

April 26, 1966

W. W. BIRD

3,247,627

DUAL WALL AIR INFLATED STRUCTURE

Original Filed Sept. 25, 1962

3 Sheets-Sheet 1

FIG. 1

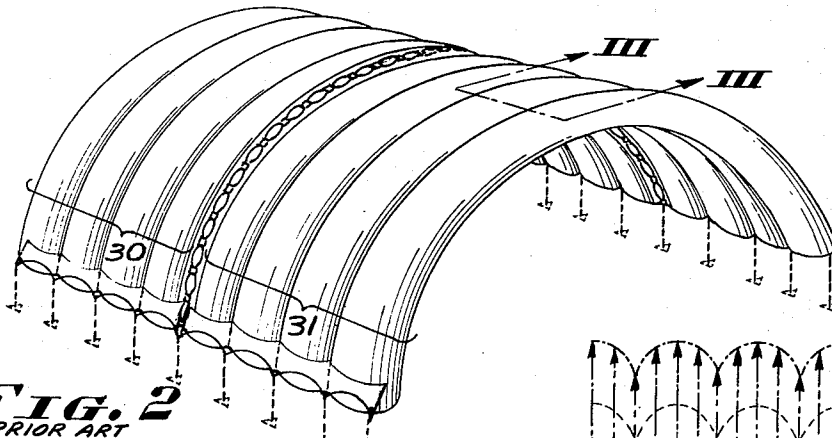


FIG. 2
PRIOR ART

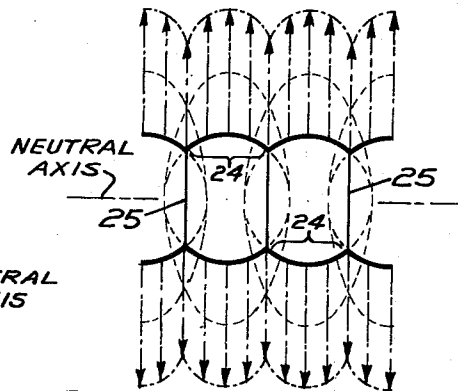
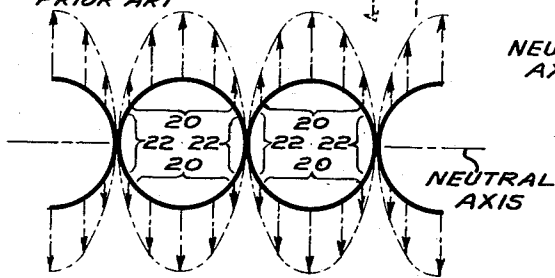


FIG. 2A

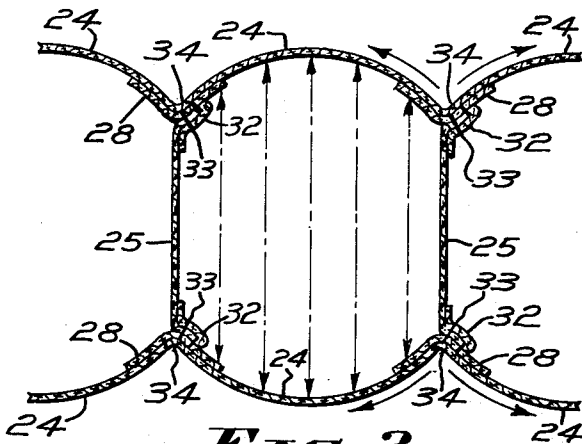


FIG. 3

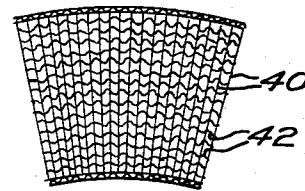


FIG. 4

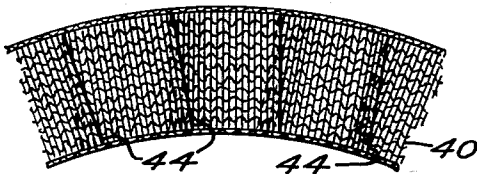


FIG. 5

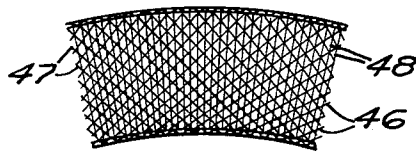


FIG. 6

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FIG. 7

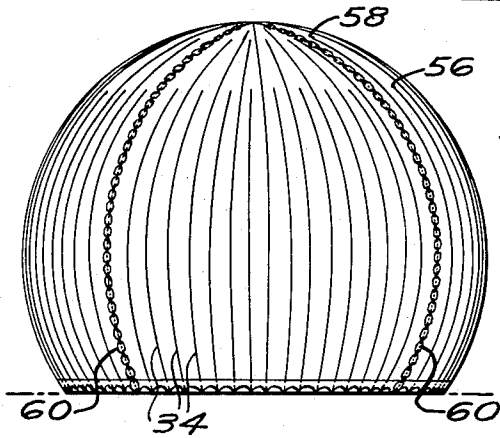


FIG. 8

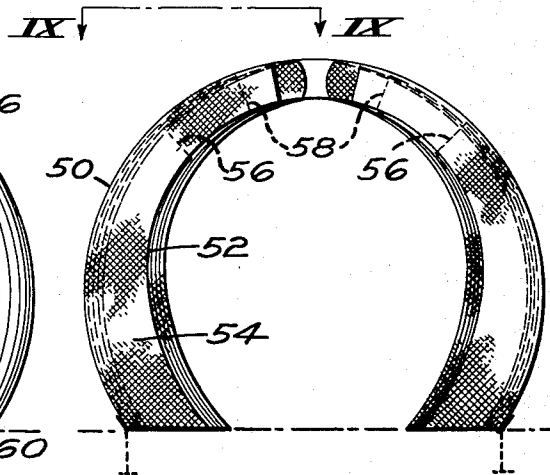


FIG. 9

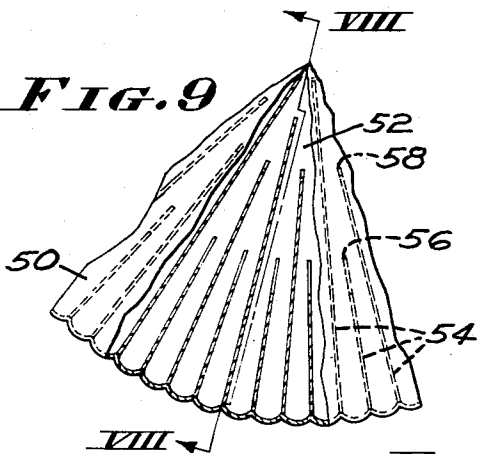


FIG. 10

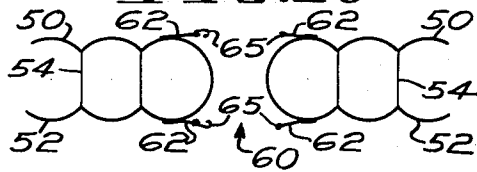


FIG. 11

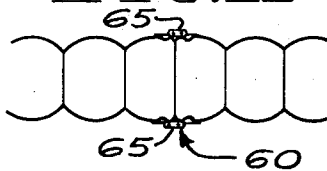


FIG. 13

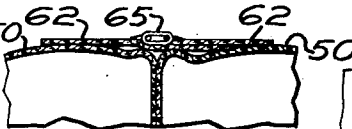


FIG. 14

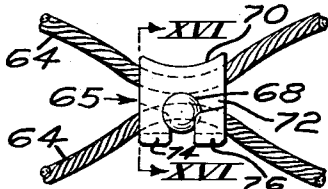


FIG. 15

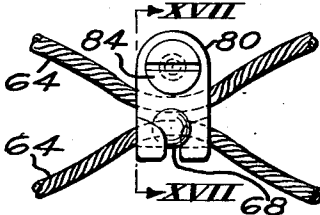


FIG. 16



FIG. 17

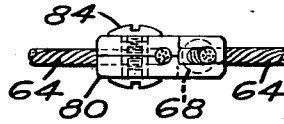
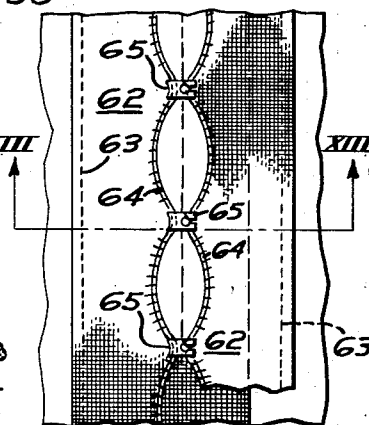


FIG. 12



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Fig. 18

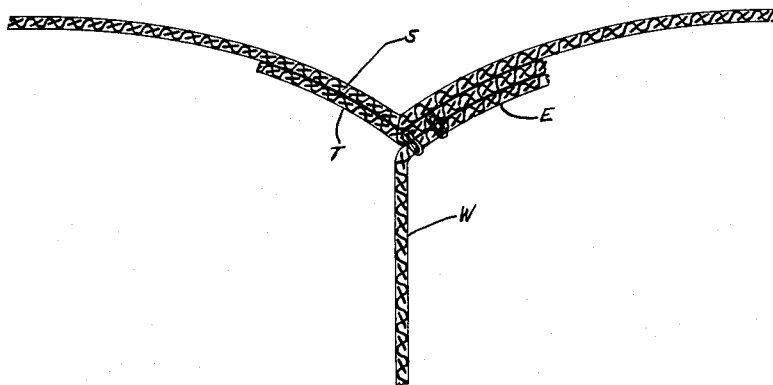
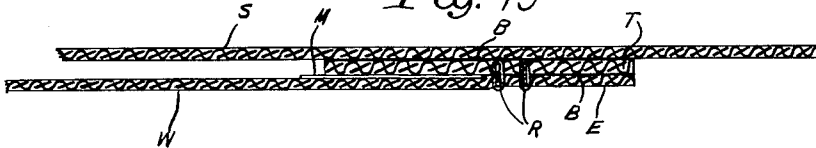


Fig. 19



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DUAL WALL AIR INFLATED STRUCTURE

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Continuation of application Ser. No. 229,253, Sept. 25, 1962. This application Apr. 26, 1965, Ser. No. 453,875
18 Claims. (Cl. 52-2)

This invention relates to structural members, building structures and the like and, more particularly, the present invention is concerned with certain improvements in inflatable members, structures and the like wherein greater efficiency tending toward greater practicability and economy is realized as compared with prior art structures. This application is a continuation of my copending application Serial No. 229,253, filed September 25, 1962, a continuation-in-part of application Serial No. 709,025, filed January 15, 1958, both now abandoned.

This invention is principally concerned with increasing the efficiency and reducing the fabrication cost of dual wall air inflated structures. This primary objective is achieved by controlling the shape of a dual wall air inflated structure while simultaneously controlling the inflation-induced tension therein in a specific and particular fashion related to the controlled shape. In this manner, and according to the present invention, the materials used in fabricating the structure are utilized to maximum effectiveness while, concurrently therewith, the cost of manufacture is materially reduced as compared with prior art structures. Generally speaking, the specific manner of obtaining the beneficial results of this invention involves the method and means by which the inner and outer flexible skin elements of a dual wall structure are joined, such being effected by web elements which not only constrain the skin elements to assume a transversely corrugated form but also permit tensioning of the skin elements to a greater degree in the longitudinal direction. Accordingly, these two factors interact to substantially rigidify the structure in the longitudinal direction. Further, the web means according to this invention permits a longitudinal bow or arch to be imparted to the structure, thus additionally increasing its longitudinal rigidity and all without requiring exotic and expensive fabrication techniques.

In accord with this invention, in addition to forming the envelope of valleyed configuration and permitting of greater longitudinal tension in the skin or envelope, the web means readily permits the sections to be formed with a desired curvature or arch without requiring involved and expensive fabrication techniques.

A further object of this invention resides in novel means for joining the web means to the skin members, the joining being accomplished by means forming a strong joint, obviating the necessity for puncture of the skin members, and permitting of natural shaping of the structure without unduly stressing the joining means.

It is an object of the present invention to provide improvements in building constructions as aforesaid such as are suitable for use in large air-supported buildings of the hangar or other types. Another object of the invention is to provide improvements in the construction of hangar-like structures or the like, in which flexible fabric or film or sheet materials of low air permeability is employed and maintained in erect state by air pressure interiorly thereof. The features of the present invention are particularly applicable to construction of relatively large structures in sub-assembled sectional form subsequently relatively assembled by interconnection means as will be described hereinafter.

Generally stated, the present invention contemplates an improved form of structure as aforesaid, and a method

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of assembling the components of an air supported structure which provides a structurally more efficient utilization of the structural materials used, while at the same time being a more economical method of construction, particularly well adapted to the building of large structures.

Air inflated members are capable of resisting bending load only to the degree to which they are pre-tensioned by the inflation pressure. The comprehensive load due to bending is thus resisted by the pre-tension in the compressed element. For maximum efficiency, the inflation pressure should provide the maximum amount of pre-tension in that portion of the material subjected to compressive loading.

5 An air inflated member inherently tends to assume a circular cross sectional form because this form represents an equilibrium condition. In generally cylindrical members the inflation pressure results in hoop tension having a value approximately twice that of the tension in the longitudinal direction. The ability of such a member to resist bending load is thus essentially limited to the pre-tension in the longitudinal direction at the point furthest from the bending axes of the member. When this value of pre-tension is reached in bending, the member will start to buckle. The pre-tension existing in the sides of the tube in the zones of intersection by the bending axis has little influence on the bending stiffness of the member although a large proportion of the inflation pressure is consumed in pre-tensioning this area. The present invention provides a method of designing an inflatable structure which results in pretensioning of the elements furthest from the neutral axis to values approximately double the pre-tension loads imposed upon the corresponding elements of a similar conventional tube structure under equal inflation pressures.

Thus, in accord with the present invention there is provided a structure employing less material which will support a much higher load; and the invention is applicable for example to replace conventional dual wall or multiple tube constructions, with increased efficiency.

Other objects and advantages of the invention will appear from the description hereinbelow and the accompanying drawing wherein:

FIG. 1 is a perspective view of an air-stiffened hangar type structure embodying the principles of the present invention;

FIG. 2 is a sectional view through a tubular structure of the prior art illustrating diagrammatically the distribution of loads due to bending;

50 FIG. 2a is a view corresponding to FIG. 2, but illustrating the more uniform distribution of bending loads and higher load resistance offered by the present invention;

FIG. 3 is a fragmentary section, on an enlarged scale, taken along line III—III of FIG. 1;

FIGS. 4, 5 and 6 illustrate schematically a variety of web component stock materials as may be used in the structure of the invention;

FIG. 7 is a side elevational view of another form of structure of the invention;

FIG. 8 is a sectional view taken along line VIII—VIII of FIG. 9;

FIG. 9 is a fragmentary plan view taken along line IX—IX of FIG. 8, with a portion of the outer skin component of the structure removed;

FIG. 10 is a view corresponding to FIG. 3, but illustrating the mode of relative assembly of two sections of structure of the present invention;

FIG. 11 corresponds to FIG. 10 but illustrates the structure when in relatively assembled position;

FIG. 12 is an elevational view of a joint arrangement

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applicable to the connection devices of FIGS. 10 and 11;

FIG. 13 is a fragmentary sectional view taken along line XIII—XIII of FIG. 12;

FIG. 14 is an elevational view of a cable clamp or holding device such as may be used in conjunction with the construction of the invention;

FIG. 15 is a view corresponding to FIG. 14 but of another form of holding device;

FIG. 16 is a sectional view taken along line XVI—XVI of FIG. 14;

FIG. 17 is a view taken along line XVII—XVII of FIG. 15;

FIG. 18 is an enlarged sectional view taken through one of the skin elements and showing an alternate method of attaching the web structure thereto; and

FIG. 19 is a view of the assembly shown in FIG. 18 in position for heat sealing.

If structural arches having sectional forms such as illustrated in FIG. 2 herein are embodied in a structure as illustrated generally in FIG. 1, the resistances of such arches to bending deflection under wind or snow loads or the like, will be substantially limited to the tension-compression resistances of the portions designated 20—20; while the fabric sections comprising the generally side wall portions 22—22 of the tubular sections are substantially inactive and impotent with respect to assisting in resistance to such bending loads.

As distinguished from the above, the present invention contemplates a structure such as is illustrated schematically in FIG. 2a wherein the components of the structure are so shaped and relatively arranged as to provide for more efficient resistance to bending loads and deflection; the outer skin components 24—24 being interconnected by single web elements 25 functioning primarily to stabilize the unitary construction. The efficiency of this type construction is obtained by designing the webs 25 so that they take little or no load in the direction of the tension-compression loads on the outer skin components, but perform substantially only the function of cross-tying the skin components and resisting shear loads. Thus, there is provided a method of constructing an arch form such as illustrated by FIG. 1 which is structurally simplified and of reduced cost, and furthermore features positioning of the web elements (sewn or otherwise attached, as by cementing, etc.) to load transfer strips 28 which in turn are bonded to the outer skins carrying the bending loads of the structure (FIG. 3). This method permits the web and transfer strip assemblies to be more quickly and cheaply assembled as by simply cementing or vulcanizing together flat fabric pieces without the necessity of first forming curved tubes and then joining them into an assembly as in the prior art. Sewing is preferably employed only internally of the pressurized areas, wherefore the sewing perforations need not be sealed. Thus, uncoated fabric may be used for the web components if desired. The cemented or vulcanized joints between the transfer strip and outer skin components of structures of the present invention are subjected only to shear loads, and therefore no sewing thereof is required.

In the drawings herewith, FIG. 1 illustrates generally, by way of example, one form of structure embodying features of the present invention; the structure of FIG. 1 comprising a hangar type building or the like comprising a plurality of relatively joined arch or roof sections 30—31. Each sectional component of the structure of FIG. 1 comprises a novelly integrated series of parallel vertical arch components each of which is of modified tubular sectional form.

Maximum rigidity is achieved according to this invention by controlled shape of the fabric structure and controlled tension therein. Thus, as in FIG. 1, each section is (a) of corrugated form which, in and of itself, imparts increased rigidity to the structure; (b) the inner and outer skin elements 24—24, whose inflation-induced tension resists bending, are materially displaced in their

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entireties from the neutral axis (FIG. 2a); and (c) the inflation-induced tension in the inner and outer skin elements 24—24 is materially increased in the direction longitudinally of the arch sections. In each case, it will be appreciated that the result is achieved by virtue of the presence of web elements 25.

Insofar as (a) is concerned, it will be appreciated that the presence of the web members 25 effects the corrugated form of each section. That is, the web members extend completely or substantially completely in the longitudinal direction of each section and are, throughout, joined or secured along their opposite side edges to the inner, opposed surfaces of the inner and outer skin members 24—24. In this fashion, the skin elements are constrained, when inflated, to balloon between the web members to provide the corrugated effect as aforesaid.

Insofar as (b) is concerned, FIG. 2 illustrates diagrammatically the distribution of loads on a conventional tubular wall type structure for similar purposes, and demonstrates that in such a structure the peak loading in bending occurs only at the top center portion of each tube element, and drops off rapidly at the sides thereof. On the other hand, FIG. 2a illustrates diagrammatically the distribution of loadings on a structure element fabricated in accord with the present invention, wherein it will be noted that the loads are much more uniformly distributed over the entire outer envelope since the width of the web members 25 displaces the skin members 24—24 a substantial distance from the neutral axis, as shown in FIG. 2a.

Insofar as (c) is concerned, as will hereinafter appear in more detail, the web members 25 are so constructed, arranged and secured to the skin members 24—24 that when the sections are inflated, the web members offer little or no resistance to the inflating pressure in their longitudinal directions. As a consequence, the longitudinal tension in the skin elements is increased.

Thus, it will be manifest that the basic principles of this invention are realized by means of the web members and their relationship to the skin elements or members, their effect being of a compound and cumulative nature to achieve a dual wall air inflated structure which exhibits vastly superior structural characteristics as compared to known prior art structures.

As stated hereinabove, the web means 25 are so constructed and arranged as to be substantially incapable, in the assembly, of being tensioned in the longitudinal direction thereof. Instead, the inner and outer skin members 24—24 are constrained to provide substantially all of the resistance to inflation-induced elongation in such longitudinal direction so that, as a result, the longitudinal tension in the skin members is materially increased as compared to a structure in which the web members were also tensioned longitudinally. That is to say, it is an important feature of this invention that the web members are joined to the skin members in such fashion that, in the longitudinal direction, the web members are relaxed as compared to the skin members and that they remain relatively relaxed compared to the skin members even when the assembly is inflated and thus elongated. By the term "relaxed" or "longitudinally relaxed" is meant the characteristic of being under little or no tension in the direction specified.

One way in which this can be accomplished is to use woven fabric for the skin and web members and to join the skin members and web members so that the warp of the skin members and fill threads of the web members run longitudinally or parallel to the webs. Because the warp threads are straight whereas the fill threads normally have a "crimp" or undulation to weave across the warp threads, the above relationship of warp and fill in the skin and web members will normally cause the warp threads of the skin members to take substantially all of the longitudinal tension, when the assembly is inflated,

before the "crimped" fill threads of the web members have had an opportunity to become unkninked or straightened and thus rendered capable of being tensioned. The relationship between the "crimp" of the warp and fill yarns can be controlled during weaving. Thus, it will be seen that by the definition given above, the assembly constructed as aforesaid will be characterized by the fact that the web members, when joined to the skin members, will be longitudinally relaxed and will remain so even when inflated. Of course, it would be possible to force the web members to take tension if the inflating pressure is high enough, but this invention is characterized by the use of low inflating pressure, in the order of 1 to 2 pounds per square inch, and in any event of such degree that the web members take little or no tension as compared to the tension induced longitudinally in the skin members.

The same effect as above could be achieved by using film or sheet material, as compared to woven material, in either or both the skin and web members. In any case, the longitudinal elongation produced by the inflation pressure would induce, in the web members, little or no tension longitudinally thereof as compared to the tension induced by such elongation in the skin members. For skin and web members both made of sheet or film exhibiting isotropic properties, this could be accomplished by using web members of much thinner construction than the skin, by cutting or perforating the webs to reduce the load carrying capacity in the longitudinal direction or by crimping the web members. However, it must be borne in mind that the web members must be tensioned to a substantial degree in the transverse direction since they constitute the means preventing separation of the skin members and effective to produce the corrugated shape thereof.

A preferred embodiment of the invention for securing the web means to the skin or envelope is shown in FIG. 3 wherein the outer envelope elements designated 24-24 are interconnected by spaced generally parallel web elements designated 25. The web elements are preferably connected to the load transfer strips 28 as shown by stitching reverse-folded edge portions 32 of the webs as indicated at 33 to the strips 28 which may be formed of flexible material similar to the material used in the outer skin components. In turn the strips 28 are cemented or otherwise attached to the inner surfaces of the envelope elements 24-24. In any case the object is to provide an interconnection between each web and envelope element such as will transmit the structure loads through the web elements in pure shear without generation of secondary peel loads or the like such as would tend to rupture the interconnections.

The method of construction shown in FIG. 3 accomplishes this purpose by reason of the fact that the web is attached to the load transfer strips along the center lines thereof so that their opposite side portions are free to assume configurations complementing the shapes tending to be assumed by the contiguous portions of the envelope members when the structure is inflated. The tension loads in the envelope elements are transferred across the positions of attachment through the strips 28, whereby the peak portions 34 of the envelope elements are shielded from stresses which otherwise would tend to cause peeling separation of the envelope and strip elements. Thus, the present invention provides for greater utilization of the material incorporated in the structure, with resultant increased inherent stiffness and structural efficiency.

It should be noted that the use of the web means permits the fabrication of curved structural sections as referred to hereinabove, without requiring the "laying-up" of curved sectional tube elements or of other involved and expensive techniques. Thus, a dual wall or inflated structure as shown in FIG. 1 may be provided at substantially reduced cost. For example, FIGS. 4, 5 and 6

illustrate various forms of web element fabrications such as may be employed to provide the elements designated 25 in FIG. 3 for this purpose. In FIG. 4, the web means is illustrated to be made from an initially straight strip of fabric comprising substantially non-elastic warp threads 40 and slack or elastic filler threads 42. This type of fabric is readily adapted to provision of web elements required to be arcuately shaped as for example in conjunction with a structure as illustrated in FIG. 1, because the filler threads will adjust themselves longitudinally to dimensional changes required to conform the web element to the required configuration while the warp strands are directed substantially normal to the skin elements. FIG. 5 illustrates adaptation of a similar type fabric to an installation requiring a small radius of web curvature; and in this case the web fabric may be conveniently slit as indicated at 44 at intervals therearound, whereby the fabric sections may be segmentally lapped to accommodate the fabric to the required curvature while maintaining the warp strands 40 of the fabric in attitudes substantially normal to the surfaces of the inner and outer wall elements.

FIG. 6 illustrates another form of fabrication suitable for the web elements 25 which is provided by employing a piece of bias-cut fabric comprising diagonally running warp and fill threads 46-47 together with another fabric sheet having tension carrying warp strands 48 for the purpose of carrying the loads as explained hereinabove. This type of construction is particularly adapted for installations wherein somewhat greater resistance to bending deflections in the finished structure may be required. The diagonal strands 46-47 will offer little resistance to inflation-induced elongation as compared to the skin members and will serve to transfer the shear loads as tension, thereby providing a so-called diagonal tension field.

FIGS. 7, 8, 9 illustrate another form of structure embodying the present invention, wherein a spherical or modified spherically shaped structure may be advantageously assembled. As shown in FIG. 8, the structure comprises an outer skin element 50 and an inner skin 52, both of which are dome-shaped, thereby providing in effect a dual wall radome type structure. In accord with the present invention the skin elements 50-52 are interconnected at intervals circumferentially thereof by web elements as indicated at 54. As in the construction of FIGS. 1, 2a and 3, the web elements 54 are connected at their peripheral edges to the skin elements by any suitable stitching or cementing means, and may be preferably connected as illustrated in FIG. 3. To accommodate the convergencies of the web elements 54 toward the apex of the dome structure, alternate webs are terminated short of the apex as indicated for example at 56, 58. The structure will of course be air-sealed at the bottom so as to provide an air holding chamber between the inner and outer skin elements.

Thus, it will be appreciated that upon inflation of the structure, as explained hereinabove, the skin elements will balloon slightly as indicated in FIGS. 9, 10, 11; the web elements 54 restraining the skin elements in the transverse direction so as to provide therein the valley formations 34 as explained hereinabove in conjunction with FIG. 3. As illustrated in FIG. 7 the structure may preferably be initially fabricated in sectional form, such as providing two or more sections adapted to be interconnected in the field by means of connection devices indicated generally at 60. As shown in FIGS. 10-13, the interconnections are conveniently provided by means comprising a skirt member 62 at each marginal edge portion of the skin members 50-52; said skirt members being sewn or otherwise suitably attached to the elements as indicated at 63 (FIG. 12). The skirt members 62 terminate at their outer edges in looped portions enclosing tension cables 64; and interconnecting detachable hook devices as indicated at 65 are carried at intervals therealong. Thus, during assembly of the structure in the field

and prior to inflation thereof, the sectional portions of the structure are readily interconnected by means of the hook devices 65 as shown in FIG. 11 whereupon the structure may be inflated to assume the erect form illustrated in FIGS. 7-8.

FIGS. 14, 16 illustrate in further detail one form of connection device such as is designated at 65 in FIG. 12. In this case the connection device includes a spherically shaped ball 68 which is slip-fitted on the cable 64 and swaged thereon to firm it in place. A clamp device 70 is swaged upon the opposite cable and comprises an extending bifurcated jaw portion 72 terminating in two hooked shaped fingers 74-76 adapted to straddle the ball 68 and to lock on the cable when it is engaged therewith by a twisting motion.

FIGS. 15, 17 illustrate another form of detachable clamp device which may be used in lieu of the clamp devices previously referred to. In this instance a ball 68 is mounted upon one of the cables 64, as in the manner of the construction of FIG. 14, and the clamp device per se comprises a two piece member 80 comprising two identical parts clamped upon the cable 64 by means of a screw 84. The extending end portions of the clamp members are bifurcated and hook shaped to permit the twisting insertion of the ball member into locking engagement therewith as explained hereinabove. Whereas, FIGS. 10-17 illustrate specific forms of section interconnection and clamp devices, it is to be understood that any other suitable means may be employed in lieu thereof.

From the above, it will be manifest that the purpose of the novel combination according to this invention is to provide a building or similar structure which is capable of sustaining loads to an improved degree while achieving this objective in an economical and practical fashion. The web means as related to the skin or wall means are responsible for these objectives, it being appreciated that the web means divide the structure into a series of load-carrying cells or beams, so to speak. Each such cell or beam is of distorted cylindrical configuration with the arcuate portions thereof longitudinally tensioned to a maximum degree to resist bending, the flat sides being substantially devoid of longitudinal tension. In order to achieve this maximum tensioning effect of the skin elements, the web means should be spaced apart by distances in the order of their widths. Spacing materially exceeding the above will cause the structure to approach the deleterious condition of FIG. 2 whereas spacing materially less than the above will tend to be wasteful of material and consequently more costly while achieving no practical increase in strength. With a purely cylindrical cellular structure as in FIG. 2, the transverse or hoop tension will be substantially twice the longitudinal tension induced by the inflation pressure. According to the present invention, using a spacing as above, the longitudinal tension in the wall or skin members of a multicell structure may be made substantially equal to the transverse tension therein.

FIGS. 18 and 19 illustrate a modified form of web-to-skin connection which is adapted to a heat molded construction and permits a reduced fabrication cost. In FIG. 18, one of the skin members S will be seen to be bonded to the securing and load transfer strip T while the web member W has its corresponding side edge portion E bonded as well as stitched to one half of the securing strip T. By means of this particular construction the actual securing together of the several elements S, T and V is simplified as best illustrated in FIG. 19. The web members W are first provided with the transfer strip long their opposite side edges, this securement being effected by stitching R, as shown, then with several heats in flatwise condition as illustrated in FIG. 19 and with a strip or sheet of material M, which is of a composition to prevent fusion of the two surfaces separated

thereby, interposed between the main body of the web and the transfer strip, the substantially uniform three-layer thickness as illustrated (the material M is of insignificant thickness) simultaneous heat bonding at the interfaces B is readily accomplished without any significant non-uniformity of thickness detracting from the homogeneity of such bondings as achieved for example by parallel opposed heated platens sandwiching the layers therebetween. This construction, like that of FIG. 3, achieves the objective of efficiently securing the opposite side edges of the web members to the skin members and in such fashion that the load transfer and securing strips T distribute both the web-to-skin tension and the skin tension transversely of the webs as shear loads between the skin and transfer strips. Because of this, the transfer strips do not tend to "peel" from the skin members. As a matter of fact, if the skin members are left unbonded to the transfer strips at the bottoms of the valleys, the skin will merely "pucker" at this point since the skin material is completely relaxed at this point because the regions of the transfer strip on either side of the valley bottom are in maximum tension tending to pull the corresponding and contiguous regions of the skin member together, hence the aforementioned "pucker."

From the preceding description, it will be manifest that a unique combination has been provided wherein the various intrinsic factors thereof cooperate and interact to effect an extremely efficient building structure. It must be remembered that the invention is preferentially applied to rather large structures, in some instances to structures having spans in the hundreds of feet. With such structures, it can be appreciated that snow, wind and other loads may reach enormous proportions, aside from the difficulties of fabrication afforded by such sizes. Moreover, the inflation pressure sustaining the loads imposed are only a few pounds per square inch. From this, it may be seen that to perform successfully, the structure must exhibit an unusual degree of efficiency.

The factors contributing to this efficiency are primarily concerned with maximum utilization of each element or material part used. Thus, the web means not only readily permit the arch shape to be achieved; permit the structure to assume the rigid corrugated form; permit the skin members to be tensioned to a maximum degree in the longitudinal direction so as to more effectively resist bending; but also they permit the tensioned skin members to be spaced, in their entirety, a substantial distance from the neutral axis. Cooperating with these features are the transfer strips which not only provide the means for securing the webs in longitudinally relaxed condition (permitting the maximum longitudinal tension in the skin members) but which also, with a minimum of material, effect an extremely efficient and fool-proof load transfer means which resists separation from the skin elements to an unusual degree and which allows production techniques permitting the fabrication of extremely large structures.

Adjacent webs, in conjunction with the intervening portions of the skin members form, in effect, cell or beam means of modified tubular shape. If the maximum skin tension in the longitudinal direction is to be achieved, the spacing between adjacent webs should be in the order of their widths or slightly closer, that is, the distance between corresponding valley bottoms of the two skin elements. If the web spacing is somewhat less than this distance, the inflation-induced stress in the longitudinal direction will be substantially equal to that induced in the transverse direction. Greater spacing of course effects a diminution of the longitudinally induced stress.

It is to be understood that certain changes and modifications as illustrated and described may be made without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. An air-inflated, load-sustaining structural unit including

a pair of flexible, substantially impervious, sheet-like panels disposed in superimposed spaced apart relationship relative to each other,
 a plurality of elongate longitudinally extending strip-like web elements of flexible, resilient material disposed in laterally spaced apart relationship relative to each other intermediate the sheet-like panels, and
 means joining the longitudinally extending side edge portions of each of the web elements to the adjacent sheet-like panel throughout substantially the full longitudinal extent of the respective web elements to define a plurality of elongated substantially cylindrical structural members each having a distorted configuration in cross-section,

said web elements including means for initially maintaining the respective web elements in relaxed conditions relative to said panels with the web elements each having a resistance to elongation in a longitudinal direction which is substantially less than the resistance of the sheet-like panels to elongation in such direction so that the web elements are substantially incapable of being tensioned in such direction while the sheet-like panels are stressed in such direction on inflation of the structural unit, so that tensile stress in the longitudinal direction of the panels substantially approaches the tensile stress therein which occurs in a lateral direction to enable the load carrying capacity of the structural unit to be increased by increasing the resistance of the structural members to bending forces.

2. A building arch of dual wall form comprising;

opposed inner and outer wall members of flexible, impervious material joined marginally thereof to provide a substantially airtight envelope,

a plurality of spaced, generally parallel, resilient, and flexible strip-like web members extending longitudinally of the arch substantially coextensive therewith,

means joining said web members along their opposite side edges to the respective inner surfaces of said wall members to integrate the wall members to the web members, said web members being constructed of woven material having fill threads running longitudinally of the web members, whereby said web members are maintained in relaxed condition, longitudinally thereof, with respect to said wall members so that the wall members resist elongation in the longitudinal direction to a materially greater extent than do the web members resist such elongation when said envelope is inflated,

said web members being spaced apart distances in the order of their widths.

3. An air-inflated, load-sustaining structural unit including

inner and outer wall elements interconnected by web elements and marginally joined to provide an inflatable envelope,

said wall and web elements being formed of flexible, resilient material and the material of said wall elements being of substantially airtight form,

said web elements being generally parallel and shaped in the planes thereof to conform the structure to its prescribed profile form and extending throughout substantially the longitudinal extent of the envelope,

means joining the opposite side edges of said web elements to the respective inner surfaces of said wall elements, said web elements including means for maintaining said web elements in longitudinally relaxed condition relative to said wall elements when the unit is inflated, whereby the wall elements resist inflation-induced longitudinal elongation to a materially greater degree than do said web elements,

said web elements being spaced apart by amounts in the order of their widths.

4. An air-inflated, load-sustaining structural unit including

a pair of flexible, substantially impervious, sheet-like panels disposed in superimposed spaced apart relationship relative to each other,

a plurality of elongate longitudinally extending strip-like web elements of flexible, resilient material disposed in laterally spaced apart, generally parallel relationship relative to each other intermediate the sheet-like panels,

said strip-like web elements each having a resistance to deformation in a longitudinal direction which is substantially less than the resistance to deformation of the sheet-like panels in such direction,

means joining the longitudinally extending side edge portions of each of the web elements to the adjacent sheet-like member throughout substantially the full longitudinal extent of the respective web elements, said web elements being constructed of woven material having fill threads running longitudinally of the web elements, whereby said web elements are maintained in longitudinally relaxed condition relative to said panels so that said web elements are substantially incapable of being tensioned in such longitudinal direction in response to inflation induced elongation of the unit.

5. An air-inflated, load-sustaining structural unit including

a pair of flexible, substantially impervious, sheet-like panels disposed in superimposed spaced apart relationship relative to each other,

a plurality of elongated longitudinally extending strip-like web elements of flexible, resilient material disposed in laterally spaced apart relationship relative to each other intermediate the sheet-like panels,

said strip-like web elements each having a resistance to deformation in a longitudinal direction which is substantially less than the deformation of the sheet-like panels in such direction with the web elements being substantially incapable of being tensioned in such direction, and means for stressing the sheet-like panels in a direction common to such direction for resisting tension to enable the load carrying capacity of the structural unit to be increased by increasing the resistance thereof to bending forces,

said means joining the longitudinally extending side edge portions of each of the web elements to the adjacent sheet-like member throughout substantially the full longitudinal extent of the respective web elements to define a plurality of elongated substantially cylindrical structural members each having a distorted configuration in cross section,

said web elements including means initially maintaining the respective web elements in relaxed condition with the web elements having substantial lateral resistance in tension with the sheet-like panels being stressed and possessing properties in longitudinal tension which are greater than any similar properties which exist in the web elements and creating, on inflation of the structural unit, in each of the structural members, a tensile stress in a longitudinal direction which substantially approaches the tensile stress therein which occurs in a lateral direction.

6. In an air-inflated, load-sustaining structural member, including a pair of flexible, substantially impervious panels disposed in opposed relation to each other, the combination of

web means of flexible, resilient material interconnecting said panels and serving to maintain the same in predetermined spaced relationship in opposition to inflating force tending to separate said panels, and of means joining said web means to the opposed surfaces of the panel for transferring stresses between adjacent

sections of the panels on opposite sides of the web means,

said means for joining the web means to the panels being in the form of elongate strips of flexible material secured to the respective panels and said web means being fixedly secured along their opposite side edges to said strips whereby the inflating force balloons the panels between adjacent web means so as to form valleys along the strips in alignment with said web means such that the force tending to separate the strips from the panels is substantially only a shear force and wherein stresses within the panel on opposite sides of said valleys are transferred primarily therebetween through said strips,

said web means being constructed of woven material having fill threads running longitudinally of the web means, whereby said web means are maintained in longitudinally relaxed condition relative to said panels when the member is inflated.

7. In the structure as defined in claim 6, wherein said strips are adhesively bonded to said panels and are devoid of any securing means perforating both the panels and the strips.

8. An air-inflated, load-sustaining structural member comprising

- a pair of flexible, substantially impervious panels disposed in opposed relation to each other,
- a plurality of longitudinally extending strip-like web means of flexible, resilient material,

means joining said web means along their opposite edges to the opposed surfaces of said panels,

said web means being capable widthwise thereof of opposing, in tension, inflating force tending to separate said panels and being spaced apart so as to permit said panels to balloon outwardly between said web means substantially the full length of the structural member,

said web means being constructed of woven material having fill threads running longitudinally of the web means, whereby the web means are maintained in longitudinally relaxed condition relative to said panels so that the web means have substantially no resistance to tension loads in their longitudinal direction when the member is inflated, whereby when inflated, the tensile stress induced in said panels in a longitudinal direction approaches the tensile stress induced therein in a transverse direction.

9. In an air-inflated load-sustaining structural member including a pair of flexible, substantially impervious panels disposed in opposed relation to each other, a plurality of generally parallel, elongate flexible and resilient webs secured between said panels and dividing the space therebetween into a plurality of elongate cells, means along the ends of said panels isolating said cells from ambient atmosphere whereby the cells may be inflated to tension said panels and form the same into a load-sustaining structural member, the improvement comprising

means joining said webs along their opposite edges to said panels, said webs being constructed of woven material having fill threads running longitudinally of the webs, whereby the webs are maintained in longitudinally relaxed condition relative to the panels whereby when inflated, the panels balloon between adjacent webs to assume the cellular configuration and the tension stress induced in said panels in a longitudinal direction is taken up substantially entirely by said panels due to the initially relaxed condition of said webs in the longitudinal direction and approaches the tension stress induced in the panels in a transverse direction.

10. A building arch of dual wall form comprising, opposed inner and outer wall members of flexible, impervious material joined marginally thereof to provide a substantially airtight envelope,

a plurality of spaced, generally parallel, resilient, and

flexible strip-like web members extending longitudinally of the arch substantially coextensive therewith, means joining said web members along their opposite side edges to the respective inner surfaces of said wall members to integrate the wall members to the web members,

said web members being constructed of woven material having warp and fill threads running diagonally with respect to the longitudinal direction of the web members, whereby said web members are maintained in relaxed condition, longitudinally thereof, with respect to said wall members so that the wall members resist elongation in the longitudinal direction to a materially greater extent than do the web members resist such elongation when said envelope is inflated,

said web members being spaced apart distances in the order of their widths.

11. An air-inflated, load sustaining structural unit including

- a pair of flexible, substantially impervious, sheet-like panels disposed in superimposed spaced apart relationship relative to each other,
- a plurality of elongate longitudinally extending strip-like web elements of flexible, resilient material disposed in laterally spaced apart, generally parallel relationship relative to each other intermediate the sheet-like panels,

said strip-like web elements each having a resistance to deformation in a longitudinal direction which is substantially less than the resistance to deformation of the sheet-like panels in such direction,

means joining the longitudinally extending side edge portions of each of the web elements to the adjacent sheet-like member throughout substantially the full longitudinal extent of the respective web elements,

said web elements being constructed of woven material having warp and fill threads running diagonally with respect to the longitudinal direction of the web elements, whereby said web elements are maintained in longitudinally relaxed condition relative to said panels so that said web elements are substantially incapable of being tensioned in such longitudinal direction in response to inflation induced elongation of the unit.

12. In an air-inflated, load-sustaining structural member, including a pair of flexible, substantially impervious panels disposed in opposed relation to each other, the combination of

- web means of flexible, resilient material interconnecting said panels and serving to maintain the same in predetermined spaced relationship in opposition to inflating force tending to separate said panels, and of
- means joining said web means to the opposed surfaces of the panel for transferring stresses between adjacent sections of the panels on opposite sides of the web means,

said means for joining the web means to the panels being in the form of elongate strips of flexible material secured to the respective panels and said web means being fixedly secured along their opposite side edges to said strips whereby the inflating force balloons the panels between adjacent web means so as to form valleys along the strips in alignment with said web means such that the force tending to separate the strips from the panels is substantially only a shear force and wherein stresses within the panel on opposite sides of said valleys are transferred primarily therebetween through said strips,

said web means being constructed of woven material having warp and fill threads running diagonally with respect to the longitudinal direction of the web means, whereby said web means are maintained in

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longitudinally relaxed condition relative to said panels when the member is inflated.

13. An air-inflated, load-sustaining structural member comprising
- a pair of flexible, substantially impervious panels disposed in opposed relation to each other,
 - a plurality of longitudinally extending strip-like web means of flexible, resilient material,
 - means joining said web means along their opposite edges to the opposed surfaces of said panels,
 - said web means being capable widthwise thereof of opposing, in tension, inflation force tending to separate said panels and being spaced apart so as to permit said panels to balloon outwardly between said web means substantially the full length of the structural member,
 - said web means being constructed of woven material having warp and fill threads running diagonally of the longitudinal direction of the web means, whereby the web means are maintained in longitudinally relaxed condition relative to said panels so that the web means have substantially no resistance to tension loads in their longitudinal direction when the member is inflated, whereby when inflated, the tensile stress induced in said panels in a longitudinal direction approaches the tensile stress induced therein in a transverse direction.
14. In an air-inflated load-sustaining structural member including a pair of flexible, substantially impervious panels disposed in opposed relation to each other, a plurality of generally parallel, elongate flexible and resilient webs secured between said panels and dividing the space therebetween into a plurality of elongate cells, means along the ends of said panels isolating said cells from ambient atmosphere whereby the cells may be inflated to tension said panels and form the same into a load-sustaining structural member, the improvement comprising
- means joining said webs along their opposite edges to said panels, said webs being constructed of woven material having warp and fill threads running diagonally with respect to the longitudinal direction of the webs, whereby the webs are maintained in longitudinally relaxed condition relative to the panels whereby when inflated, the panels balloon between adjacent webs to assume the cellular configuration and the tension stress induced in said panels in a longitudinal direction is taken up substantially entirely by said panels due to the initially relaxed condition of said webs in the longitudinal direction and approaches the tension stress induced in the panels in a transverse direction.
15. A building arch of dual wall form comprising, opposed inner and outer wall members of flexible, impervious material joined marginally thereof to provide a substantially airtight envelope,
- a plurality of spaced, generally parallel, resilient, and flexible strip-like web members extending longitudinally of the arch substantially coextensive therewith,
 - means joining said web members along their opposite side edges to the respective inner surfaces of said wall members to integrate the wall members to the web members,
 - said web members including means for maintaining the web members in longitudinally relaxed condition relative to said wall members whereby the wall members resist elongation in the longitudinal direction to a materially greater extent than do the web members resist such elongation when said envelope is inflated,
 - said web members being spaced apart distances in the order of their widths.

16. An air-inflated, load-sustaining structural unit including

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panels disposed in superimposed spaced apart relationship relative to each other,

- a plurality of elongate longitudinally extending strip-like web elements of flexible, resilient material disposed in laterally spaced apart, generally parallel relationship relative to each other intermediate the sheet-like panels,

said strip-like web elements each having a resistance to deformation in a longitudinal direction which is substantially less than the resistance to deformation of the sheet-like panels in such direction,

- means joining the longitudinally extending side edge portions of each of the web elements to the adjacent sheet-like member throughout substantially the full longitudinal extent of the respective web elements,

said web elements including means for maintaining the web elements in longitudinally relaxed condition relative to said panels so that the web elements are substantially incapable of being tensioned in such longitudinal direction in response to inflation induced elongation of the unit.

17. An air-inflated, load-sustaining structural member comprising

- a pair of flexible, substantially impervious panels disposed in opposed relation to each other,

- a plurality of longitudinally extending strip-like web means of flexible, resilient material,

means joining said web means along their opposite edges to the opposed surfaces of said panels,

- said web means being capable widthwise thereof of opposing, in tension, inflating force tending to separate said panels and being spaced apart so as to permit said panels to balloon outwardly between said web means substantially the full length of the structural member,

said web means including means for maintaining the web means in longitudinally relaxed condition relative to said panels so that the web means have substantially no resistance to tension loads in their longitudinal direction when the member is inflated, whereby when inflated, the tensile stress induced in said panels in a longitudinal direction approaches the tensile stress induced therein in a transverse direction.

18. In an air-inflated, load-sustaining structural member including a pair of flexible, substantially impervious panels disposed in opposed relation to each other, a plurality of generally parallel, elongate flexible and resilient webs secured between said panels and dividing the space therebetween into a plurality of elongate cells, means along the ends of said panels isolating said cells from ambient atmosphere whereby the cells may be inflated to tension said panels and form the same into a load-sustaining structural member, the improvement comprising

- means joining said webs along their opposite edges to said panels, said webs including means for maintaining the webs in longitudinally relaxed condition relative to the panels whereby when inflated, the panels balloon between adjacent webs to assume the cellular configuration and the tension stress induced in said panels in a longitudinal direction is taken up substantially entirely by said panels due to the initially relaxed condition of said webs in the longitudinal direction and approaches the tension stress induced in the panels in a transverse direction.

References Cited by the Examiner

UNITED STATES PATENTS

511,472	12/1893	Sumovski.	
691,118	1/1902	Curlin	5-349
1,970,052	8/1934	Hamza	5-350
2,748,401	6/1956	Winstead.	

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