Nov. 29, 1960 H. B. CONDIFF 2,962,077

PIPE BENDING MANDREL

Filed Nov. 18, 1958

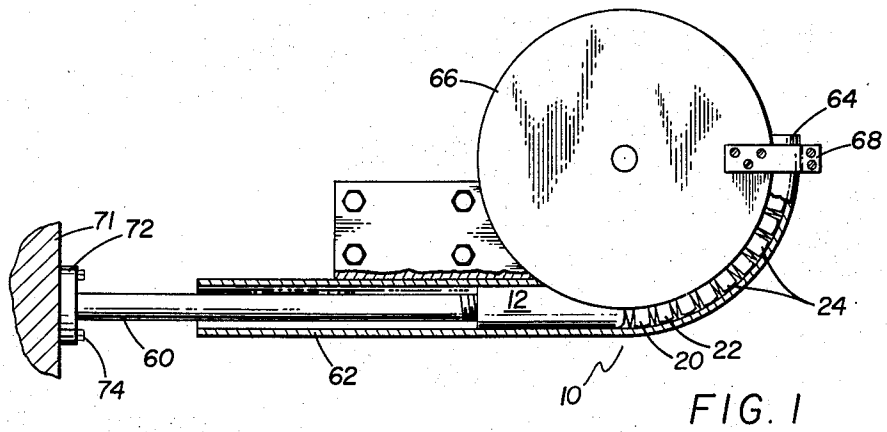


FIG. 1

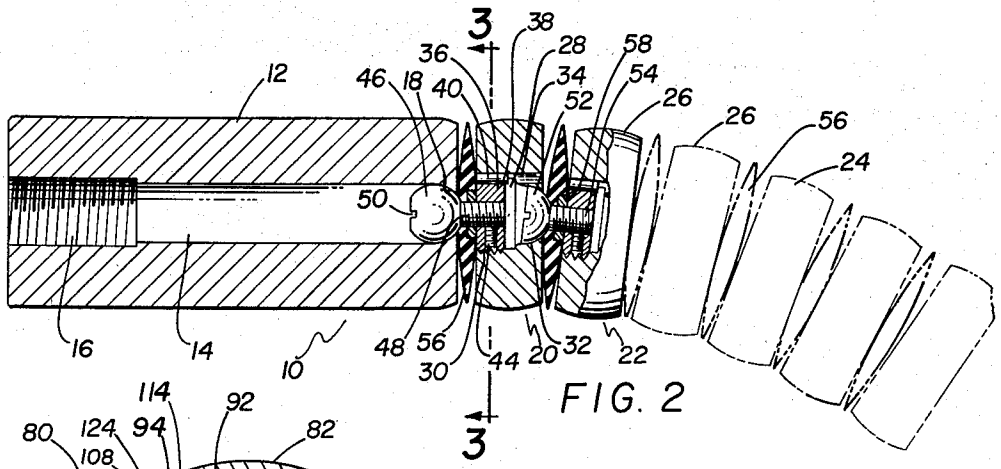


FIG. 2

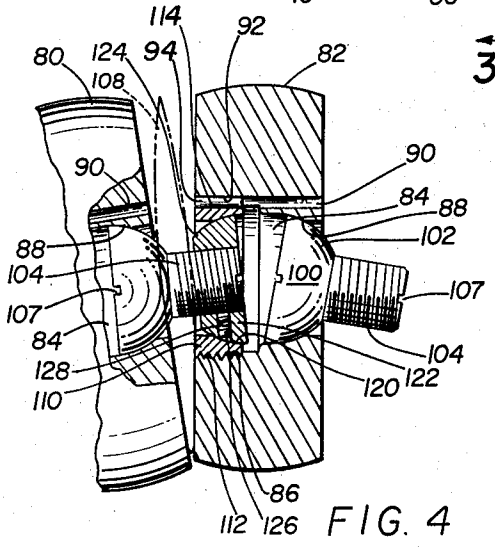


FIG. 4

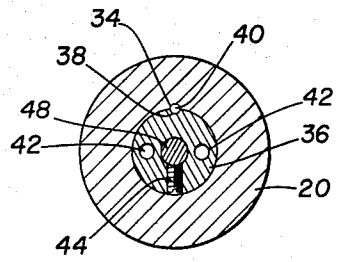


FIG. 3

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PIPE BENDING MANDREL

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13 Claims. (Cl. 153—63)

This invention relates generally to tube or pipe bending mandrels, and pertains more particularly to a mandrel of this type that can be varied in length.

This is a continuation-in-part of a prior, copending patent application, Serial Number 592,817, filed June 21, 1956, now abandoned, by Hays B. Condiff, entitled "Pipe Bending Mandrel."

The purpose of pipe bending mandrels is to prevent reduction in bore size of pipes and tubes while the pipes or tubes are being bent to desired degrees of curvature. While mandrels have been marketed that permit universal flexing of the plurality of mandrel sections relative to each other, an improved mandrel is needed that is constructed so that the various mandrel sections may be removed or added as circumstances dictate, thereby rendering the mandrel adaptable for different pipe lengths. Other areas of needed improvement include adaptability for minimum bending radiuses, adequate support of the pipe in the area being bent, and economy of manufacture.

The objects of my invention include: to provide a pipe or tube bending mandrel that can be readily changed in over-all length; to devise such a variable-length mandrel with universal flexing characteristics, thereby obviating a need to orient the mandrel relative the plane of flexing; to provide such a mandrel with means preventing inadvertent separation of parts during use; to devise a structure preventing excessive looseness or play between the mandrel sections; to provide such a mandrel of economical manufacture and permitting easy replacement of worn parts; to provide a structure that permits bending to common minimum radiuses, e.g., 2D (2 times mandrel diameter) and to devise means whereby the mandrel may be used for even lower minimum radiuses, e.g., as low as 1D (1 times mandrel diameter); and to provide adequate support of the pipe in the area being bent.

My invention will be best understood, together with additional objectives and advantages thereof, from the following description, read with reference to the drawings, in which:

Figure 1 is a side elevational view illustrating an actual bending operation, the pipe being sectionalized in order to show my mandrel in a flexed condition therein;

Figure 2 is a sectional view of one end of the mandrel forming the subject matter of the invention, two mandrel sections being shown in detail and additional sections being depicted in phantom outline to show the variable length of the mandrel;

Figure 3 is a sectional view taken in the direction of line 3—3 of Figure 2; and

Figure 4 is an enlarged, fragmentary sectional view of a mandrel having modified mandrel sections of more flexible construction whereby small minimum bending radiuses may be achieved, i.e., as low as one times the mandrel diameter.

Referring first to Figure 2, the cross sectional make-up of my mandrel may be seen here to good advantage, the mandrel being designated in its entirety by the numeral **10**. Mandrel **10** includes a sleeve **12** having a

bore **14** extending completely therethrough. One end of the sleeve's bore **14** is internally threaded at **16** to secure a tension rod to the mandrel and the other end terminates in an inwardly facing, parti-spherical or rounded seat **18**. In other words, the bore **14** is counterbored and tapped at **16** with a longitudinal or mid-portion of uniform diameter, though somewhat smaller than the portion **16**, and with the end portion denoted by the numeral **18** necking down in a curved fashion to the smallest diameter at the right end, as viewed in Figure 2.

Next to be described are the various mandrel sections making up the flexible portion of the mandrel. Although these various sections are each of identical construction, it will facilitate the description if the first several sections are assigned different reference numerals. Accordingly, the mandrel section nearest the sleeve **12** bears the numeral **20**, the next adjacent the numeral **22** and all of the following ones the numeral **24**, these last ones being the ones indicated in phantom outline.

As can be discerned from Figure 2, the sections **20**, **22** and **24** have rounded peripheries **26** when viewed in cross section. These sections are of annular configuration and each has a bore **28** extending therethrough which is basically similar to the bore **14** of the sleeve **12**, although considerably shorter. Bore **28** has a counterbored portion **30** at one end which is threaded and a parti-spherical or rounded opposite end forming a seat **32**.

The bore **28** extends axially through the center of each mandrel section, and radially displaced from the center is a longitudinal aperture **34**. More will be said presently as to how the aperture **34** may best be formed. At this time, though, it is to be noted that it is spaced radially from the seat **32** throughout that length thereof paralleling the seat, merging into a semi-circular groove disposed at the same radius as the counterbored portion **30**.

An annular disc or insert member **36** is threadedly received in each counterbored portion **30**, the insert member **36** having a threaded circumference permitting it to be so accommodated. By virtue of a longitudinal semi-circular groove **38** (Figure 3) extending along the peripheral surface of the insert member **36**, which groove **38** is angularly registrable with the semi-circular groove forming an axial continuation of the aperture **34**, means are provided for locking the insert member relative to the mandrel section, this means including a locking pin **40**. The length of the locking pin **40** should not be over half the axial length of the mandrel sections **20**, **22**, **24**, thereby permitting the pin **40** to be axially shifted from a position of engagement with the insert member **36** to a position of disengagement in which it then resides wholly within the other end of the aperture **34**. When thus shifted, the insert member **36** can be unscrewed and removed from the mandrel section in which it has been placed. To facilitate insertion and removal of the member **36** a pair of holes **42** (Figure 3) are provided to accommodate a spanner-type wrench.

The bore of each insert member **36** is threaded or tapped throughout its axial length and communicating radially with this bore is a tapped aperture leading inwardly from the threaded circumference of the insert member. Contained in this tapped aperture is a set screw **44** of slightly less length than is the aperture itself, thereby permitting the insert member to be screwed into the threaded counterbore **30** without interference.

An anchor ball member having a parti-spherical or rounded head **46** and a threaded shank **48** serves as the connecting means between the sleeve **12** and the insert member **36**, the shank **48** being threadedly received in the bore of said insert member. Inasmuch as the insert member **36** is in turn threadedly received in the annular mandrel section **20**, there being a screwdriver slot **50** on the head **46** for the accommodation of a screwdriver

when inserted through the bore 14 via the counterbore 16, it will be appreciated that the section 20 may in this way be attached to the sleeve 12. Owing to the slidable engagement of the head 46 with the seat 18, however, the anchor member, and hence the first mandrel section 20, is permitted to swivel in any angular direction from the axial or central position actually pictured when urged to do so.

Resembling the anchor ball member composed of the head 46 and threaded shank 48, both in appearance and function, is an intersection connecting ball member comprised of a parti-spherical or rounded head 52 and a threaded shank 54. Like the engagement of the head 46 with the seat 18 of the sleeve 12, the head 52 engages the seat 32 of the mandrel section 20. The shank 54, by the same token, is threadedly received by the insert member 36 threadedly received in the mandrel section 22. Repeated use of additional connecting members equipped with rounded heads 52 and threaded shanks 54 serve to connect in successive fashion the various mandrel sections 24. Accordingly, it will be perceived that the first section 20 is attached to the sleeve 12 in a universal manner and the succeeding sections 22 and 24 are similarly connected to each other, each mandrel section in this way being angularly pivotal in any direction relative to its next adjacent section, and of course the section 20 being similarly mounted with respect to the sleeve 12.

Interposed between the sleeve 12 and the mandrel 20, as well as between the successive sections 22 and 24, is a compressible washer 56, preferably of rubber or other resilient material. Washers 56 hold the mandrel partly erect and facilitate insertion into a tube to be bent. If desired, the various compressible washers 56 may be threadedly attached to the shanks 48, 54 which they encircle by a metallic nut element 58 embedded therein. Due to the convex configuration imparted to the opposite faces of the washer 56, it will be appreciated that a considerable amount of swiveling between mandrel sections may take place without any obstruction from the interposed material. However, the inherent resiliency of the washer 56 when held under compression by sufficient advancement of the shank 48 or 54 into its associated insert member 36 will assure a pressural action of the head 46 against the seat 18 or the head 52 against the seat 32 and so on throughout the complete string of mandrel sections 20, 22, 24.

While the manner of assembling and disassembling the various mandrel sections 20, 22, 24 will be apparent from the foregoing description, a specific explanation of the preferred attaching and detaching procedure will be given. To prepare the pipe bending mandrel for use, the over-all mandrel length that is needed is first determined. Then the number of sections 20, 22, 24 necessary to fulfill the length of bend requirement is selected and the various sections are connected together.

As a preliminary to the actual connecting of the mandrel sections together, the set screws 44 are advanced inwardly in their radially-directed apertures until the inner ends thereof just enter the counterbored portions 30. If desired, this extent of advancement may be physically ascertained by screwing in one of the shanks 48 or 54. Since preferably only a frictional drag is to be effected between the set screw 44 and the innerlying shank, the actual presence of a shank will be of help during this initial stage. The set screw should permit forceful turning of the shank 48 or 54, as the case may be.

The first step in assembling a string of mandrel sections is to screw an insert member 36 into the counterbore 30 of the most remote mandrel section 24, obtaining an alignment or registry between the aperture 34 and the groove 38. By having originally drilled the aperture 34 with the insert member in threaded engagement with the counterbore, it will be appreciated that the aperture 34, in effect, extends from one end of each mandrel section to the other, the groove 38 being automatically formed during the course of this planned drilling.

Continuing with the assembling procedure, when the aperture 34 and groove 38 are aligned, the locking pin 40 may be inserted, and the insert member 36 for that particular mandrel section 24 can not then rotate so as to work itself loose.

To attach this mandrel section 24 to the one next before in the string, the shank 54 of a connecting member is introduced through the bore 28, and a washer 56 is threaded onto the shank. Then the distal end of the shank 54 is threaded into the insert member 36 of the mandrel section 24 which has been prepared in the manner set forth in the two preceding paragraphs, tightening thereof being possible by means of a screwdriver introduced through the bore 28 that has not yet had its insert member 36 added.

This action is duplicated for each mandrel section to be incorporated into the string. After adding the insert member 36 to the mandrel section 20 and precluding its rotational dislodgment by means of the locking pin 40, the anchor ball member is ready to have its shank 48 threaded into the member 36 that has been locked in said mandrel section 20. To do this, access of a screwdriver is had to the slot 50 through the bore 14 after having first introduced the anchor member via this route. As with the connecting ball members utilized in holding the sections 20, 22 and 24 together, tightening of the anchor ball member until the head 46 engages the seat 18 will complete the stringing action.

Having connected the mandrel sections together, as outlined above, any number of sections may later be removed by merely reversing the procedure. Forced axial movement of the pin 40 in the section 20 may be accomplished with a thin rod or other implement, the movement being toward the next section 22. Through this action the pin 40 is shifted so it then resides in that portion of the aperture 34 paralleling the seat 32 and is then totally out of engagement with the longitudinal groove 38 formed in the insert member 36. The insert member 36 can then be removed for access to the head 52 and so on.

In order to demonstrate my pipe bending mandrel 10 in actual use, reference is now made to Figure 1. As illustrated, a tension rod 60 has one end threaded into the counterbore 16 of sleeve 12. The mandrel 10 is next inserted into the bore of a pipe 62 until the various assembled mandrel sections occupy that portion of the pipe which is to be bent. The free end 64 of the pipe is next secured to a rotatable forming block 66 by means of a clamp 68. That end of the rod 60 which projects from the opposite end of the pipe is affixed to the outer end of a plunger 71 of a hydraulic cylinder, not shown, by means of a flange 72 and stud bolts 74. Powered rotation of the block 66 in a counterclockwise direction forces the pipe 62, the enclosed mandrel 10, and the rod 60 to travel with the form block until the desired bend of the pipe is accomplished. During this travel hydraulic plunger 71 maintains the entire mandrel in tension.

The mandrel as shown in Figures 1 to 3 is usable for most pipe bending applications. However, the modified form of mandrel sections shown in Figure 4 is used when the bending radius is less than two times the mandrel radius (2D), the Figure 4 construction being usable for as low as 1D bending radiuses. It is also preferable to use the Figure 4 mandrel when bending tubes less than two inches in diameter.

To describe the Figure 4 construction, the principal difference from the Figure 2 structure is that a universal bending connection is provided at both ends of each mandrel section. Mandrel sections 80, 82 are similar to mandrel sections 20, 22. The similar structural details include central bore 84, threaded counterbore 86, the outwardly necked end of the bore forming the semi-spherical seat 88, and the opening 90 and aligned groove 92

to receive locking pin **94**. Connecting members **100** are constructed the same as connecting members of Figure 2 and include a head having a semi-spherical surface **102**, a threaded end **104**, and slots **107** at both ends to accept a screwdriver blade. Resilient washers **108** are provided between adjacent mandrel sections.

The Figure 4 modification is in the insert disc **110**. Like the Figure 2 insert disc **36**, insert disc **110** has threads **112** on its circumference threadedly engaged in threaded counterbore **86** and has a groove **114** accepting locking pin **94**. The insert disc also has holes (not shown) for a spanner wrench.

Insert disc **110** has a bore forming an inwardly facing semi-spherical seat **120**. A separate nut member **122** in provided which has a semi-spherical surface **124** engaging seat **120**. A set screw **126** is threadedly engaged in a radial aperture **128** in nut member **122** to secure shank **104** of connecting member **100** in a central threaded bore **130** in nut member **122**. Preferably, set screw **126** is sufficiently advanced to frictionally secure shank **104** as it is advanced into central bore **130**, as this facilitates assembly of the mandrel and sufficiently secures connecting member **100** from becoming disengaged during use. Nut member **122** may have openings (not shown) for engagement of a spanner wrench.

By the use of these modified insert discs **110**, in effect connecting members **100** become double-headed and universal flexing is accomplished at two locations in each mandrel section **80, 82**. This construction accommodates the abrupt bending occurring when minimum bending radiuses are used and adequately supports and conforms to the desired interior contour of the tube being bent when the bending is severe or small diameter tubing is being bent. All that is needed to convert mandrel sections **20, 22** of Figure 2 to the Figure 4 configuration, when minimum radius bends are to be performed, is to substitute insert discs **110** and nut members **122** for insert discs **36**.

The mandrels shown and described are economical to manufacture, use and maintain and a minimum stock of parts is required. One characteristic of the design, which hitherto was not obtained in a mandrel having the other desirable features of my mandrel, is compactness in an axial direction, the length of the mandrel sections being small in an axial direction considering the need to provide universal pivotal connections and the need to accommodate easy connection and disconnection of sections. Preferably, the diameter of the mandrel sections is at least double the axial length and likewise the insert discs have less axial length than outer diameter. The axial shortness of the sections achieves good support of the tube being bent, yet permits tube bending on small radiuses. The mandrel sections may be formed of tool steel. To prevent marring interior surfaces of aluminum tubes, it is sometimes desirable to provide a plastic coating on the exterior of the mandrel sleeve and sections.

When the expression is used in the claims, "the insert discs and mandrel sections having no fixed connecting means therebetween," the expression is meant to exclude bridging means such as welds or brazes that adhere to or unite with the metal of the parts and must be destroyed for disassembly.

Having described the invention with sufficient clarity to enable those familiar with this art to construct and use it, I claim:

1. The improvement in a mandrel for a pipe bending machine wherein the mandrel is contained in a tube to prevent collapse thereof while the tube is bent about a forming block, comprising: a series of similar annular mandrel sections each being circular in cross section transversely of said mandrel and having a diameter at least twice the axial length longitudinally of said mandrel section and the exterior surface being rounded in the direction longitudinally of said mandrel, each mandrel section having an axial bore therethrough which is threaded at one end and is outwardly necked at the other end, the necked portion forming an inwardly facing semi-spherical seat, an annular insert disc of lesser axial length than outer diameter threaded into the threaded end of said bore in each mandrel section, each insert disc having a threaded axial bore, a series of connecting members each having one end threaded and having a head at its other end with its surface facing the threaded end thereof being semi-spherical, each connecting member having its threaded end engaged in the threaded bore of an insert disc in one mandrel section and having its head disposed in the necked bore portion of the next adjacent mandrel section with the semi-spherical head surface engaged with the corresponding semi-spherical seat, a sleeve at one end of said series of mandrel sections having a bore extending therethrough that is necked at the end adjacent the mandrel sections forming an inwardly facing semi-spherical seat and an anchor member having a semi-spherical head engaged in the sleeve semi-spherical seat and having a threaded shank engaged in the threaded bore of an insert disc in the adjacent mandrel section, resilient cushioning means interposed between said mandrel sections, locking means engaging each mandrel section and the insert disc therein releasably locking the insert disc against rotation relative to the mandrel section and means engaging each insert disc and the connecting member therein and acting to prevent rotation between the connecting member and the insert disc.

2. The improvement in a mandrel for a pipe bending machine wherein the mandrel is contained in a tube to prevent collapse thereof while the tube is bent about a forming block, comprising: a series of similar annular mandrel sections each being circular in cross section transversely of said mandrel and having a diameter greater than the axial length longitudinally of said mandrel section and the exterior surface being rounded in the direction longitudinally of said mandrel, each mandrel section having means forming an axial bore therethrough which has a threaded portion at one end and which has an outwardly necked portion at the other end, the necked portion forming an inwardly facing semi-spherical seat, an annular insert disc threadedly engaged with the threaded portion of each mandrel section, each insert disc having a threaded axial bore, a series of connecting members each having one end threaded and having a head at its other end with its surface facing the threaded end thereof being semi-spherical, each connecting member having its threaded end engaged in the threaded bore of an insert disc in one mandrel section and having its head disposed in the necked portion of the next adjacent mandrel section with the semi-spherical head surface engaged with the corresponding semi-spherical seat, positioning means acting between each adjacent mandrel section and acting to hold said semi-spherical surface of said head in engagement with said semi-spherical seat, said positioning means being resilient and being placed in compression upon application of forces tending to collapse the mandrel and said positioning means resiliently resisting such forces to hold the mandrel extended, locking means engaging the threaded portion of each mandrel section and the insert disc engaged therewith and acting to prevent rotation between the threaded portion of the mandrel section and the insert disc, and means engaging each insert disc and the connecting member therein and acting to prevent rotation between the connecting member and the insert disc.

3. The improvement in a mandrel in a pipe bending machine wherein the mandrel is contained in a tube to prevent collapse thereof while the tube is bent about a forming block, comprising: a series of similar annular mandrel sections each being circular in cross section transversely of said mandrel and having a diameter at least twice the axial length longitudinally of said mandrel section and the exterior surface being rounded in the

direction longitudinally of said mandrel, each mandrel section having an axial bore therethrough which is threaded at one end and is outwardly necked at the other end, the necked portion forming an inwardly facing semi-spherical seat, an annular insert disc of lesser axial length than outer diameter threaded into the threaded end of said bore in each mandrel section, each insert disc having a threaded axial bore, a series of connecting members each having one end threaded and having a head at its other end with its surface facing the threaded end thereof being semi-spherical, each connecting member having its threaded end engaged in the threaded bore of an insert disc in one mandrel section and having its head disposed in the necked bore portion of the next adjacent mandrel section with the semi-spherical head surface engaged with the corresponding semi-spherical seat, resilient cushioning means interposed between each adjacent mandrel section and acting to hold said semi-spherical surface of said head in engagement with said semi-spherical seat, said resilient cushioning means being placed in compression upon application of forces tending to collapse the mandrel and resiliently resisting such forces to hold the mandrel extended.

4. The subject matter of claim 3 in which there is locking means engaging each mandrel section and the insert disc therein releasably locking the insert disc against rotation relative to the mandrel section, said locking means including a shiftable pin received in aligned openings in each mandrel section and corresponding insert disc in locking position, the pin having such length whereby the pin may be shifted to a position in the mandrel section opening and out of the insert disc opening for unlocking the parts.

5. The improvement in a mandrel in a pipe bending machine wherein the mandrel is contained in a tube to prevent collapse thereof while the tube is bent about a forming block, comprising: a series of similar annular mandrel sections each being circular in cross section transversely of said mandrel and having a diameter at least twice the axial length longitudinally of said mandrel section and the exterior surface being rounded in the direction longitudinally of said mandrel, each mandrel section having an axial bore therethrough which is threaded at one end and is outwardly necked at the other end, the necked portion forming an inwardly facing semi-spherical seat, an annular insert disc of lesser axial length than outer diameter threaded into the threaded end of said bore in each mandrel section and each insert disc having a threaded axial bore, a series of connecting members each having one end threaded and having a head at its other end with its surface facing the threaded end thereof being semi-spherical, each connecting member having its threaded end engaged in the threaded bore of an insert disc in one mandrel section and having its head disposed in the necked bore portion of the next adjacent mandrel section with the semi-spherical head surface engaged with the corresponding semi-spherical seat, positioning means acting between each adjacent mandrel section and acting to hold said semi-spherical surface of said head in engagement with said semi-spherical seat, said positioning means being placed in compression upon application of forces tending to collapse the mandrel and said positioning means resisting such forces to hold the mandrel extended, and means engaging each insert disc and the connecting member therein and acting to prevent rotation between the connecting member and the insert disc.

6. The subject matter of claim 5 in which each connecting member has a slot in an end thereof to receive a screwdriver for rotation of the connecting member during assembly and disassembly.

7. The improvement in a mandrel in a pipe bending machine wherein the mandrel is contained in a tube to prevent collapse thereof while the tube is bent about a forming block, comprising: a series of similar annular mandrel sections each being circular in cross section transversely of said mandrel and having a diameter at least twice the axial length longitudinally of said mandrel section and the exterior surface being rounded in the direction longitudinally of said mandrel, each mandrel section having an axial bore therethrough which is threaded at one end and is outwardly necked at the other end, the necked portion forming an inwardly facing semi-spherical seat, an annular insert disc of lesser diameter than said mandrel sections and of substantially the same maximum diameter as said bore and of lesser axial length than outer diameter threaded into the threaded end of said bore in each mandrel section, each insert disc having a threaded axial bore, a series of connecting members each having one end threaded and having a head at its other end with its surface facing the threaded end thereof being semi-spherical, each connecting member having its threaded end engaged in the threaded bore of an insert disc in one mandrel section and having its head disposed in the necked bore portion of the next adjacent mandrel section with the semi-spherical head surface engaged with the corresponding semi-spherical seat, positioning means acting between each adjacent mandrel section and acting to hold said semi-spherical surface of said head in engagement with said semi-spherical seat, said positioning means being resilient and being placed in compression upon application of forces tending to collapse the mandrel and said positioning means resiliently resisting such forces to hold the mandrel extended, and a sleeve at one end of said series of mandrel sections having a bore extending therethrough that is necked at the end adjacent the mandrel sections forming an inwardly facing semi-spherical seat and an anchor member having a semi-spherical head engaged in the sleeve semi-spherical seat and having a threaded shank engaged in the threaded bore of an insert disc in the adjacent mandrel section.

8. The improvement in a mandrel in a pipe bending machine wherein the mandrel is contained in a tube to prevent collapse thereof while the tube is bent about a forming block, comprising: a series of similar annular mandrel sections each being circular in cross section transversely of said mandrel and having a diameter at least twice the axial length longitudinally of said mandrel section and the exterior surface being rounded in the direction longitudinally of said mandrel, each mandrel section having an axial bore therethrough which is threaded at one end and is outwardly necked at the other end, the necked portion forming an inwardly facing semi-spherical seat, an annular insert disc of lesser axial length than outer diameter threaded into the threaded end of said bore in each mandrel section, each insert disc having a threaded axial bore, a series of connecting members each having one end threaded and having a head at its other end with its surface facing the threaded end thereof being semi-spherical, each connecting member having its threaded end engaged in the threaded bore of an insert disc in one mandrel section and having its head disposed in the necked bore portion of the next adjacent mandrel section with the semi-spherical head surface engaged with the corresponding semi-spherical seat, positioning means acting between each adjacent mandrel section and acting to hold said semi-spherical surface of said head in engagement with said semi-spherical seat, said positioning means being placed in compression upon application of forecs tending to collapse the mandrel and said positioning means resisting such forces to hold the mandrel extended.

9. The improvement in a mandrel in a pipe bending machine wherein the mandrel is contained in a tube to prevent collapse thereof while the tube is bent about a forming block, comprising: a series of similar annular mandrel sections each being circular in cross section transversely of said mandrel and having a diameter at least twice the axial length longitudinally of said mandrel section and the exterior surface being rounded in

the direction longitudinally of said mandrel, each mandrel section having an axial bore therethrough which is threaded at one end and is outwardly necked at the other end, the necked portion forming an inwardly facing semi-spherical seat, an annular insert disc of lesser axial length than outer diameter threaded into the threaded end of said bore in each mandrel section, each insert disc having a bore therethrough which has a portion which is outwardly necked forming a semi-spherical seat, a nut member in each insert disc having a semi-spherical outer surface engaged with the insert disc semi-spherical seat and each nut member having a threaded axial bore, a series of connecting members each having one end threaded and having a head at its other end with its surface facing the threaded end thereof being semi-spherical, each connecting member having its threaded end engaged in the threaded bore of a nut member in one mandrel section and having its head disposed in the necked bore portion of the next adjacent mandrel section with the semi-spherical head surface engaged with the corresponding semi-spherical seat of the mandrel section, whereby each end of the connecting members has a universally pivotal connection with one of said mandrel sections, positioning means acting between each adjacent mandrel section and acting to hold said semi-spherical surfaces of said heads and said nut members in engagement with said semi-spherical seats, said positioning means being placed in compression upon application of forces tending to collapse the mandrel and said positioning means resisting such forces to hold the mandrel extended.

10. The subject matter of claim 9 in which there is locking means between each nut member and the connecting member in the nut member threaded bore acting to prevent relative rotation therebetween.

11. The subject matter of claim 10 in which there is locking means between each mandrel section and the insert disc therein acting to prevent relative rotation therebetween and said positioning means is annular resilient cushioning means interposed between said mandrel sections.

12. The improvement in a mandrel in a pipe bending machine wherein the mandrel is contained in a tube to prevent collapse thereof while the tube is bent about a forming block, comprising: a series of similar annular mandrel sections each being circular in cross section transversely of said mandrel, each mandrel section having means forming an axial bore therethrough which has a threaded portion at one end and which has an outwardly necked portion at the other end, the necked portion forming an inwardly facing semi-spherical seat, an annular insert disc threadedly engaged with the threaded portion of each mandrel section, each insert disc having a bore therethrough which has a portion which is outwardly necked forming a semi-spherical seat, a nut member in each insert disc having a semi-spherical outer surface engaged with the insert disc semi-spherical seat and each nut member having a threaded axial bore, a series of connecting members each having one end threaded and having a head at its other end with its surface facing the threaded end thereof being semi-spherical, each connecting member having its threaded end engaged in the threaded bore of a nut member in one mandrel section and having its head disposed in the necked portion of the next adjacent mandrel section with the semi-spherical head surface engaged with the corresponding semi-spherical seat of the mandrel section necked portion, whereby each end of the connecting members has a universally pivotal connection with one of said mandrel sections, positioning means acting between each adjacent mandrel section and acting to hold said semi-spherical surfaces of said heads and said nut members in engagement with said semi-spherical seats, said positioning means being resilient and being placed in compression upon application of forces tending to collapse the mandrel and said positioning means resiliently resisting such forces to hold the mandrel extended.

13. The improvement in a mandrel in a pipe bending machine wherein the mandrel is contained in a tube to prevent collapse thereof while the tube is bent about a forming block, comprising: a series of similar mandrel sections each being circular in cross section transversely of said mandrel, each mandrel section having means forming an axial bore therethrough having at each end an outwardly necked portion forming a semi-spherical seat, a series of connecting members each having one end threaded and having a head at its other end with its surface facing the threaded end being semi-spherical, a nut member on each connecting member threaded end having a semi-spherical surface facing said connecting member head, each connecting member connecting a pair of adjacent mandrel sections with the semi-spherical surface of its head engaging the adjacent semi-spherical seat of one of the connected mandrel sections and with the semi-spherical surface of the nut member on said connecting member engaging the adjacent semi-spherical seat of the other of the connected mandrel sections whereby each end of the connecting members has a universally pivotal connection with one of the mandrel sections, each mandrel section being divided in the area between the two semi-spherical seats therein and the divided portions being connected by inter-engaging threads thereby providing access to the interior of the mandrel section between the seats in assembling and disassembling the mandrel, positioning means acting between each adjacent mandrel section and acting to hold said semi-spherical surfaces of said heads and said nut members in engagement with said semi-spherical seats of the mandrel sections, said positioning means being placed in compression upon application of forces tending to collapse the mandrel and said positioning means resisting such forces to hold the mandrel extended.

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