March 9, 1926. 1,575,928

P. MUELLER ET AL

PIPE OR TUBE BENDING MACHINE

Filed March 16, 1922 12 Sheets-Sheet 1

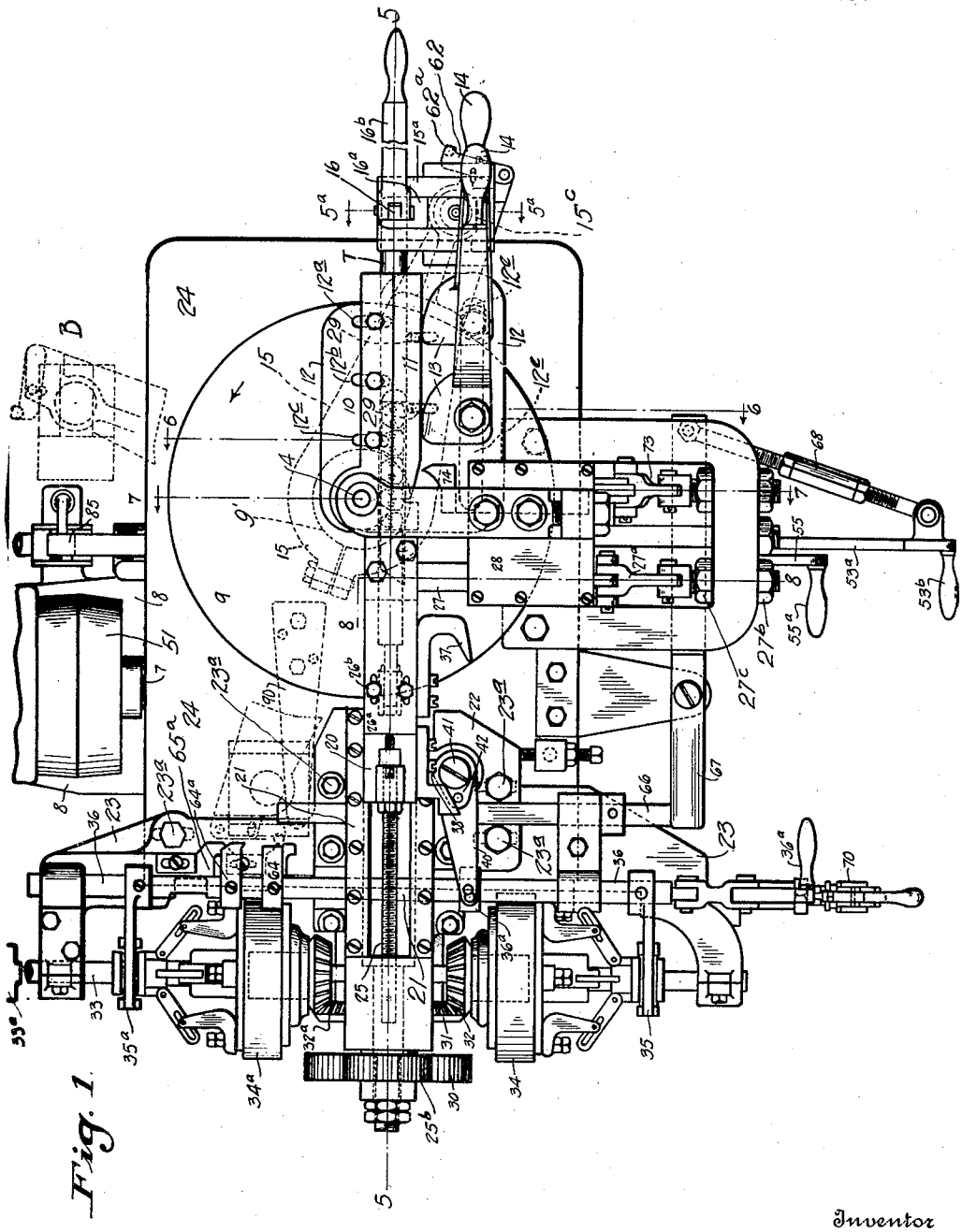

Fig. 1.

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PIPE OR TUBE BENDING MACHINE

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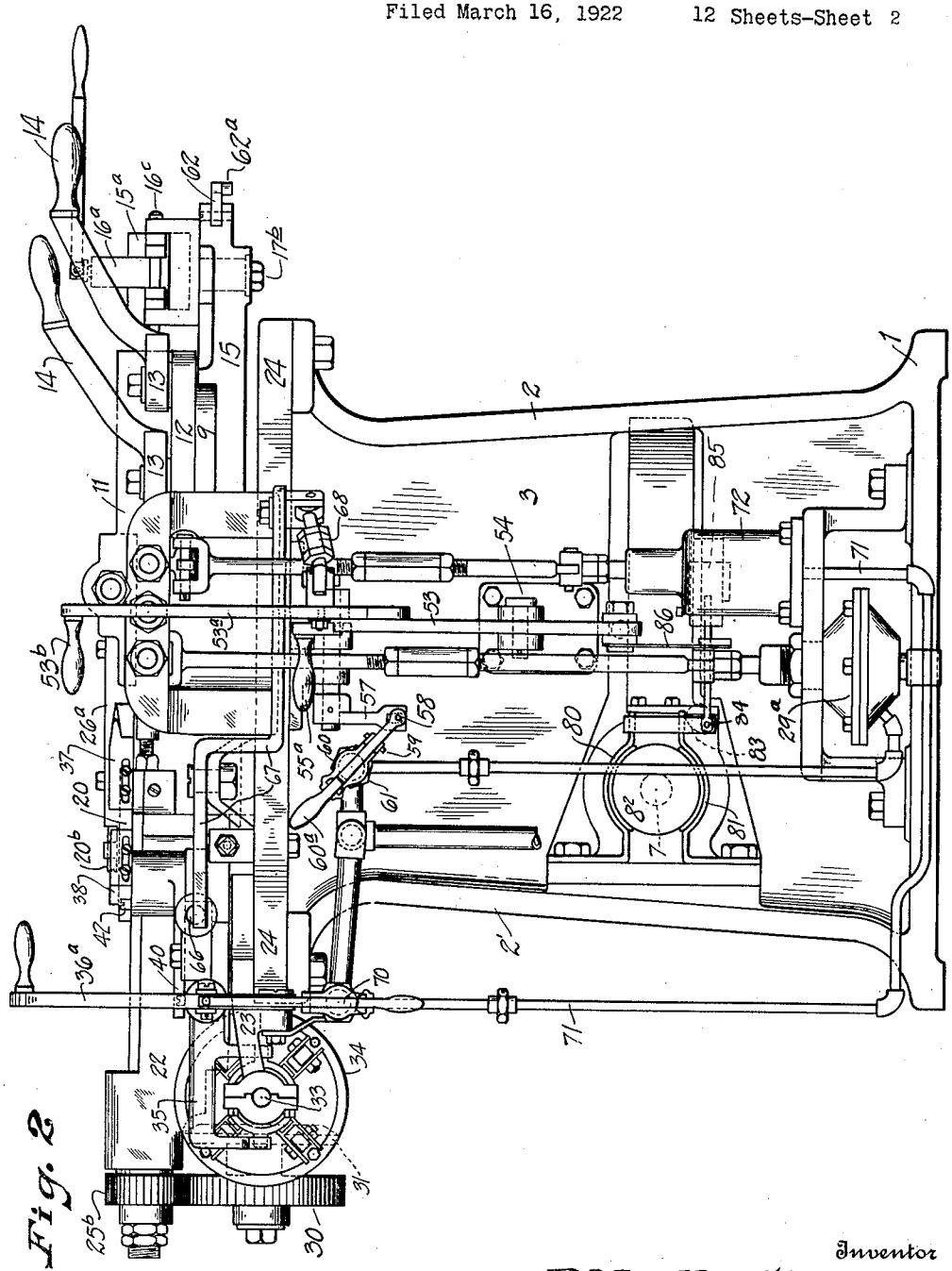

Fig. 2

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PIPE OR TUBE BENDING MACHINE

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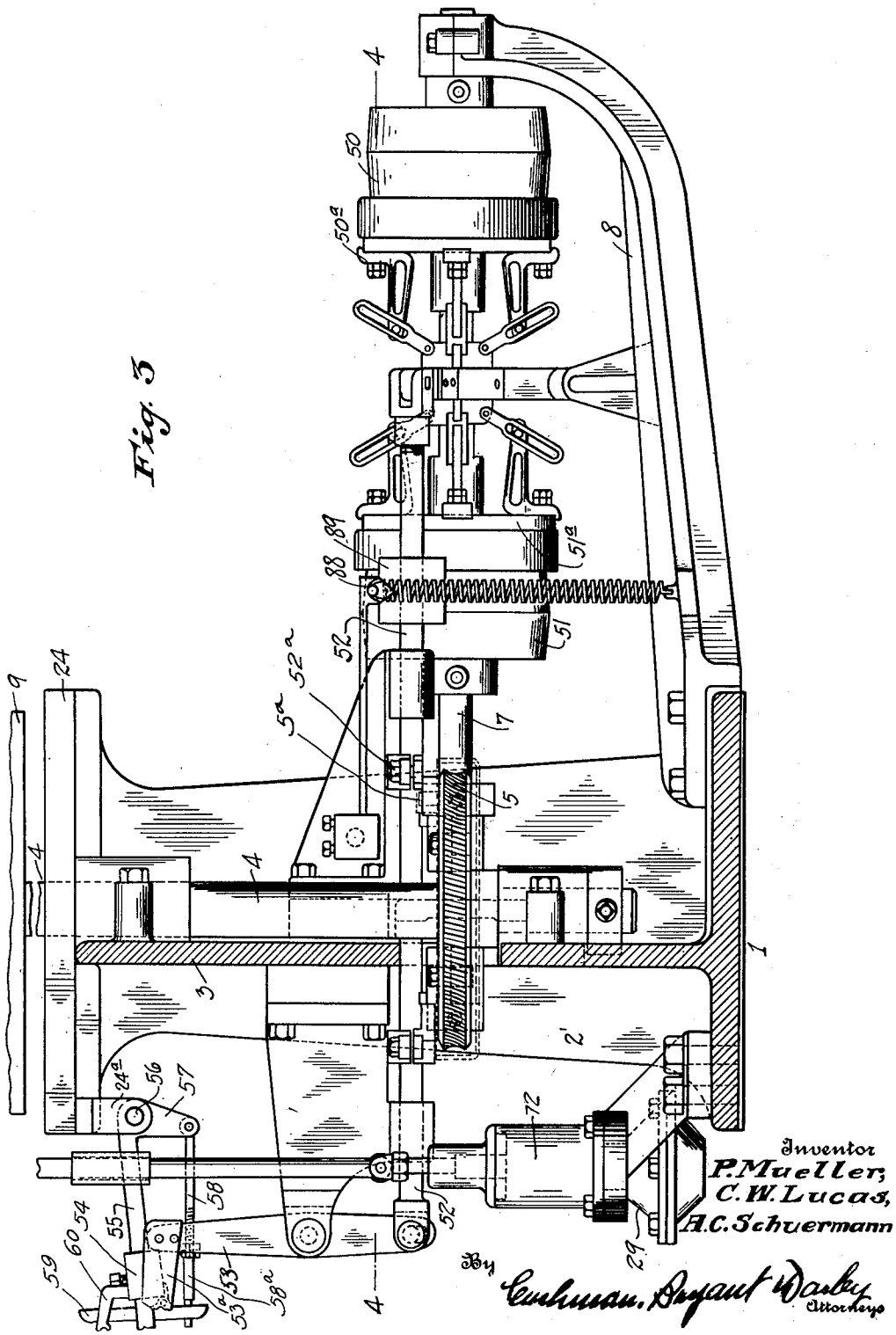
Fig. 3



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March 9, 1926. 1,575,928

P. MUELLER ET AL

PIPE OR TUBE BENDING MACHINE

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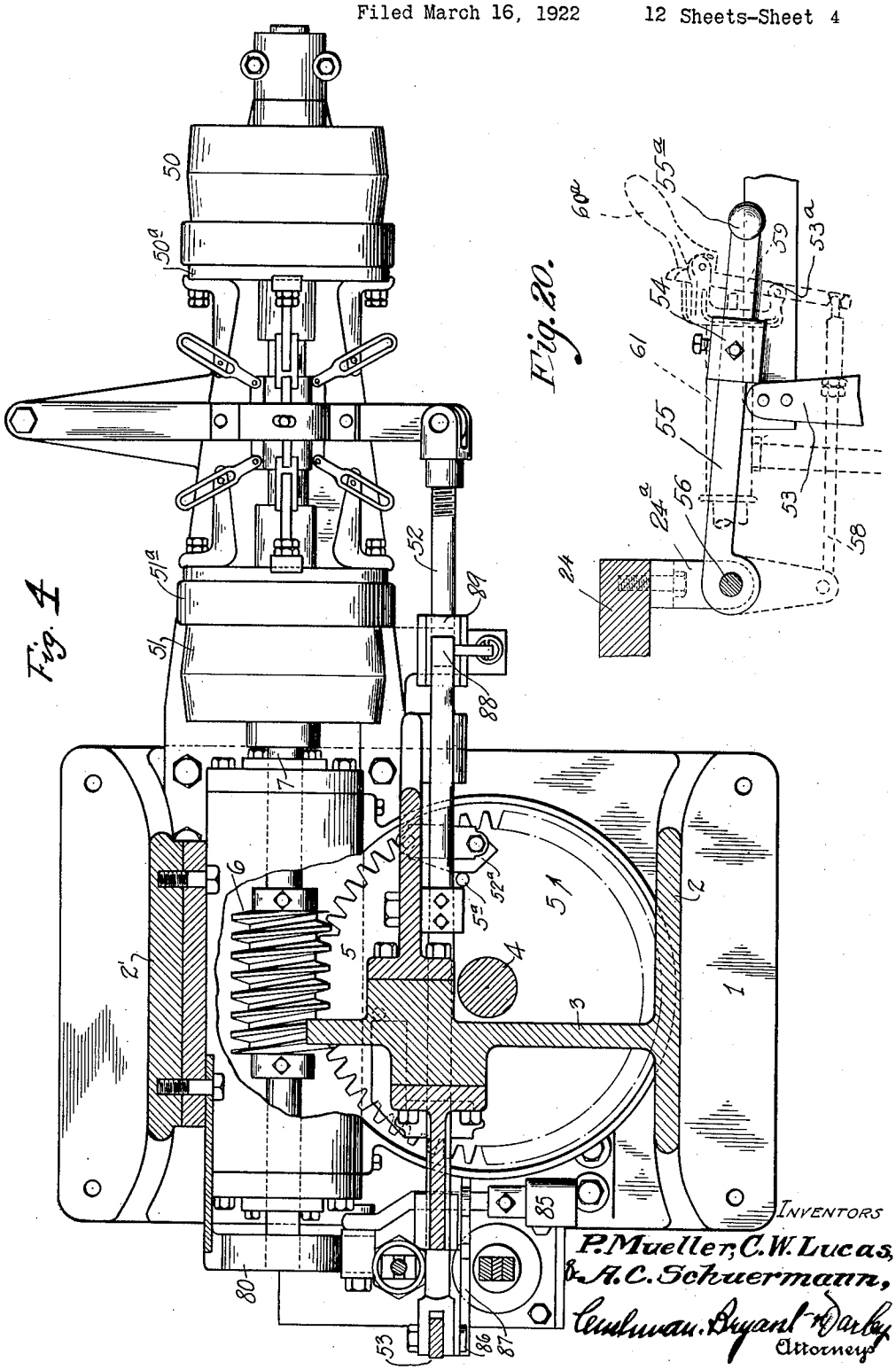

Fig. 4

Fig. 20.

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PIPE OR TUBE BENDING MACHINE

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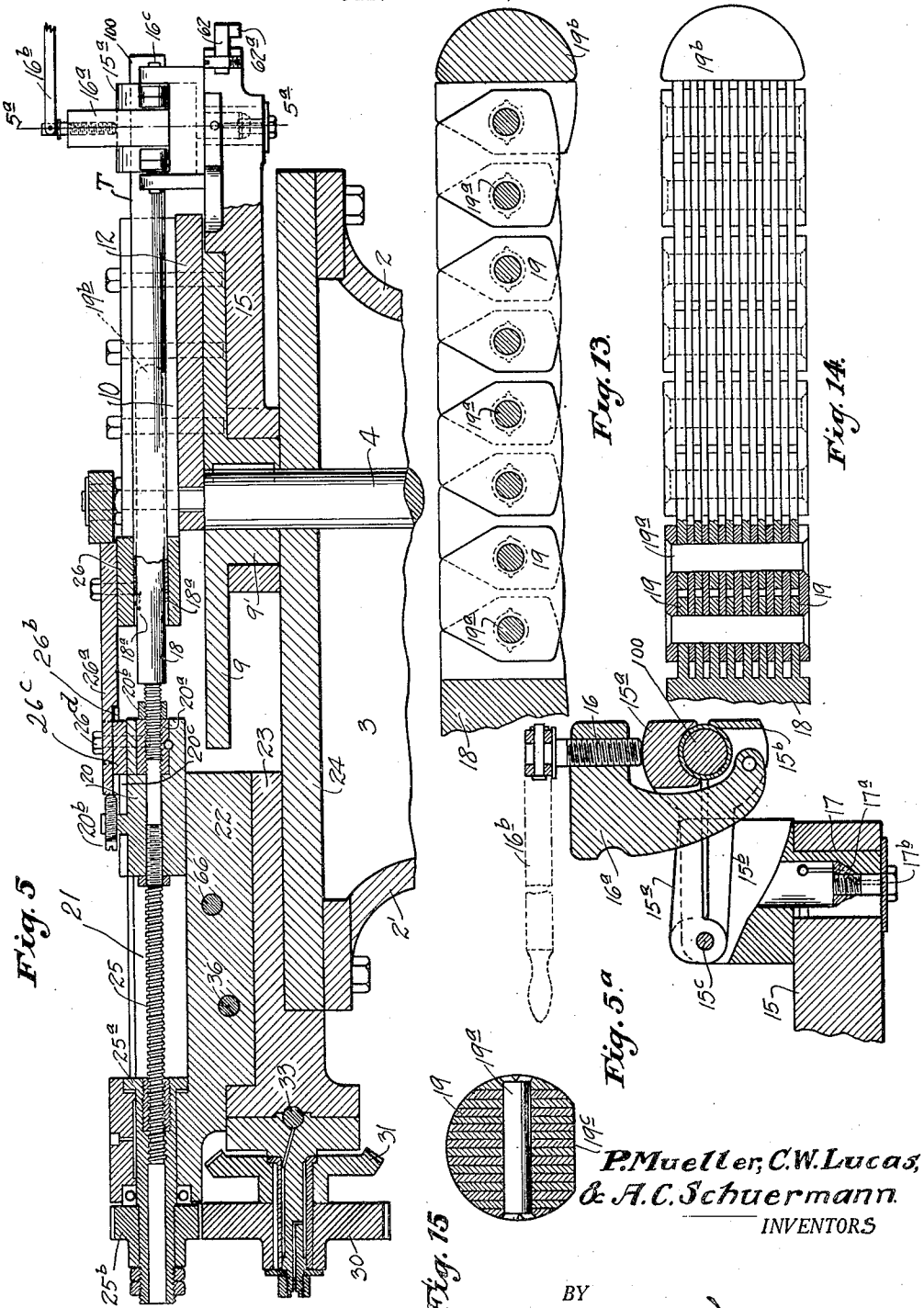

Fig. 5

Fig. 13.

Fig. 14.

Fig. 5a

Fig. 15

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P. MUELLER ET AL

PIPE OR TUBE BENDING MACHINE

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Fig. 6.

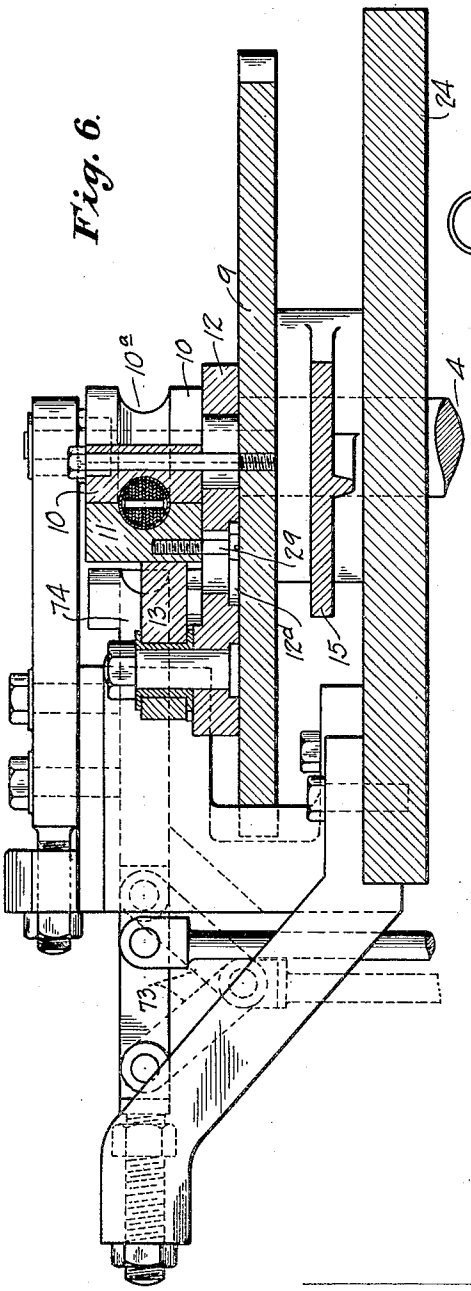
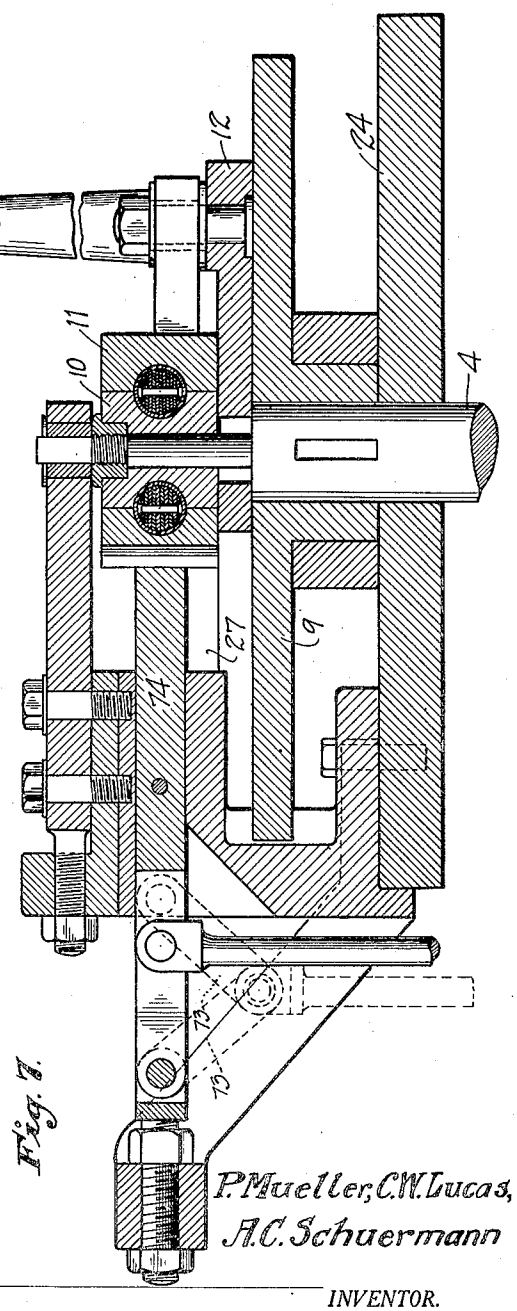


Fig. 7.



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P. MUELLER ET AL

PIPE OR TUBE BENDING MACHINE

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Fig. 8.

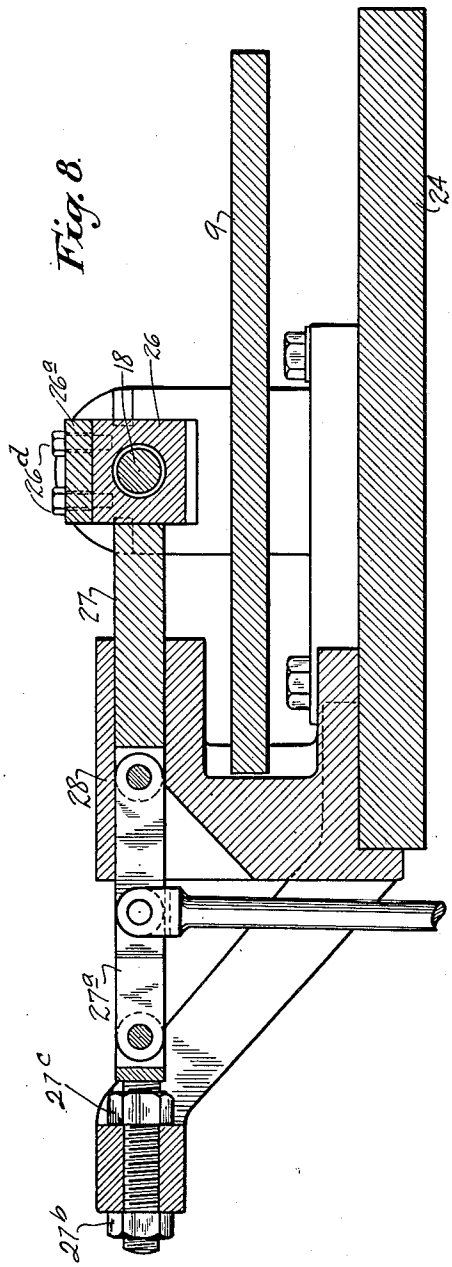


Fig. 16.

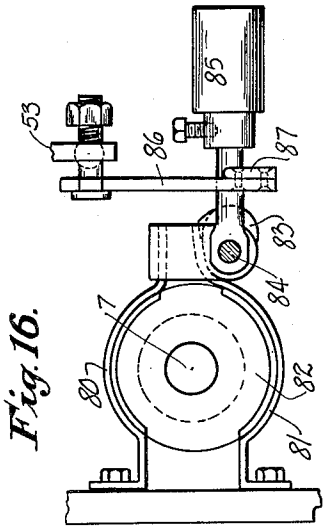
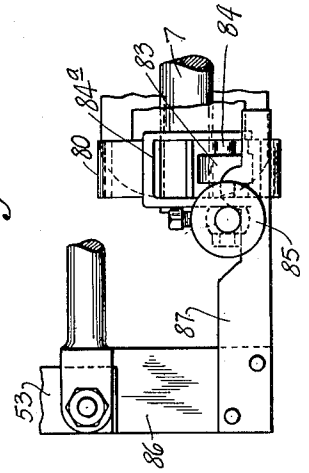


Fig. 17.



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March 9, 1926. 1,575,928

P. MUELLER ET AL

PIPE OR TUBE BENDING MACHINE

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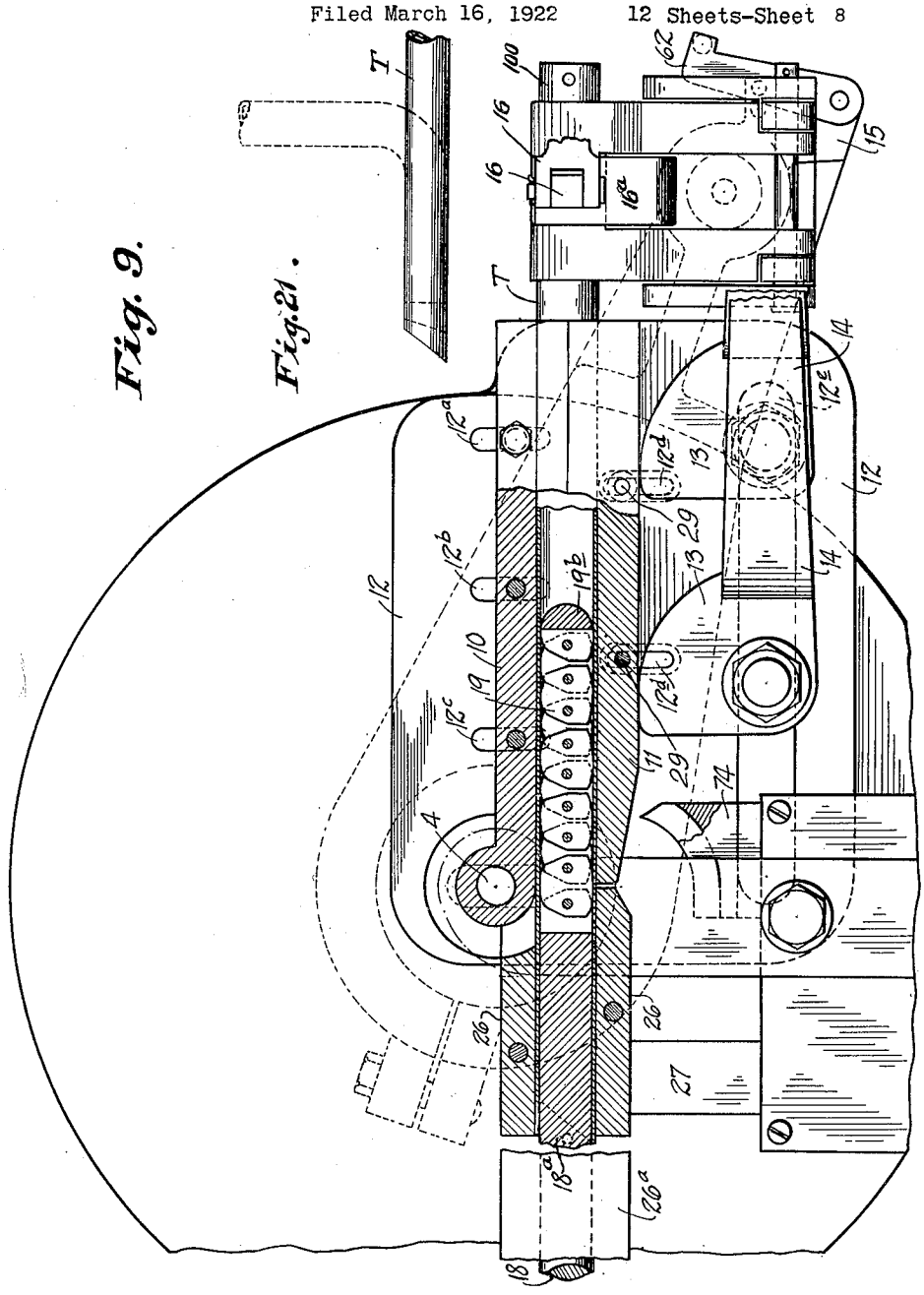
Fig. 9.

Fig. 21.



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March 9, 1926. 1,575,928

P. MUELLER ET AL

PIPE OR TUBE BENDING MACHINE

Filed March 16, 1922 12 Sheets-Sheet 9

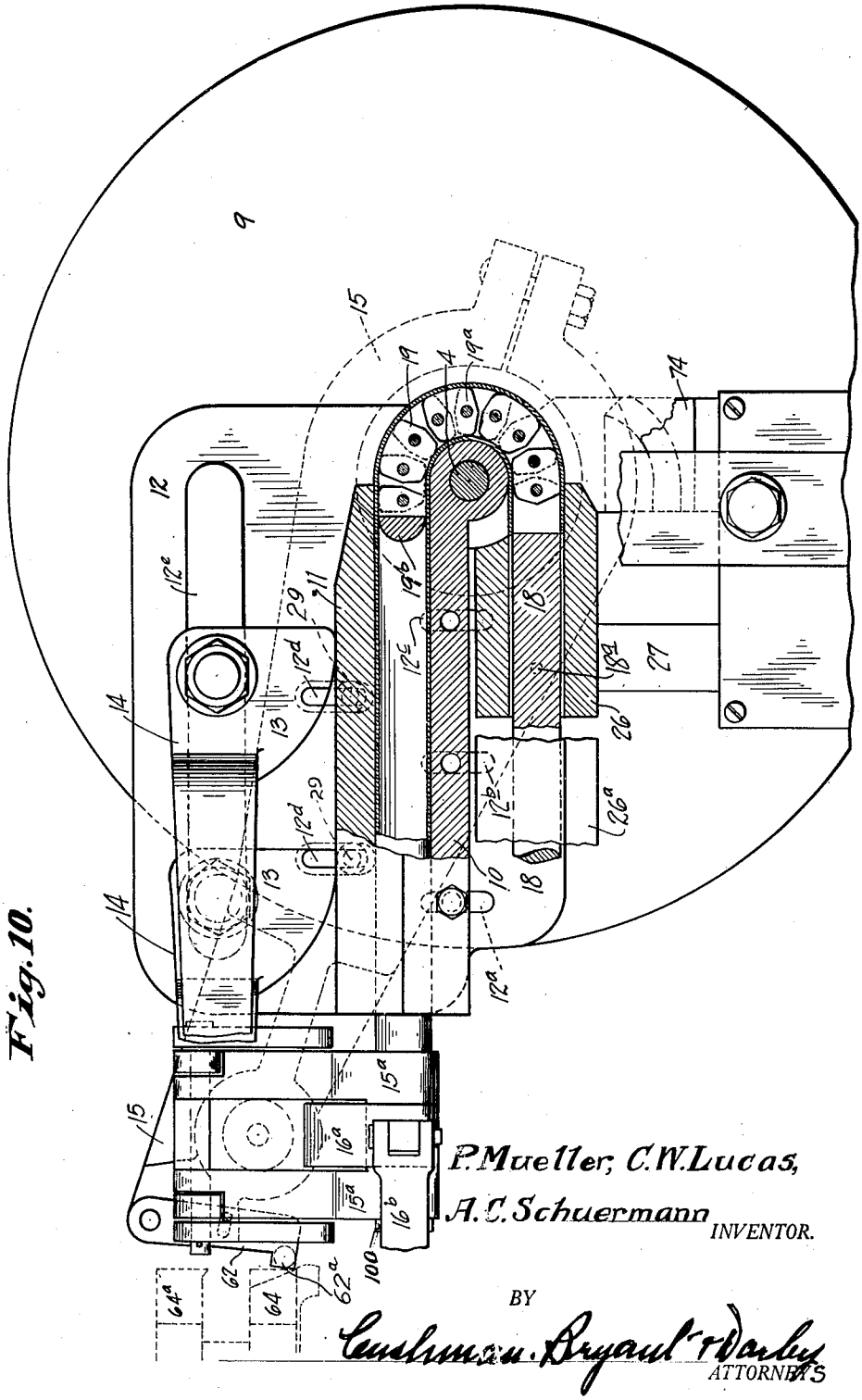

Fig. 10.

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PIPE OR TUBE BENDING MACHINE

Filed March 16, 1922 12 Sheets-Sheet 10

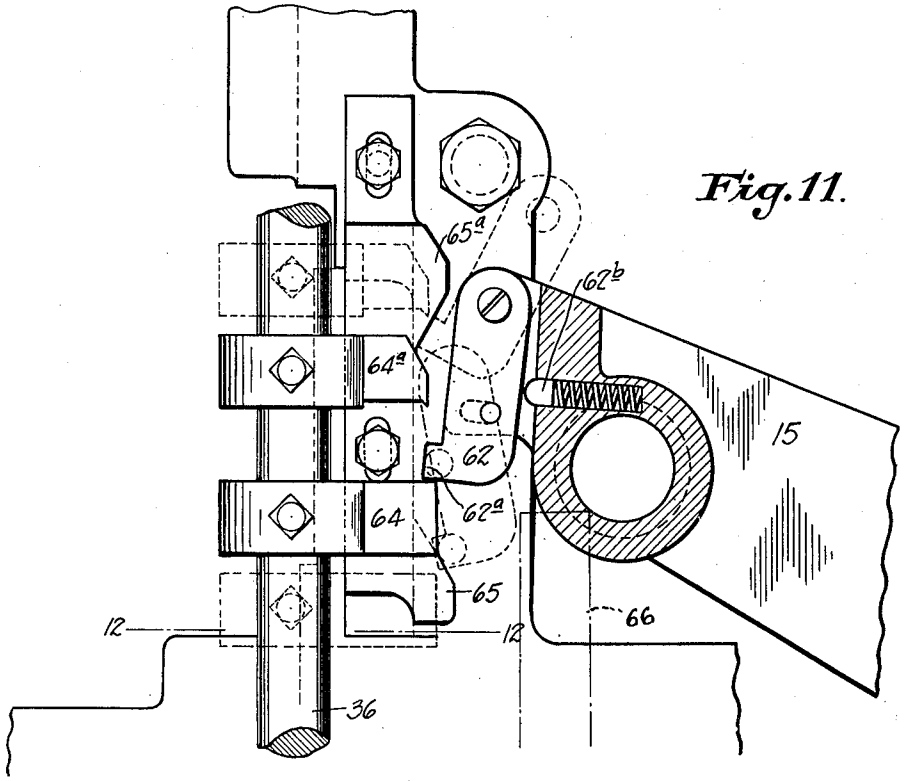

Fig. 11.

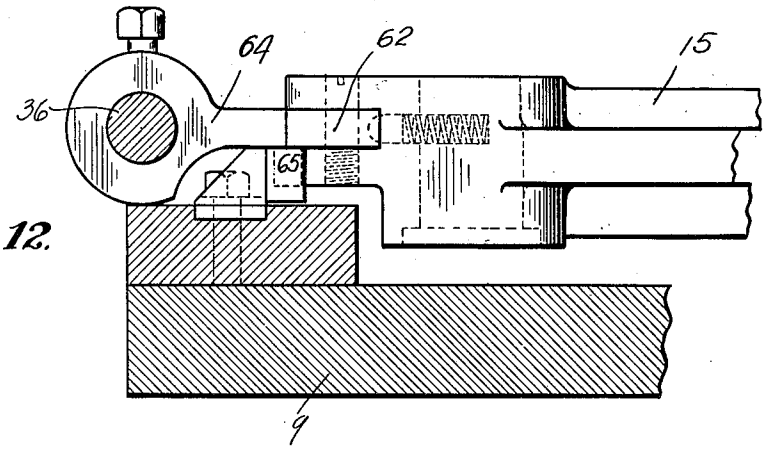

Fig. 12.

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March 9, 1926. 1,575,928

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PIPE OR TUBE BENDING MACHINE

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Fig. 22.

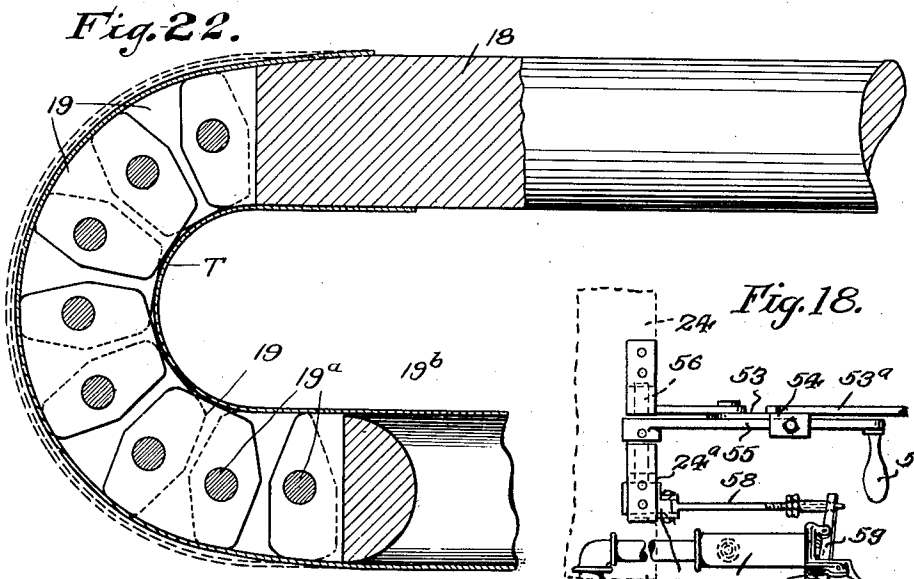

Fig. 18.

Fig. 23.

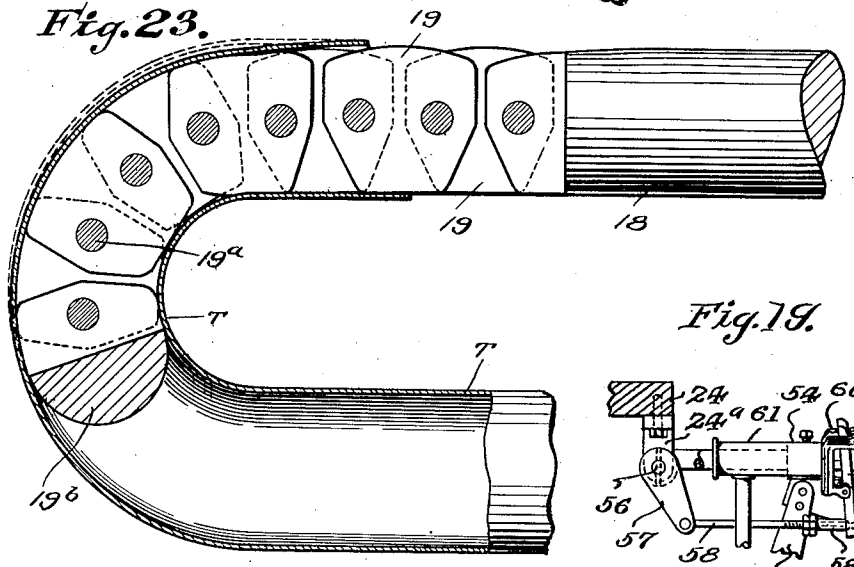

Fig. 19.

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March 9, 1926. 1,575,928

P. MUELLER ET AL

PIPE OR TUBE BENDING MACHINE

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Fig. 24.

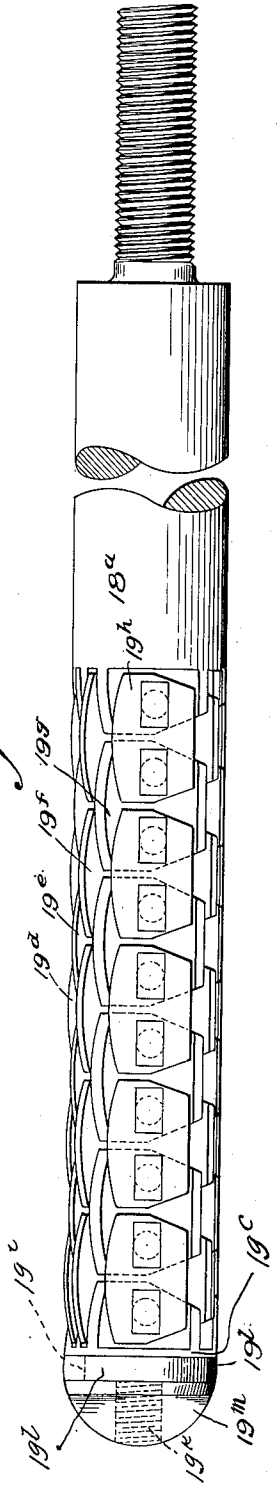


Fig. 25.

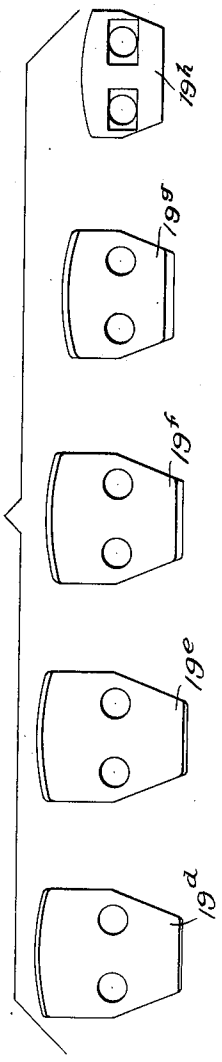


Fig. 28.

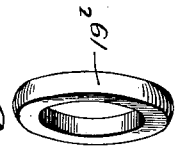


Fig. 27

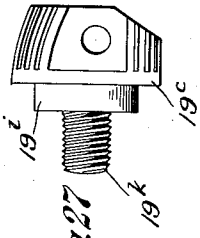
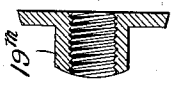


Fig. 26.



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Patented Mar. 9, 1926. 1,575,928

UNITED STATES PATENT OFFICE.

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PIPE OR TUBE BENDING MACHINE.

Application filed March 16, 1922. Serial No. 544,133.

To all whom it may concern:

Be it known that PHILIP MUELLER, CLARENCE W. LUCAS, and ANTON C. SCHEURMANN, citizens of the United States, residing at Decatur, in the county of Macon and State of Illinois, have invented new and useful Improvements in Pipe or Tube Bending Machines, of which the following is a specification.

The present invention relates to improvements in machines for bending pipes or tubes, and particularly for bending metal tubes having thin walls.

Machines of the character or type to which the invention relates are extensively used for bending tubes or pipes to any desired angle, up to 180°, on a small radius in the manufacture of bent tube traps for plumbing fixtures and other purposes.

Heretofore, in the bending of thin wall tubes for the purposes noted, it has been necessary to employ two different machines to complete the bending operation. That is, during the initial bending of the tube or pipe, it was somewhat flattened in cross section on the outer periphery of the bend, and in order to restore the normal cross sectional form of the tube it has been necessary to employ a second machine acting upon such flattened portion.

By the machine of the present invention a tube or pipe may be, at a single operation, bent to the desired extent, and all portions of the finished product be of the proper or normal cross sectional form.

The invention also relates to a novel method by which it is possible to produce bent pipes or tubes in which the wall of the bent portions will not be materially thinner than the other sections.

With these and other objects in view, the invention resides in the novel method that will be hereinafter described and the construction and arrangement of parts illustrated in the accompanying drawings and set forth in the appended claims.

In the accompanying drawings, which illustrate an embodiment of the invention:—

Figure 1 is a plan view.

Fig. 2 is a side elevation.

Fig. 3 is a transverse vertical section.

Fig. 4 is a horizontal section substantially on the line 4—4 of Fig. 3.

Fig. 5 is a vertical sectional view of the upper portion of the machine substantially on the line 5—5 of Fig. 1.

Fig. 5ª is a detail view, being a transverse vertical section substantially on the lines 5ª—5ª of Figs. 1 and 5, of the tube clamping jaws.

Fig. 6 is a section on the line 6—6 of Fig. 1 showing the tube clamped in position prior to the bending operation.

Fig. 7 is a view on the line 7—7 of Fig. 1 with the parts in the position assumed when the tube has been bent.

Fig. 8 is a section on the line 8—8 of Fig. 1.

Fig. 9 is a plan, partly in section, on a slightly enlarged scale, of the tube clamping and bending means, showing the parts in the initial position prior to bending.

Fig. 10 is a similar view showing the position of the parts when the bending operation has been completed.

Fig. 11 is an enlarged detail plan of a portion of the automatic means for controlling starting of the mandrel withdrawing devices.

Fig. 12 is a sectional view substantially on the line 12—12 of Fig. 11.

Figs. 13 to 15 are severally a plan, side elevation partly in section, and a transverse section of the flexible portion of the bending mandrel.

Figs. 16 and 17 are details of portions of the brake mechanism.

Figs. 18 and 19 are detail views of the normally operative lock for the starting lever.

Fig. 20 is a view of parts shown in Figures 18 and 19, showing the starting lever in locked position.

Fig. 21 is a detail view illustrating in full lines a section of tube prior to its being bent by the machine and according to the method of the present invention, and in dotted lines the relative change effected by the bending operation.

Figs. 22 and 23 illustrate the slight flattening of the tube that occurs during the bending operation and how the same is removed by withdrawing the mandrel from the tube.

Figs. 24 to 28 illustrate a slightly modified form of mandrel.

Referring to the drawings, the machine is

supported by a suitable pedestal comprising a base 1, and upwardly extending side members 2, 2′, connected by a web or connecting portion 3 which is suitably apertured to receive the main power shaft, hereinafter more particularly referred to.

A vertical shaft 4 is mounted in bearings on the web 3 of the supporting pedestal and to the lower portion of this shaft is suitably secured a worm gear 5 with which meshes a worm 6 mounted on the main power shaft 7 that is supported in bearings carried by the pedestal and a bracket arm 8 that extends laterally from the pedestal, being securely bolted to the base plate 1.

The shaft 4 extends above the upper end of the supporting pedestal and on the upper end of said shaft is secured the carrier by which the tube bending devices are directly supported.

As shown, this carrier comprises a disk-like member 9 to which are connected the members 10, 11 of a tube clamp. The member 10 is adjustably mounted on the carrier 9, but is held relatively stationary thereon, while the member 11 is adapted to be moved bodily toward and from the relatively stationary clamp member 10, being held in position to firmly grasp a tube between said members when the machine is being operated.

As shown, the tube clamping jaws 10, 11, are carried by a plate 12, which is mounted on the disk-like carirer 9, and in order that the machine may be adapted for treating tubes of different diameters the clamps 10, 11, are removably connected to said plate.

In the embodiment of the invention illustrated, the plate 12 is provided with slots 12^a, 12^b, 12^c, through which pass suitable bolts that serve to connect the plate 12 to the carrier 9, said bolts also holding the tube clamping member 10 in position. The adjustable tube clamp member 11 is connected with the plate 12 by guide bolts 29 that extend from said clamp member into countersunk slots 12^d in the plate 12 (see Fig. 6), and said clamp member is moved into engagement with the tube to be bent and into operative relation to the relatively stationary clamp member 10 by cams 13 carried by lever arms 14 suitably pivoted on the plate 12. The pivot bolts for the levers 14 extend through a suitable slot 12^e in the plate 12, so that the cams 13 may be moved relatively toward and away from each other.

As above described in the embodiment of the invention illustrated in the accompanying drawings, the tube clamp cams 13 are adapted to be manually operated, but it will be evident that said cams might be actuated by fluid pressure in a manner similar to other movable elements of the machine hereinafter referred to.

In operation, the tube to be bent is supported upon a suitable mandrel, hereinafter more particulary described, including a rigid stem or shank held stationary at one side of the rotary carrier 9, and between the clamping members 10, 11. The end of the tube, which projects beyond the periphery of the carrier 9 at the right hand side of the machine in Fig. 1, is engaged by suitable jaws carried by an arm 15, which is clamped about a centrally arranged depending hub 9′ on the carrier 9.

This clamp, as shown particularly in Figs. 1, 2, 5 and 5^a, comprises two jaws 15^a, 15^b, pivotally mounted at 15^c on a member that is supported at the outer end of the arm 15. The jaws are moved into and held in engaging relation with a tube by a screw 16 carried in a pivotally mounted holder 16^a and having at its outer end an arm or hand piece 16^b by which it may be rotated. The support for the jaws 15^a, 15^b, has a depending expandible, tubular, shank 17, which has a pivotal bearing in an aperture adjacent the outer end of the arm 15. A nut 17^a arranged within the expanding shank 17 and engaged by a screw 17^b acts to effect close engagement of the shank 17 with the arm 15 and yet permits of angular adjustment of the pipe engaging jaws 15^a, 15^b, relative to said arm, if desired.

The particular arrangement or construction and relation of the jaws 15^a, 15^b, described and illustrated is of considerable importance. It will be seen that by loosening the screw 16 the holder 16^a may be swung about its pivotal support, and the jaws 15^a, 15^b turned on the axis 15^c so that the bent tube will be entirely released and can be lifted away from the clamp without any turning thereof.

The end of the arm 15 which embraces the hub 9′ of the carrier 9 is split, as shown in Fig. 1, and the two sections are drawn tightly together by means of a suitable screw bolt. Therefore, said arm may be adjusted about the hub of the rotary carrier 9, and the jaws 15^a, 15^b, carried by said arm, correspondingly adjusted so as to properly receive tubes of different diameters. As before stated, the forms or tube clamp members 10 and 11 are detachable, and similar forms adapted to properly engage tubes of different diameters may be substituted for the one shown.

When such substitution is effected, it is necessary to adjust the clamping jaws at the outer end of the arm 15 to properly align said jaws with the tube grasped between the clamp members 10 and 11. If it is desired to make such a change the proper forms of clamps 10 and 11 are attached to the carrier 9, a tube placed in position thereagainst and the adjustable clamp 11 moved to properly engage the tube. The screw connecting the members of the arm 15 adjacent the hub of

the rotary carrier being loosened, said arm is properly adjusted about said hub into its correct position with relation to the tube and clamps 10, 11, and the jaws 15^a, 15^b, thereon engaged with the tube. The screw 17^b and the screw connecting the sections of the arm 15 at the hub 9' are then tightened and the several parts thus secured in the new and proper relation for operation.

The relatively stationary tube clamp member 10 is mounted on the carrier 9, as before described, and comprises a hub-like portion which is fitted about the upper end of the shaft 4 and a longitudinally extending section in one face of which is formed a semi-circular groove or channel 10^a that is continued about the hub-like portion of the clamp member. The other member 11 of the clamp has a correspondingly shaped groove in its face adjacent the member 10 so that when the two members are brought together by the action of the cam levers 14, they will closely surround the tube to be bent. Any danger of the action of the cams 13 causing the tube clamps to engage the tube in such manner as to effect a collapsing thereof is avoided by inserting a suitable mandrel in the tube.

During the bending operation the tube is supported by such mandrel which is adjustably connected with a reciprocating carrier mounted in bearings on the machine at one side of the rotary carrier 9 in substantial alignment with the space between the tube clamping members 10, 11, when in the position shown in Fig. 1.

The mandrel shown comprises a rigid stem 18 which is connected to the reciprocating carrier, as will be hereinafter described, and a flexible extension that projects into the tube and between the clamp members 10, 11, beyond the axis of the shaft 4 so that it is adapted to flex with the tube as it is bent about the shaft 4 as the carrier 9 is rotated.

In the form of mandrel shown particularly in Figs. 13 to 15, the flexible section is formed by several series of links 19 pivotally connected by rivets 19^a and terminates in a hemispherical head 19^b. The flexible section is gradually reduced slightly in diameter from the solid section 18 to within a short distance from the head 19^b and then gradually increases slightly in diameter to such ball end. Preferably, the several links are slightly ground off on one side as at 19^c so that when the mandrel is bent it will be slightly flattened on its outer periphery, or on the convex face of the bent mandrel.

The other end of the mandrel stem 18 from that to which the flexible section is secured has a reduced threaded portion which (see Fig. 5) is screwed into a bushing 20^a mounted in the mandrel carrier 20. This carrier is supported between guide rails 21 carried by a member 22 mounted on a bracket 23 adjustably connected with the top plate 24 of the main supporting pedestal.

A shown, four bolts 23^a hold the bracket 23 to the top plate of the pedestal, said bolts extending through slots in the plate 24 so that, as above stated, the bracket and parts carried thereby may be adjusted laterally. The necessity for this adjustment is that when a change of the tube clamps 10, 11 is made to adapt the machine to work on tubes of a different diameter, it is, of course, necessary to effect a lateral movement of the plate 23 so that the axes of the mandrel and tube will be in accurate alignment when the parts are positioned as in Fig. 1.

The threaded end of the mandrel is secured within the bushing of the carrier 20 by a lock nut 20^b. The carrier and mandrel connected thereto are adjusted longitudinally of the guide-way in the member 22 by means of a feed screw 25 which is connected at one end to the carrier and extends into engagement with an interiorly threaded feed nut 25^a mounted in a bearing on the member 22 and to the outer end of which is secured a gear 25^b. As this gear is rotated, by means to be hereinafter more particularly described, the mandrel carrier and mandrel will be moved longitudinally into proper relation to the tube clamping members on the carrier 9.

The mandrel extends through a passage formed in a tension guide 26 supported by a plate 26^a that is adjustably connected with the mandrel carrier 20. The passage through the tension guide is sufficiently large to permit the entrance thereinto, about the mandrel stem 18, of the end of the tube which is to be bent. The bolts 26^d which connect the plate 26^a with the carrier 20 extend through suitable slots formed in said plate and by means of a screw 20^b, bearing against the rear end of the plate 26^a, said plate and the tension guide may be adjusted relative to the mandrel and tube clamps 10, 11 so as to fix and determine the distance that the mandrel can be moved toward the axis of the shaft 4 about which the tube is to be bent, said movement being effected by the feed screw 25. The end of the tension guide 26 is so formed that it will contact closely with the hub of the tube clamp member 10 on the carrier 9, thus limiting the movement of the mandrel in that direction. Such contact occurs just after the clutch controlling movement of the feed screw is thrown out as hereinafter described.

As shown, the mandrel stem or body 18 is provided at diametrically opposite points with short projecting studs or pins 18^a which serve as stops to endwise movement of the tube which is slipped over the mandrel.

Preferably, the mandrel carrier 20 and

the plate 26ª which carries the tension guide 26 are held from relative lateral movement by a key 26ᶜ which is fitted in aligned grooves 20ᶜ and 26ᵇ formed in the adjacent faces of the carrier 20 and plate 26ª.

When the machine is operating, the tension guide 26 is held rigid and against the abutment provided by the hub-like portion of the clamp member 10 on the plate 9 by a presser foot 27 which has a sliding bearing in a housing 28 suitably supported from the main frame and is connected through a toggle 27ª and a connecting rod with a diaphragm arranged in a fluid pressure chamber 29ª. The supply of fluid for operating the diaphragm in the chamber 29ª is automatically controlled, as will be hereinafter more particularly described, and when fluid is supplied to said chamber the toggle 27ª is spread to force the presser foot or plunger 27 into contact with the tension guide 26 and check relative longitudinal movement between the tube and mandrel as the carrier 9 is rotated.

The gear 25ᵇ, which controls longitudinal movement of the mandrel carrier and mandrel, meshes with a gear 30 which is keyed to a sleeve surrounding a stud that is carried by a plate secured to the bracket 23. To said sleeve is also secured a bevel gear 31 that meshes with two bevels 32, 32ª, on a countershaft 33, mounted in suitable bearings on the aforesaid bracket 23, carried by the pedestal top plate 24. The shaft 33 is constantly rotated by a suitable belt, not shown, engaging a band wheel 33ª; and on said shaft adjacent each of the bevel gears 32, 32ª, is mounted a suitable clutch mechanism 34, 34ª, by means of which said gears 32, 32ª, can be alternately connected with the shaft and through the gears 31, 30 and 25ᵇ, caused to reciprocate the mandrel carrier and mandrel as required.

The clutches 34, 34ª, are simultaneously actuated by shifter arms 35, 35ª, mounted on a shifter rod 36, which is supported on the bracket 23. At one end the shifter rod 36 is connected to a manually operable shift lever 36ª. When the clutch 34 is engaged with the shaft 33 the feed screw nut 25ª will be turned to feed the mandrel carrier and mandrel toward the shaft 4 and into operative position, whereas when the clutch 34ª is engaged with the shaft the feed screw nut 25ª will be oppositely rotated and act to withdraw the mandrel from the tension guide 26 and the tube in which it may be inserted.

Means are provided whereby independent of any movement of the manually operable lever 36ª, the shifter rod 36 will be automatically shifted as the mandrel carrier approaches the limit of its reciprocating movement in either direction. Such means, in the embodiment of the invention illustrated, comprises stop dogs 37, 38, which are attached to one side of the mandrel carrier 20 and adapted to cooperate with a clutch shifter arm 40 which engages a collar 36ª on the shifter rod 36. The shifter arm 40 is pivotally connected at 41 to the bracket 22 and carries a pin 42 which is alternately engaged by the stop dogs 37, 38, on the mandrel carrier, so as to disengage whichever clutch 34, 34ª is operative at the limit of movement of the mandrel and mandrel carrier in either direction. In case the momentum of the parts should tend to continue movement of the mandrel toward the tube clamps after the clutch 34 is disengaged, such movement will be properly checked by contact of the tension guide 26 with the hub of the clamp member 10.

On the main power shaft 7 are mounted two loose pulleys 50, 51, which are adapted to be constantly rotated by power belts, not shown, and associated with each of these pulleys is a clutch 50ª, 51ª, by operation of which the direction of rotation of the shaft may be controlled. Said clutches are simultaneously operated through a rod 52 which is connected with the starting lever 53. The lever 53 is pivotally mounted on a bracket extending laterally from the supporting pedestal (see Fig. 3). The upper portion of the lever 53 is provided with a laterally projecting angular extension 53ª which terminates in a handle 53ᵇ that is situated some distance in front of the machine.

Means are provided whereby it is impossible to start the machine and effect rotation of the carrier 9 and the tube engaging members carried thereby until the plunger 27 is in proper relation to the tension guide 26. Such means includes a lock normally preventing outward movement of the starting lever 53 and starting of the machine, and the disengagement of which automatically opens a valve in a conduit for supplying fluid, under pressure, to the diaphragm chamber 29ª. The particular locking means shown is a block or dog 54 which is adjustably mounted on a lever 55 that is carried by a short shaft 56 mounted in a suitable bearing on an ear 24ª depending from the top plate of the supporting frame or pedestal. At its outer end the lever 55 is provided with a handle 55ª, by means of which it may be raised to lift the dog or block 54 from the path of the starting lever 53.

The shaft 56 is also provided with a short arm 57 from which extends a rod 58, the free end of which passes through a lever 59 mounted in a suitable yoke-like frame 60 on the head of a valve casing 61 forming part of a system of piping for supplying fluid under pressure. A sleeve 58ª adjustably mounted on the rod 58 bears against the lever 59, and by adjustment of such

sleeve the actuation of the valve in the casing 61 may be accurately controlled. When the lever 55 is raised to permit operation of the starting lever 53, it will be seen that the valve in casing 61 will be opened and fluid under pressure supplied to the diaphragm chamber 29ª, which, as before pointed out, will extend the members of the toggle 27ª and move the presser foot 27 into proper engagement with the tension guide 26.

Fig. 19 illustrates the positions of the several parts when the lever 53 is released, and in Fig. 23 the positions of said elements when the lever is locked are shown. It will be seen that in the latter condition the fluid controlling valve stem will be out of contact with the lever 59, and, therefore, the latter will be closed. A manually adjustable lever 60ª, fulcrumed in the frame 60, is provided so that the lever 59 may be rocked to operate the valve in the casing 61 at will.

After the lock of the starting lever has been disengaged and the tension guide engaged by the presser foot 27, as above described, forward movement of the lever 53 will, through the rod 52, cause engagement of clutch 50ª with the driving shaft 7, and the worm 6 and gear 5 will rotate the disk carrier 9 in the direction of the arrow in Figs. 1 and 4. Such rotary movement will carry the portion of the tube engaged by the clamping members 10, 11, about the axis of the shaft 4 and will effect a longitudinal movement or slip of the tube through the tension guide 26. The pressure exerted on tension guide 26 by the presser foot 27, which may be varied as desired by means of the adjusting nuts 27ᵇ and 27ᶜ, will prevent such longitudinal movement of the tube through the tension guide as would result in wrinkling the inner periphery of the bend or cause rupture of the tube. The mandrel being held stationary by reason of the tension guide 26 abutting the end of the tube clamp 10 adjacent the shaft 4, the tube end being treated will be drawn away from the stops 18ª and will slip over the mandrel as the bending continues.

As the rotating carrier 9 advances in the direction of the arrow in Fig. 1, the flexible portion of the mandrel is bent with the tube about the hub-like end of the tube clamp member 10, and the tube may thus be bent to any desired angle.

Movement of the rotating carrier may be checked at any time by returning the starting lever to stop position in which the rod 52 will disengage the clutch 50ª, such stopping being assisted by a suitable brake, hereinafter more particularly referred to.

Means are provided, as illustrated in Figs. 1 and 10, whereby angular movement of the carrier 9 may be automatically checked, as desired, and the mandrel carrier moved to effect automatic withdrawal of the mandrel from the bent tube. Pivotally connected to the outer end of the arm 15 is a pawl 62 that terminates in a depending lug 62ª. This pawl is normally projected from the end of the arm 15 by a spring pressed plug 62ᵇ mounted in a socket in the arm 15. Movement of the pawl, relative to the arm, is limited by a pin and slot connection, as shown particularly in Figs. 1 and 9 to 11 inclusive.

On the shifter rod 36, controlling, as heretofore pointed out, the clutches 34, 34ª, of the mandrel feed mechanism are secured two dogs 64, 64ª. As the carrier arm 15 approaches the limit of its turning movement the depending lug 62ª, at the free end of the pawl 62, will contact with the dog 64 and move the rod 36 longitudinally to engage the clutch 34ª with the shaft 33 and thus initiate movement of the feed screw 25 in a direction to withdraw the mandrel from the tube. As the dog 64 is shifted to the dotted line position shown in Fig. 11, a stationary cam 65 will contact with the pawl lug 62ª and move the pawl against the action of the spring plug 62ᵇ away from the dog 64.

Simultaneously, with the engagement of the shifter dog 64 by the pawl 62, as above described, the carrier arm 15 engages the end of a shifter rod 66 which extends transversely across the machine and has one end engaging one arm of a lever 67, the other arm of which, through an adjustable rod 68, is connected to the starting lever 53. Therefore, as said shifter arm 66 is operated the starting lever is returned to stop position, during which movement the fluid pressure valve in casing 61 is closed, and, by escape of pressure from the chamber 29ª, the toggle 27ª is permitted to drop and withdraw the presser foot 27 from the tension guide 26.

When the shifter rod 36 is moved, as above described, by the pawl 62, said rod is caused to actuate a lever 70 controlling a valve in the fluid pressure system connecting a branch 71 with the main supply pipe, said branch 71 in turn being connected to a chamber 72 containing a piston, the stem of which is suitably connected with a toggle 73. This toggle is also connected with a slide 74, the forward end of which is curved to conform to the bent surface of the tube. Therefore, during the period that the mandrel is being withdrawn and the pressure on the tension guide 26 is released, said sliding member 74 is maintained in contact with the bent tube. Such engagment of the member 74 with the bent tube prevents distortion or rupture thereof, as the mandrel is withdrawn. The lever 70 is connected with the lever 36ª so that when the latter is moved to manually effect connection of the mandrel carrier with the

power means for withdrawing the mandrel from a tube, or in its forward position, the valve controlling movement of slide 74 will also be actuated to project said slide from its casing. Further, the lever 70 may be independently moved manually to effect such movement of the slide 74.

Movement of the starting lever 53, to stop position, also effects operation of a brake by means of which rotation of the carrier 9 is checked as said starting lever reaches stop position.

The brake comprises brake bands 80, 81, (shown particularly in Figs. 2, 4, 16 and 17) which are bolted to a portion of the supporting frame at one end and partially embrace a brake wheel or drum 82 mounted on the end of the worm shaft 7. The bands 80, 81, are adapted to be engaged with the brake wheel to check rotation of the worm shaft and parts actuated thereby, by a cam 83 which is mounted on a short shaft 84 from which projects an arm carrying a weight 85. The free ends of the brake bands are embraced by a yoke 84^a which is supported by the shaft 84. The weight 85 normally holds the parts in the position shown in Fig. 16 in which the brake is released. An arm 86, attached to and extending downwardly from the starting lever 53, is provided with a lateral extension 87 having a cam portion which is adapted to cooperate with the arm carrying the weight 85, so that as the starting lever is returned to stop position the cam on the arm 87 will lift said weight carrying arm, actuate the cam 83, and apply the brake.

By moving the starting lever 53 toward the machine from the stop position the rod 52 will be caused to connect the drive pulley 51 to the worm drive shaft 7 and thus produce a reverse rotation of the shaft 4 and rotary carrier 9. When, during this movement, the lug 62^a on the pawl 62 engages the dog 64^a on the shifter rod 36, the latter will be moved to effect disengagement of the clutch 34^a and connect the clutch 34 to the shaft 33 so that the mandrel feed screw 25 will be turned to feed the mandrel forward into the position shown in Fig. 1 to receive another tube. It will be understood that the bent tube is to be removed from the machine, as hereinafter described, prior to moving the starting lever 53^a toward the machine to effect such reverse movement of the rotary carrier 9.

As the pawl 62, by engaging with the dog 64^a, moves the shift rod, as last described, such pawl will come against a stationary cam 65^a and be thereby disengaged from the dog 64^a so that the return movement of the arm 15 will not be interfered with.

The worm gear 5 is provided with an upwardly projecting pin 5^a which is adapted to cooperate with a dog 52^a secured on the shift rod 52 whereby, as the tube clamp member 10 comes into proper alignment with the tension guide 26, the rod 52 will be moved longitudinally to disengage both of the clutches on the shaft 7. Such movement will restore the starting lever to stop position, and, through the arm 86 and cam 83, effect an application of the brake as above described. A pawl 88 is adapted to cooperate with a collar 89 on the clutch shift rod 52 when said rod is in position to disengage both clutches 50^a, 51^a, and the starting lever is in stop position. This retains the rod 52 temporarily in neutral position and eliminates danger of the machine being started accidentally and prematurely.

While the operation of the machine illustrated in the drawings has been generally described in the foregoing pages, it may be briefly recapitulated as follows:—

The tube T to be bent is preferably, though not necessarily, cut diagonally at that end which is to fit over the mandrel, as shown in Figs. 1 and 9, for example, and initially may have a solid core 100 inserted in the portion thereof which is to be grasped by the jaws 15^a, 15^b, of the swinging arm 15, for the purpose of preventing cross sectional collapse of the tube when clamped by said jaws. The tube is then positioned as shown in Fig. 1, being shoved through the open jaws 15^a, 15^b, between the clamping members 10, 11, of the carrier 9, over the flexible section of the mandrel and into the tension guide member 26 until the end thereof abuts the stop pin or pins 18^a. The screw 16 is then actuated to cause the jaws 15^a, 15^b, to closely embrace the tube. The cam levers 13, 14, or equivalent means, are actuated to move the laterally slidable tube clamp 11 into engagement with the tube, and the locking lever 55 is raised to release the starting lever 53. It will be recalled that raising the locking lever in this manner acts through the means controlling the valve 61 to supply fluid under pressure to the diaphragm chamber 29, and thus causes the presser foot 27 to bear against the tension guide 26.

The starting lever 53 is then moved, causing shift rod 52 to effect engagement of the clutch 50 with the power shaft 7 in such manner that the worm 6 and worm wheel 5 will rotate the shaft 4 and carrier 9 in the direction of the arrow in Fig. 1. Rotation of the carrier 9, arm 15, carrying the clamping jaws 15^a, 15^b, and the tube clamp members 10, 11, all of which rotate together, will cause the end of the tube within the tension guide 26 to move longitudinally, and the flexible portion of the mandrel and tube surrounding the same will be bent about the hub-like portion of the tube clamping member 10. When the arm 15 comes into

position to engage the end of the shifter rod 66 the starting lever 53 will be returned to normal "stop" position, and rotation of the carrier 9, and parts secured thereto checked by the application of the brake as previously described. As the arm 15 thus approaches the termination of its swinging movement in the direction of the arrow, the pawl 62 thereon will actuate the shifter rod 36 through the dog 64, to effect engagement of the clutch 34^a with the mandrel feed drive shaft 33 so that the screw 25 will be turned to withdraw the mandrel from the tube. The ball end 19^b of the mandrel is exactly circular in cross section and of the full diameter of the tube so that, as the mandrel is withdrawn, such ball will correct any lateral distortion of the tube.

As the starting lever is returned to stop position by the shifter rod 66 and lever 67 the locking lever 55 will fall, thus actuating the valve 61 and releasing the pressure of the presser foot 27 against the tension guide 26.

Movement of the shifter rod 36, by pawl 62 and dog 64 will actuate the lever 70 and valve controlled thereby and effect communication between the fluid pressure main and cylinder 72 so that the toggle 73 will be operated to carry the outside movable form 74 against the portion of the tube adjacent the clamp members 10, 11. As the mandrel carrier moves to the left in Fig. 1 to withdraw the mandrel, as just described, the stop 37 will engage the pin 42 and rock the lever 40, at the termination of the return movement of the feed screw 25, to impart a slight movement to the rod 36 to disengage clutch 34^a therefrom and allow these parts to come to rest. This latter movement of the shifter rod 36 also cuts off the supply of fluid to the cylinder 72 and permits the toggle 73 to drop and withdraw the member 74 from engagement with the tube.

The jaws of the clamp at the outer end of the arm 15 are then released by turning the screw 16^b, after which the cams 13 are moved to release the clamp member 11 and permit the same to be moved away from the tube and clamp member 10. The bent tube, together with the solid core therein, is then removed from the machine, and the core manually withdrawn from the tube.

Moving the starting lever 53 toward the machine sufficiently to cause the shifter rod 52 to effect engagement of the reverse clutch 51^a with the worm shaft 7 will cause the carrier 9 and parts connected therewith, to move in a direction opposite to that indicated by the arrow in Fig. 1 to position to permit another tube to be inserted for bending. During the first portion of such rearward movement of the arm 15 the pawl 62 will engage the dog 64^a on the shifter rod 36 and effect engagement of the clutch, which causes the feed screw 25 to turn to feed the mandrel toward the shaft 4. As the mandrel approaches the shaft 4 the stop 38 on the mandrel carrier will engage the pin 42, and, through the lever 40, move the shifter 36 to disconnect both clutches from the mandrel drive shaft; and, at the same time, as the tube clamp 10 comes into proper alignment with the tension guide 26, the pin 5^a on the worm gear 5, will, through the collar 52^a, move the rod 62 to release the worm shaft 7 from the clutch 51^a and restore the starting lever to "stop" position, such movement of the starting lever acting to apply the brake as before described.

By the method followed with the machine hereinbefore described, the tube is permitted to flatten but slightly over the flattened portion of the mandrel, and, therefore, as very little stretching of the tube in cross section is required in restoring it to normal or circular cross section, which is effected by the ball or head 19^b of the mandrel being withdrawn from the tube, the thickness of the walls of the tube is reduced very slightly, and such wall is maintained of a substantially uniform thickness throughout the length of the tube. By use of such a mandrel, as hereinbefore described, therefore, one operation and annealing of the tube is avoided. If desired, the flat portion of the mandrel might be omitted and the entire mandrel made circular in cross section to prevent any lateral distortion of the tube during the bending operation.

Figs. 22 and 23 illustrate the slight flattening of the tube which occurs during the bending operation, and the restoring of the bent section to normal cross sectional form as the mandrel is withdrawn.

When the tube has been completely bent, as shown in Fig. 22, it will be seen that the wall of the bend is slightly flattened, the distance between the dotted and full lines indicating the extent of such flattening. As the mandrel is withdrawn, this flattening, as shown in Fig. 23, is gradually eliminated, and the normal cross sectional form of the tube restored by the spherical head 19^b of the mandrel.

In Figs. 24 to 28, there is illustrated a slightly modified form of mandrel which may be employed. In this form the mandrel comprises the rigid stem or shank portion 18^a, a head 19^c, and an intermediate flexible section composed of superposed plates 19^d, 19^e, 19^f, 19^g and 19^h which are connected by suitable pivot pins. The head 19^c includes a body portion which is provided, at one end, with grooves to receive the adjacent plates composing the flexible section, and with a reduced portion 19^i from which projects a threaded stud 19^k. A ring 19^l is threaded about the portion 19^i, being free

to rotate thereon, and is held against the enlarged portion of the head 19e by a flange at the inner end of a cap 19m which is screwed upon the stud 19b. The ring 19l is freely rotatable on the mandrel head, and will take all of the wear incident to contact with the tube as the mandrel is withdrawn, and the slight flattening produced by the bending operation eliminated. As before stated, and as shown in the drawings, it is preferred to initally cut the end of the tube which extends over the mandrel at an angle. After the tube has been bent, the projecting portion of this angular cut end of the tube is distributed throughout the wall of the tube on the outer periphery, thus more nearly maintaining the original thickness of the tube wall than was possible with the methods heretofore employed. Cutting the end of the tube on an angle provides a projecting end which is distributed during the bending operation and effects a considerable saving of material that would be waste if the end of the tube was initially square or at right angles to the length thereof.

In the foregoing description of the operation of the machine it has been assumed that a complete "return bend", such as shown in Fig. 10, is to be produced. In case it is desired to bend the tube to an angle less than that shown in Fig. 10, for example, to an angle of ninety (90) degrees, an arm 90 (shown in dotted lines in Figure 1) is detachably connected to the rotary carrier 9, said arm being provided at its outer end with a pawl similar to the pawl 62 at the outer end of the arm 15. With this arrangement it will be understood that the arm 90 will actuate the shifter 36 when the arm 15 has reached the position B indicated in dotted lines in Fig. 1. The arm 90 is, of course, removed when it is desired to form complete return bends in which operation, as above described, the pawl 62 on the arm 15 controls actuation of the shifters 36 and 66. The arm 90 may be applied at any suitable position on the carrier 9, according to the particular angle to which it is desired to bend the pipe.

As hereinbefore described, and as illustrated, the arm 15 is not only adapted to control proper actuation of the power devices when the machine is employed for effecting a bending through 180° but as supporting the tube jaws 15, 15a. It will be evident, however, that said jaws may be supported independently of the arm, and the latter merely constitute a means for shifting the clutches and effecting stopping of the machine when a tube has been bent to any desired, predetermined, extent.

We claim:

1. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel having a flexible section, means for moving the mandrel to and from a position where the flexible section is within the end of a tube in the carrier adjacent the axis of the carrier, means for turning the tube carrier about its axis, automatically acting means for applying pressure to the tube and mandrel at the opposite side of the axis of said carrier from the body thereof during the bending operation, and automatically acting means for applying pressure to the bent tube adjacent said axis while the mandrel is being withdrawn.

2. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel having a flexible section adapted to be positioned with the flexible section within the end of a tube in the carrier adjacent the axis of the latter, power devices for moving the tube carrier about its axis, bending the tube and flexible section of the mandrel therein, means for withdrawing the mandrel from the tube at the termination of the turning movement of the carrier, and automatically acting means for applying pressure to the bent tube adjacent said axis while the mandrel is being withdrawn.

3. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel having a flexible section, means for positively moving the mandrel to and from a postion where the flexible section is within the end of a tube in the carrier adjacent the axis of the latter, power devices for moving the tube carrier about its pivot, means for automatically disconnecting the tube carrier and power devices when the carrier has been turned through a predetermined angle, means for automatically withdrawing the mandrel from the tube when the turning movement of the carrier ceases, and means for applying pressure to the bent tube section as the mandrel is being withdrawn.

4. In a tube bending machine, the combination of a pivotally mounted tube clamp, a mandrel having a flexible section adapted to be positioned in the end of a tube engaged by the clamp adjacent the axis of the latter, means for exerting pressure on the tube to resist movement thereof longitudinally of the mandrel, power devices for moving the tube clamp about its pivot, means for automatically disconnecting the power devices and tube clamp when the latter has been turned through a predetermined angle, and means for automatically withdrawing the mandrel from the bent tube when the clamp and power devices are disconnected.

5. In a tube bending machine, the combination of a pivotally mounted tube clamp, a mandrel having a flexible section adapted to be positioned in the end of a tube engaged by the clamp adjacent the axis of the latter, means for exerting pressure on the tube to resist movement thereof longitudinally of

the mandrel, power devices for moving the tube clamp about its pivot, means for automatically disconnecting the power devices and tube clamp when the latter has been turned through a predetermined angle, means for automatically withdrawing the mandrel from the bent tube when the clamp and power devices are disconnected, and means for applying pressure to the bent section of the tube while the mandrel is being withdrawn.

6. In a tube bending machine the combination of a supporting frame, a shaft mounted in bearings on said frame, a tube carrier mounted on the shaft adjacent one end thereof, a mandrel mounted on the frame and movable to and from a position to receive the end of a tube in the carrier adjacent the shaft, means for rotating the shaft, means controlled by the tube carrier for moving the mandrel, a presser foot adapted to bear upon the tube and mandrel at the opposite side of the axis of the tube carrier from the body of such carrier during the bending operation, and a second presser foot adapted to exert pressure on the bent tube adjacent the axis of the carrier as the mandrel is withdrawn from the tube.

7. In a tube bending machine, the combination of a supporting frame, a tube engaging member revolvably mounted on said frame, a mandrel supported on the frame at one side of said axis and including a flexible section, the mandrel being movable to and from a position where the flexible portion thereof will extend past said axis, and into one end of a tube held by the tube engaging member, means for turning the tube engaging member, fluid pressure means acting to check relative longitudinal movement between the tube and mandrel during the bending operation, means for automatically stopping turning movement of the tube engaging member when the tube has been bent to a predetermined degree, and means controlled by the tube engaging member for releasing said fluid pressure means when the bending movement ceases, so that the mandrel may be withdrawn from the bent tube.

8. In a tube bending machine, the combination of a supporting frame, a tube engaging member revolvably mounted on said frame, a mandrel supported on the frame at one side of the axis of the tube engaging member and including a flexible section, the mandrel being movable to and from a position where the flexible section thereof will extend past said axis, and be within the tube held by the tube engaging member, means for turning the tube engaging member, fluid pressure means acting to check relative longitudinal movement between the tube and mandrel during the bending operation, means for automatically stopping turning movement of the tube engaging member when the tube has been bent to a predetermined degree, means controlled by the tube engaging member for releasing said fluid pressure means when the bending is completed, so that the mandrel may be withdrawn from the bent tube, and means for applying pressure to the bent tube adjacent the axis of the tube engaging member as the mandrel is withdrawn.

9. In a tube bending machine, the combination of a tube carrier pivotally supported adjacent one end, a mandrel movable to and from position to receive the end of the tube adjacent the axis of said carrier and including a rigid section and a flexible section adapted to be bent with the tube about said axis, means movable laterally toward and from the mandrel for applying pressure to the tube on the rigid section of the mandrel means for turning the carrier about its axis, means for automatically rendering said pressure means inoperative when the carrier has been turned a predetermined distance, and means for thereafter withdrawing the mandrel from the tube.

10. In a tube bending machine, the combination of a tube carrier pivotally supported adjacent one end, a mandrel movable to and from position to receive the end of the tube adjacent the axis of said carrier and including a flexible section adapted to be bent with the tube about said axis, means for turning the carrier about its axis, means adapted to be automatically actuated when the carrier has been turned a predetermined distance for withdrawing the mandrel from the tube, and automatically controlled means for applying pressure to the bent tube adjacent said axis while the mandrel is being withdrawn.

11. In a tube bending machine, the combination of a tube carrier pivotally supported adjacent one end, a mandrel movable to and from position to receive the end of the tube adjacent the axis of said carrier and including a rigid section and a flexible section adapted to be bent with the tube about said axis, means for applying pressure to the tube on the rigid section of the mandrel, means for turning the carrier, means for automatically rendering said pressure means inoperative when the carrier has been turned a predetermined distance, means controlled by the carrier for withdrawing the mandrel from the tube when the carrier has been turned said predetermined distance, and means for applying pressure to the bent tube adjacent said axis while the mandrel is being withdrawn.

12. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel supported at the opposite side of the axis of the tube carrier from the body thereof and adjustable to and from a position to receive the end of a tube in the car-

rier adjacent said axis, said mandrel including a flexible section adapted to be bent with the tube about the axis of said carrier, a tension guide surrounding the mandrel and a portion of the tube, a fluid actuated presser adapted to be moved to and from contact with said guide, power devices for turning the tube carrier, a manually movable lever controlling the power devices, and means whereby said presser will be moved into contact with the tension guide prior to said lever being moved to start a turning movement of the tube carrier.

13. In a tube bending machine, the combination of a supporting frame, a tube carrier pivotally supported on the frame adjacent one end, a mandrel having a rigid section connected to the frame, on the opposite side of the axis of said carrier from the body thereof, and a flexible section that extends past said axis into position to be surrounded by the end of a tube in said carrier adjacent its axis, a guide surrounding the rigid section of the mandrel and receiving an end of the tube in the carrier, means movable to and from engagement with said guide for preventing lateral movement thereof, means for turning the carrier, means for automatically stopping the carrier when it has been turned a predetermined distance, and means for automatically withdrawing the mandrel from the tube when the turning movement of the carrier ceases.

14. In a tube bending machine, the combination of a supporting frame, a shaft mounted in said frame, a tube carrier supported by the shaft and having a tube receiving passage extending tangentially to the shaft, a slide mounted on the frame on the opposite side of the shaft from the tube carrier, a mandrel attached to said slide and having a flexible section adapted to extend into the tube carrier, gearing for moving the slide to cause the mandrel to move past said shaft, means for applying pressure laterally to the portion of a tube on the mandrel between said shaft and slide, means for turning the tube carrier to bend the flexible section of the mandrel about the shaft axis, means for stopping movement of the shaft when the carrier has turned a predetermined distance, means for rendering the aforesaid pressure applying device inoperative when turning movement of the shaft ceases, and automatically acting means for subsequently moving said slide away from the shaft to withdraw the mandrel from the tube carrier.

15. In a tube bending machine, the combination of a shaft, a tube carrier supported by said shaft, a mandrel supported on the opposite side of the shaft from the body of the carrier, means for positively moving the mandrel to and from a position to receive the end of a tube in the carrier adjacent the shaft, and gearing connected to said shaft and mandrel adjusting means and adapted to effect intermittent operation thereof, whereby the mandrel will be moved into operative relation to the carrier, the latter turned to bend the tube, and the mandrel withdrawn from the bent tube.

16. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel, a feed screw connected with and adapted to move the mandrel to and from a position to receive the end of a tube in the carrier adjacent the axis thereof, means for turning the carrier about its axis, and means controlled by the carrier for automatically effecting rotation of the mandrel feed screw in opposite directions.

17. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel, means for positively moving the mandrel to and from a position to receive the end of a tube in the carrier adjacent the axis thereof, means for turning the carrier about its axis, a presser foot adapted to exert pressure on the tube and mandrel on the opposite side of the axis of the tube carrier from the body thereof, a toggle for moving said presser foot to and from operative position, and means for expanding and contracting the toggle controlled by movement of the tube carrier.

18. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel, means for positively moving the mandrel to and from a position to receive the end of a tube in the carrier adjacent the axis thereof, a presser foot adapted to exert pressure on the bent tube adjacent said axis as the mandrel is withdrawn, a toggle for moving the presser foot to and from operative position, means controlled by the tube carrier for extending the toggle to render the presser foot operative as the mandrel is withdrawn from the tube, and means whereby the toggle will be contracted when the mandrel has been withdrawn.

19. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel having a flexible section adapted to be bent with a tube about the axis of the tube carrier, means for moving the mandrel to and from a position where its flexible section will receive the end of a tube in the carrier adjacent the axis of the latter, an arm adapted to move with the tube carrier and to control the means for moving the mandrel as the carrier completes a turning movement of predetermined length, and means for applying pressure to the bent tube adjacent the axis of the carrier while the mandrel is being withdrawn.

20. In a tube bending machine, the combination of a supporting frame, a tube carrier pivotally mounted on the frame, a mandrel having a flexible section adapted to be

bent with a tube in the carrier about the axis of the latter, a mandrel carrier on the frame adapted to move toward and from the axis of the tube carrier, a feed screw connected to the mandrel carrier, a threaded sleeve mounted on the frame and surrounding the feed screw, means for turning the tube carrier, and means for positively rotating the threaded sleeve to move the mandrel carrier from the tube carrier adapted to be automatically actuated when the tube carrier has turned a predetermined distance.

21. In a tube bending machine, the combination of a supporting frame, a tube carrier pivotally mounted on the frame, a mandrel having a flexible section adapted to be bent with a tube in the carrier about the axis of the latter, a mandrel carrier on the frame adapted to move toward and from the axis of the tube carrier, a tension guide supported by the mandrel carrier and surrounding the mandrel, said guide receiving the end of the tube to be bent adjacent the axis of the tube carrier, gearing adapted to positively move the mandrel carrier toward and from the tube carrier, a device acting to apply pressure laterally upon said tension guide, means for turning the tube carrier, means for automatically actuating the gearing to move the mandrel carrier and tension guide from the axis of the tube carrier when the tube carrier has turned a predetermined distance, and means for rendering said pressure device inoperative while the tension guide is being moved.

22. In a tube bending machine, the combination of a frame, a shaft, a tube carrier mounted on said shaft, a mandrel carrier mounted on the frame and adapted to be moved toward and from the tube carrier shaft, a mandrel connected to the mandrel carrier and having a flexible section adapted to extend into the end of a tube in the tube carrier adjacent the axis of the latter and to be bent with the tube about said axis, means for moving the mandrel carrier including suitable reversible gearing, manually controlled means for rendering the gearing operative and moving the mandrel carrier toward the tube carrier shaft, means for automatically rendering said gearing inoperative when the mandrel is positioned in operative relation to the tube carrier, means for turning the tube carrier shaft, and means for automatically rendering the gearing operative to move the mandrel carrier from the tube carrier when the latter has been turned through a predetermined angle.

23. In a tube bending machine, the combination of a frame, a power shaft, a second shaft, a tube carrier mounted on said second shaft, a mandrel carrier mounted on the frame and adapted to be moved toward and from the tube carrier shaft, a mandrel connected to the mandrel carrier and having a flexible section adapted to extend into the end of a tube in the tube carrier adjacent the axis of the latter and to be bent with the tube about said axis, means for positively moving the mandrel carrier toward and from the tube carrier shaft including two bevel pinions loosely mounted on the power shaft, a bevel gear meshing with both said pinions and geared to the mandrel carrier, a manually controlled clutch for connecting one of the pinions to its supporting shaft and causing the bevel gear to turn in a direction to move the mandrel carrier toward the tube carrier shaft, means for automatically disengaging said clutch when the mandrel has been adjusted into operative relation to the tube carrier, a second clutch adapted to connect the other pinion to its shaft, means for turning the tube carrier shaft, and means for automatically engaging said second clutch with its associated pinion to turn the bevel gear in the opposite direction and move the mandrel carrier and mandrel away from the tube carrier when the latter has moved a predetermined distance.

24. In a tube bending machine, the combination of a frame, a power shaft, a second shaft, a tube carrier mounted on said second shaft, a mandrel carrier mounted on the frame and adapted to be moved toward and from the tube carrier shaft, a mandrel connected to the mandrel carrier and having a flexible section adapted to extend into the end of a tube in the tube carrier adjacent the axis of the latter and to be bent with the tube about said axis, means for positively moving the mandrel carrier toward and from the tube carrier shaft including two bevel pinions loosely mounted on the power shaft, a bevel gear meshing with both said pinions and geared to the mandrel carrier, two clutches each adapted to connect one of the pinions to the power shaft, a reciprocating clutch actuating rod controlling both clutches, a manually operable lever adapted to shift said rod to clutch one of the pinions to its shaft and rotate the gear in a direction to move the mandrel carrier toward the shaft of the tube carrier, means for automatically moving said rod to disengage the previously engaged clutch when the mandrel comes into operative relation to the tube carrier, means for turning the tube carrier shaft, and means for automatically shifting said rod to actuate the other clutch and cause the gear to turn in a direction to move the mandrel carrier from the shaft of the tube carrier when the latter has been turned a predetermined distance.

25. In a tube bending machine, the combination of a frame, a power shaft, a second shaft, a tube carrier mounted on said second shaft, a mandrel carrier mounted on the frame and adapted to be moved toward and

from the tube carrier shaft, a mandrel connected to the mandrel carrier and having a flexible section adapted to extend into the end of a tube in the tube carrier adjacent the axis of the latter and to be bent with the tube about said axis, means for positively moving the mandrel carrier toward and from the tube carrier shaft including two bevel pinions loosely mounted on the power shaft, a bevel gear meshing with both said pinions and geared to the mandrel carrier, two clutches each adapted to connect one of the pinions to its shaft, a reciprocating clutch actuating rod controlling both clutches, a manually operable lever adapted to shift said rod to clutch one of the pinions to its shaft and rotate the gear in a direction to move the mandrel carrier toward the shaft of the tube carrier, means for automatically moving said rod to disengage the previously engaged clutch when the mandrel comes into operative relation to the tube carrier, means for turning the tube carrier shaft, means for automatically shifting said rod to actuate the other clutch and cause the gear to turn in a direction to move the mandrel carrier from the shaft of the tube carrier when the latter has been turned a predetermined distance, and means for shifting the rod to disengage the last said clutch when the mandrel carrier has moved a certain distance from the tube carrier.

26. In a tube bending machine, the combination of a supporting frame, a tube carrier pivotally mounted on the frame, a mandrel carrier mounted on the frame and adapted to be moved toward and from the tube carrier, a mandrel connected to the mandrel carrier and having a flexible section adapted to extend into the end of a tube in the tube carrier adjacent the axis of the latter and to be bent with the tube about said axis, means for moving the mandrel carrier, means for turning the tube carrier on its axis, a pressure member adapted to bear against the bent portion of the tube, and means for automatically shifting said pressure device to operative position and effecting movement of the mandrel carrier to withdraw the mandrel from the bent tube when the tube carrier has been turned a predetermined distance.

27. In a tube bending machine, the combination of a frame, a power shaft, a tube carrier pivotally mounted on the frame, a mandrel carrier mounted on the frame and adapted to be moved toward and from the tube carrier, a mandrel connected to the mandrel carrier and having a flexible section adapted to extend into the end of a tube in the tube carrier adjacent the axis of the latter and to be bent with the tube about said axis, means for positively moving the mandrel carrier toward and from the tube carrier including, two bevel pinions mounted on the power shaft, a bevel gear meshing with both said pinions and connected with the mandrel carrier, a manually controlled clutch for connecting one of the pinions to its supporting shaft and causing the bevel gear to turn in a direction to move the mandrel carrier toward the tube carrier, means for automatically disengaging said clutch when the mandrel has been adjusted into operative relation to the tube carrier, a second clutch adapted to connect the other pinion to its shaft, means for turning the tube carrier about its axis, a pressure device adapted to cooperate with the bent tube, and means for automatically shifting said pressure device to operative position and simultaneously engaging said second clutch with its associated pinion to turn the bevel gear to move the mandrel carrier and mandrel away from the tube carrier when the latter has moved a predetermined distance.

28. In a tube bending machine, the combination of a supporting frame, a tube carrier pivotally mounted on the frame, a mandrel carrier on the frame, a mandrel secured to the mandrel carrier and having a flexible section extending past the axis of the tube carrier and into the tube receiving space of said carrier, means for moving the mandrel carrier and mandrel toward and from the tube carrier, means acting to exert pressure laterally on the mandrel at points between the axis of the tube carrier and the mandrel carrier, means for oscillating the tube carrier, means for automatically relieving the mandrel from said lateral pressure means and rendering operative the means for moving the mandrel carrier from the tube carrier when the tube carrier has been turned a predetermined distance in one direction, and means for automatically causing the mandrel carrier feed devices to move said carrier to bring the mandrel into operative relation to the tube carrier as the latter returns to its starting position.

29. In a tube bending machine, the combination of a supporting frame, a tube carrier pivotally mounted on the frame, a mandrel mounted on the frame and having a flexible section adapted to extend into the tube receiving space of the tube carrier and to be bent about the axis of said carrier by turning movement of the latter, gearing for moving the mandrel to and from the tube carrier, means for applying pressure to a tube on the mandrel to check relative longitudinal movement between them, a reciprocating rod controlling the direction of longitudinal movement of the mandrel and movement of said pressure means, and means controlled by the tube carrier for reciprocating said rod as said carrier is oscillated about its pivotal axis.

30. In a tube bending machine, the com-

bination of a frame, a shaft mounted in the frame, a tube carrier connected to said shaft, power devices for actuating the shaft to rock the tube carrier about its axis, a starting lever controlling the power devices, a mandrel supported on the frame and having a flexible section adapted to extend into the tube carrier and to bend with a tube therein about the axis of the said carrier, means for moving the mandrel toward and from the tube carrier, means for exerting pressure laterally on a tube surrounding the mandrel at points on the opposite side of the axis of the tube carrier from the body thereof, means whereby before the starting lever can be moved to effect movement of the shaft said pressure means are rendered operative, means for automatically rendering said pressure means inoperative and moving the mandrel from the tube carrier when the latter has been turned a predetermined distance, and means for disconnecting the power devices from the shaft at the termination of such predetermined movement of the tube carrier.

31. In a tube bending machine, the combination of a supporting frame, a tube carrier pivotally mounted on the frame, a power shaft, means connecting the tube carrier to the power shaft, a lever controlling said means, a mandrel having a flexible section adapted to be bent with a tube about the axis of the tube carrier, a lock normally preventing movement of the control lever, a pressure means adapted to check relative longitudinal movement between the mandrel and a tube thereon as the tube carrier turns, means operable by the release of said lever lock for rendering the pressure means operative, means for automatically rendering said pressure means inoperative and disconnecting the tube carrier from the power shaft when said carrier has been turned a predetermined distance, means for withdrawing the mandrel from the tube carrier at the termination of such predetermined movement of the latter, and means for applying pressure to the bent tube while the mandrel is being withdrawn.

32. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel having a flexible section adapted to be positioned within a tube in the carrier adjacent the axis of the carrier, means for turning the tube carrier about its axis and bending the tube and flexible section of mandrel therein, means for applying pressure laterally to the tube and mandrel at the opposite side of the axis of said carrier from the body thereof during the bending operation, means for withdrawing the mandrel from the bent tube, and automatically acting means movable laterally relative to the mandrel for applying pressure to the bent tube adjacent the carrier axis while the mandrel is being withdrawn.

33. In a tube bending machine, the combination of a supporting frame, a tube carrier pivotally mounted on the frame and adapted to turn in opposite directions about its pivotal axis, means for turning the tube carrier, a manually actuated lever controlling said means, a mandrel having a flexible section adapted to bend with a tube in the carrier about the axis of the latter, means for moving the mandrel to and from the tube carrier, means for applying pressure to a tube on the mandrel at the opposite side of said axis from the body of the carrier to check relative longitudinal movement between the tube and mandrel, means for stopping turning of the tube carrier when it has moved a predetermined distance, means for automatically rendering said pressure means inoperative and connecting the mandrel with the means for withdrawing it from the tube carrier at the termination of such predetermined movement, means for applying pressure to the bent tube as the mandrel is withdrawn adapted to be rendered operative at the termination of said predetermined movement, means controlled by the manually actuated lever for moving the tube carrier in the opposite direction, and means controlled by the tube carrier during the last said movement for connecting the mandrel with the means for returning it to operative relation to said carrier.

34. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel comprising a rigid stem, a flexible section which is slightly tapered in diameter from said stem, and a head having a section of substantially the same diameter as the tube to be bent, a support for the mandrel at the opposite side of the axis of the tube carrier from the body of such carrier, means for turning the tube carrier to bend the flexible section of the mandrel and the tube thereon about the axis of the carrier, and means for withdrawing the mandrel from the bent tube, during which movement the mandrel head will automatically correct any flattening of the tube that may have occurred during the bending operation.

35. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel comprising a rigid stem, a flexible section composed of a series of overlapping and pivotally connected plates, and a head having an exterior curved surface of substantially the same diameter as the tube to be bent, a support for the mandrel at the opposite side of the axis of the tube carrier from the body thereof, means for turning the tube carrier to bend the flexible section of the mandrel and a tube thereon about the axis of the tube carrier, and means for

withdrawing the mandrel from the bent tube.

36. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel comprising a rigid stem, a flexible section composed of a series of overlapping pivotally connected plates, and a head, the plates being shaped and arranged to provide a substantially cylindrical body that tapers gradually from the rigid stem to the head and has a slightly flattened face at one side, the head having a convex curved section of the same diameter as the interior of the tube to be bent, a support for the mandrel at the opposite side of the axis of the tube carrier from the body thereof, means for turning the tube carrier to bend the flexible mandrel section and the tube thereon about the axis of the carrier, and means for withdrawing the mandrel from the bent tube.

37. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel comprising a rigid stem, a flexible section composed of a series of overlapping pivotally connected plates, and a head, the head including a freely rotatable ring member having an exterior diameter corresponding to the interior diameter of the tube to be bent, a support for the mandrel at the opposite side of the axis of the tube carrier from the body thereof, means for turning the tube carrier to bend the flexible mandrel section and a tube thereon about the axis of the carrier, and means for withdrawing the mandrel from the bent tube, the movable ring member of the head operating during the withdrawal of the mandrel to correct any flattening of the tube that may have occurred during the bending operation.

38. A mandrel for a tube bending machine, comprising a rigid stem, a flexible section connected to the stem at one end and gradually reduced in diameter toward its opposite end, and a head connected to the flexible section and having a portion of exterior convex curvature and of substantially the same diameter as the tube to be bent, for the purpose described.

39. A mandrel for a tube bending machine comprising a rigid stem provided at one end with means for securing it to a suitable support and having a plurality of grooves formed in its opposite end, a flexible section comprising a series of overlapping, pivotally connected, plates, the plates at one end of said section being secured in the slots in the stem, and a head provided with grooves to receive the plates at the other end of the flexible section and having a portion of exterior convex curvature and of a diameter corresponding to the interior diameter of the tube to be bent.

40. A mandrel for a tube bending machine comprising a rigid stem provided at one end with means for securing it to a suitable support and having a plurality of grooves formed in its opposite end, a flexible section comprising a series of overlapping, pivotally connected, plates, the plates at one end of said section being secured in the slots in the stem, and a head provided at one end with grooves to receive the plates at the other end of the flexible section and at its other end with a circular boss, a ring loosely mounted on said boss and having an exterior surface of the same diameter as the interior of the tube to be bent, and means for holding said ring on the head without interfering with free rotation thereof.

41. A mandrel for a tube bending machine comprising a rigid stem provided at one end with means for securing it to a suitable support and having a plurality of grooves formed in its opposite end, a flexible section comprising a series of overlapping, pivotally connected, plates, the plates at one end of said section being secured in the slots in the stem, and a head provided with grooves to receive the plates at the other end of the flexible section, said flexible section tapering slightly from the stem to the head and the latter having a section of the same diameter as the interior of the tube to be bent, for the purpose described.

42. A mandrel for a tube bending machine comprising a rigid stem provided at one end with means for securing it to a suitable support and having a plurality of grooves formed in its opposite end, a flexible section comprising a series of overlapping, pivotally connected, plates, the plates at one end of said section being secured in the slots in the stem, and a head provided at one end with grooves to receive the plates at the other end of the flexible section and at its other end with a circular boss and a reduced threaded stem projecting axially therefrom, a ring loosely mounted on said boss and having an exterior surface of the same diameter as the interior of the tube to be bent, and a nut screwed upon said threaded stem and holding the ring in place on the boss.

43. In a tube bending machine, the combination of a shaft, a plate connected to and extending radially from the plate, a tube clamp comprising laterally separable members mounted on the plate at one side of the supporting shaft, a mandrel supported at the opposite side of the shaft from the tube clamp and having a flexible section adapted to extend past the shaft into the tube clamp and to bend about the shaft axis as the latter is turned, an arm attached to the shaft and provided with means for engaging the portion of a tube that projects from the end of the clamp remote from the shaft, means for turning the shaft, means for stopping the shaft when the tube clamp

has been turned through a predetermined angle, and means controlled by said arm for withdrawing the mandrel from the tube clamp at the termination of said predetermined movement.

44. In a tube bending machine, the combination of a shaft, a plate attached to the shaft and extending radially therefrom, a tube clamp on said plate including two relatively adjustable members, a mandrel supported on the opposite side of said shaft from the tube clamp and having a flexible section adapted to extend past the shaft and into the tube clamp, means for moving the mandrel to and from operative relation to the tube clamp, an arm projecting from the shaft and provided with jaws adapted to engage the section of a tube that projects from the end of the tube clamp remote from the shaft, means for turning the shaft to move the tube clamp and said arm to bend the flexible mandrel section, and tube thereon, about the axis of the shaft, means for stopping the shaft when the tube clamp has moved a predetermined distance, means for automatically effecting withdrawal of the mandrel from the tube clamp at the termination of said predetermined movement, and means controlled by a member of the tube engaging means for exerting pressure on the bent tube during the withdrawal of the mandrel.

45. In a tube bending machine, the combination of a shaft, means connected with the shaft for engaging a tube, a mandrel supported on the opposite side of the shaft from the tube engaging means and including a flexible section adapted to bend about the axis of the shaft as the tube engaging means turns, means for moving the mandrel to and from operative position, means for actuating the shaft, means for checking relative longitudinal movement between the mandrel and tube during the bending operation, means for stopping movement of the shaft and rendering the last said means inoperative when the tube engaging means has moved a predetermined distance, means connected to the shaft for connecting the mandrel with the means for withdrawing it from the tube engaging means at the termination of said predetermined movement, and automatically acting means adapted to exert pressure on the tube adjacent the shaft while the mandrel is being withdrawn.

46. In a tube bending machine, the combination of a supporting frame, a shaft mounted in bearings on the frame, a plate mounted in the shaft, a tube clamp on the plate comprising a relatively fixed member and a movable member, means for adjusting the movable clamp member toward the stationary member and retaining it in adjusted position, a mandrel supported by the frame and having a flexible section adapted to extend into the space between the members of the tube clamp and to bend about the axis of the shaft as the latter is turned, means for turning the shaft a predetermined distance, and means for withdrawing the mandrel from the tube clamp at the termination of said predetermined movement of the shaft.

47. In a tube bending machine, the combination of a shaft, a tube clamp secured to the shaft and comprising laterally separable members, an arm extending radially from the shaft and provided with jaws adapted to engage a tube projecting from the end of the clamp remote from the shaft, a mandrel supported on the frame and having a flexible section adapted to extend into the end of the tube clamp adjacent the shaft, means for positively moving the mandrel to and from the tube clamp, means for turning the shaft a predetermined distance, and means connected to the jaw-supporting arm for effecting actuation of the means for moving the mandrel from the tube clamp at the termination of said predetermined movement of the shaft.

48. In a tube bending machine, the combination of a pivotally mounted tube carrier, a mandrel having a flexible section adapted to extend within the tube to be bent, and terminating in a head of substantially the same diameter as the interior of the tube to be bent, means for moving the mandrel into a tube in the carrier so that the head thereof will be beyond the transverse plane including the axis of the tube carrier, means for turning the carrier about its axis to bend the tube and flexible section of the mandrel, means for withdrawing the mandrel from the bent tube, and means for applying pressure to the tube adjacent said axis while the mandrel is being withdrawn.

In testimony whereof we have hereunto set our hands.

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CLARENCE W. LUCAS.
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