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(54) Braided airbeams and method of making the same.

(57) An airbeam is formed of a bladder covered by a sleeve having a preselected shape, which may be for example curvilinear. When the bladder is inflated it takes the shape of the sleeve to form a structural member for a shelter or other temporary structure. Preferably the sleeve is a braided fabric. The airbeam is made by first forming a solid mandrel of the bladder and then braiding the sleeve about the mandrel. The fabric is formed of several interlocked layers.

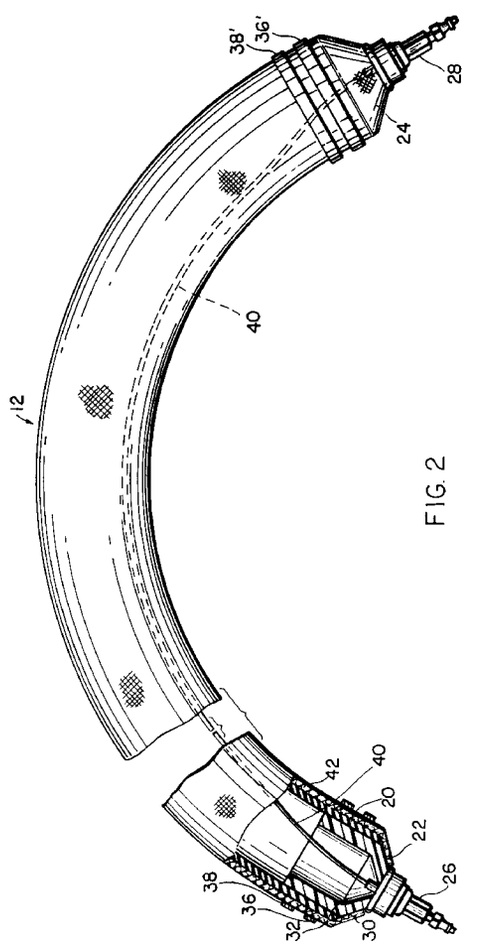

FIG. 2

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BACKGROUND OF THE INVENTION

a. Field of Invention

This invention pertains to beams used in making various structures such hangars, temporary shelters and the like, and more particularly to air-inflated beams and a method of making such airbeams.

b. Description of the Prior Art

Sometimes it is necessary to erect relatively temporary structures in a short period of time. These structures may be necessary for providing shelter to homeless people, military personnel, for storing equipment during extreme weather conditions, or for storing hazardous waste prior to disposal. Such structures may also be used as hangars for aircraft or to provide a protective dome for tennis courts or sport stadiums.

Typically such temporary structures are supported in three different ways. One common method is to provide a substantially semi-circular air impermeable membrane which is inflated and supported by the internal air-pressure. This method can be unsatisfactory because it makes use of noisy air pumps which must be operated continuously. Moreover entrance and egress through these structures can be effected only through air locks which are slow and cumbersome to operate. In addition, economically it is unfeasible to provide these structures with air locks large enough to accommodate large equipment, such as for example a truck or a helicopter and thus are unsuitable as hangars.

Another method of structural support frequently used consists of frame work formed of metal bars, beams or pipes. A membrane is then pulled over and secured to the frame. This method is also unsatisfactory because it is expensive, time consuming and can requires special skill and/or equipment to erect. Moveover because of the weight of the frame components, it is difficult and expensive to transport from one location to another.

A third method for supporting shelters also provides a frame work, however its components consist of tubular pressurized fabric members bent into curvilinear shapes. A membrane is either integrally attached to, or pulled over and secured to the pressurized fabric members. As a result these members require substantial forces to bend them into curvilinear shapes. Moreover if punctured they are prone to explosive depressurization accompanied by catastrophic and rapid collapse of the structure.

OBJECTIVES AND SUMMARY OF THE INVENTION

In view of the above mentioned disadvantages of the prior art, it is an objective of the present invention to provide an air beam which is lightweight so that it is easy to transport form location to location yet strong so that it can easily support a membrane.

A further objective is to provide an airbeam which can be made to any desired curvature without subjecting it to excessive external forces.

Other objectives and advantages shall become apparent from the following description. Briefly, an airbeam constructed in accordance with this invention includes a bladder formed of a gas impermeable material and surrounded by a sleeve. When the bladder is inflated it takes on the shape of the sleeve to form a straight or curvilinear airbeam. The sleeve is preferably made of a braided fabric. Preferably the braided fabric is a multilayer braided fabric with the layers being interlocked to prevent delamination. A resin may be used to bond the fabric to the bladder and to provide a protective coating to the fabric.

One method of making the airbeam consists of filling the tubular bladder with a solid granular material. The filled bladder is bent to a preselected shape and then a vacuum pressure is applied to the bladder to cause it collapse around the granular material and form a solid mandrel. The fabric is braided around this mandrel, after which the granular material is removed.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows somewhat schematically, a structure having airbeams constructed in accordance with this invention;

Figure 2 shows an elevational view of an air beam of Figure 1;

Figures 3-8 shows the steps required to make the airbeam of Figures 1 and 2; and

Figure 9 shows a cross-sectional view of the fabric using a multilayered braiding system.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows an example of one type of temporary shelter 10 constructed of several airbeams 12, 12' forming a cross arch frame work 11. Other significant types of frame works which can be made with the subject airbeams include "arch and purling" and "leaning arch". The frame work 11 supports a fabric 14 made of canvas or other material satiable to provide roofing for the temporary shelter 10 as discussed above. In Figure 1, airbeam 12 is curvilinear and is arranged amd constructed to extend circumferentially from one side of the structure 10 to the other with its ends being secured to the ground or other floor surface. Beam 12' is also curvilinear and extends from the floor surface until it intersects and is secured to beam 12 to form a crossed arch framework. It should be understood that depending on the size of the shel-

ter 10 it supporting, the frame work 11 may be constructed of several beams 12 and/or 12' as required. Since the fabric 14 is supported by the frame work 11 of airbeams 12, 12', the shelter 10 can be provided with doors of various sizes which have been omitted in the Figure for the sake of clarity.

Details of the airbeam 12 are shown in Figure 2. Airbeam 12 includes a tubular bladder 20 made of a material impervious to air. For example the bladder 20 may be made of a polymeric material. At its ends, bladder 20 is provided with two end fittings 22, 24 arranged to provide an air-tight seal with the bladder 20. Each fitting 22, 24 is provided with an air valve 26, 28 used to pump air into and out of the bladder 20 as described more fully below. The fittings 22, 24 are provided with threaded holes and the valves 26, 28 are screwed into these holes, discussed more fully below. Preferably each end fitting 22, 24 has a conical section 30 and a substantially cylindrical section 32. The bladder 20 is mounted peripherally on the cylindrical section 32 of the end fittings as shown. End fitting 24 has a construction similar to end fitting 22 just described.

Disposed inside and extending through the bladder 20 is a tether 40 with two ends. Each end of the tether 40 is attached to the end fittings 22, 24 respectively. The function of the tether is to hold onto the end fittings 22, 24 if the airbeam 12 is punctured to insure that the end fittings 22, 24 do not fly off and cause damage.

A sleeve such as a fabric 42 is mounted on bladder 20 extending from one end fitting 22 to the other. As shown in the drawings, the fabric 42 preferably overlaps the entire end fittings to thereby provide an additional coupling means for coupling the bladder 20 and end fittings 22, 24 together. The fabric 42 and bladder 20 are secured to the fittings 22, 24 by clamps 36, 38, 36', 38'. The fabric 42 is constructed and arranged to defined a shape for the airbeam 12. For example in Figures 1 and 2 the beam 12 is curvilinear with a preselected radius of curvature. Alternatively, the airbeam may be a straight for use as a ridge or purlin.

Preferably the fabric 42 is a braided fabric because these types of fabrics can be made in a tubular, seamless configuration of with a curved longitudinal axis. A method of making the a airbeam 12 is shown in Figures 3-8.

The first step, illustrated in Figure 3 is to provide bladder 20 in a desired length, thickness and outer diameter. The bladder may be made, for example of a polymeric material by extrusion. The tether 40 (which has been omitted from Figure 3 for the sake of clarity) is positioned so that it extends longitudinally through the bladder 20. The bladder is then filled with a granular material such as a plurality of small plastic pellets 50 without substantially changing its generally tubular shape. The bladder ends are then pulled over the cylindrical section 32 of shoulders of the end fittings 22, 24 and the bladder and end fittings are temporarily coupled together by clamps 36, 38, 36', 38' (Figure 4).

The bladder is now bent (Figure 5) so that its longitudinal axis assumes a preselected curvilinear shape such as toroidal shape, an elliptical shape and so forth as required. Of course for straight airbeams the bladder is not bent. A vacuum source 52 is attached to valve 28 to reduce the pressure within the bladder 20. As a result, the bladder 20 collapses over the pellets 50 to form a solid curvilinear mandrel. Immediately prior to the depositing of the yarns about the mandrel, the outer surface 54 of bladder is preferably sprayed with an aqueous solution of resin from a resin reservoir 56 (Figure 5). A resin useful for this purpose is available from Rohmtech of Malden, Massachusetts under the name of RODAPUR 8055.

Next, the mandrel formed by the bladder 20 is positioned co-axially with the axis of a braiding machine 58 and is fed into the machine 58. As the mandrel advances through the braiding machine 58, the machine braids a plurality of yarns 60 about the mandrel to form the braided fabric 42. (Figure 6). In addition, during this process in order to insure that the mandrel is completely covered by fabric, clamps 36, 38, 36', 38' are removed from the mandrel, without changing the low internal pressure of the bladder. If necessary two clamps(not shown) much smaller than clamps 36, 38 may be mounted on the ends of bladder 20 to keep it secured to the end fittings while clamps 36, 38, 36', 38' are removed. These smaller clamps remain on the bladder 20 under fabric 42. The resin solution sprayed on the mandrel from reservoir 56 dries in the air and binds the inner yarns of the fabric 42 to the mandrel. After the fabric 42 is braided onto the mandrel, another resin solution is sprayed onto surface 54 of the bladder to impregnate and bind the outer yards of the fabric 42 together and form a protective coating thereon. (Figure 7).

After the fabric 42 has been coated clamps 36, 38, 36', 38' are again mounted to secure the fabric 42 and the bladder 20 to the end fittings 22, 24. One of the valves, for example valve 28 is then opened to allow air to enter into the bladder 20. Next the valve 28 is removed from the fitting 24 and the airbeam 12 is turned with the fitting 24 pointed downward to allow the pellets 50 to fall out (Figure 7).

Once the pellets 50 have been removed, the airbeams 12 can be rolled up into a small package and transported to the site of shelter 10. At the site, the bladder 20 is inflated through one of the valves 26, 28 by air supply 74. (Figure 8). Once the airbeam 12 is inflated, it is ready to be used to make a shelter 10. As the airbeam 12 is inflated it takes on the shape of the fabric 42.

The braiding process for making fabric 42 may be a conventional two dimensional triaxial process. After

braiding the layers of the fabric may be impregnated more fully to insure that the lager do not delaminate. However a three dimensional multi-layer braiding system may also be in accordance with commonly assigned co-pending U.S. application SN 551,266 filed July 12, 1990 and entitled SOLID BRAID STRUCTURE, and related U.S. application SN 961, 885 filed January 6, 1993. This system, shown in Figure 9 is formed by simultaneously braiding several layers concentrically about a common axis. Importantly, at regular intervals some of the yarns of each layer are exchanged with the yarns of an adjacent layer. More specifically, as shown in Figure 9, a multi-layer interlocked braiding system 80 for forming fabric 42 includes a first layer 83 formed of yarns 82, 84 and a second layer 87 formed of yarns 86, 88 and disposed adjacent to the first layer 83. At regular intervals, such as 90 and 92, a yarn from first layer 83 is exchanged with a yarn from the second layer 87. At other locations such as 94, 96 a yarn from layer 87 is exchanged with a yarn of a third layer 89 disposed adjacent to layer 87. In the last layer (not shown); a similar yarn traveling in the opposite direction of yarn 82 creates an opposite border.

As a result, the several concentric layers are solidly interlocked with each other to form a strong, substantially homogeneous three dimensional fabric. Because the layers of the fabric are inherently interlocked, these layers will not delaminate and hence a bonding agent between each layer is not required. Preferably the yarns used to make the fabric 42 are high performance yarn such as a polyaramid such as Kevlar®. Other suitable yarn materials include polyester, nylon, Spectra®, fiberglass or carbon fibers. As these yarns are braided over the solid curvilinear mandrel, the yarns in the longitudinal direction inherently have different lengths to form the curvilinear fabric. Using the method described above, airbeams can be constructed having an outer diameter varying from 1" to 12", and a radius of curvature of the longitudinal axis varying from 4' to 25'. Moreover these airbeams can be inflated up to 170 psi and when used to make a shelter will support a standard roofing membrane and additional loads disposed thereon such as snow.

It has been found that the airbeam this produced, even if it is punctured, it will release air at a relatively slow rate and therefore it is made safer than pressurized fabrics previously used.

Obviously numerous modifications can be made to this invention without departing from its scope as defined in the appended claims.

Claims

1. An airbeam comprising:

a bladder made of a gas impermeable material; and

a sleeve surrounding said bladder, said bladder and sleeve cooperating to form a structural member when said bladder is inflated, said structural member having a preselected shape substantially defined by said sleeve.

2. The airbeam of claim 1 wherein said bladder and sleeve cooperate to form a curvilinear structural member.

3. The airbeam of claim 1 wherein said sleeve is made of a non-stretch fabric.

4. The airbeam of claim 3 wherein said sleeve is a braided fabric.

5. The airbeam of claim 4 wherein said braided fabric consists of several layers.

6. The airbeam of claim 5 wherein said bladder is formed with a longitudinal axis when inflated and wherein said layers are disposed co-axially about said longitudinal axis.

7. The airbeam of claim 6 wherein said layers are interlocked.

8. An airbeam for making a frame for a shelter, said airbeam comprising:

a tubular bladder having two opposed ends and made of a gas impervious material; and

a sleeve disposed over said bladder, said sleeve having a preselected shape, wherein said bladder assumes said preselected shape when pressurized with a gas to form with said sleeve a structural member for said frame.

8. The airbeam of claim 7 further comprising closure means disposed at said ends for closing said bladder.

9. The airbeam of claim 8 wherein said closure means include two end fittings, each end fitting being attached to one of said ends.

10. The airbeam of claim 9 further comprising a valve passing through one of said end fittings for pressurizing said bladder.

11. The airbeam of claim 9 further comprising a tether extending between and attached to said end fittings.

12. The airbeam of claim 7 wherein said sleeve is curvilinear.

13. The airbeam of claim 7 wherein said sleeve is made of a braided fabric.

14. The airbeam of claim 13 wherein said braided fabric extends over said end fittings.

15. The airbeam of claim 13 wherein said braided fabric is made of several layers.

16. The airbeam of claim 15 wherein said layers are interlocked.

17. The airbeam of claim 7 wherein said bladder is made of a polymeric material.

18. The airbeam of claim 7 wherein said sleeve is formed of yarns made of polyaramid.

19. The airbeam of claim 18 wherein said sleeve is bonded to said bladder.

20. The airbeam of claim 7 wherein said sleeve is a braided fabric made of a plurality of yards and impregnated with a resin.

21. A method of making an airbeam for temporary shelters, said airbeam being made by the steps comprising;

providing an elongated tubular bladder made of a gas impervious material; and

applying a sleeve having a preselected shape onto said bladder.

22. The method of claim 21 further comprising pressurizing said bladder to form a structural member for said shelter.

23. The method of claim 21 wherein said tubular member has at least one open end, further comprising the steps of :

filling said bladder with a filler material to form a solid mandrel prior to the application of said sleeve.

24. The method of claim 23 wherein said sleeve is fabric formed around said mandrel.

25. The method of claim 26 wherein said fabric is braided about said mandrel.

26. The method of claim 25 wherein said fabric is braided in a plurality of layers.

27. The method of claim 26 wherein said layers are interlocked as they are formed about said mandrel.

28. The method of claim 25 further comprising the step of bonding said sleeve to said bladder.

29. The method of claim 25 wherein said fabric is braided of polyaramid yarns.

30. The method of claim 29 further comprising the step of impregnating said sleeve with a resin.

31. The method of claim 23 wherein after said filling, said bladder is formed into a curvilinear shape.

32. The method of claim 21 further comprising the step of securing two end fittings to said bladder.

33. The method of claim 32 further comprising the step of inserting a tether in said bladder and securing said tether between said end fittings.

34. The method of claim 23 wherein after said filling step a vacuum is applied to said bladder.

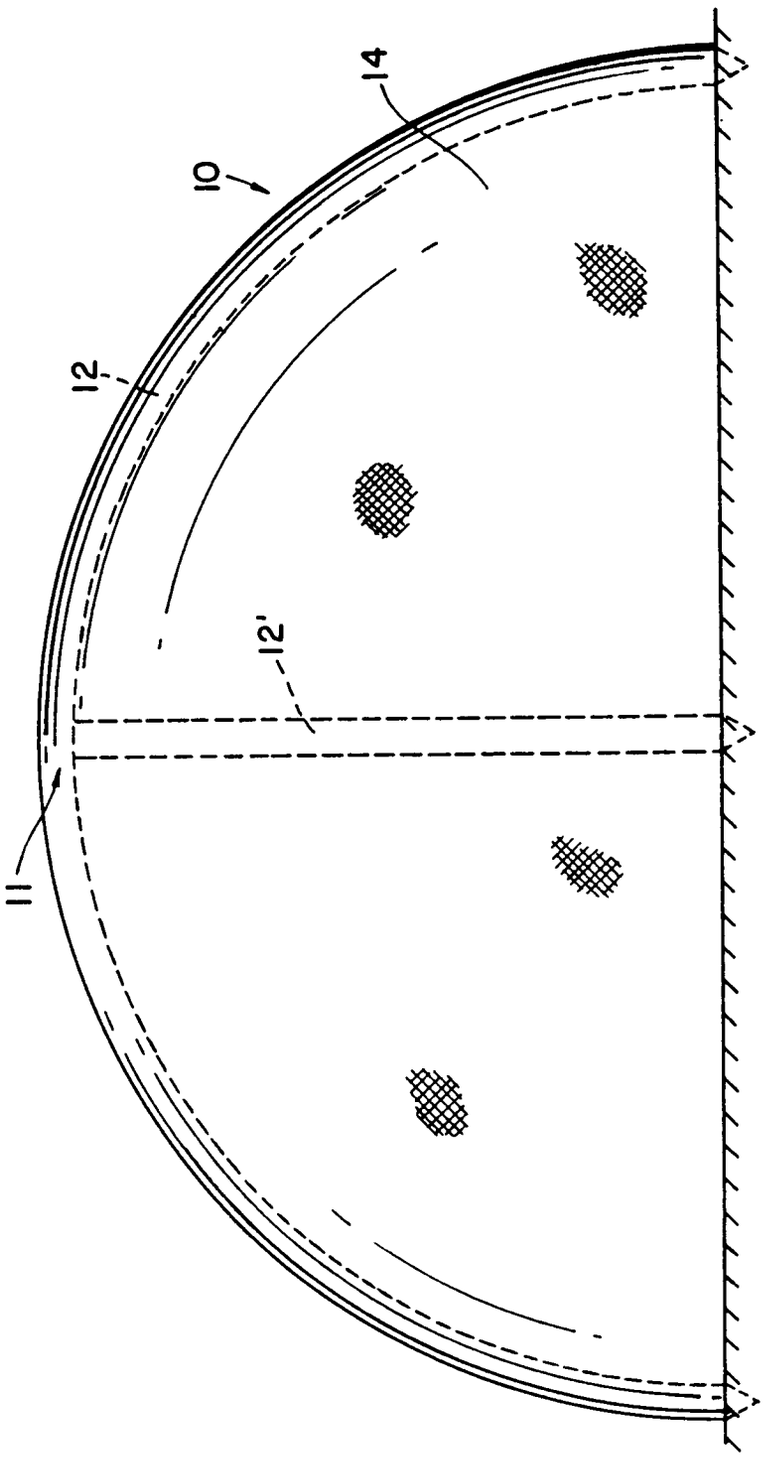

FIG.1

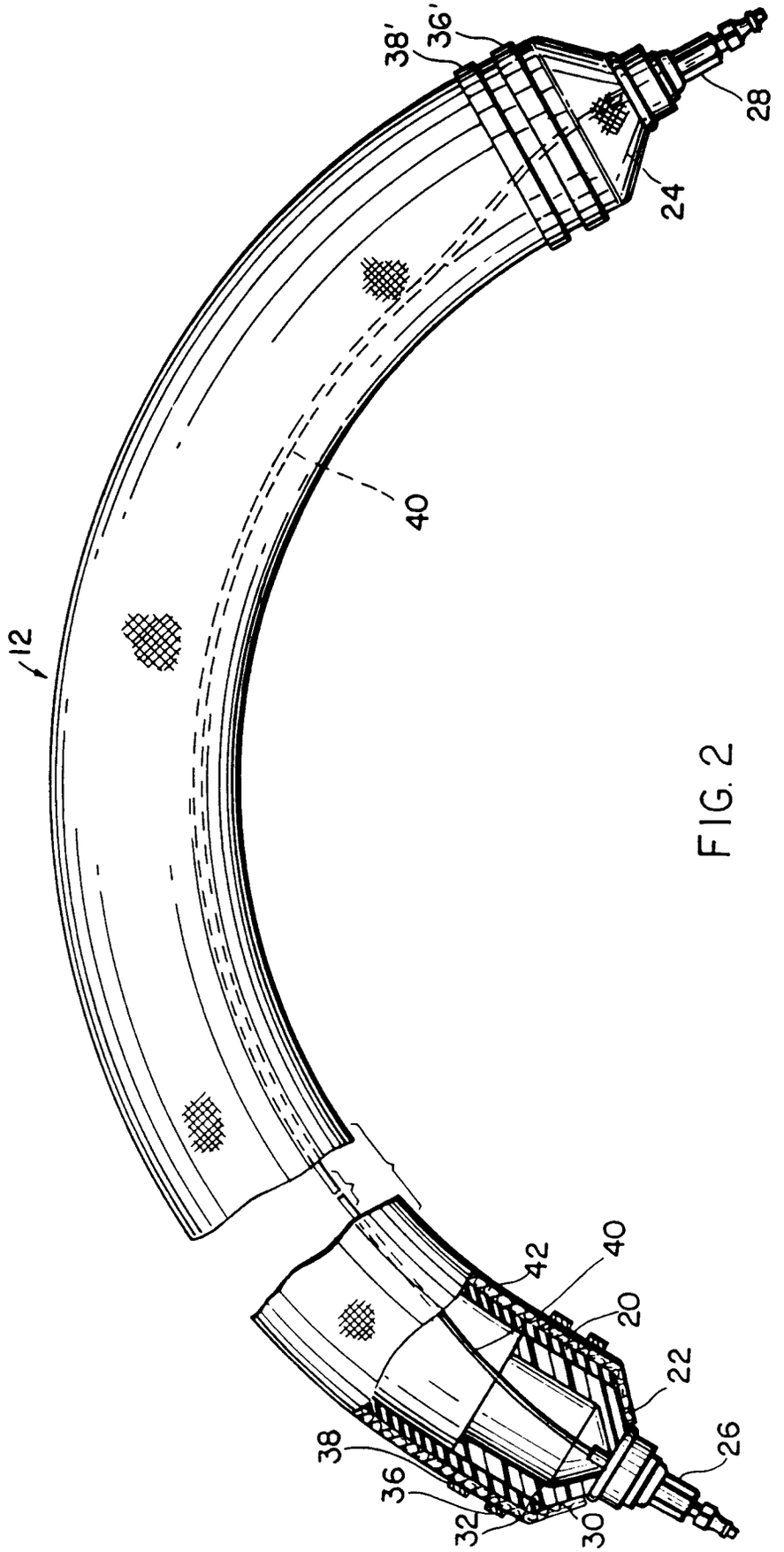

FIG. 2

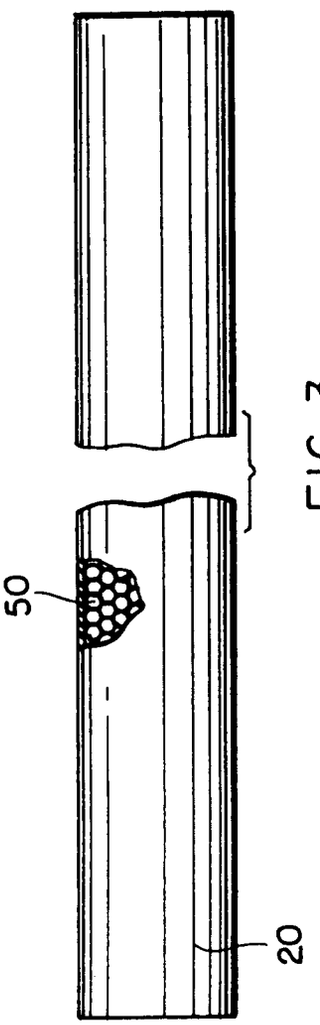

FIG. 3

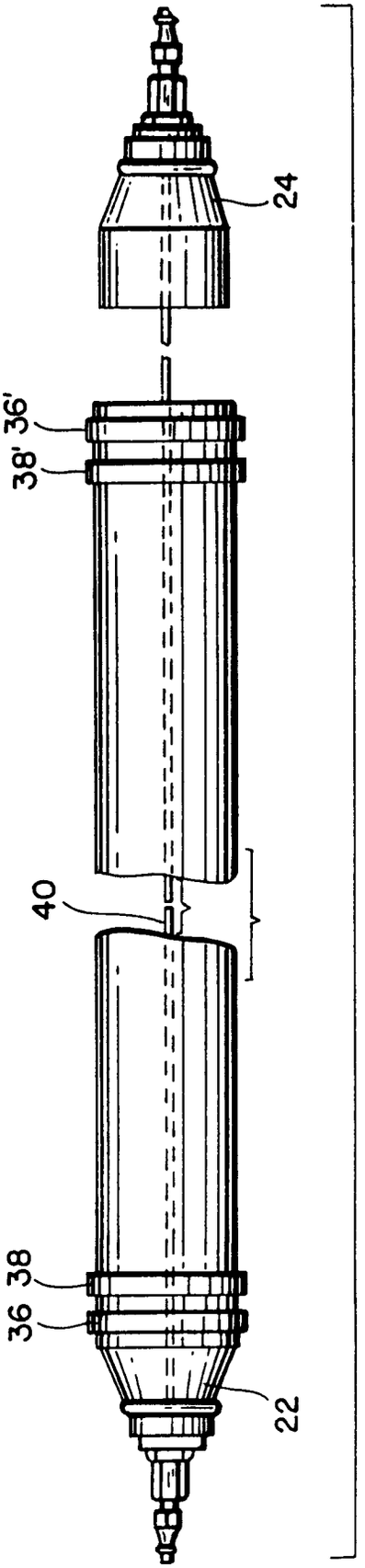

FIG. 4

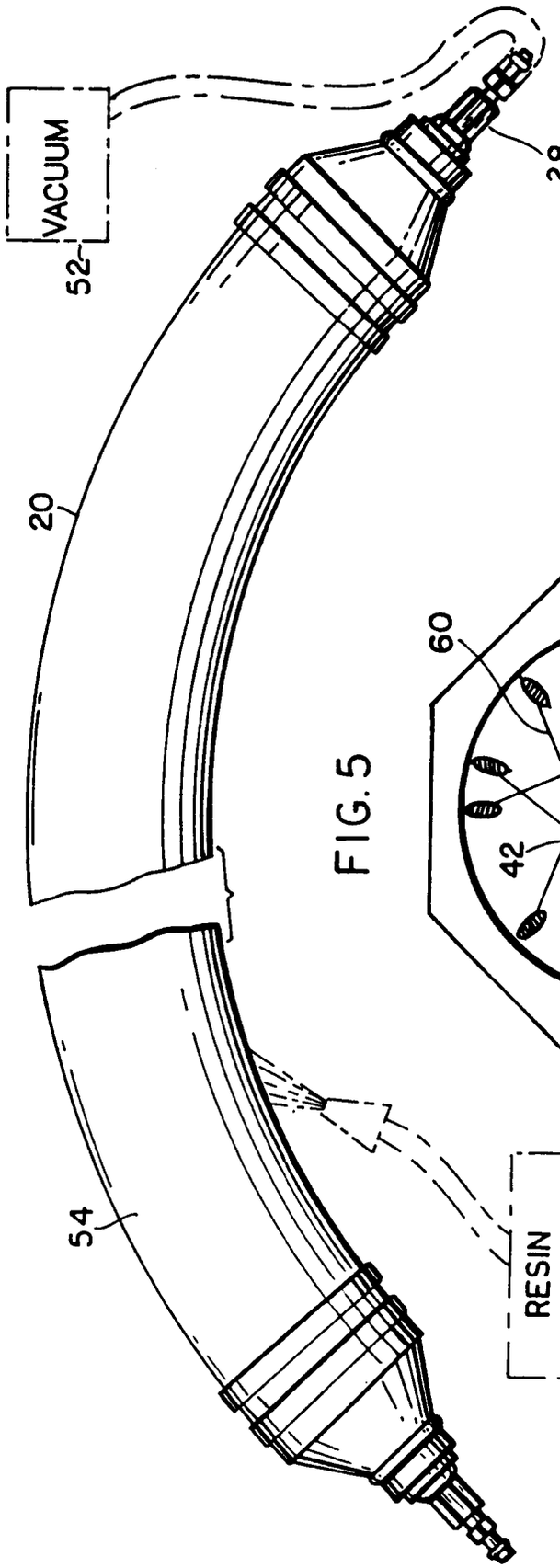

FIG. 5

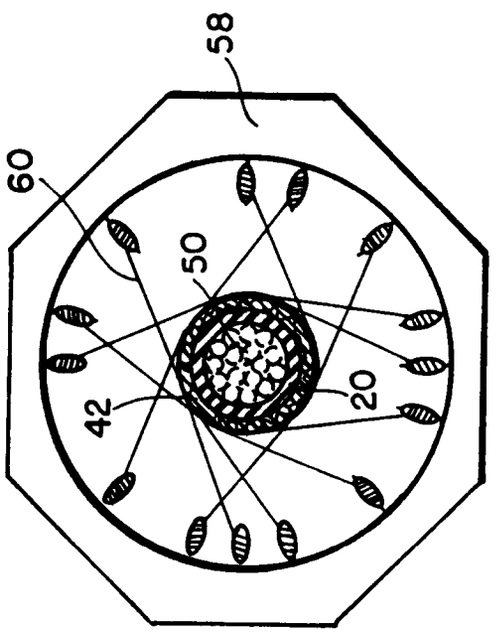

FIG. 6

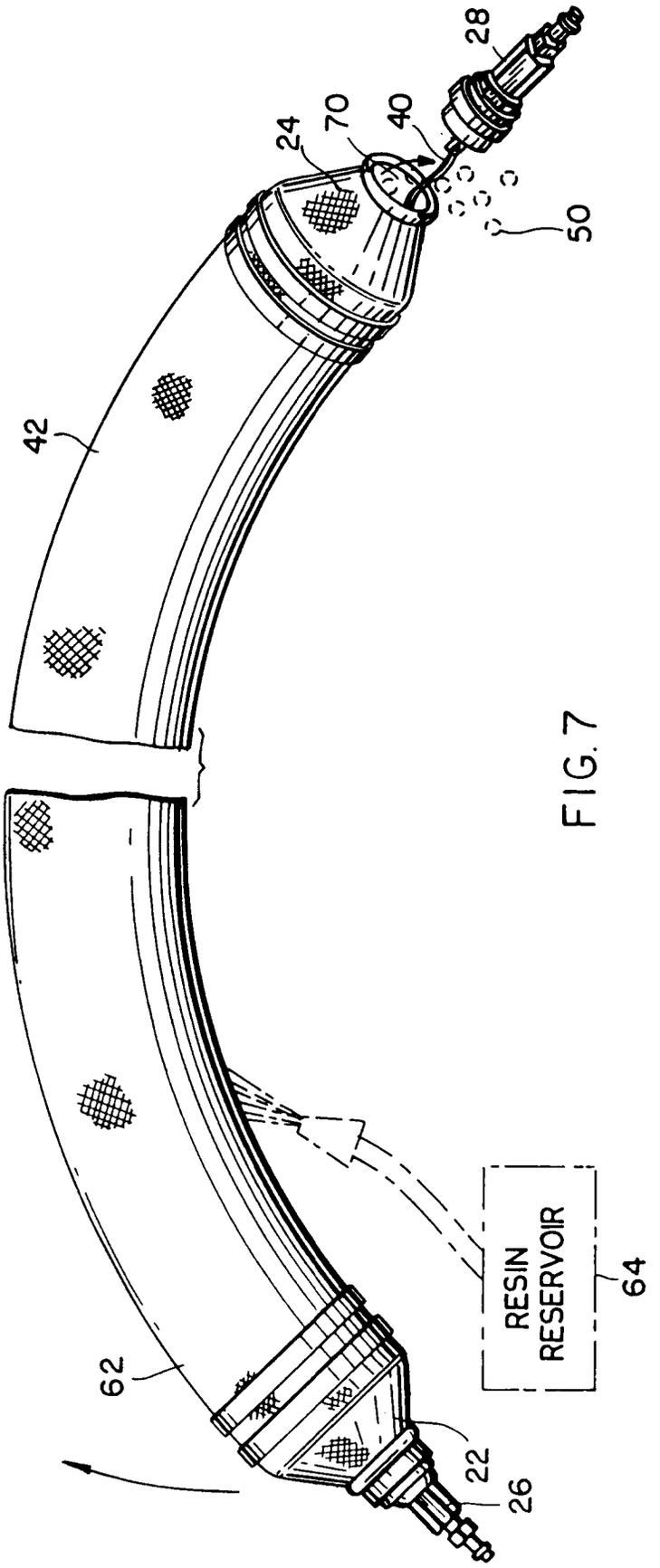

FIG. 7

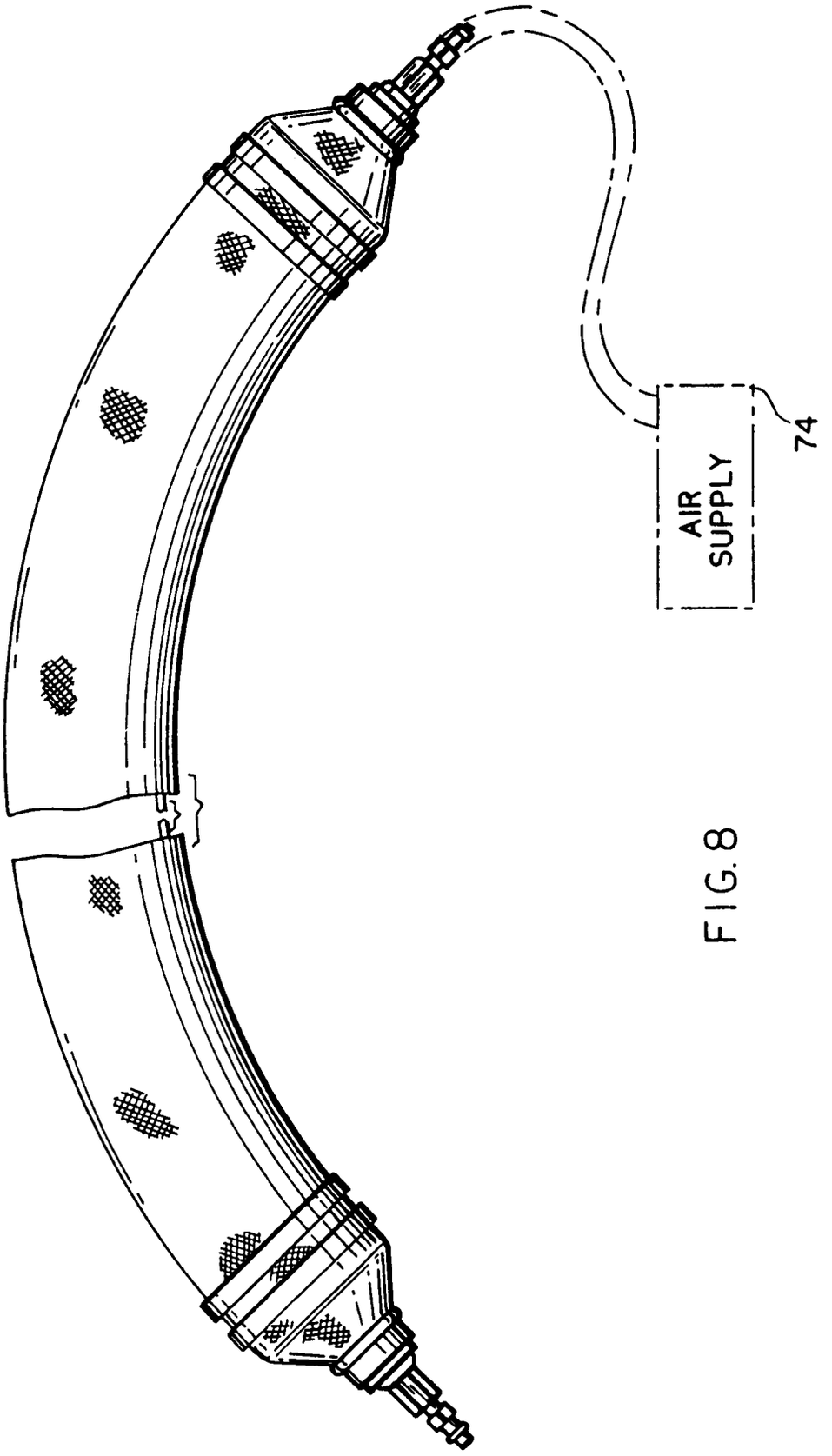

FIG. 8

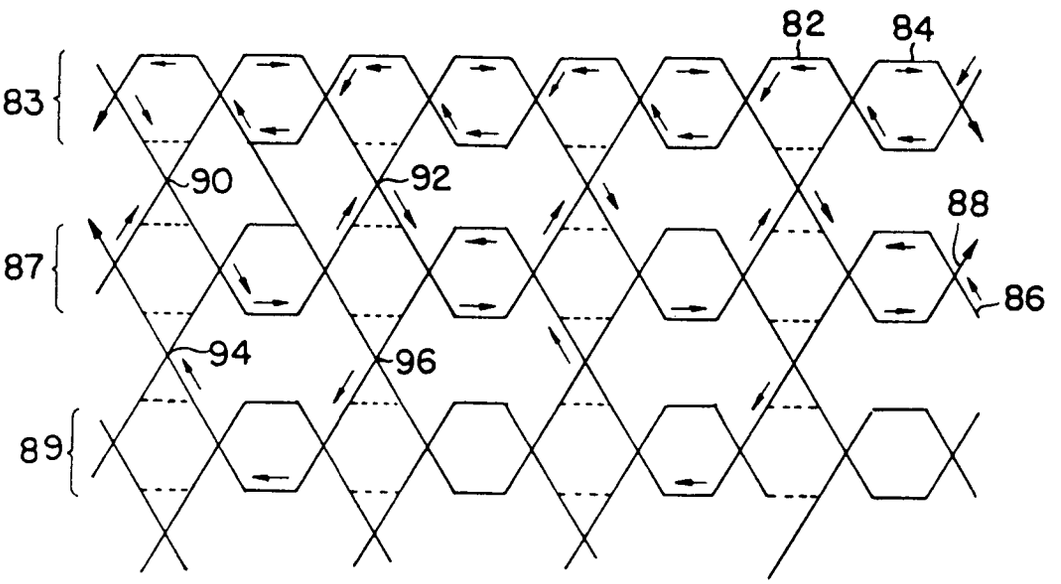

FIG.9