked up by the cable and carried around the opening. Because of variations in the loads developed in different areas of the structure, the load transfer cable must be differently shaped to perform effectively in accord with the present invention. The present invention contemplates provision of a cable shaped to complement the normal load distribution in the envelope fabric in the area of the cable installation. For example, in spherically shaped wall portions, the normal inflation pressure results in a uniform load, and an approximately circular cable shape is required to provide equilibrium conditions. For similar reasons, for surfaces with compound curvatures the cable shape must be varied in accordance with the normal fabric loading in the principal planes of stress. In cylindrically shaped portions, the load in the vertical direction is twice that in the horizontal direction and hence the reinforcing cable must have a shape approximately that of a 2:1 ellipse in order to maintain equilibrium conditions. Furthermore, it is also necessary to inter-connect the cabled section and rigid structure with a flexible diaphragm which will allow the envelope to move relative to rigid structure without substantial transfer of load.

In accord with this invention, therefore, by way of one example a cable or the like may be encased in a fabric sleeve which is bonded directly to the envelope in a manner such that the cable picks up full envelope loads; the cable being thereby fixed to the envelope in a shape that most closely corresponds to the local equilibrium condition of envelope stress under its normal loading. In order to accommodate the distortion due to the aerodynamic loads superimposed on top of the normal loading, the closing diaphragm between the cable section and the rigid door structure is cut at the corners and shaped to provide an oversized skirt which flexibly encloses the area between the cabled opening and the door frame, without transfer of any appreciable load to the rigid door frame. The smooth curvature of the cabled section permits the redistribution of load in the envelope to take place without any appreciable concentration of stress, thus minimizing any problem of load concentration which would be likely to cause local failure of the envelope.

If the stationary structure connected to the envelope does not extend to the ground in the plane of the envelope, an endless cable can be used as shown in FIG. 5 which illustrates an opening of the type such as may be used to accommodate an elevated track or conveyor or similar type of device. Where the door or opening is required to be flush with the ground and the cable terminates at ground level, it is necessary that a ground attachment be provided which is able to carry the cable loads and transfer them across the opening into the ground. One method of attaching the cable is illustrated in FIG. 6. Several methods of making attachments of the skirt to the stationary structure are illustrated in FIGS. 7, 8 and 9.

As stated hereinabove, a primary objective of this invention is to permit the installation of doors and like equipment of a variety of shapes within a given opening, thus permitting standardization of the structure and allowing a considerable degree of versatility.

Thus, for example, as shown in FIG. 1, the invention may be embodied in an air inflated structure comprising generally a fabric envelope 10, such as includes a spherically shaped end portion of a generally cylindrically shaped air inflated building. An anchor cable, as indicated at 12, is enclosed within a bottom edge seam portion of the lower margin of the envelope 10, and at intervals therearound is anchored to the ground as indicated at 14 by any suitable tie-down devices. The en-

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velope 10 is provided with an access door arrangement comprising a framed enclosure 15, into which are mounted the access doors 16. The entire door framing assembly is enclosed by a cable 18, which is encased in a fabric sleeve 20 and is bonded to the envelope 10 in a manner such that it can pick up and redistribute the loads imposed thereon as shown in FIG. 2. The flexible skirt 21 between the reinforcing cable 18, and the door framing members 15, is cut and patterned so as to billow out from the normal envelope contour and is shaped so as to permit relative movement between the envelope and door framing as shown in FIG. 3. The inner edge of the skirt 21 is attached to the door enclosure 15 by providing a roped edge 22 (FIG. 3) which can be clamped to the door framing member by means of grip blocks 23 or by any other suitable means of attachment.

Where an access door is located in the cylindrical side section of the building, the reinforcing cable is installed in an elliptical shape having a height to width ratio of approximately 2:1 as illustrated in FIG. 4. In this case, as in the case where the entrance door is located in a spherical section, the skirt 21 between the reinforcing cable 18 and door framing 15, is shaped and patterned so as to allow relative movement between the envelope and door framing without resulting in substantial transfer of load to the door framing members. In order to pick up and transfer the loads in the door reinforcing cable 18 and lower skirt catenary cable 12 at the door opening, continuity must be provided by carrying a cable portion 24 across under the door as illustrated in FIG. 5 and by providing an anchor 25 connected to the intersection of the cables 18, 12 and 24 to carry the vertical component of load necessary to provide stability. Collars 26 and 27 are used to join the cables to provide necessary transfer of load. An alternate method of attaching the skirt 21 to the door framing member 15 is illustrated in FIG. 5 and comprises a clamping strip 28 which is clamped down on the marginal edge of the skirt and is secured by bolts and wing nuts 30 to clamp the skirt tightly against the door enclosure 15. A section of this attachment is shown in FIG. 7.

Alternate methods of making an attachment between the envelope and door framing members are shown in FIGS. 8 and 9. For example, in FIG. 8, a strip 32 made of wood or metal and internally grooved as shown to accommodate the roped edge 33 of the skirt 21 is shaped to correspond to the envelope intersection on the door framing member and is securely attached to the door enclosure by screws 34. A second strip 35 is shaped to correspond to that of 32 and spaced out away from 32 sufficient to allow insertion of strip 36, the strip 35 being permanently joined to the door enclosure member by means of screws 37 or other suitable attachment devices. The skirt member 21 is secured to the door enclosure simply by inserting strip 36 into place. As tension on the skirt, tending to pull the rope edge out of place is exerted against the grooved edge of members 32, there is no load delivered to strip 36 such as to cause it to come out of place, and the attachment device is capable of carrying relatively high loads. Thumb nut 38 is used to prevent strip 36 from being accidentally dislodged.

The method of attachment shown in FIG. 9 employs a strip 32 having a groove section similar to that shown in FIG. 8. In this case, a small angle 39 is pressed back against the rope edge of the skirt 21 to secure it in place. The angle is secured in position by dowels, top and bottom, which position it and by screws or bolts as illustrated.

The framed enclosure 15 is preferably anchored to the ground or base mounting platform in any suitable manner as indicated at 19 (FIG. 2) so as to hold it securely in position. A floor sill may or may not be employed as preferred and one or more door panels, as indicated at 16 hingedly carried by the framed enclosure 15, may

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be used. In order to transfer the load carried in the reinforcement cable 18, and in the anchor cables 12 where they join and terminate adjacent to the door frame, provision must be made to transfer this load into the base structure, either by attaching the cables to a suitable connection on the framed enclosure 15, which is in turn attached to the ground, or by carrying the cable across under the door enclosure as illustrated in FIG. 5 and by employing a ground anchor identical to that used for securing the envelope 10, to the ground to resist the vertical component of load. The door arrangement as described thus provides a convenient, relatively air tight door and framing enclosure, secured to the ground but joined to the envelope in such a manner as to permit movement of the envelope relative to the framing as required to avoid transfer of any substantial load from the envelope to the door enclosure, thus assuring a uniform distribution of load into the envelope and the avoidance of stress concentrations which would be likely to lead to failure of the fabric and possibly ultimate destruction of the building. Thus, in addition to allowing the desired relative movement of the envelope to the framed enclosure, the basic stress in this element is kept small so that the attachment to the enclosure is not structurally critical.

FIG. 6 illustrates the application of the principles of the present invention to a cylindrically shaped side wall section of the structure where the framed enclosure is not mounted flush with the ground so as to accommodate a raised walkway or conveyor, the reinforcing cable 18 may be endless. As illustrated in FIG. 6, the reinforcing cable 18 is again bonded to the envelope with an elliptical shape having a height to width ratio of approximately 2:1. The framed enclosure 15 is supported from the ground or base of structure inside of the envelope and has one edge of the enclosure projecting out through the envelope to provide an entrance through which packages or other materials may be passed by means of a ramp 40 or other type of conveyor.

I claim:

1. In combination, an air inflated flexible wall structure including a curving wall portion subjected to flexing movement responsive to loadings applied to the structure, a rigid structural component disposed in positionally anchored relation adjacent said wall portion, and means providing connection between said rigid component and said structure comprising a flexible skirt device substantially surrounding said rigid component and fixed thereto in substantially air tight relation and extending therefrom into connection with said air inflated structure, the connection between said skirt member and said air inflated structure being provided at a wall portion of said air inflated structure and including a flexible cable fixed to the wall portion and adapted to flex therewith and shaped to complement the load distribution pattern in said inflated structure at that area, said skirt element being flexible to permit said air inflated structure and said flexible cable to move relative to said rigid component without transfer of substantial loads thereto, the fixed connection between said skirt and said rigid component being provided by an undercut grooved molding fixed to said rigid component, said skirt having a bead integral therewith at its edge and adapted to lie in the undercut portion of said groove, and a locking strip slip-fitting into said groove thereby preventing withdrawal of said bead portion from the groove.

2. In combination, an air inflated flexible wall structure including a curving wall portion subjected to flexing movement responsive to loadings applied to the structure, a positionally stationary structural component disposed in positionally anchored relation adjacent said wall portion, and means providing open communication between said stationary component and the interior of said structure comprising a flexible skirt device substantially surrounding said stationary component and fixed thereto in substantial-

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ly air tight relation by a two-piece molding device and extending therefrom into connection with said air inflated structure, the connection between said skirt member and said air inflated structure being provided at an apertured wall portion of said air inflated structure and including a flexible cable fixed to the marginal edge adjacent the aperture therein and adapted to flex therewith and shaped to complement the load distribution pattern in said inflated structure in the region of said aperture, said skirt element being flexible to permit said air inflated structure and said flexible cable to move relative to said stationary component without transfer of substantial loads thereto.

3. In an air-inflated structure comprising an inflation-tensioned and load sustaining flexible wall structure of predetermined shape provided with an opening, an elongate, flexible tension member for uniformly relieving tension in said wall structure around said opening to avoid any substantial stress concentration in the wall structure adjacent such tension member outwardly of the opening, said tension member being connected to and forming an integral part of said wall structure to be tensioned thereby when the wall structure is inflated, said tension member being fixed relative to said wall structure in such geometric shape relevant to said predetermined shape of the wall structure as to maintain substantially the same dis-

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tribution of stress within that region of the wall structure immediately adjacent the tension member as that resulting from inflation of the wall structure, and said tension member being free to flex and change shape in accommodation with changes in load distribution pattern in the wall structure as occasioned by weather loads thereon, a structural component disposed in positionally anchored relation adjacent said opening in the wall structure, and means sealingly interconnecting said wall structure around said opening and said structural component while permitting relative movement therebetween without substantial stress transfer from one to the other.

4. The combination defined in claim 3 wherein said means is a flexible skirt extending widthwise between said wall structure and said structural component and being of substantially greater width than the distance between its points of attachment thereto so as to balloon therebetween.

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