

[54] **ERECT TUBE BENDING MANDREL**

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[51] Int. Cl. **B21d 9/01**

[58] Field of Search **72/466, 478, 479**

[56] **References Cited**

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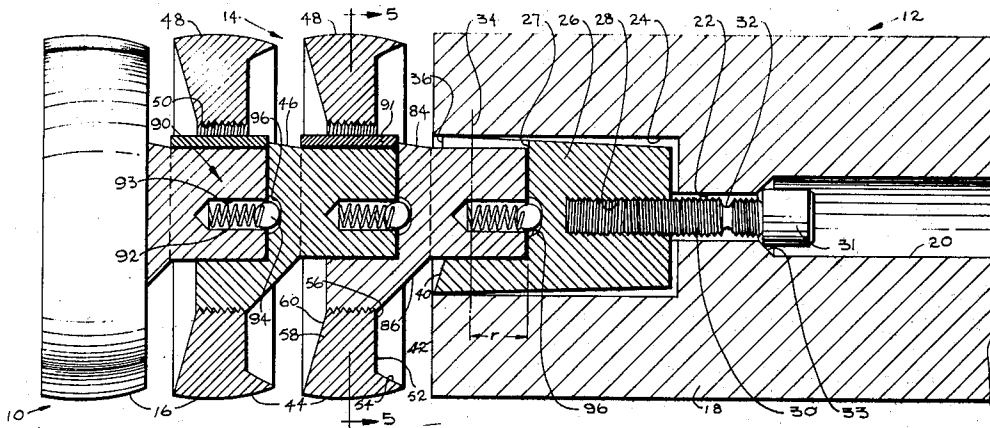
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[57] **ABSTRACT**

A tube bending mandrel for bending tubes in a single plane has a flexible mandrel section comprising connecting links having a cylindrical male portion and a cylindrical socket female portion of one-piece construction wherein each male portion is pivotally seated in the socket portion of each next connecting link and retained therein by outer ring members that are threaded onto the respective links.

12 Claims, 5 Drawing Figures



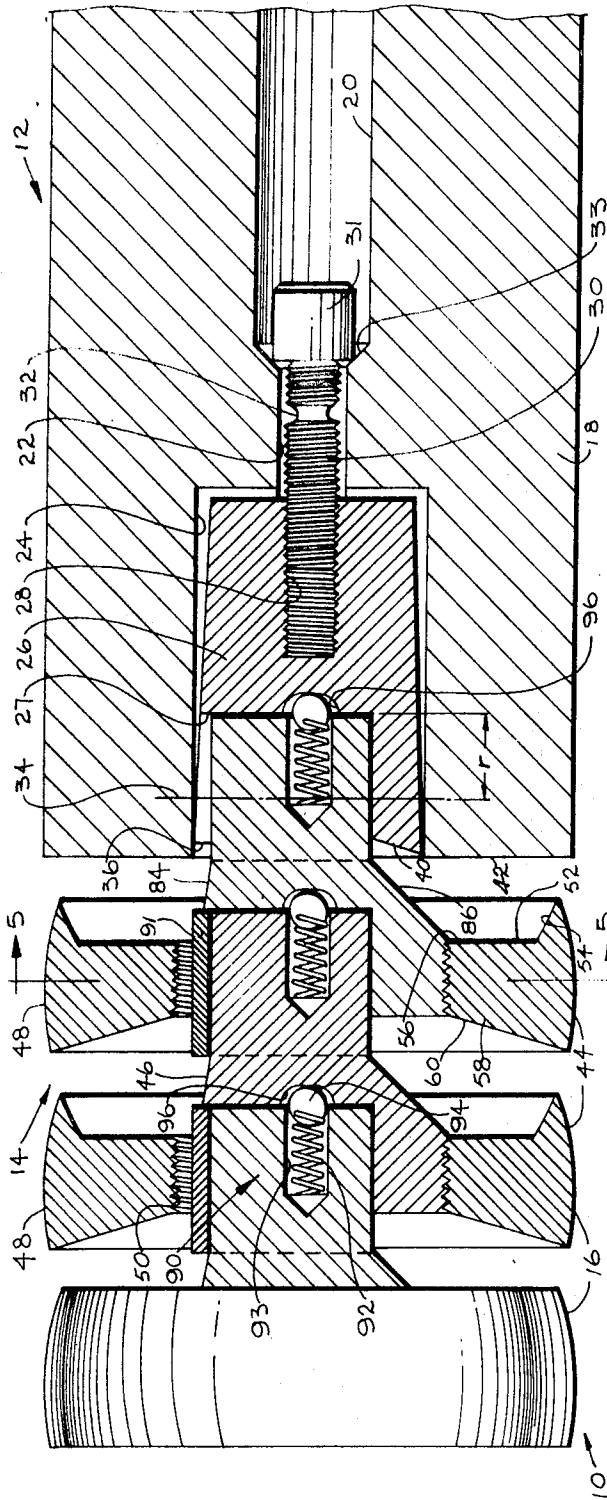


FIG. 1

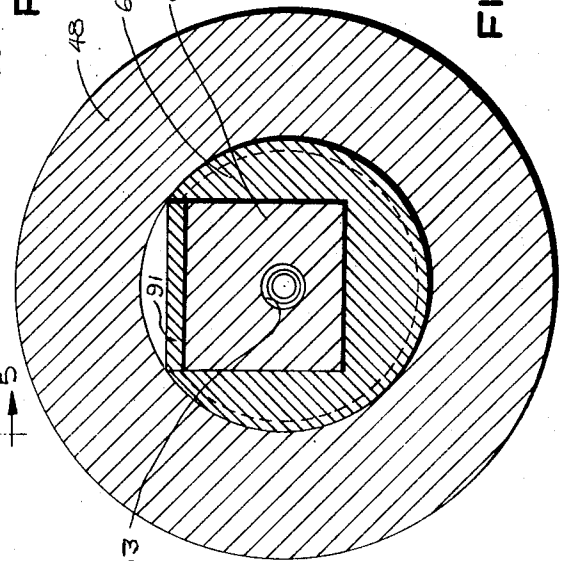


FIG. 2

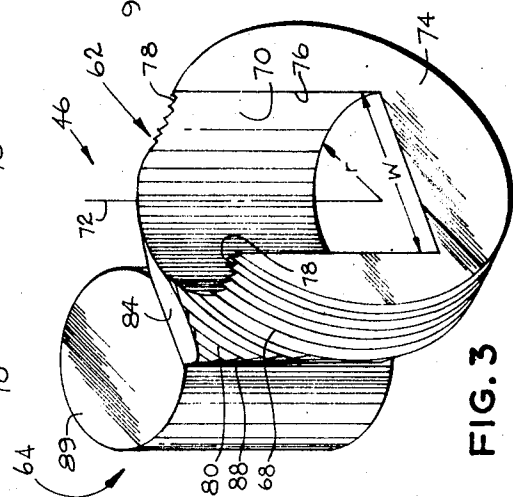


FIG. 3

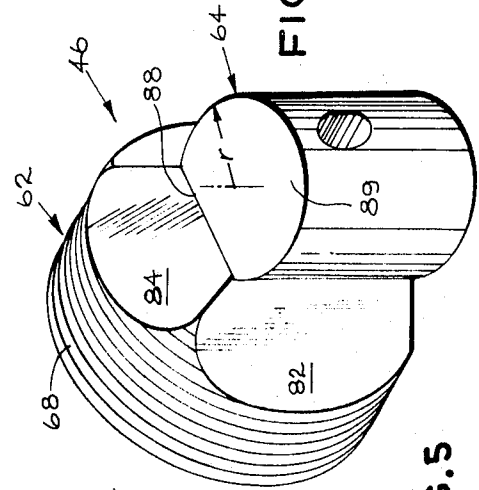


FIG. 4

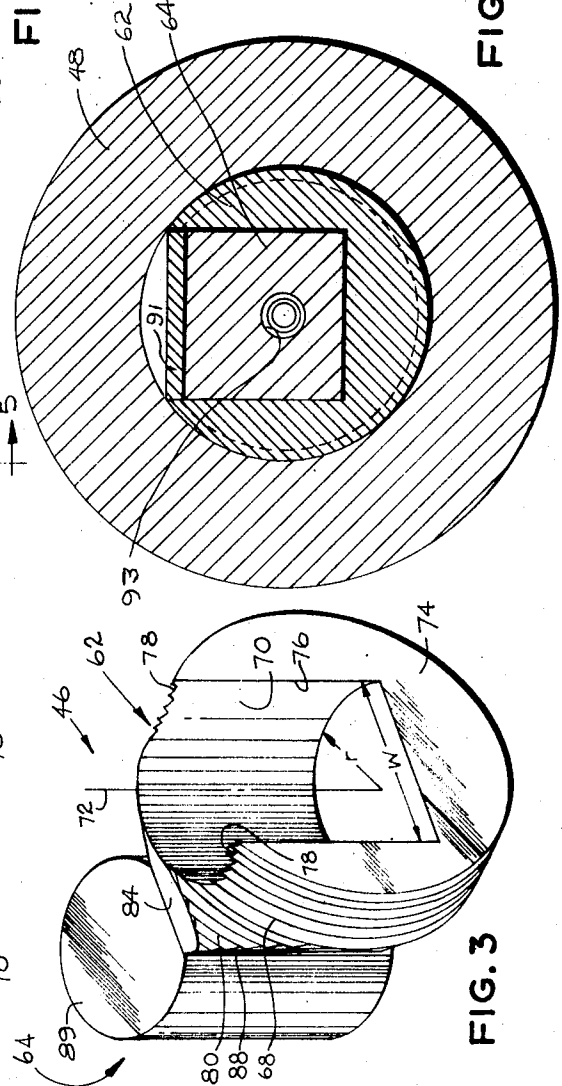
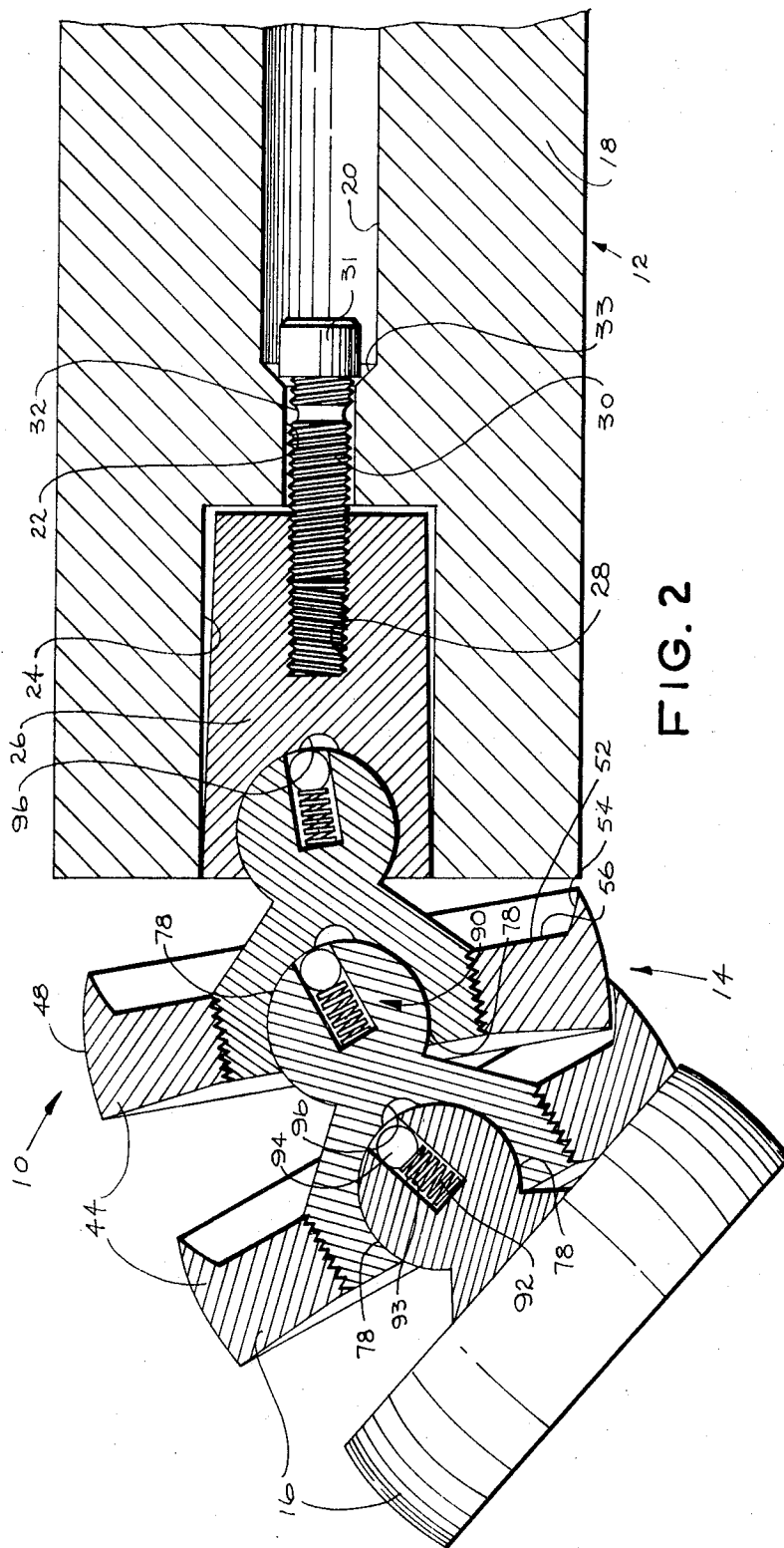


FIG. 5



ERECT TUBE BENDING MANDREL

This invention generally relates to tube bending mandrels and more particularly relates to a novel and improved mandrel or tool which is adapted for insertion into a tube along the section to be bent and which upon bending will internally support the tube to prevent flattening or collapse thereof.

In tube or pipe bending operations, it is customary to employ a mandrel which will fit within the tube along a length thereof to afford the necessary internal support in order to prevent reduction in size or collapse of the tube in bending. In conventional practice the mandrel is universally flexible and at least the flexible section of the mandrel is variable in length by adding or subtracting sections or links depending upon the length of the tubular section to be bent. For example, typical mandrels of this type are set forth and described in the U.S. Pat. to C. H. Roberts No. 3,455,142, to H. M. Spates U.S. Pat. No. 3,190,106 and to H. B. Condiff U.S. Pat. No. 2,962,077.

In accordance with the present invention it is proposed to greatly facilitate the tube or pipe bending operation, particularly with regard to larger diameter tubes, by devising an improved flexible mandrel construction that is self-supporting in one direction, preferably vertical, but which can be pivoted in a direction transverse to the one direction, preferably the horizontal direction.

Most conventional tube bending mandrels of the type which insert into the tube are provided with a ball and socket connection whereby the separate links are universally movable relative to the next adjacent links. In the past some difficulty has been encountered in keeping the mandrels horizontally erect to facilitate insertion of the mandrel into a tube to be bent, particularly for larger diameter tubes. One solution to the problem is the provision of a ball detent assembly, as disclosed in the aforementioned Roberts patent; however, when the diameter of the mandrel links are large enough, as with mandrels used to bend large diameter tubes of approximately three inches or more, the retentive strength of the ball detent is not great enough to support the larger and heavier mandrel links. Accordingly, with large mandrels other means are necessary for vertically supporting the mandrels while still allowing the mandrels to flex freely in the horizontal direction for bending of the tubes.

The tube bending mandrel of the present invention is primarily adapted for use in bending large tubes of three inches in diameter and more but is equally useful on a smaller scale for bending tubes which are smaller in size, e.g., between $\frac{1}{4}$ inch and 3 inches in diameter. The mandrel of the present invention is characterized by one-piece links having a generally cylindrical male portion at one end and a cylindrical socket female portion at the other. The links are joined together in a manner such that the longitudinal axes of the cylindrical sockets extend vertically whereby only lateral horizontal pivotal movement about the axis of the vertical socket is allowed.

Accordingly, it is an object of the present invention to provide a tube bending mandrel which is self-supporting and will remain erect in one plane.

It is another object of the present invention to provide a tube bending mandrel having extension links for internal support of a tube wherein the links are coupled for pivotal movement in a single plane.

It is still another object of the present invention to provide a tube bending mandrel for tubes of circular cross section wherein connective links of the mandrel are characterized by one-piece construction having a generally cylindrical male portion on one end and a generally cylindrical socket female portion on the other.

Other objects, advantages and features of the present invention will become more readily understood and appreciated from a consideration of the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a vertical section with parts left in full taken through the longitudinal center of a mandrel of the present invention;

FIG. 2 is a horizontal section with parts left in full taken along the longitudinal center line of a mandrel of the invention with the flexible mandrel section curved;

FIG. 3 is a perspective view of a link used in the mandrel of FIG. 1 looking at the leading or socket end of the link;

FIG. 4 is a perspective view of the link of FIG. 3 looking at the trailing or male end of the link; and

FIG. 5 is a diagrammatic section taken along line 5—5 of FIG. 1.

Referring in more detail to the drawings, a preferred form of invention is shown in FIGS. 1 and 2 in which a tube bending mandrel or tool 10 is broadly comprised of a straight mandrel section 12 and a flexible mandrel section 14 having a series of mandrel units 16. In this form the straight section 12 consists of an elongated rod 18 provided with an axial central passage 20 and an inner central passage 22 of reduced diameter which communicates with an enlarged open central passage 24 at the forward or leading end of the rod. A generally cylindrical insert 26 is positioned within the passage 24 to establish connection of the flexible mandrel section 14 to the straight section 12, and for this purpose the insert is provided with a socket 27 opening in facing relation to the flexible mandrel section. The side wall of the insert 26 is conical and tapers inwardly in the rearward direction so that the forward end portion of the insert will be tightly received in the recess 24 without having to worry about a high degree of tolerance. An internally threaded opening 28 at the opposite rear end of the insert receives the externally threaded end portion of a cap screw 30 having an enlarged head 31 which is inserted through the passages 20 and 22 so that the head 31 engages an annular beveled surface 33 of the mandrel section 12 in order to secure the insert 26 in place within the central passage 24. It will be noted that the cap screw 30 is selectively weakened by notching the shank as at 32 so that the cap screw will separate under excessive loading and thereby prevent undue strain from being placed on the more flexible mandrel section 14.

The socket or female portion 27 is generally cylindrical in shape with a radius r and having its longitudinal axis 34 extending vertically as can be seen in FIG. 1. The longitudinal axis 34 is spaced horizontally from the leading end 36 of the insert 26 a distance which is less than the radius r of the socket so that the socket 27 resembles a cylindrical recess which has been reduced in volume by a vertical plane passing through a portion thereof. It will, therefore, be apparent that the socket has a fragmented circular opening at the top which is greater than a semicircle but less than a complete cir-

cle. The socket also has a generally U-shaped opening at the leading end of the insert through which a portion of the first mandrel unit can protrude in a manner to be described hereinafter. Around the U-shaped socket opening, the insert is provided with an inclined or beveled end surface 40 which terminates at the leading end surface 42 of the mandrel rod 18 in order to afford adequate clearance for bending of the first mandrel unit in a manner to be described.

Now considering in more detail the construction and arrangement of the flexible mandrel section 14 and particularly the mandrel units 16, the mandrel units 16 are seen to include outer ring members 44 being connected in axially spaced, end-to-end relation by means of one-piece connecting links 46. Each ring 44 is relatively thick-walled but of limited length and has an outer rounded or convex periphery 48 and an inner internally threaded wall section 50 (FIG. 1) surrounding the central opening through the ring. The trailing end surface 52 of the ring, in facing relation to the leading end of the straight mandrel section 12, is somewhat dish-shaped or concave as defined by an inwardly inclined peripheral wall surface 54 terminating in an inner flat wall surface 56. The opposite forward end 58 of each ring is beveled inwardly to define an inner inclined surface 60 terminating at the end of the inner threaded section 50 of the ring.

Each connecting link 46 is of one-piece construction and has a generally cylindrical socket female portion 62 at one end and a generally cylindrical male or bulb portion 64 at the opposite end each having a radius r equivalent to the radius of the socket 27. The socket portion 62 is provided with a threaded, external wall surface 68 engageable with the internally threaded section 50 of the ring and a socket or cavity 70 corresponding in configuration and size to that of the socket 27 for insert 26. Thus each socket 70 comprises a generally cylindrically shaped cavity having a vertical longitudinal axis 72 which is spaced horizontally from the leading end 74 of the link 46 a distance which is less than the radius of the cavity so that the cavity resembles a cylinder which has been fragmented by a vertical plane passing through a portion thereof. The top end of each socket 70 is, therefore, shaped like a fragmented circle and the leading end of the socket defines a generally U-shaped opening 76 in the flattened leading end of the link. It should be noted that the width w of the opening 76 is less than the diameter of the socket 70. Due to the horizontal positioning of the cavity 70 relative to the flattened end 74 of the link, a pair of opposed retaining arm portions 78 (FIG. 2) are created for positively holding the cylindrical bulb portion 64 of the adjacent link in the cavity 70, as will become more apparent later.

The external wall of the socket portion 62 of each link 46 is threaded at 68 for a length corresponding to the length of the threaded section 50 of the ring and tapers rearwardly and inwardly along four flat surfaces 80, 82, 84 and 86 into an intermediate rectangular portion 88 of limited width which serves to join the cylinder and socket portions.

Each cylindrical bulb portion 64 is of generally cylindrical configuration having upper and lower flattened ends 89 with a diameter corresponding to that of the socket 70. The bulb or male portion terminates at its intersection with the four flat tapering surfaces 80, 82, 84 and 86.

It will be appreciated that the longitudinal axis of the male portion is parallel to the longitudinal axis of the female portion and the longitudinal axes of the male and female portions are normal to the longitudinal axis of the associated link and consequently the longitudinal axis of the entire tube bending mandrel 10.

Each of the cylinder and socket connecting links 46 is of corresponding size and shape so that the cylindrical male portion of each link will be in close-fitting complementary relation to the socket of each next link when inserted therein and will be positively held therein by the opposed retaining arm portions 78. It will be apparent that in the usual disposition the cylindrical bulb 70 of each link is free to pivot in a single plane within the socket of the next adjacent link about the vertical axis of the cylindrical bulb portion but will be restricted from pivotal movement in any other direction. It will be appreciated that, when assembled, a small space exists between the flattened upper end of a cylindrical bulb portion 64 and the internal threads 50 of the associated ring member 44 whereby, unless prevented, the bulb portion could slide up and down in the associated socket 70 possibly damaging the threads 50 of the ring. Inasmuch as it is difficult to machine the bulb portions to the tolerance necessary to prevent such sliding motion, a circular spacer slug 91 of any soft material such as brass or rubber and having a radius equivalent to that of the bulb portion, is placed on top of the bulb portion to bridge the gap sufficiently to prevent any sliding movement of the bulb in the socket. In actual use, the threads 50 cut mating grooves in the soft slug so that the slug is securely held in place. It should also be noted that the socket 70 as well as the bulb portion 64 of each mandrel unit 16 is not symmetrical about a horizontal plane bisecting a mandrel unit but rather is offset slightly in the upward direction to provide a more sturdy construction. In other words, if the socket 70 of each mandrel unit were deep enough from top to bottom to make the socket symmetrical about a horizontal plane bisecting the mandrel unit, the lower end of the socket would be very close to the flat tapering surface 86 of the link thereby weakening that part of the link. Therefore, by offsetting the socket upwardly a more desirably functioning connection between links can be made without sacrificing strength in the individual mandrel units.

In assembly, the mandrel is put together from the leading end back to the straight section 12. The ring 44 of the leading most mandrel unit would first be screwed onto the associated link 46 of the leading unit. Next the cylindrical bulb 64 of the leading link would be slid down into the socket of the link next behind so that it protruded through the opening 76 and the ring 44 of the link next behind screwed onto the associated link to lock or seal the bulb in the socket. Thereafter, each mandrel unit would be assembled with the bulb or male portion being locked in the socket portion of the mandrel unit next behind until the desired number of mandrel units were assembled which in length would correspond to the length of the tubing to be bent. When the trailing most mandrel unit 16 had been linked to the other mandrel units, the cylindrical bulb 64 of the trailing most mandrel unit would be slid into the socket 27 of the insert 26 and the insert then fitted into the central passage 24 in the rod 18. The cap screw 30 would then be screwed into the threaded bore 18 in the insert 26 from the bores 20 and 22 in the rod 18 thereby

tightly securing the flexible portion 14 of the mandrel 10 to the straight portion 12.

It will be evident that when assembled the mandrel will remain horizontally erect but the flexible portion 14 will be freely flexible in the horizontal direction, being limited only by the restrictions placed thereon by the cylinder and socket connection of the respective links. As can be seen in FIG. 2, when the links are fully flexed in one direction, a leading portion of the ring 44 of each mandrel unit will be disposed in the dish-shaped recess 52 in the trailing end of the ring of the mandrel unit next ahead so that the rings in no way inhibit flexing movement of the mandrel.

It is desirable when inserting the mandrel into a tube that the mandrel be perfectly straight for the tube to slide easily over the mandrel. For this purpose a ball detent assembly 90 may be disposed between the bulb portion 64 and the closed wall of the socket 70 or in the case of the first link, the socket 27. The ball detent assembly can be seen in FIGS. 1 and 2 to comprise a compression spring 92 received in a horizontal bore 93 in the bulb 64 of a link 46 to bias a detent 94 outwardly into a shallow depression 96 in the wall of the associated socket 70 or, in the case of the trailing most link, in the wall of the socket 27 in the insert 26. In assembled relation, the ball detent assembly facilitates pre-alignment of the mandrel units but in operation the force of the compression spring is readily overcome to permit flexing of the mandrel units into the desired bend.

In a typical tube bending operation the mandrel is inserted within a tube to be bent and clamped to a suitable die so that as pressure is applied in bending the tube, the mandrel will flex to the desired extent while internally supporting the tube against flattening or collapse. Customarily, the straight section of the mandrel may be secured to one end of a hydraulic cylinder rod with the flexible mandrel sections aligned to extend through the section of tubing to be bent. The tubing is then suitably clamped to a forming or bending die which is actuated to force the inserted mandrel sections through the desired bend. The relationship between the cylinder and socket portions as well as close spacing of the mandrel units will permit a high degree of flexing while maintaining a common center line radius and uniform external diameter throughout the mandrel units. Also, the cylinders are held within the sockets against shifting or any other undesired movement so that the flexible mandrel section will be of uniform length when in use.

Although a preferred form of the present invention has been herein shown and described, it will be apparent that modification and variation may be made without departing from the spirit and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A tube bending mandrel comprising a series of flexibly interconnected mandrel units arranged end to end, each mandrel unit having a one-piece link, the link having a generally cylindrical socket female portion adjacent one end, said cylindrical socket having a transverse cross-section which is greater than a semi-circle but less than a circle, and a generally cylindrical male portion at the other end received in the female portion of the next adjacent link whereby a succession of the links are flexibly attached together, said link having a longitudinal axis extending from said one end to said

other end and said male and female portions having parallel longitudinal axes which lie substantially normal to the longitudinal axis of the link, and an outer ring fastened to its associated link portion so as to retain the male portion of the next adjacent link in the socket of the associated link while permitting freedom of pivotal movement of each link relative to the next adjacent link in a single plane.

2. The tube bending mandrel of claim 1 wherein the longitudinal axis of the female portion is spaced inwardly from the one end of the associated link a distance which is less than the radius of the socket so that the female portion has an opening in the one end through which the attached link can protrude, said opening having a width which is smaller than the diameter of the generally cylindrical male portion.

3. The tube bending mandrel of claim 2 wherein the link portions of the mandrel are attached together so that the longitudinal axes of the substantially cylindrical socket female portion and the cylindrically shaped male portion are vertical and the socket of each link opens through the top of the link so that the male portion of an adjacent link can be inserted into the socket female portion through the opening in the top of the link and retained therein by the outer ring.

4. The tube bending mandrel of claim 3 further including a circular spacer slug abutting against the top of said male portion so as to be disposed between the top of the male portion and the outer ring.

5. The tube bending mandrel of claim 2 wherein the one end of said link is flattened and the socket opening therein is U-shaped with a width less than the diameter of the socket.

6. The tube bending mandrel of claim 1 further including a ball detent assembly having a compression spring disposed in a bore in the cylindrically shaped male portion and a detent ball biased outwardly by the spring so that the ball will drop into a depression in the socket female portion wall when the associated attached links are axially aligned.

7. A tube bending mandrel comprising in combination a straight mandrel section including a socket portion of substantially cylindrical configuration at one end and a series of flexibly interconnected mandrel units disposed in end-to-end relation with respect to one another and with respect to the end of the straight mandrel section, each of said flexibly interconnected mandrel units including an outer ring member and a one-piece inner connecting link, each connecting link including a socket portion of substantially cylindrical configuration adjacent one end with a transverse cross-section which is greater than a semi-circle but less than a circle and a generally cylindrical bulb portion at the other end adapted to seat in the socket portion of an adjacent link or in the socket portion of the straight mandrel section, the outer ring member of each unit being attachable to the associated link so as to retain the bulb portion of the adjacent link in the socket of the associated link in a manner such that the links will be free to pivot in a single plane.

8. The tube bending mandrel of claim 7 wherein the socket portion of the straight mandrel section is in a removable insert which can be fixedly secured in a recess in a bar portion of the straight mandrel section.

9. The tube bending mandrel of claim 7 wherein the longitudinal axis of the substantially cylindrical socket is spaced from the one end of the associated link a dis-

tance which is less than the radius of the socket so that the socket has an opening in the one end through which the attached link can protrude.

10. The tube bending mandrel of claim 9 wherein the link portions of the mandrel are attached together so that the longitudinal axes of the substantially cylindrical socket and the cylindrically shaped bulb are vertical and the socket opens through the top of the link so that the bulb of an adjacent link can be inserted into the socket through the opening in the top of the link and retained therein by the outer ring.

11. The tube bending mandrel of claim 7 further including a ball detent assembly having a compression spring disposed in a bore in the cylindrically shaped bulb and a detent ball biased outwardly by the spring so that the ball will drop into a depression in the socket wall when the associated attached links are axially aligned.

12. A tube bending mandrel comprising in combination a straight mandrel section having a recess in one end, an insert adapted to be fixedly secured in said recess so as to have an exposed end with an opening therein, the insert having a generally cylindrically shaped socket communicating with said opening, said socket having a vertical longitudinal axis, a series of flexibly interconnected mandrel units disposed in end-to-end relation with respect to one another and with re-

spect to the end of the straight mandrel section, each of said flexibly interconnected mandrel units including an outer ring member and an inner one-piece connecting link, each connecting link including a socket portion of substantially cylindrical configuration adjacent one end, said cylindrical socket portion having a transverse cross-section which is greater than a semi-circle but less than a circle, and a generally cylindrical bulb portion at the other end adapted to pivotally seat in the socket portion of an adjacent link or in the socket of the straight mandrel section, the longitudinal axes of the socket portion and the bulb portion both being spaced from the one end of the associated link a distance which is less than the radius of the socket portion so that the socket portion has an opening in the one end through which the attached link can protrude, the outer ring member of each unit being attachable to the associated link so as to retain the bulb portion of the adjacent link in the socket of the associated link in a manner such that the links will be free to pivot in a single horizontal plane, and a spacer abutting against the upper end of said bulb portion of each link so as to be disposed between the bulb portion and the outer ring such that linear movement of the bulb portion in the socket portion will be prevented.

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