(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 195 408**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 86103646.5

(22) Date of filing: 18.03.86

(51) Int. Cl.⁴: B 21 D 9/01

(30) Priority: 21.03.85 US 714363

(43) Date of publication of application:
24.09.86 Bulletin 86/39

(84) Designated Contracting States:
DE FR GB IT NL SE

(71) Applicant: ALUMINIUM COMPANY OF AMERICA
Alcoa Building
Pittsburgh Pennsylvania(US)

(72) Inventor: Klingensmith, James Donald
106 Oxford Drive
Apollo Pennsylvania(US)

(72) Inventor: Evert, Robert Paul
209 Allison Road
Gibsonia Pennsylvania(US)

(74) Representative: Baillie, Iain Cameron et al,
c/o Ladas & Parry Isartorplatz 5
D-8000 München 2(DE)

(54) Improved flexible mandrel for bending hollow articles.

(57) The invention comprises a flexible mandrel for insertion into and removal from a hollow member, said mandrel being adapted to provide support for the walls of the hollow member in the process of bending the member, the mandrel comprising a plurality of elongated individual hoses disposed together in a side-by-side manner to form a unitary, elongated mandrel structure, said hoses being capable of expanding in cross section when a fluid is directed to them under pressure at a predetermined pressure value and contracting in cross section when the pressure value is lowered to or below a predetermined value, the cross-sectional expansion and contraction of the hoses being effective to expand and contract the cross-sectional area of the mandrel structure.

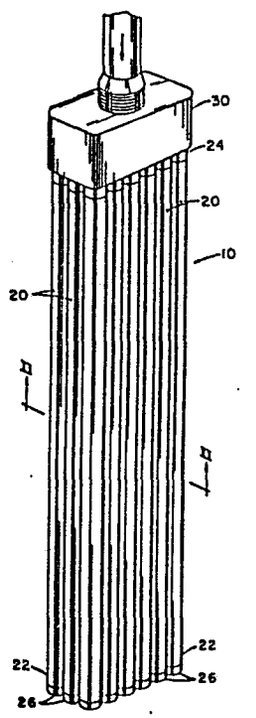

FIGURE I

EP 0 195 408 A2

0195408

IMPROVED FLEXIBLE MANDREL FOR BENDING HOLLOW ARTICLES

This invention relates to a flexible mandrel for bending hollow articles.

Bending a non-flexible hollow article involves some degree of risk of undesirable buckling or deformation of the article unless some means of internal support, such as a mandrel is utilized. While the insertion and use of a mandrel will serve to adequately support the walls of a hollow article during a bending operation, withdrawal of the mandrel after the bending function can present problems depending upon the complexity of the bend and the flexibility of the mandrel.

In addition to the withdrawal problem a problem of insertion is often involved with available flexible mandrels, i.e., the diameters or cross sectional dimensions and/or configurations of hollow members to be bent do not always match those of available mandrels. This results in a difficult insertion effort if tolerances are close. If the mandrel cross section is smaller than that of the hollow member, the fit between the hollow member and mandrel is too loose such that the hollow member is not adequately supported during the bending process.

Further, because of the large variety of sizes and shapes of hollow members that require bending, a large number of mandrel sizes and shapes are required.

This involves substantial costs in keeping a supply of appropriately sized mandrels on hand.

Various approaches have been advanced to address the problem of providing adequate support for a hollow object by withdrawable mandrel means. The use of a coil spring for such purposes is disclosed by Weber U.S. Patent 1,555,895. However, if the spring is constructed of a material sufficiently hard to provide the desired support, i.e., spring steel, the deformation or bending of the article may leave objectionable helical marks, particularly if the article being bent is a soft metal.

Zinnbauer et al U.S. Patent 3,841,138 proposes the use of stiff spherical balls within a tubular member to prevent collapse or buckling of the member during subsequent forming operations. Himstedt U.S. 3,251,126 teaches the use of a burnable mass of fibrous filler mandrel to be used as a removable supporting mandrel when forming coils. Gill U.S. Patent 3,016,081 uses a stack of substantially flat metal strips to internally support a waveguide during bending operations.

Kupfrian U.S. Patent 3,922,134 discusses the inadequacies of prior art approaches for supporting pipes during bending operations and then discloses the use of a helically wound expandable coil of flexible tubing, such as rubber wrapped around a flexible mandrel core. The mandrel is inserted into a conduit to be formed and a pressurized fluid is applied to the expandable helically wound tubing to render the tubing turgescent or swollen. However, the helical shape of the mandrel may give rise to the same objections raised by the use of a spring as well as complicate the subsequent withdrawal of the mandrel when used in soft hollow objects due to the helical nature of the indentations which may be made in the soft hollow object being bent.

Summary of the Invention

It is, therefore, an object of the invention to provide a radially expandable flexible mandrel to support the walls of a hollow member during forming operations.

It is another object of the invention to provide a radially expandable flexible mandrel to support the walls of a hollow member during forming operations comprising a plurality of elongated tubular members disposed in the hollow member generally parallel to the axis of the hollow member to facilitate subsequent removal of the mandrel.

These and other objects of the invention will be apparent from the following description and accompanying drawings.

In accordance with the invention, a flexible mandrel for insertion into and removal from a hollow member and adapted to provide support for the walls of the hollow member in the process of bending the member, comprises a plurality of elongated individual hoses disposed together in a side-by-side manner to form a unitary, elongated mandrel structure, said hoses being capable of expanding in cross section when a fluid is directed to them under pressure at a predetermined pressure value and contracting in cross section when the pressure value is lowered to or below a predetermined value. The cross-sectional expansion and contraction of the hoses are effective to expand and contract the cross-sectional area of the mandrel structure to provide the desired support while facilitating easy withdrawal of the mandrel.

Brief Description of the Drawings

Figure 1 is an isometric view of the mandrel of the invention.

Figure 2 is a horizontal cross-section view of the mandrel of Figure 1 taken along lines II-II.

Figure 3 is a horizontal cross section of a

modified version of the embodiment of Figures 1 and 2.

Figure 4 is an isometric view of the supporting spline shown in Figure 3.

Figure 5 is a horizontal cutaway showing the mandrel of Figures 3 and 4 installed in a bend tube.

Figure 6 is a horizontal cross-section of another modification of the embodiment of Figures 1 and 2.

Figure 7 is an isometric view of the tube supporting spline shown in Figure 4.

Figure 8 is a cutaway view of another embodiment of the mandrel of the invention shown installed in a bent tube.

Figure 9 is an isometric segment of a portion of the embodiment shown in Figure 8.

The flexible mandrel of the invention generally comprises a plurality of yieldable tube member adapted to be disposed within a bendable hollow object generally parallel to the axis of the hollow object.

In Figures 1 and 2, a mandrel constructed in accordance with the invention is generally indicated at 10 comprising a plurality of parallel flexible tubes 20 which are sealed at one end 22, for example, by plug means 26 and connected, at an opposite, open end 24, to a manifold 30. A line 40 connected to manifold 30 supplies fluid pressure from a pneumatic or, preferably, a hydraulic source.

Tubes 20 are preferably constructed of a flexible, expandable material, such as a heavy gauge neoprene rubber to permit radial expansion of tubes 20 upon application of fluid pressure thereto through manifold 30. The tube bundle, in unpressurized or relaxed form, which maintains the integrity of its original shape wherein relaxed, is inserted into a hollow article 60, and fluid pressure is then applied to expand tubes 20 tightly against the surface of the

inner wall of the hollow article as shown in Figure 2. Upon subsequent bending of the article, uniform support is imparted to the inner wall of the article due to the inflation of tubes 20 as well as the disposition of tubes 20 generally parallel to the axis of the hollow article and, therefore, generally normal or perpendicular to the bending force applied to the article as shown by the arrows in Figure 2. After the bend is completed, the tubes are deflated and removed from the article. Withdrawal of the mandrel device of the invention from the bent article is expedited by the disposition of the tubes of the mandrel parallel to the axis of the hollow article.

Turning now to Figures 3-5, a modified form of the embodiment of Figures 1 and 2 is illustrated. In this embodiment, tubes 20 comprising mandrel 10 are supported or guided by a flexible frame comprising a pair of flexible sheets 44 and 48 having slotted openings 50 therein to receive flexible upright members 54 to form an eggcrate-like support frame for tubes 20. This embodiment is useful when a large number of tubes 20 will be used in a hollow article of large diameter, such as article 60', as shown in Figures 3 and 5. Flexible sheets 44 and 48 and flexible upright members 54 may be constructed of a hard but somewhat flexible rubber or plastic, e.g., a hard vinyl.

Figures 6-7 illustrates another modification of mandrel 10 wherein a molded spline 70 made from hard rubber or similar materials is formed with grooves or keyways 72. Divider members 80 having a first arm or wing 82 and a second arm 84 are secured to spline 70 via a tongue or key 88 thereon which is lockingly received in groove or keyway 72 by sliding key 88 into keyway 72 from the end of spline 70.

Divider members 80 may also be constructed of any flexible material having the required amount of stiffness to act as a guide for the nest of tubes com-

prising mandrel 10.

In both of the embodiments of Figures 3-5 and 6-7, the length of the support frame may be easily altered by trimming sheets 44 and 48 or spline 70 to the desired length and then inserting, respectively, the appropriate number of upright members 54 or divider members 80.

Yet another embodiment is illustrated in Figures 8-9. In this embodiment, the row of tubes 20 which will be next to the inner radius of the bent tubing is replaced by a flexible metal member which, in the illustrated embodiment, comprises a link chain 90, such as a bearing chain. A series of alternately spaced links 92 comprising a metal, such as aluminum, are linked together by rods 94 of a hard aluminum or steel alloy passing through holes 96 in chain 90. As shown in Figure 8, link chain 90 replaces the row of tubes 20 on the inside of the bend of hollow article 60 to provide the hardest--or most firm--support in the critical area most likely to crimp or buckle during the bending operation. Inflation of hoses 20 retains chain 90 firmly against the wall of article 60 while deflation of tubes 20 allows mandrel 10 to be easily withdrawn from article 60. The embodiments previously illustrated and described can, of course, be easily modified to accommodate the inclusion of chain 90 in mandrel 10 by appropriate modification of upright members 54 or divider members 80.

Thus, the invention provides a flexible mandrel comprising inflatable tubes disposed in a hollow article parallel to the axis of the article to permit easy insertion and withdrawal of the mandrel while providing maximum support to the walls of the article normal or perpendicular to the bending force applied thereto to inhibit or prevent buckling of the article during subsequent forming operation.

CLAIMS

1. A flexible mandrel for insertion into and removal from a hollow member and being adapted to provide support for the walls of the hollow member in the process of bending the member, said mandrel comprising a plurality of elongated individual hoses disposed together in a side-by-side manner to form a unitary, elongated mandrel structure, said hoses being capable of expanding in cross section when a fluid is directed to them under pressure at a predetermined pressure value and contracting in cross section when the pressure value is lowered to or below a predetermined value, the cross-sectional expansion and contraction of the hoses being effective to expand and contract the cross-sectional area of the mandrel structure.

2. A mandrel according to claim 1, which includes a manifold for directing the liquid to one end of each of the hoses, and plug means insertable in the ends of the hoses opposite the manifold.

3. A mandrel according to claim 1 or 2, which includes flexible spacers located between the hoses and crosswise of the longitudinal axis of the mandrel structure.

4. A mandrel according to claim 3, in which the spacers are oriented in a manner that allows bending of the mandrel structure in either of two opposed directions.

5. A mandrel according to claim 3, which includes a flexible spline member adapted to receive and secure the flexible spacers in a manner crosswise of the longitudinal axis of the mandrel structure, said spline permitting bending in any direction including a twisted direction.

6. A mandrel according to claim 1 or 2, wherein a plurality of spacers are carried between adjoining tubes and disposed in a plane having a first axis parallel to the axis of said tubes and a second axis normal to the axis of said tubes to promote the orderly arrangement of said

tubes in said bundle to thereby facilitate insertion into and removal from said hollow article.

7. A mandrel according to any one of the preceding claims, wherein a yieldable metal member is disposed parallel to said axis of said article along one edge of said bundle of tubes to provide a hard surface against one portion of the wall of said article to resist buckling thereof during bending of said article.

8. A mandrel according to claim 7, wherein the yieldable metal member comprises a link chain.

9. A method of bending an elongated hollow structure, which comprises inserting a mandrel according to any one of the preceding claims into a hollow member, increasing the cross sections of the hoses and, thus, the cross section of the mandrel by directing a fluid to the hoses under a predetermined pressure value, and bending the hollow member while the hoses are under pressure.

10. A method of claim 9, in which the amount of the expansion of each of the hoses is about 5 to 15% of the original size of each hose.

0195408

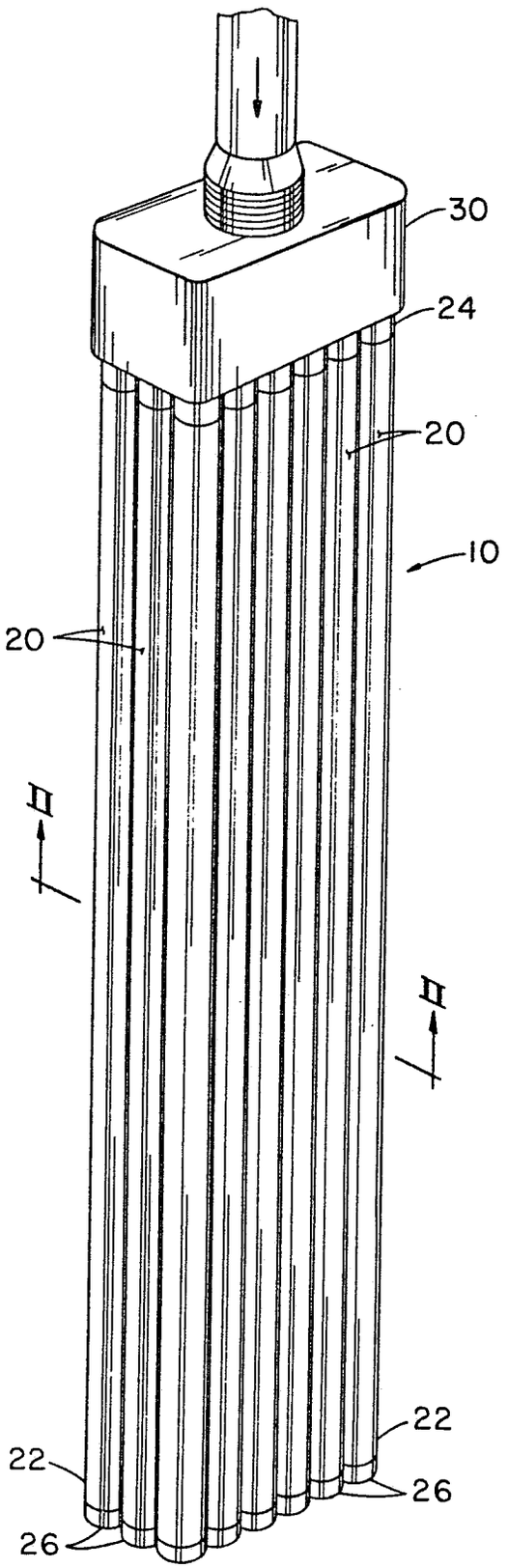

FIGURE 1

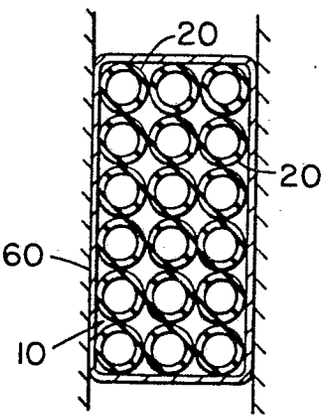

FIGURE 2

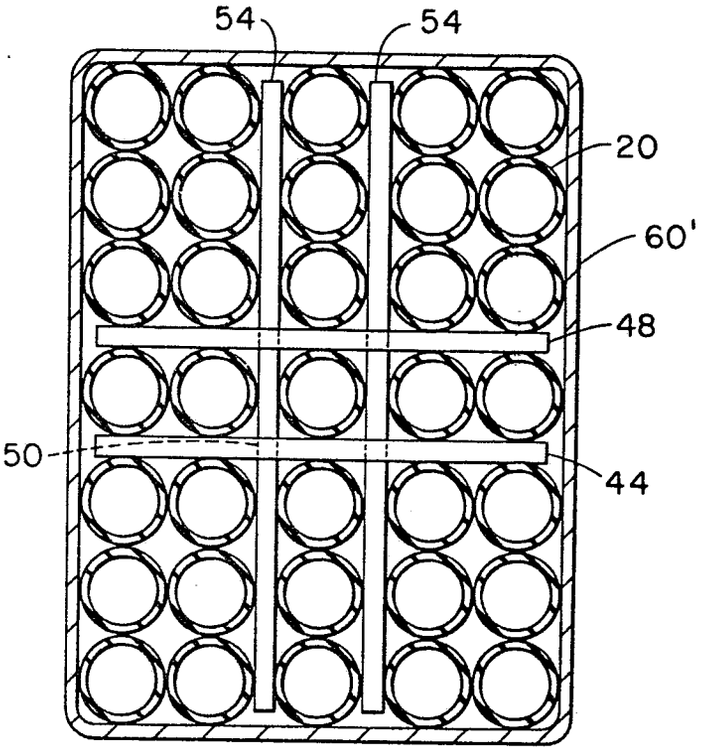

FIGURE 3

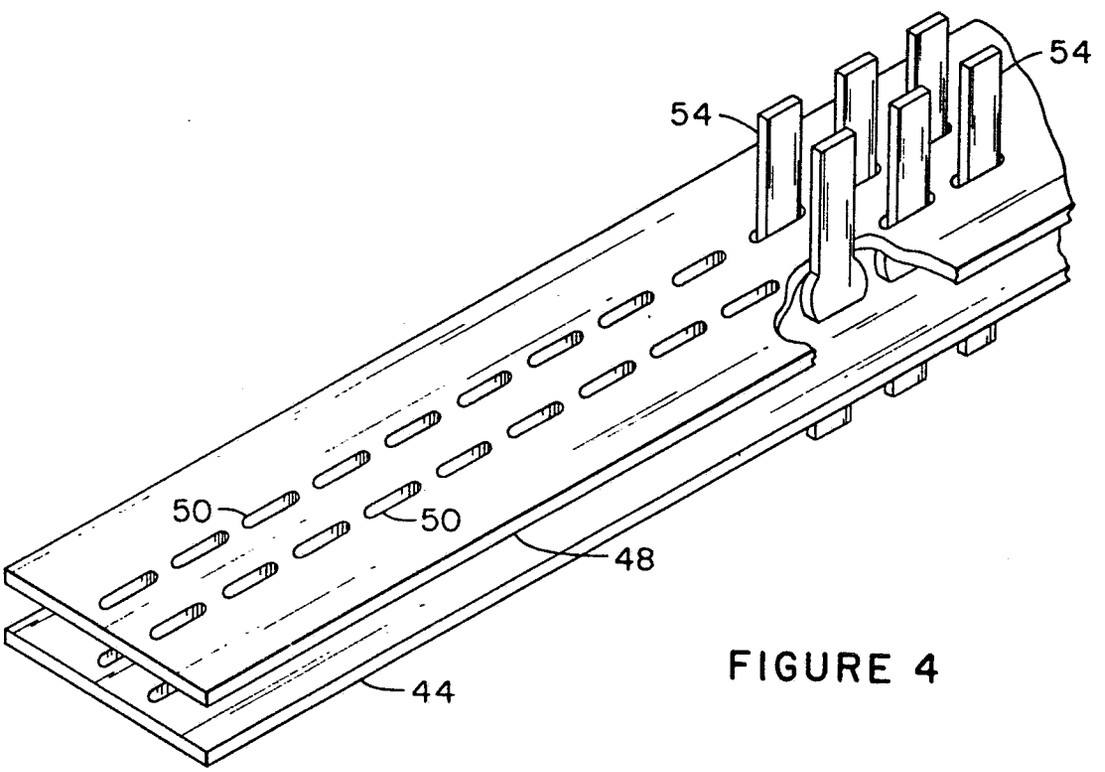

FIGURE 4

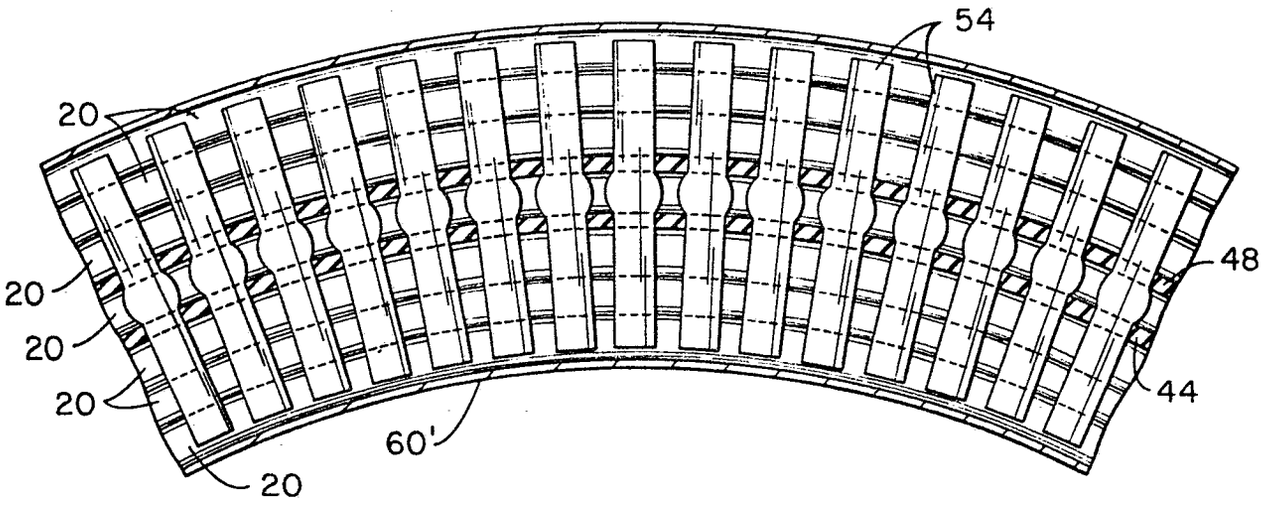

FIGURE 5

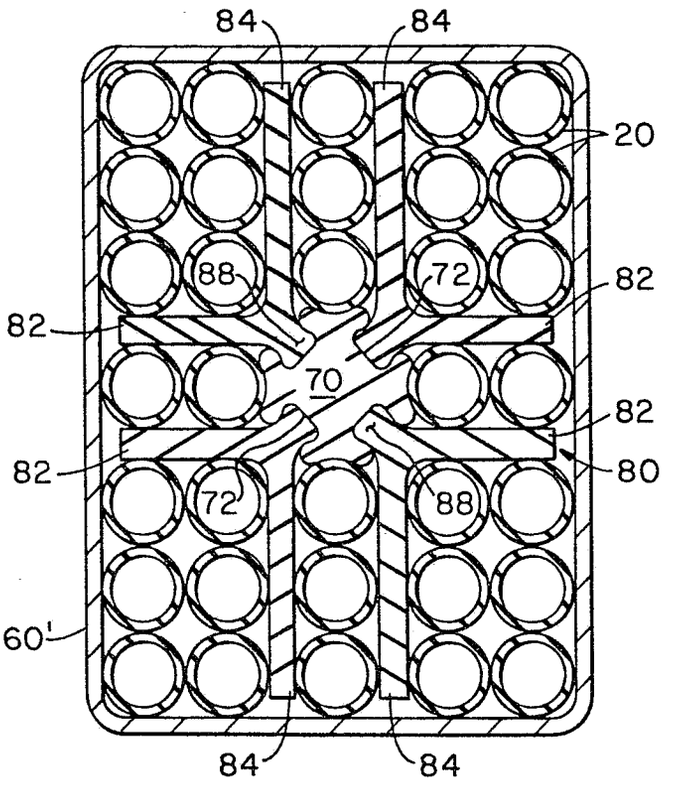

FIGURE 6

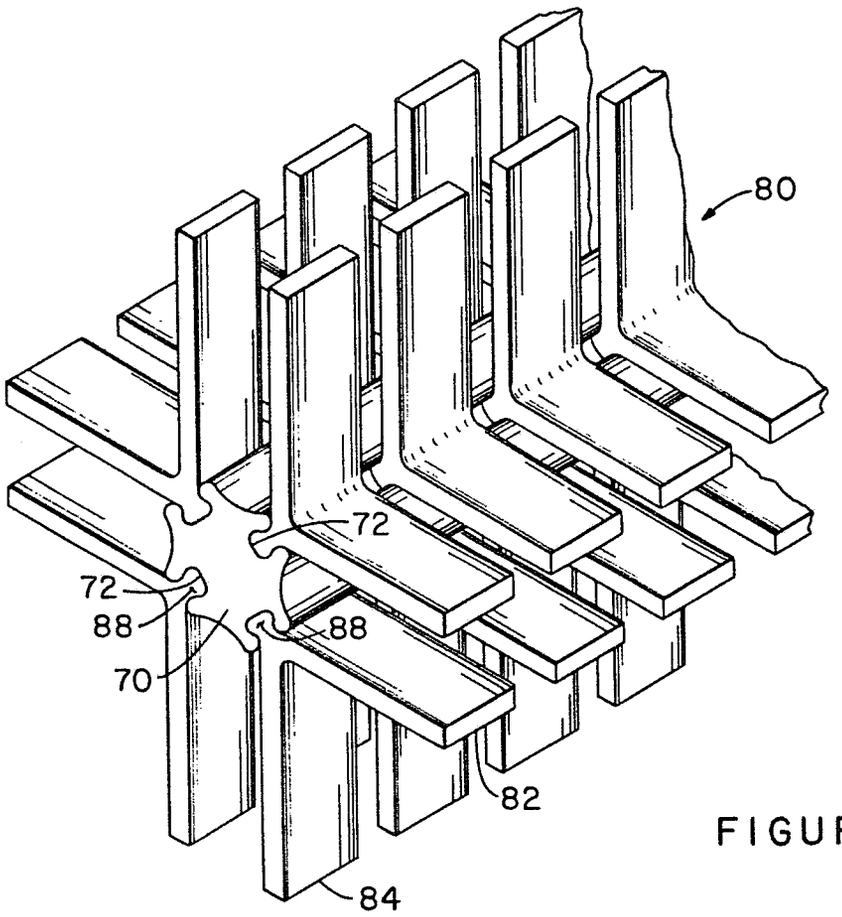

FIGURE 7

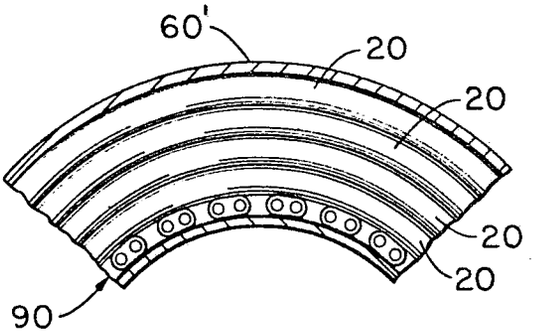

FIGURE 8

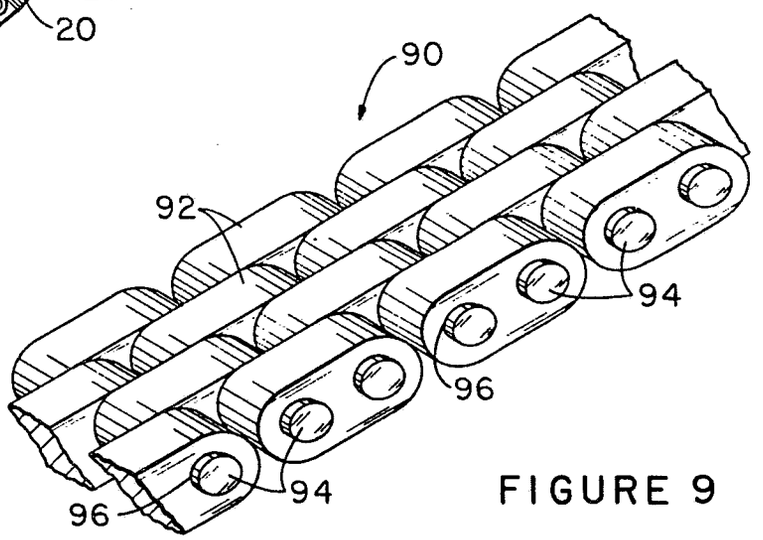

FIGURE 9