United States Patent [19]

Cunningham

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[54] **PIPE MANDREL FOR USE DURING BENDING**

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[73] Assignee: **Evans, Pipeline Equipment Co.,** Tulsa, Okla.

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[21] Appl. No.: **238,107**

[52] **U.S. Cl.** **72/466,** 72/392

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

[58] **Field of Search** 72/392, 393, 398, 72/466; 269/48.1

[56] **References Cited**

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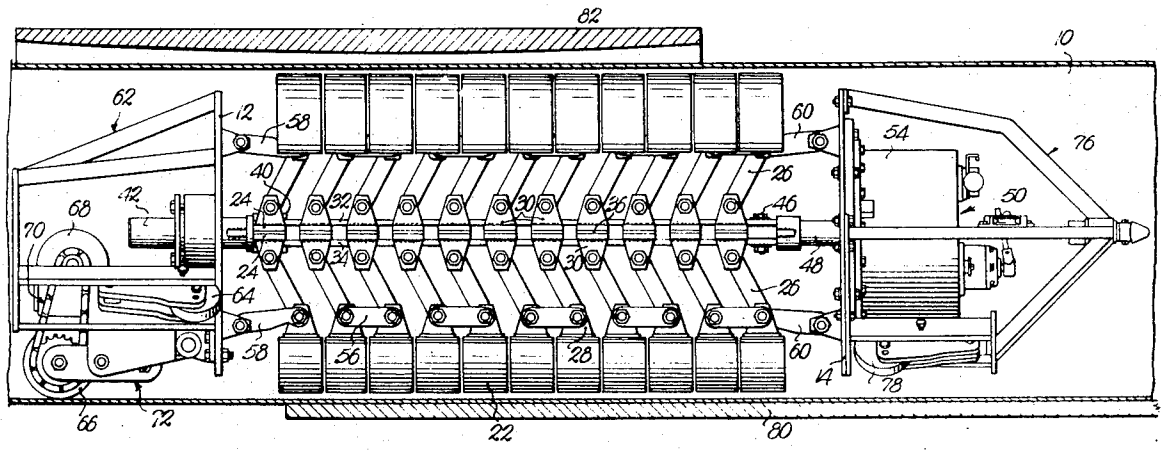
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Primary Examiner—Lowell A. Larson
Attorney—Schmidt, Johnson, Hovey & Williams

[57] **ABSTRACT**

A pipe bending mandrel for use inside the pipe embodies a flexible body suspended between spaced supports and made of a series of diametrically opposed, pipe-engaging shoes that are clamped tightly in place against the pipe by toggle joints in a manner to preclude displacement during bending so that pipe buckling and wrinkling at the bend are effectively eliminated. A reciprocable control common to the toggles and actuated by a single power device results in equalized forces imparted to the pipe by all of the shoe assemblies, assures complete lock-in of all of the assemblies prior to bending, and causes all of the assemblies to cooperate in preventing collapse of any one or more of the assemblies while bending takes place. The shoes are stragetically arranged only along those zones where buckling and wrinkling would normally occur, but at those zones the shoes are shaped, sized, spaced and adequate in number such as to accomplish optimum results.

16 Claims, 8 Drawing Figures



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SHEET 1 OF 3

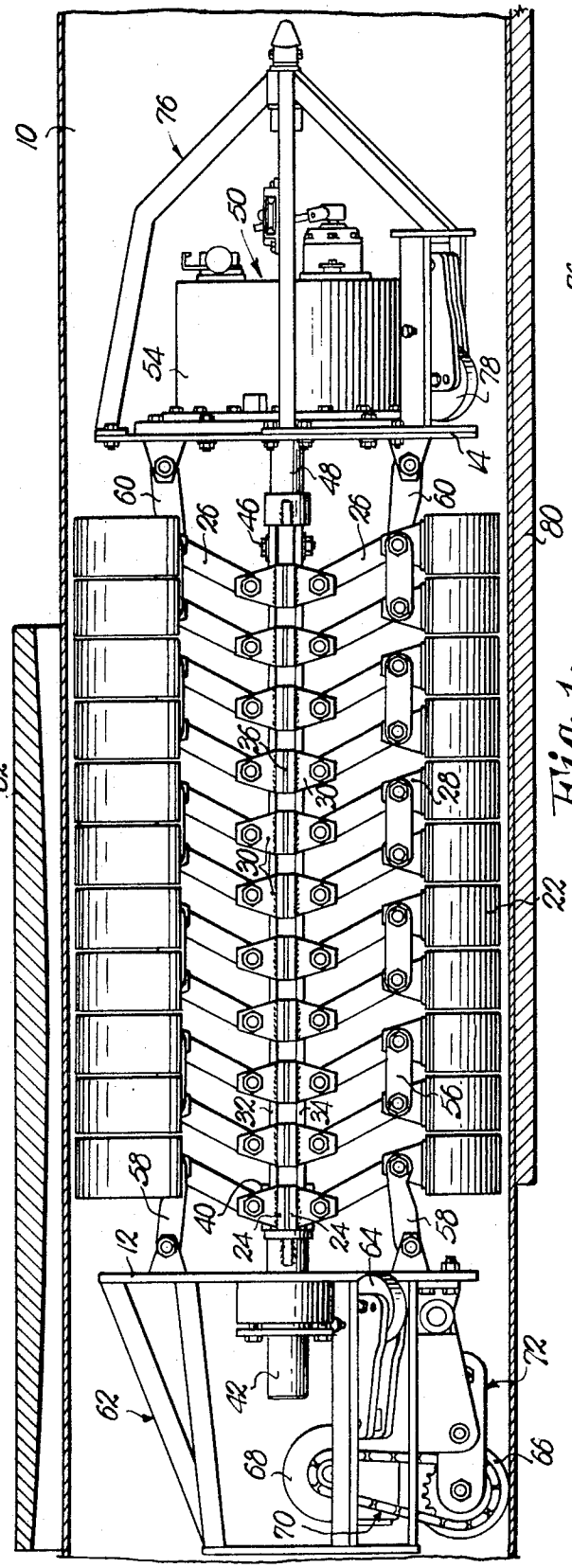


Fig. 1.

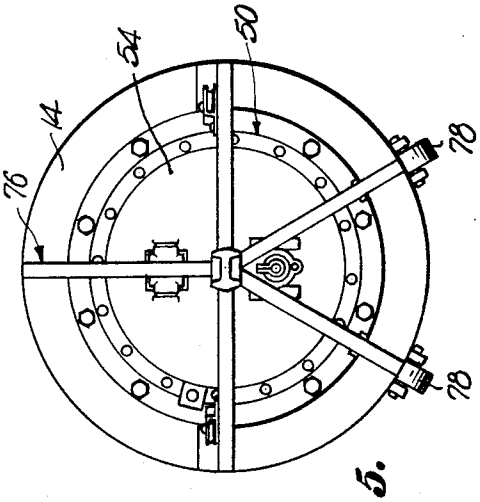


Fig. 5.

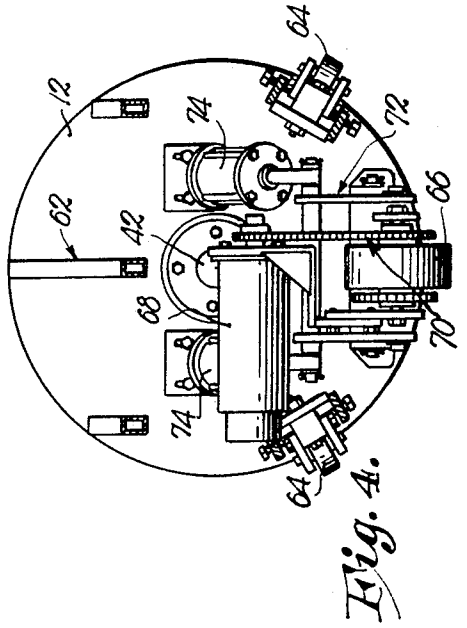


Fig. 4.

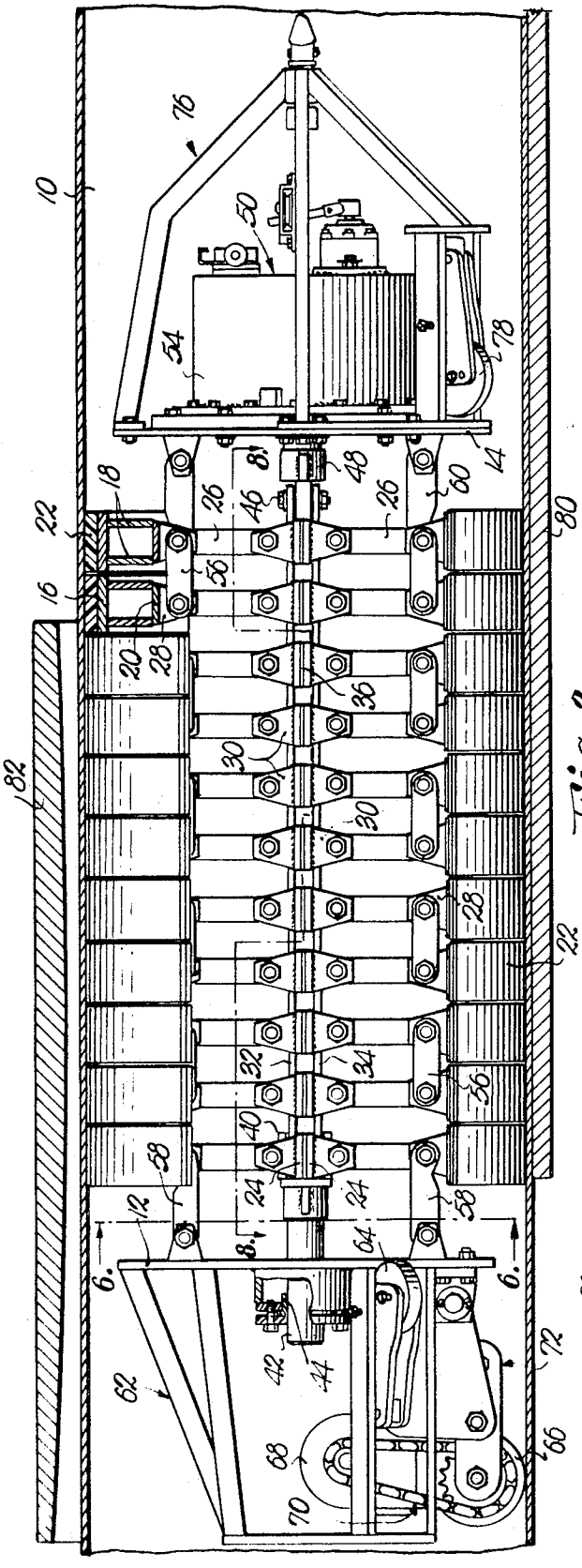


Fig. 2.

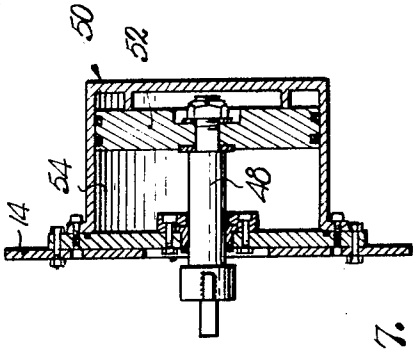


Fig. 7.

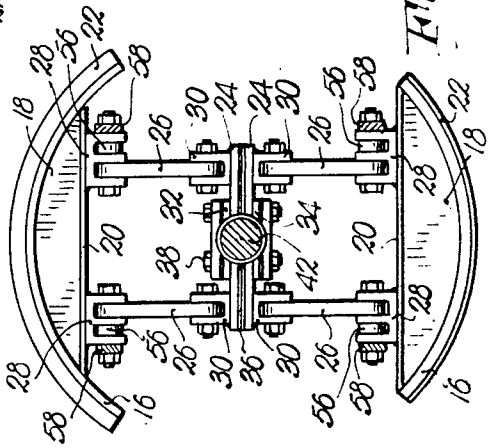


Fig. 6.

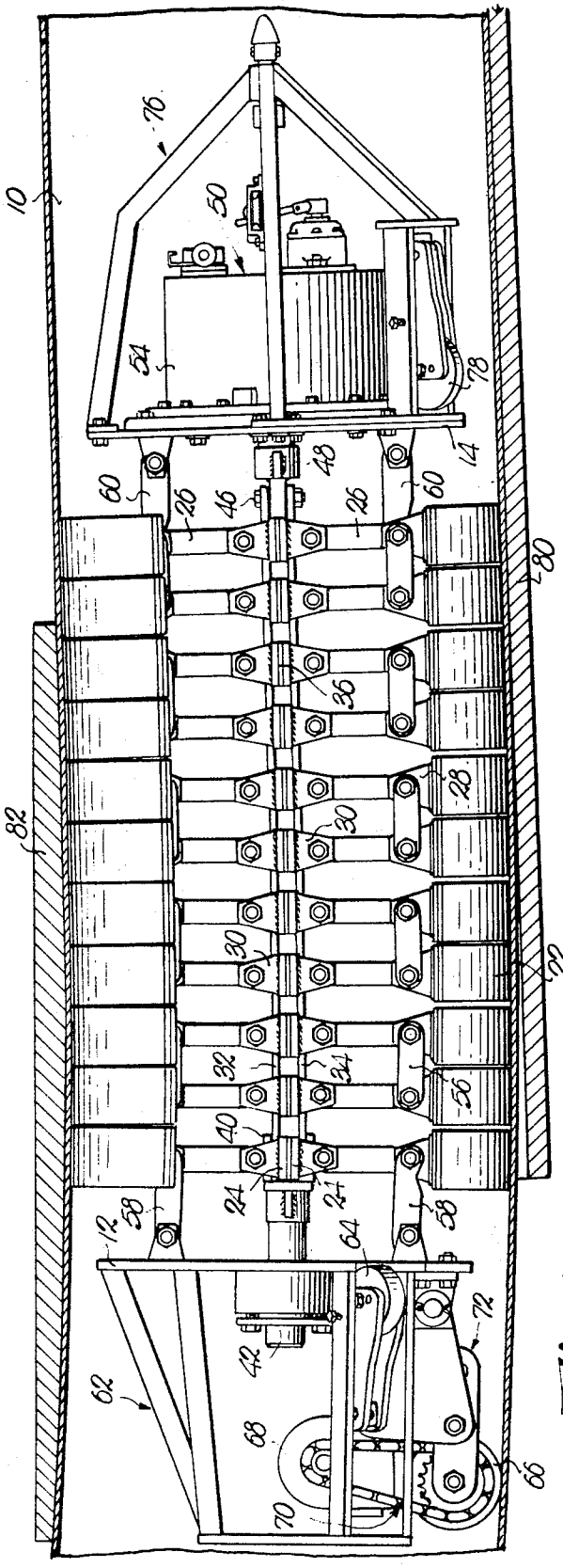


Fig. 3.

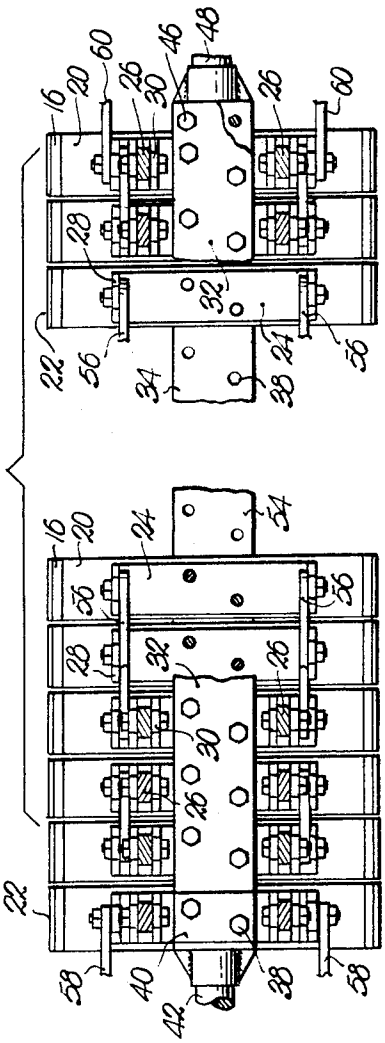


Fig. 8.

PIPE MANDREL FOR USE DURING BENDING

An important object of my present invention is to provide a pipe bending mandrel having a body which, when clamped to the pipe therewithin, is appreciably more flexible, and therefore, much more responsive to the bending imparted to the pipe than any mandrel heretofore suggested, resulting in improved bends, ease of bending and trouble-free operations.

Another important object of the instant invention is the provision of a pipe mandrel having a highly flexible body made up of shoe assemblies which, when clamped against the pipe, are locked in place in such manner as to avoid all possibility of displacement whereby they fully resist all tendency of the pipe buckling or wrinkling at any point along the entire zone of the bend.

A further object of the present invention is to provide a pipe mandrel which incorporates toggle joint principles in such manner as to permit rapid and simplified clamping of the shoes in place as well as release thereof and which contribute not only to obtaining the necessary characteristics of the body above mentioned but to avoidance of displacement or other failure of the shoe assemblies during the bending operation.

A still further object of my present invention is the provision of a pipe bending mandrel which incorporates an improved control in that the knee joints of the series of toggles may be quickly and easily operated with but a single power unit through use of a common actuator for the toggles requiring minimum movement, yet capable of yielding as need be in response to bending of the pipe.

The only mandrel within my knowledge that has enjoyed any appreciable success by actual and substantial commercial use in the bending of pipe is the one which is disclosed by U.S. Pat. No. 3,109,477 dated Nov. 5, 1963. Because of such success, certain basic principles thereof have been incorporated herein, together with those improvements which experience has proved to be desirable. Thus, as will hereinafter appear, I have reduced the cost of manufacture and maintenance, eliminated unnecessary components, provided for more simplified construction and operation, reduced the posibility of malfunction especially when used by careless or inexperienced operators and improved upon the characteristics of the bend in the pipe.

In the drawings:

FIG. 1 is a cross-sectional view through a pipe to be bent and through bending apparatus therefor, showing by side elevation a mandrel in the pipe made according to my present invention as the mandrel appears before expansion of its bendable body;

FIG. 2 is a view similar to FIG. 1 showing the mandrel expanded;

FIG. 3 is a view similar to FIG. 2 showing the pipe and the body of the mandrel bent;

FIG. 4 is a view showing one end of the mandrel;

FIG. 5 is a view showing the opposite end of the mandrel;

FIG. 6 is a cross-sectional view taken on line 6—6 of FIG. 2;

FIG. 7 is a fragmentary cross-sectional view showing the details of the fluid pressure ram unit; and

FIG. 8 is a cross-sectional view taken on line 8—8 of FIG. 2.

The mandrel shown in the drawings, which is adapted for insertion into and use during bending of a pipe **10**, has a pair of spaced, disc-shaped supports **12** and **14**, having an elongated, bendable body therebetween, such body being provided with a series of identical, side-by-side shoe assemblies each including diametrically opposed, upper and lower shoes of similar nature.

Each shoe includes an arcuate segment **16** welded to a pair of spaced crescents **18** that are in turn welded to a chord **20**, and a lining **22** of plastic or the like is attached to the outer convex surface of the segment **16**. A cross plate **24** is pivotally connected to the chord **20** by a pair of spaced, upright links **26** through use of lugs **28** and **30** on chord **20** and plate **24** respectively.

A pair of elongated, flexible, push-pull bars **32** and **34** across the plates **24**, and a shim **36** between the plates **24** are joined together by bolts **38**. One end of the bars **32** and **34** is connected by the proximal bolts **38** to a yoke **40** of a rod **42** which is in turn loosely received within a bushing **44** attached to the support **12**. The opposite ends of the bars **32** and **34** are connected by bolts **46** to the outer end of a stem **48** of a fluid pressure piston and cylinder unit **50** carried by the support **14**. The stem **48** is secured to a piston **52** of the unit **50** which is in turn reciprocable within a cylinder **54** of the unit **50**.

Certain of the lugs **28** are pivotally interconnected in pairs by horizontal links **56**. Additional horizontal links **58** pivotally connect the support **12** with proximal lugs **28** and, in the same manner, the support **14** is pivotally connected with proximal lugs **28** by links **60**.

The structures for rendering the supports **12** and **14** mobile within the pipe **10** form no part of the present invention and therefore require but brief explanation. Framework **62** on the support **12** is provided with a pair of rollers **64** and a drive wheel **66** which engage the inner face of the pipe **10**. The wheel **66** is driven by a prime mover **68** operably coupled with the wheel **66** by a chain and sprocket wheel assembly **70**. A mount **72** for the prime mover **68** and the wheel is swingable on the framework **62** and a pair of fluid pressure piston and cylinder assemblies **74** on the framework **62** connect with the mount **72** to move the wheel **66** into and out of engagement with the pipe **10**. Framework **76** on the support **12** is provided with rollers **78** comparable to the rollers **64**.

Pipe bending machines are normally provided with transversely concave members **80** and **82**, the latter of which is longitudinally convex.

From the foregoing it is seen that when the mandrel is initially rolled into the pipe **10** by operation of the prime mover **68**, it is supported by the rollers **64** and **78** such that the bendable body between the supports **12** and **14** is suspended by the latter, as shown in FIG. **1**. In this condition all of the shoes are retracted away from the pipe **10** because the push-pull device (bars **32** and **34**) has been pushed toward the support **12** by actuation of the piston **52** toward the support **14**, it being noted in FIG. **1** that all of the links **26** are obliquely disposed.

The links **26** present a toggle for each shoe assembly respectively, it being understood that each such assembly includes an upper and a corresponding lower shoe pivotally connected with their associated toggle. Thus, by virtue of the bolts **38**, the links **26** form opposed couplings for each shoe assembly respectively with the couplings connected in end-to-end relationship, presenting a series of knee joints at the bars **32** and **34**. The arrangement of the toggles is such that each pair of

couplings or links **26** is therefore normally out of alignment as shown in FIG. **1.**

Upon retraction of the wheel **66** and shifting of the piston **52** to the position shown in FIG. **7,** a pull is effected on the stem **48** and on the bars **32** and **34,** the force thus applied to the knee joints causing all of the toggle arrangements to straighten out simultaneously at the same rate and in the same amount.

The links **26** impart endwise thrusts to the shoes radially outwardly in opposite directions to clamp the linings **22** with substantially equal pressure against the inner face of the pipe **10** along the entire length of the flexible body. As seen in FIG. **2,** the toggle arrangements are now straightened out with the upper series of links **26** in end-to-end alignment with the corresponding links **26** of the lower series thereof.

The pipe **10** is now bent into conformity with the longitudinal convexity of the member **82** as illustrated in FIG. **3.** The lower series of shoes remains clamped against the lower, longitudinal, concave bend in the pipe **10** and the upper series of shoes remains clamped against the upper, longitudinal convex bend in the pipe **10.** This desired result is made possible by virtue of the flexible nature of the bars **32** and **34** which are free to bend down as the supports **12** and **14** are free to tilt and as the rod **42** is free to shift longitudinally and/or tilt in the bushing **44** because of the structures (link connections **58** and **60**) which pivotally connect the supports **12** and **14** with the next adjacent or end shoe assemblies.

Moreover, because of the arrangement of the links **56** and **58** the shoes between the support **12** and the axis of the bend are free to slope upwardly in one direction as the shoes between the support **14** and such axis of the bend are free to slope upwardly in the opposite direction. As a result, the bend in the pipe **10** remains smooth and unwrinkled not only along the upper convex portion of the bend but along the lower concave portion of the bend.

The number and sizes of the shims **36** to be used, if any, depend upon the preadjustment needed in order to assure a strong and firm clamp of the shoes against the pipe **10** when the links **26** are fully straightened out as shown in FIGS. **2** and **3.** It is important that the links **26** be in end-to-end alignment before bending commences because in such condition the shoes cannot yield radially inwardly toward the bars **32** and **34** and will not relax their firm grip on the pipe **10,** preventing the latter from buckling or wrinkling along the bend within the zone of the flexible body of shoes.

The circumferential lengths of the segments **16** need not be identical along the top and bottom, as shown in FIG. **6,** and such lengths may be varied as conditions warrant. But there is no need for shoes along the sides of the mandrel because the sides of the pipe **10** tend to bulge out during bending without any evidence of wrinkling. Thus, the upper series of shoes is circumferentially spaced in both directions from the lower series of shoes. As a result, only about one fourth of the circumference of the pipe **10** need to be engaged by each of the lower and upper shoes.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A mandrel adapted for insertion into and use during bending of a pipe comprising:

a pair of spaced supports;

an elongated, bendable body suspended between the supports and provided with a series of side-by-side shoe assemblies,

each assembly including:

a pair of diametrically opposed shoes, each provided with an outermost, convex, pipe-engaging surface, and

a toggle disposed between and pivotally connected with the shoes thereof,

each toggle having an arrangement which includes a pair of opposed couplings connected together in end-to-end relationship, presenting a knee joint,

each pair of couplings being normally out of alignment so that when a force is applied in one direction to said joint thereof to straighten the arrangement said shoes will receive endwise thrusts from the couplings radially outwardly in opposite directions to clamp said surfaces of the shoes with substantially equal pressure against the inner face of the pipe throughout the length of the body; and

an elongated, flexible, push-pull device at said joints and common thereto,

said device pivotally interconnecting the couplings, extending longitudinally of the body and the pipe, spanning the distance between the supports and being reciprocable with respect to the supports axially of the device for actuating all of the couplings simultaneously.

2. A mandrel as claimed in claim **1,** each support being provided with structure pivotally connecting the same with the couplings of the assembly next adjacent thereto.

3. A mandrel as claimed in claim **1;** and a fluid pressure piston and cylinder unit carried by one of said supports and operably connected with said device for reciprocating the latter.

4. A mandrel as claimed in claim **1,** certain of said assemblies having their couplings pivotally connected with the couplings of an assembly next adjacent thereto.

5. A mandrel as claimed in claim **1,** each coupling including a pair of spaced links having plates at opposite ends thereof secured to said device and to corresponding shoes respectively.

6. A mandrel as claimed in claim **5,** each plate being provided with a pair of lugs, each lug being pivotally attached to a corresponding link.

7. A mandrel as claimed in claim **6,** certain of said assemblies having certain of their lugs pivotally connected with corresponding lugs of an assembly next adjacent thereto.

8. A mandrel as claimed in claim **1,** each coupling having a plate pivotally attached thereto, said device including a pair of bars crossing the plates and joined thereto.

9. A mandrel as claimed in claim **8;** and shim means for increasing the diameter of said body in the direction of radial movement of the shoes.

10. A mandrel as claimed in claim **9;** and releasable fasteners clamping the shim means between the plates and clamping the plates between the bars.

11. A mandrel as claimed in claim **1** wherein each series of said assemblies is coextensive in length with said body and one of said series is circumferentially spaced from the other of said series throughout the length of the body at both ends of all shoes.

12. A mandrel as claimed in claim 11 wherein each shoe is continuous from end-to-end thereof along its said outermost surface for engagment with substantially one-fourth of the circumference of the pipe.

13. A mandrel as claimed in claim 12, each support being provided with structure pivotally connecting the same with the couplings of the assembly next adjacent thereto.

14. A mandrel as claimed in claim 13, certain of said assemblies having their couplings pivotally connected with the couplings of an assembly next adjacent thereto.

15. A mandrel as claimed in claim 14 wherein a majority of said assemblies are pivotally connected through their ccuplings in a plurality of pairs.

16. A mandrel as claimed in claim 15; and a fluid pressure piston and cylinder unit carried by one of said supports for reciprocating said device, the piston of said unit being aligned with said device, reciprocable within the one support and connected at one end thereof with one end of the device, the opposite end of the device being reciprocably carried by the other support.

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