United States Patent

Schenck et al.

[15] **3,680,347**

[45] **Aug. 1, 1972**

[54] **BENDING MACHINE**

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[21] Appl. No.: **106,032**

[52] **U.S. Cl.** **72/217**

[51] **Int. Cl.** **B21d 7/02**

[58] **Field of Search** 72/217, 153

[56] **References Cited**

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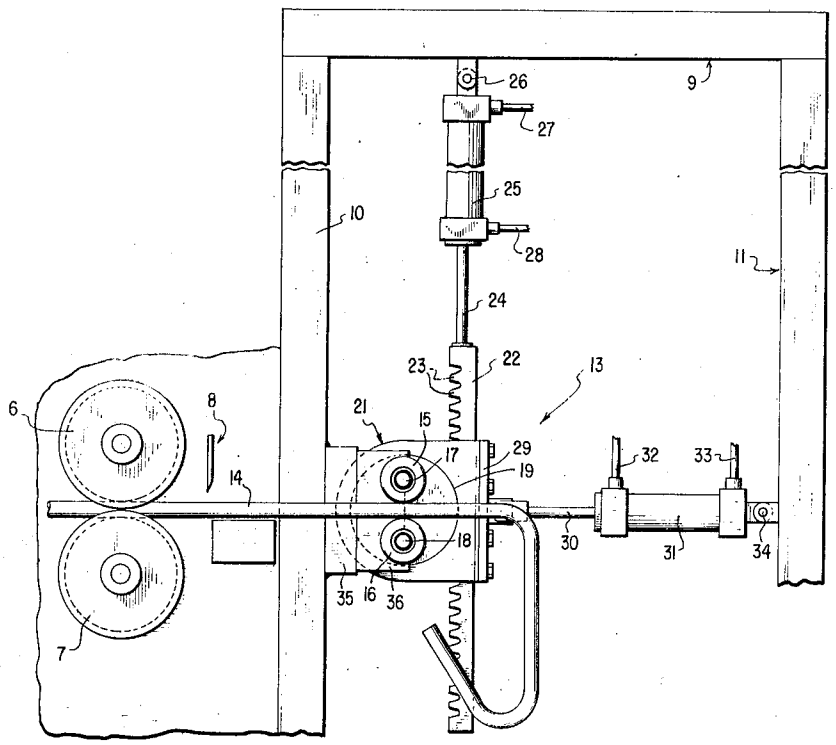
[57] **ABSTRACT**

A bending machine for reinforcing rods and the like wherein a rod is placed between two mandrels which are mounted on axles in a mandrel carrier and the carrier and one mandrel is rotated about the axle carrying the other mandrel. Means for holding the fixed axle in firm bearing relationship with a semicircular bearing includes, in one embodiment, a semiannular key surrounding each axle which engages a semicircular key slot concentric with the bearing means for that axle when the axle is the one about which the apparatus rotates. Either axle can be the "fixed" axle about which the carrier rotates, permitting bending in either direction. In another embodiment the means for holding one axle in firm bearing relationship includes a T latch which is movable to either axle, the latch having complementary bearing surfaces.

9 Claims, 11 Drawing Figures



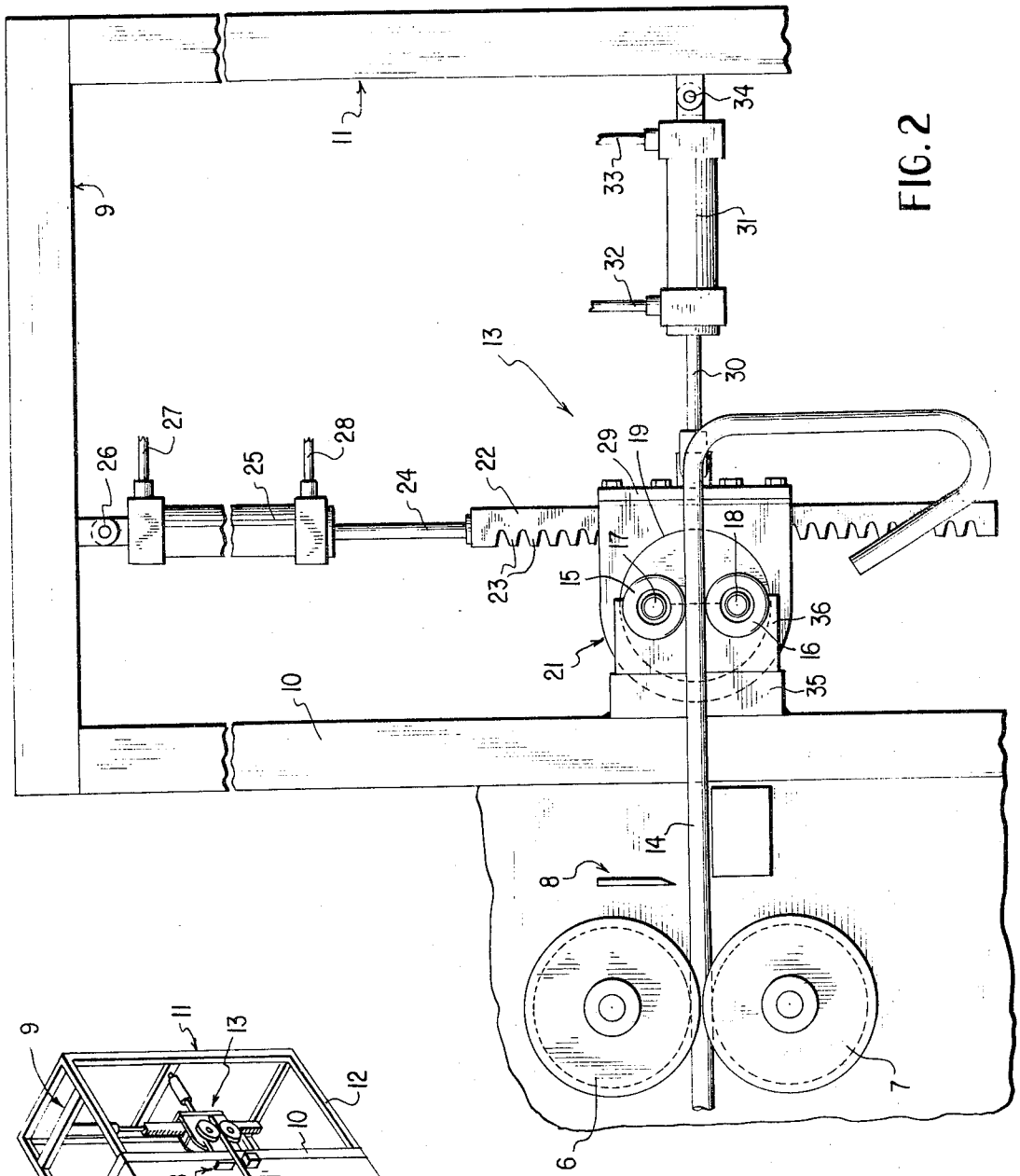


FIG. 2

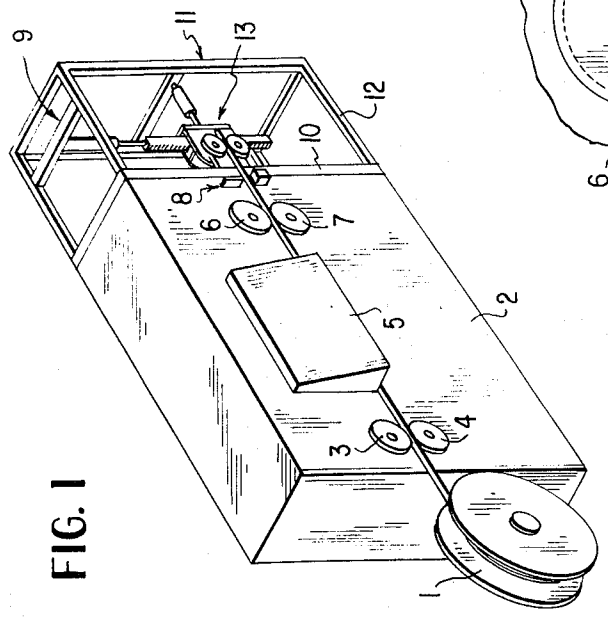


FIG. 1

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FIG. 3

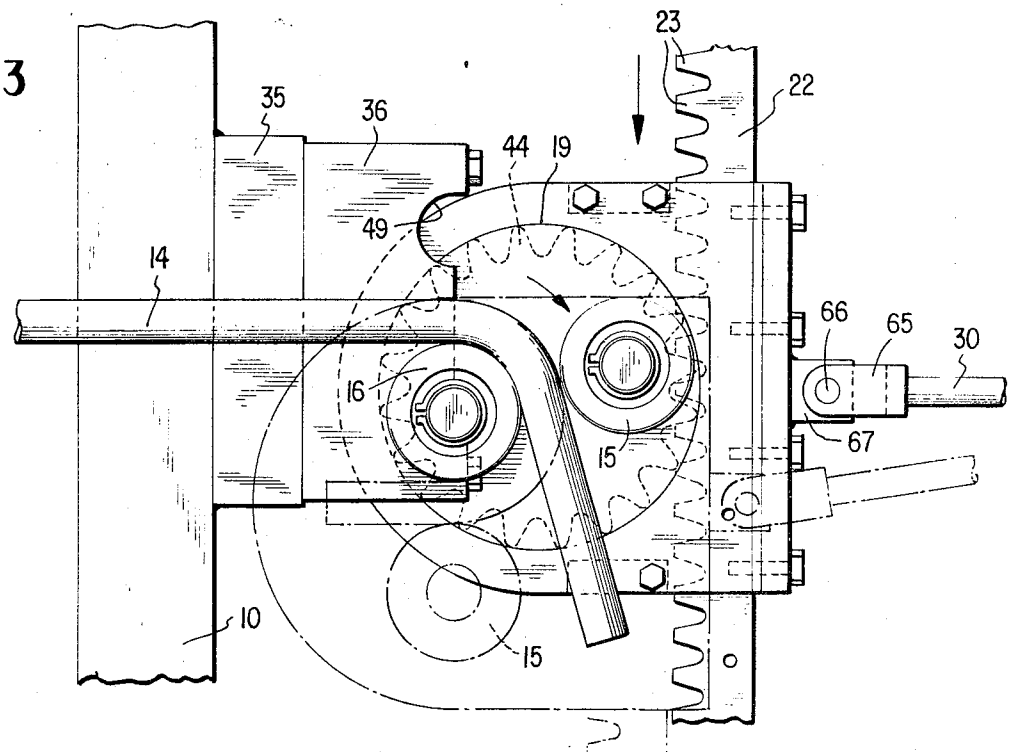

FIG. 4

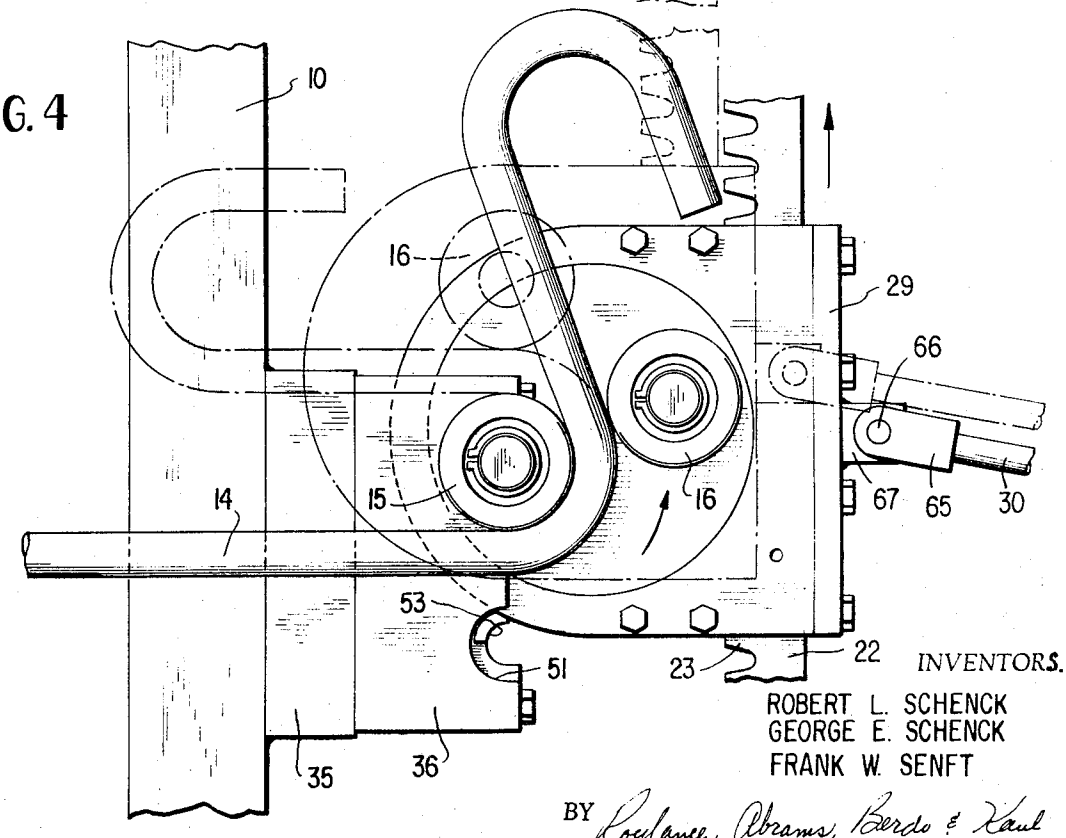

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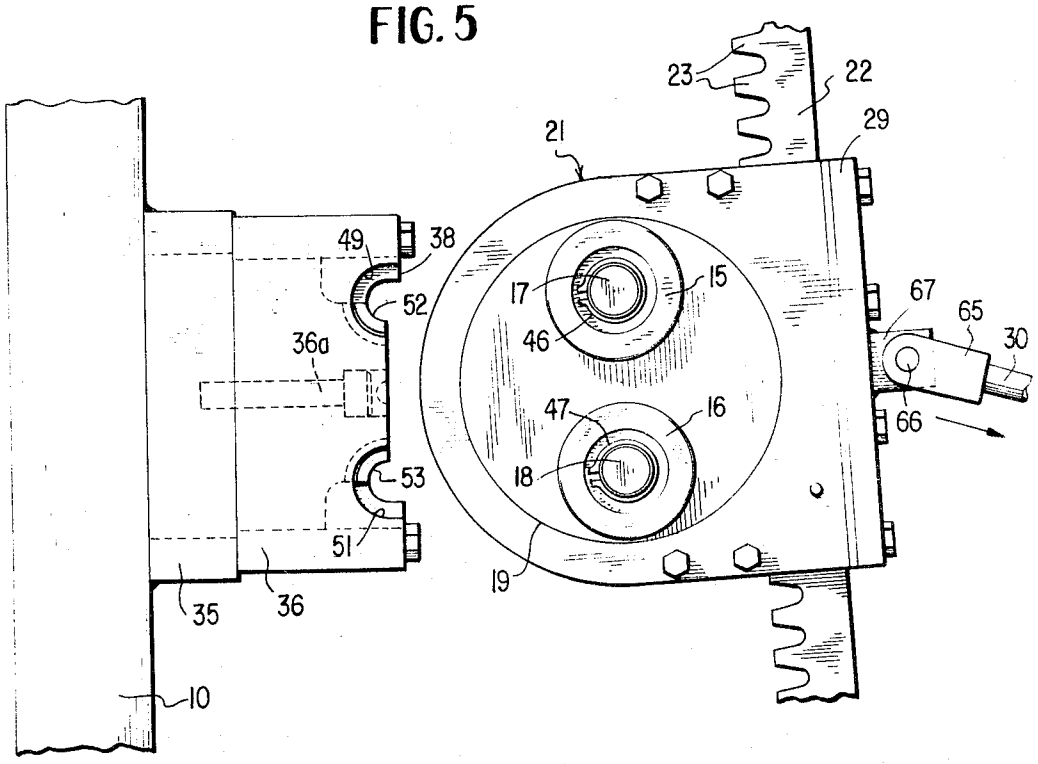
FIG. 5



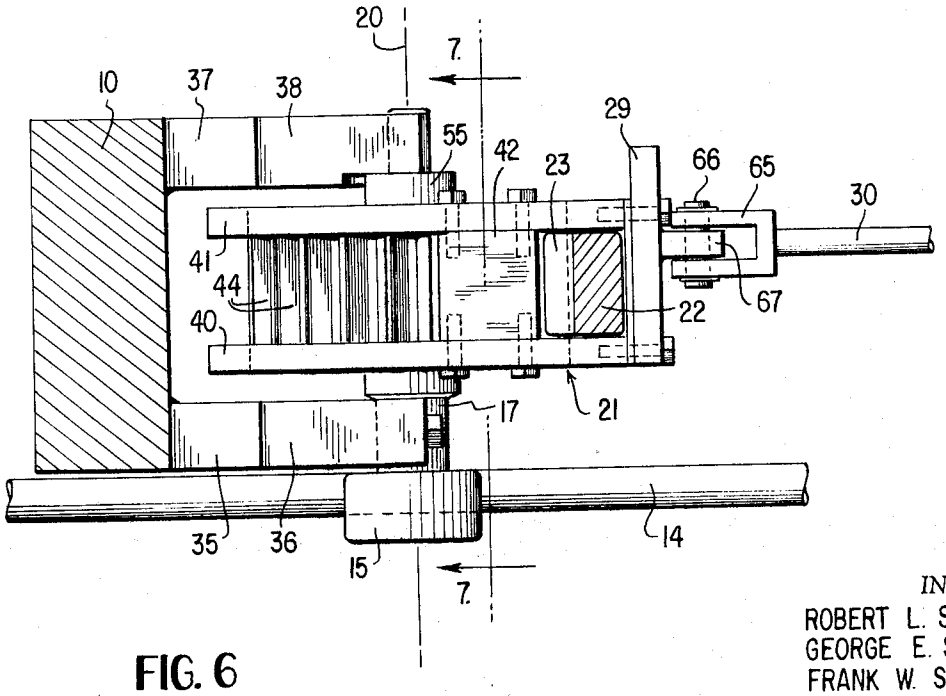


FIG. 6

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FIG. 7

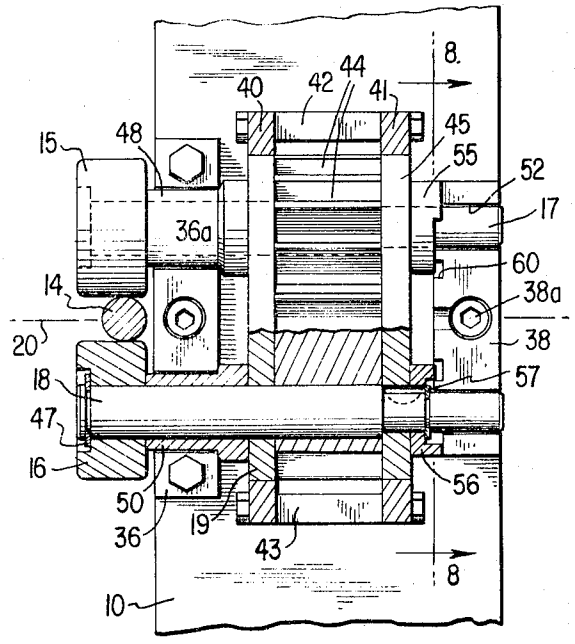


FIG. 8

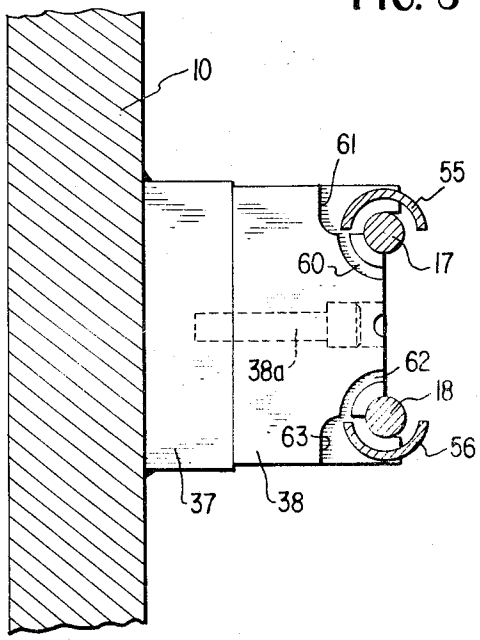


FIG. 9

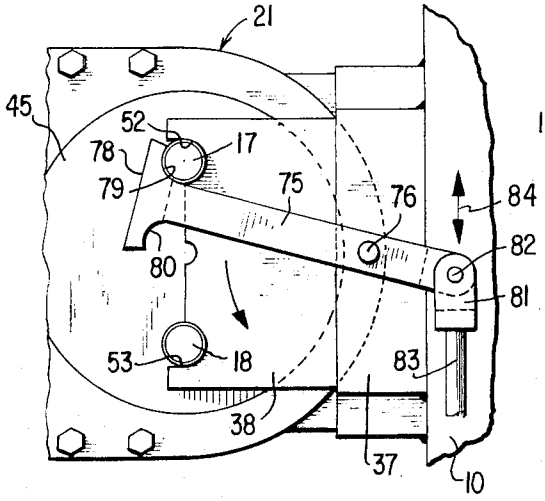
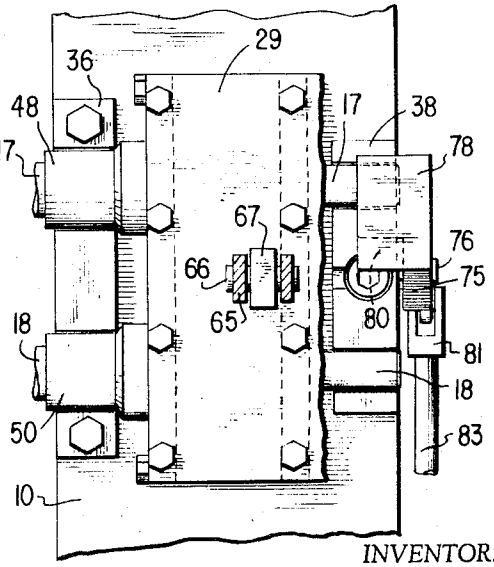


FIG. 10



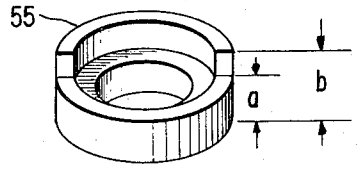


FIG. 7a

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BENDING MACHINE

This invention relates to bending machines and, more specifically, to an apparatus for handling and bending indeterminate lengths of rod into desired shapes.

It is common practice in the construction field to utilize steel reinforcing rod of various sizes and having various characteristics in the construction of concrete structures. While many of the reinforcing rods used in these structures are used simply as straight rods, it is also necessary to form segments of rod into predetermined shapes, these preformed shapes then being used to retain a plurality of straight rods in desired spacing, and for other purposes. A WIDE VARIETY OF SHAPES ARE USED, DEPENDING UPON THE SPECIFIC STRUCTURE TO BE FORMED AND THE POINT IN THE STRUCTURE AT WHICH THE ROD IS TO BE PLACED. These shapes require bends in both directions and to varying degrees.

An object of the present invention is to provide a device capable of handling reinforcing rod of indeterminate length with no need for precutting, and of bending the rod into desired shapes.

Another object is to provide a machine having bending means which can be easily replaced to facilitate accurate bending of rod of various diameters.

Yet another object is to provide a bending machine which operates rapidly and accurately and which is sufficiently simple so that it can be transported to a field location near a construction site for the production of bent rod.

Briefly described, the invention includes a mandrel carrier having two mandrels mounted on axes equally spaced from a central axis of the mandrel carrier. The diameter of the mandrels and the spacing between the mandrel axes is selected so that the minimum distance between the mandrels is slightly greater than the diameter of the rod to be bent. A gear is attached to the mandrel carrier and two axles protrude from the mandrel carrier and gear assembly and are axially aligned with the mandrel axes. Bearings are provided in a fixed location to receive the axles, the bearings constituting essentially semicircular bearing surfaces to bear against one side of the axles. A RACK IS PROVIDED TO MESH WITH AND ROTATE THE GEAR, THEREBY ALSO ROTATING THE MANDREL CARRIER ABOUT ONE OF THE AXLES. Of particular significance is the provision of means for completing the bearing surface for one of the axles to hold that axle in firm bearing relationship while the mandrel carrier is being rotated. To bend rod in one direction the means is employed to retain one of the axles in bearing relationship while the other is permitted to rotate in a circle about the first. For bending in the opposite direction rotation is accomplished around the other axle, permitting the mandrel which was previously fixed to describe the circle. A housing encloses the mandrel carrier and gear and retains the rack in meshed relationship with the gear. Drive means of conventional type is employed to move the rack longitudinally in one direction to bend in one direction and in the opposite direction to produce a bend in the opposite direction. Also provided is means for translating the housing and mandrel assembly away from the bearing surfaces to permit the mandrel assembly to be withdrawn from the housing and replaced with a similar unit having mandrel spacing dimensioned to receive a rod of different size.

In order that the manner in which the foregoing and other objects are attained in accordance with the invention can be understood in detail, particularly advantageous embodiments thereof will be described with reference to the accompanying drawings, which form a part of the specification, and wherein:

FIG. **1** is an isometric view of a complete bending machine incorporating the subject invention;

FIG. **2** is a front elevation of an apparatus in accordance with the invention showing a rod with some bends accomplished;

FIG. **3** is a front elevation of a portion of the apparatus of FIG. **2** showing a workpiece being bent in one direction, an advanced phase of the bend being shown in phantom;

FIG. **4** is a view of the apparatus of FIG. **3** showing a bend being accomplished in the opposite direction, an advanced stage of the bend being shown in phantom;

FIG. **5** is a view of the apparatus of FIGS. **3** and **4** with the mandrel housing withdrawn for replacement of the mandrel carrier and mandrels;

FIG. **6** is a plan view, in partial section, showing the apparatus of FIGS. **3–5**;

FIG. **7** is a partial section along lines **7—7** of FIG. **6**;

FIG. **8** is a section along lines **8—8** of FIG. **7**; and

FIGS. **9** and **10** are rear and side elevations, respectively, of an alternate embodiment of the invention.

Referring now to FIG. **1**, it will be seen that the apparatus of the invention is incorporated in a machine designed to handle reinforcing rod or the like fed from a large reel **1** which is supported at one end of a cabinet **2** which contains drive and control means for operating various portions of the bending machine. On the front of cabinet **2** are various applicances for feeding, measuring, sensing and controlling the advancing rod, these devices being well known in the art, in general, and constituting no part of the present invention. For clarity in describing the overall operation of the system, such apparatus is schematically shown as a pair of feed rollers **3** and **4**, a housing **5** which protrudes from the front of the cabinet and can contain means for contacting the rod and sensing its advance. A further pair of feed rollers **6** and **7** act to advance the rod, as desired, and to grip the rod in position for bending by the apparatus of the invention to be hereinafter discussed. Rod cutting means indicated generally at **8** can also be provided adjacent the bending means to sever the bent portion of the rod when the bending operations have been completed. Such shearing devices for rod cutting are well known and need not be further described, the means shown being illustrative purposes only.

The bending apparatus to be discussed in greater detail is suspended within a framework at the end of the housing including an upper frame portion indicated generally at **9**, vertical frame members **10** and **11** and a bottom frame member **12**.

The bending apparatus itself, indicated generally at **13**, is more clearly shown in the remaining figures wherein like numerals have been used to identify the various components.

In FIG. **2** it will be seen that the rod **14**, which is the workpiece to be bent, is fed by rollers **6** and **7** to the

bending apparatus 13 which includes a pair of substantially identical mandrels 15 and 16 which are rotatably mounted at one end of each of axles 17 and 18. Axles 17 and 18 are carried by a mandrel carrier 19 which, in the embodiments described herein, is a right circular cylindrical assembly having axially extending openings to receive and support axles 17 and 18. The axles are disposed on axes which lie on opposite sides of a central axis 20 of the mandrel carrier (see FIG. 6) and are equally spaced therefrom.

Mandrel carrier 19 is rotatably mounted in a mandrel carrier housing indicated generally at 21, the housing acting to enclose and support the mandrel carrier and a drive gear associated therewith, and to guide a straight rack 22 having teeth 23 which engage the drive gear and implement rotation of the mandrel carrier. The upper end of rack 22 is connected to a drive shaft 24 which is connected to a piston within a pneumatic or hydraulic cylinder and piston assembly 25. The cylinder of the drive means 25 is pivotally connected at 26 to upper frame members 9. Drive means 25 is conventional in nature and is coupled to a source of hydraulic or pneumatic pressure so that fluid pressure applied to an upper fluid coupling 27 causes motion of the piston in a downward direction and pressure applied to a lower fluid pressure coupling 28 causes movement of the piston upwardly.

Mandrel carrier housing 21 includes a cover plate 29 which is pivotally connected to a drive rod 30 which is connected to a piston within a pneumatic or hydraulic power unit 31 of substantially the same type as unit 25. Fluid pressure applied to a fluid coupling 32 causes movement of the piston and its associated drive rod toward the right, referring to FIG. 2, and pressure applied to a fluid pressure coupling 33 causes movement to the left. The cylinder of unit 31 is pivotally connected at 34 to vertical frame 11.

A front support block 35 is securely mounted on vertical frame member 10 and carries a bearing block 36 which includes bearing surfaces to be described in greater detail hereinafter.

Referring now to FIG. 6, it will be seen that the mandrel carrier and mandrel carrier housing normally lies between the front support block and bearing blocks 35 and 36 and similar blocks in the rear, identified in FIG. 6 as blocks 37 and 38, respectively. Block 38 also includes other significant portions of the invention to be described hereinafter. The mandrel carrier housing will be seen to include the end plate 29 and front and back plates 40 and 41 which are parallel to each other and perpendicular to plate 29. Plates 40 and 41 are connected to plate 29 by bolts and other suitable fasteners and are held in rigid parallel spaced relationship by an upper spacing block 42 and a lower spacing block 43, both of which are attached to the front and back plates by bolts or similar fasteners.

The mandrel carrier 19 is attached, as by welding, to a spur gear 44 which is coaxial with mandrel carrier 19 and which has an outer diameter which is, at most, equal to the diameter of the mandrel carrier itself. The teeth of gear 44 are in mesh with teeth 23 of rack 22, the rack, teeth and power means constituting the drive means for rotating the mandrel carrier.

It will be observed, from FIGS. 6 and 7, espeically that the mandrel carrier itself includes two plates, the front plate which has previously been identified as 19 and a rear plate 45 which is in parallel spaced relationship with front plate 19 which is of the same or a smaller diameter as the front plate.

As will be seen in FIG. 7, mandrels 15 and 16 constitute right circular cylinders with a central bore and are attached to their respective axles 17 and 18 by snap rings 46 and 46 which fit in annular grooves near the mandrel-holding end of the axle to retain the mandrels thereon. Axle 17 is provided with a journal sleeve 48 which bears against a semicircular bearing surface 49 in bearing block 36. Similarly, axle 18 is provided with a journal sleeve 50 which surrounds the axle and bears against a semicircular surface 51 in block 36. The bearing surfaces can more clearly be seen in FIG. 5. The axles pass through the mandrel carrier and gear assembly and protrude beyond the back face of the mandrel carrier and terminate in end portions which form journals designed to bear against semicircular bearing surfaces in rear block 38. The journal end of axle 17 bears against a bearing surface 52 which is a semicircular recess of smaller radius than bearing surface 48 and is formed in block 38. Similarly, the journal end of axle 18 bears against a semicircular bearing surface 53 in block 38.

An annular key member 55 is attached to axle 17 between back plate 45 and block 38. Member 55 constitutes an annular member having an axially projecting semicircular rib extending around approximately 180° of the back surface of the member. The rib forms a key, the function of which will be described with reference to FIG. 8. The details of the key structure can more clearly be seen in FIG. 7*a* in which the member is seen to include an annular member having a thin portion of thickness *a* which is less than the spacing between the front surface of block 38 and the back surface of back plate 45. The remaining 180° of member 55 is of thickness *b* which substantially exceeds that spacing.

A similar annular member 56 surrounds axle 18, member 56 being constructed in identical fashion to member 55. As shown in the sectional view of FIG. 7, member 56 is axially restrained on axle 18 by a snap ring 57 and is tightly pressed onto axle 18. Further, the annular member can be restrained from rotary motion relative to axle 18 by a pin, key or the like. Member 55 is similarly restrained, the two members being attached to their respective axles so that the keys open toward each other.

As will be seen in FIG. 8, block 38, in the region adjacent bearing surface 52, is milled in a specific manner to receive the key portion of annular ring 55. The special milling includes an arcuate slot 60 which extends through an arc of approximately 90° and is concentric with the axis of axle 17 when it is in its bearing relationship with surface 52. Slot 60 is just wide enough to receive the key portion of ring 55 and constitutes a key slot which is capable of receiving and holding the key when axle 17 is rotated, carrying ring 55, in a counterclockwise direction as viewed in FIG. 8. It will be observed that an additional portion of block 38 is milled out to permit a zone of free movement 61 above key slot 60 and the arcuate which remains as a result of cutting the key slot. Thus, ring 55 is free to translate to the right, as viewed in FIG. 8, when the mandrel carrier and its related structure is rotated about the axis of axle 18.

The portion of block **38** adjacent axle **18** and ring **56** is milled in a similar manner but in the mirror image of the portion adjacent axle **17**. This portion includes a key slot **62** which is likewise arcuate and extends for approximately 90°, the milling also leaving a region of free movement **63** permitting transverse movement of ring **56** when the mandrel carrier and its associated apparatus is rotated about the axis of axle **17**.

The operation of the apparatus can best be described by assuming rotation about axle **18** to produce a bend of the type shown in FIG. **3**. To produce such a bend, drive wheels **6** and **7** are actuated to extend a portion of the rod **14** to a position between mandrels **15** and **16**. Pressure is then applied through fluid inlet **27** to the piston and cylinder assembly **25**, causing rod **24** to move downwardly, as shown in FIG. **1**, driving rack **22** also downwardly. Teeth **23** engage the teeth of gear **44**, causing it to rotate in a clockwise direction as shown by the arrow in FIG. **3**. Plates **19** and **45** of the mandrel carrier move with the gear, carrying axle **17** in a clockwise direction, as shown in FIG. **3**, rotating the assembly about the axis of the axle **18**.

As soon as the beginning of this motion has taken place the key portion of ring **56** enters the lower end of key slot **62** and the key portion of ring **55** moves to the right (FIG. **8**) along with axle **17**, away from slot **60**. Once the key portion of ring **56** has entered the slot **62**, axle **18** is retained in firm bearing relationship with bearing surface **53**, preventing the axle from translating away from block **38**. As rack **22** continues to move downwardly mandrel **15** describes an arc about the axis of axle **18** and mandrel **16**, mandrel **15** then exerting force against the upper surface of rod **14** and causing it to bend downwardly as shown in FIG. **3**. This motion is continued until a bend of the desired degree has been completed, a bend of 180° being shown as an example in FIG. **3** in phantom lines. It will be observed that a bend of any degree between 0° and slightly more than 180° can be accomplished with this simple movement.

It will also be observed that minimum force can be exerted by the piston and cylinder assembly **31** through rod **30** because it is necessary, during the rotary motion, for mandrel carrier housing **21** to translate to the right and downwardly as the bend is accomplished. Thus, the piston and cylinder assembly cannot be used to maintain axle **18** in solid bearing relationship with its bearing surface, this function being accomplished by the key and slot assembly in the embodiment described.

It will also be observed that this motion is the basis for providing the pivotal connection between plate **29** and rod **30**. This connection is provided by the bifurcated end portion **65** connected to rod **30**, the pin **66** extending through the bifurcated end portion and also through the tab **67** which is welded to plate **29**.

If it is desired to produce a bend resembling a letter S, the mandrel carrier is returned to its original position, that of FIG. **2**, by applying pressure to fluid pressure connection **28**, causing the piston, rod **24** and rack **22** to move upwardly. When the apparatus is in the position shown in FIG. **2**, rod **14** is advanced to the right by the drive wheel and the rack is then moved upwardly again, as shown in FIG. **4**, causing the gear **44** to move counterclockwise, carrying with it the mandrel carrier and mandrel **16**. In this movement the mandrel carrier, gear and related apparatus rotate about the axis of axle **17** with mandrel carrier housing **21** being translated to the right and upwardly and then to the left following this rotary motion. Returning to FIG. **8**, it will be seen that in the motion in this direction the key portion of ring **55** enters key slot **60** at the beginning of the motion, thereafter retaining axle **17** in firm bearing relationship with bearing surface **52** and preventing the axle from translating away from block **38**. However, in this movement, axle **18** and ring **56** are permitted to translate away from bearing surface **53**, these members being free to move to permit mandrel **16** to accomplish the bend around mandrel **15**. As before, this bend can be accomplished to any desired degree between 0° and 180°.

Multiple bends of varying degrees and directions can be accomplished easily by simply repeating the above processes in any desired sequence. It will also be observed that the machine can be automatically controlled to produce a specified sequence of bends in either direction by providing suitable metering and programming equipment in cabinet **2**. While the control apparatus to accomplish this kind of operation is not part of the present invention, it will be observed that the equipment is uniquely adapted to be automatically operated through complicated sequences of steps with great simplicity and ease and without further modification of the basic apparatus.

As will be apparent from the above, after the desired sequence of bends has been accomplished for a particular structure, blade **8** can be activated to sever the bent portion from the remainder of the reel, after which a new bent structure can be produced.

FIGS. **9** and **10** show an alternate apparatus for retaining the selected axle in firm bearing relationship with its bearing surface in block **38**. In the apparatus of FIGS. **9** and **10**, everything which existed in the apparatus shown in FIGS. **1–8** is the same except that this embodiment does not include rings **55** or **56**, slots **60** or **62**, or milled regions **61** or **63**. Block **38** still includes bearing surfaces **52** and **53** against which the axles must be retained in firm bearing relationship, one at a time, depending upon the direction of rotation. Thus, the numerals identifying previously discussed equipment are the same as those previously used.

The equipment unique to the embodiment of FIGS. **9** and **10** includes a T-shaped bearing latch **75** which is pivotally connected to block **37** by a pin **76** which extends through the main arm of the T at a point further from the head than from the foot thereof. The head of the T latch **78** includes bearing surfaces **79** and **80**, bearing surface **79** being designed to engage the journal portion of axle **17** and cooperate with surface **52** to maintain axle **17** in firm bearing relationship with surface **52**. The other side of the head of the T-shaped arm **75** includes a bearing surface **80** which, when the arm is moved to its alternate position, is designed to engage the journal portion of axle **18** and retain that axle in firm bearing relationship with surface **53**. As will be seen in FIG. **10**, arm **75** extends essentially parallel to the back surface of block **38** and head **78** protrudes orthozonally across the end of block **38** to engage one or the other of axles **17** and **18**.

The distal end of arm **75** is pivotally connected to a bifurcated link **81** by a pin **82**, link **81** being attached to a rod **83**, the other end of which can be connected to

any suitable power deive such as a piston and cylinder assembly like those described with reference to FIG. 2.

As arm 83 is moved upwardly and downwardly as shown by arrow 84, arm 75 rocks between the position shown in FIGS. 9 and 10, wherein axle 17 is maintained in good bearing relationship with its bearing surface 52, and the opposite position in which axle 18 is so held.

As will be recognized by those skilled in the art, it is desirable to be able to bend rods of varying diameters. A specific mandrel carrier and mandrel assembly, having a predetermined axial spacing between axles 17 and 18 and, accordingly, a predetermined minimum spacing between the peripheries of mandrels 15 and 16, is suitable only for bending rods of essentially the same major diameter. In order to provide for rods of other diameters, the apparatus herein disclosed is designed to permit simple replacement of one mandrel carrier with another. This is accomplished by providing fluid pressure to fluid pressure connection 32 of piston and cylinder assembly 31, causing rod 30 to move to the right as shown in FIG. 5, translating the entire mandrel carrier housing and mandrel assembly to the right away from blocks 36 and 38. The movement is continued until the mandrel carrier is completely clear of block 36. The mandrels 15 and 16 can then be pulled axially, causing the mandrels, the mandrel carrier plates and the drive gear 44 to be extracted from the mandrel housing. As will be recalled, it was previously mentioned that the outer diameter of gear 44 and the outer diameter of plate 45 are selected to be of equal or smaller diameter than that of plate 19. The reason for this selection is so that the apparatus can be axially withdrawn from the mandrel housing without there being a problem of having to disassemble portions of the housing itself.

The back plate 45 can also be provided with notches (not shown) which, when the mandrel carrier is in its "-home" position as in FIG. 2, are aligned with those teeth 23 of rack 22 which are in mesh with gear 44 so that the back plate will not conflict with the rack when the mandrel carrier is withdrawn.

The mandrel carrier shown can then be replaced with a similar carrier having its own gear, axles and mandrels with suitable spacing for handling a rod of different size. The new carrier can be inserted with a simple axial motion, after which piston and cylinder 31 can be activated by applying fluid pressure to connection 33, driving the mandrel carrier to the left until the axles again engage surfaces 49, 51, 52 and 53 as before.

As shown in FIG. 7, blocks 36 and 38 are attached to blocks 35 and 37, respectively, by bolts 36*a* and 38*a*. Thus, when the mandrel carrier assembly is replaced, blocks 36 and 38 are also replaced with similar blocks having bearing surfaces spaced to match the new center-to-center spacing of axles 17 and 18 of the new mandrels.

While certain advantageous embodiments have been chosen to illustrate the invention it will be understood by those skilled in the art that various changes and modifications can be made therein without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. A bending machine comprising the combination of
first and second axles;
first and second mandrels carried respectively by said first and second axles;
mandrel carrier means for supporting said first and second axles in parallel spaced relationship so that said mandrels are spaced apart by a distance at least as great as the thickness of a workpiece to be bent;
first and second semicircular bearing means for said first and second axles, respectively;
means for inserting a workpiece between said mandrels and for holding said workpiece in the inserted position;
means for rotating said mandrel carrier means, said first axle and said first mandrel around the axis of said second axle to bend the workpiece in one direction, and for rotating said mandrel carrier means, said second axle and said second mandrel around the axis of said first axle to bend the workpiece in the other direction; and
means associated with said bearing means for retaining only said first axle in firm bearing relationship with said first bearing means when said mandrel carrier is rotated about said first axle, and for retaining only said second axle in firm bearing relationship with said second bearing means when said mandrel carrier is rotated about said second axle.

2. A bending machine according to claim 1 wherein
said means associated with said bearing means comprises
a semiannular keyway concentrically disposed around each of said bearing means, and
a semiannular key concentrically carried by and movable with each of said axles,
each of said keys being engagable with its associated keyway only when the axle by which the key is carried is acting as the center of rotation.

3. A bending machine according to claim 1 in which
said means associated with said bearing means comprises
a latch member movable between said first and second bearing means,
said latch member having first and second bearing surfaces to cooperate with said first and second bearing means, respectively, to retain a selected one of said axles in bearing relationship its associated bearing means.

4. A bending machine comprising the combination of
a mandrel carrier
a translatable housing for said mandrel carrier, said mandrel carrier being rotatably mounted in said housing for rotation about a first axis, sais axis being translatable with said housing;
first and second mandrels carried by said mandrel carrier and extending from one face thereof,
said mandrels being mounted on second and third axes which are parallel with and equally spaced from said first axis,
said first second and third axes being on one diameter of said mandrel carrier;
means for delivering a portion of rod to be bent to a position between said mandrels and for holding said rod in said position;

first and second axles extending from said mandrel carrier along said second and third axes, respectively;

substantially semicircular bearing means for said axles;

means for rotating said mandrel carrier about one of said second and third axes;

means for retaining a selected one of said first and second axles which is aligned with said one of said second and third axes in bearing relationship with said journal means.

5. A bending machine according to claim **4** wherein

said means for retaining includes latch means having two bearing surfaces,

said latch means being movable between a first position in which one of said bearing surfaces cooperates with said bearing means to retain one of said axles in bearing relationship while said mandrel carrier is being rotated about said one axle,

and a second position in which the other of said bearing surfaces cooperates with said bearing means to retain the other of said axles in bearing relationship while said mandrel carrier is being rotated about said other axle.

6. A bending machine according to claim **4** wherein

said means for retaining includes

an arcuate key carried by each of said first and second axles;

means defining a pair of arcuate slots adjacent said bearing means,

said slots each being positioned to receive one of said keys when said mandrel carrier is rotated.

7. A bending machine according to claim **4** wherein

said first and second mandrels include cylindrical surfaces,

and wherein the spacing between said second and third axes and the diameter of said mandrels are selected to provide a minimum distance between said mandrels which is slightly greater than the diameter of the rod to be bent.

8. Apparatus according to claim **7** wherein

said means for rotating said mandrel carrier includes

a gear coaxially attached to said mandrel carrier;

a rack longitudinally movable to rotate said gear;

power means for moving said rack longitudinally.

9. Apparatus according to claim **4** and further comprising

means for translating said housing away from said bearing means to permit replacement of said mandrel carrier with a carrier having different spacing between said mandrels.

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