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Sept. 12, 1944. B. F. BOWER 2,357,873

TUBE BENDING MACHINE

Filed Oct. 19, 1942 3 Sheets-Sheet 1

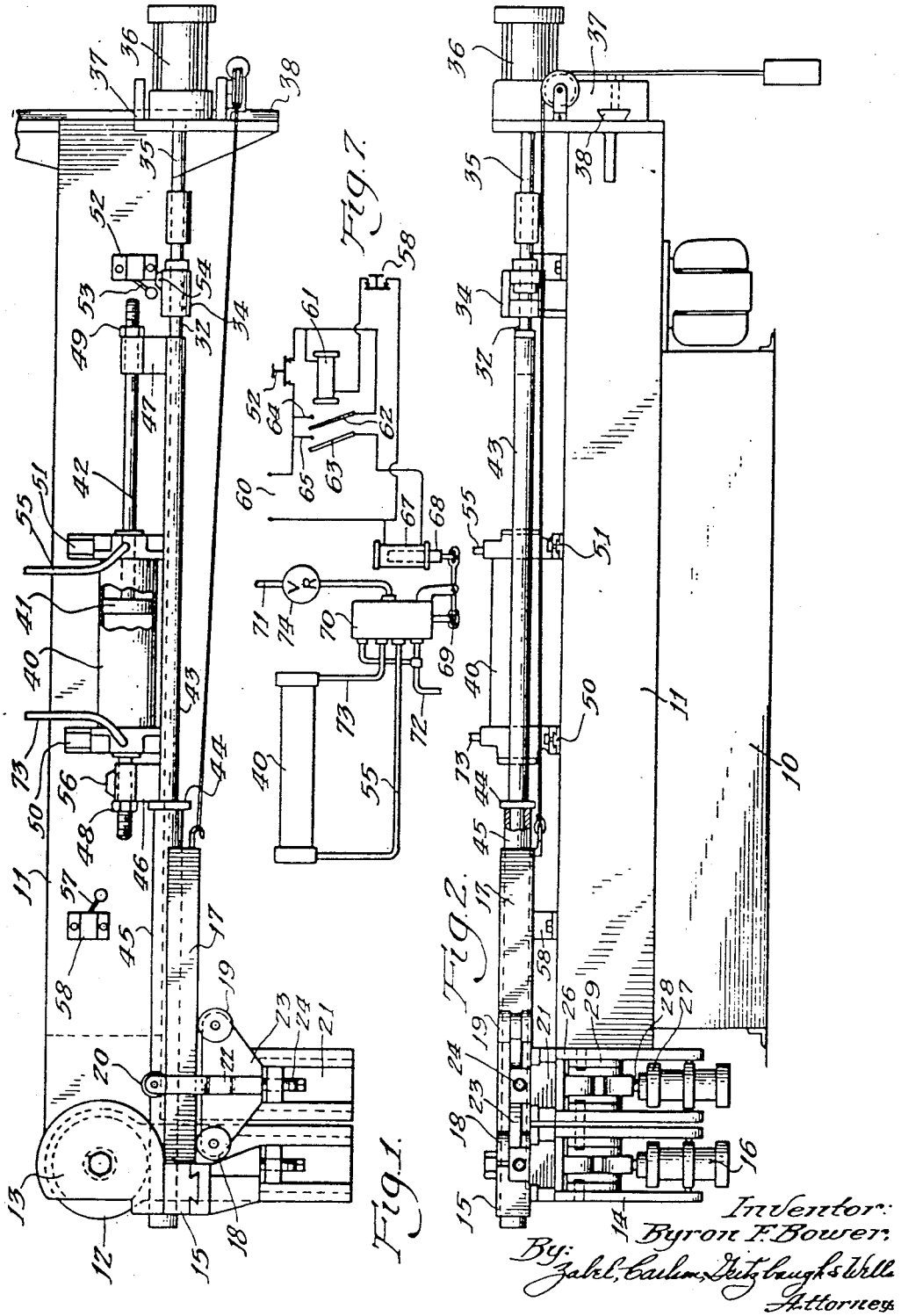


Fig. 1.

Fig. 2.

Fig. 7.

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Fig. 4.

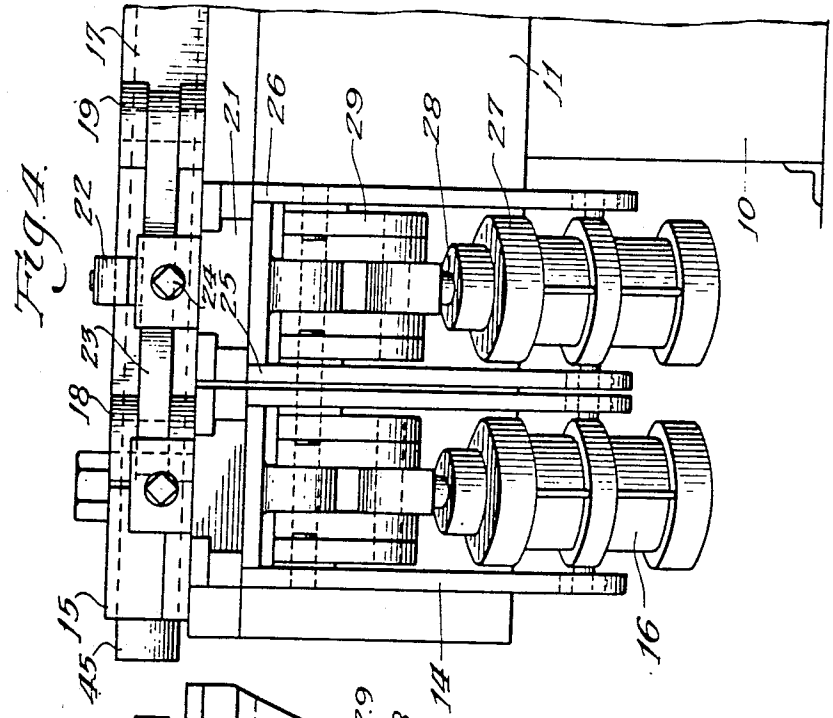
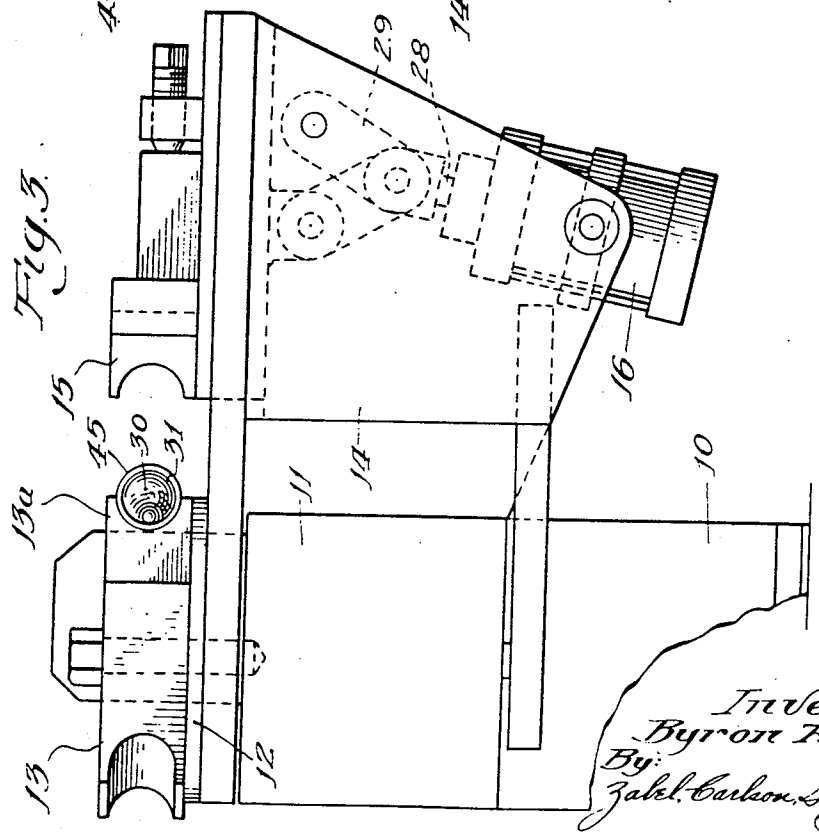


Fig. 5.

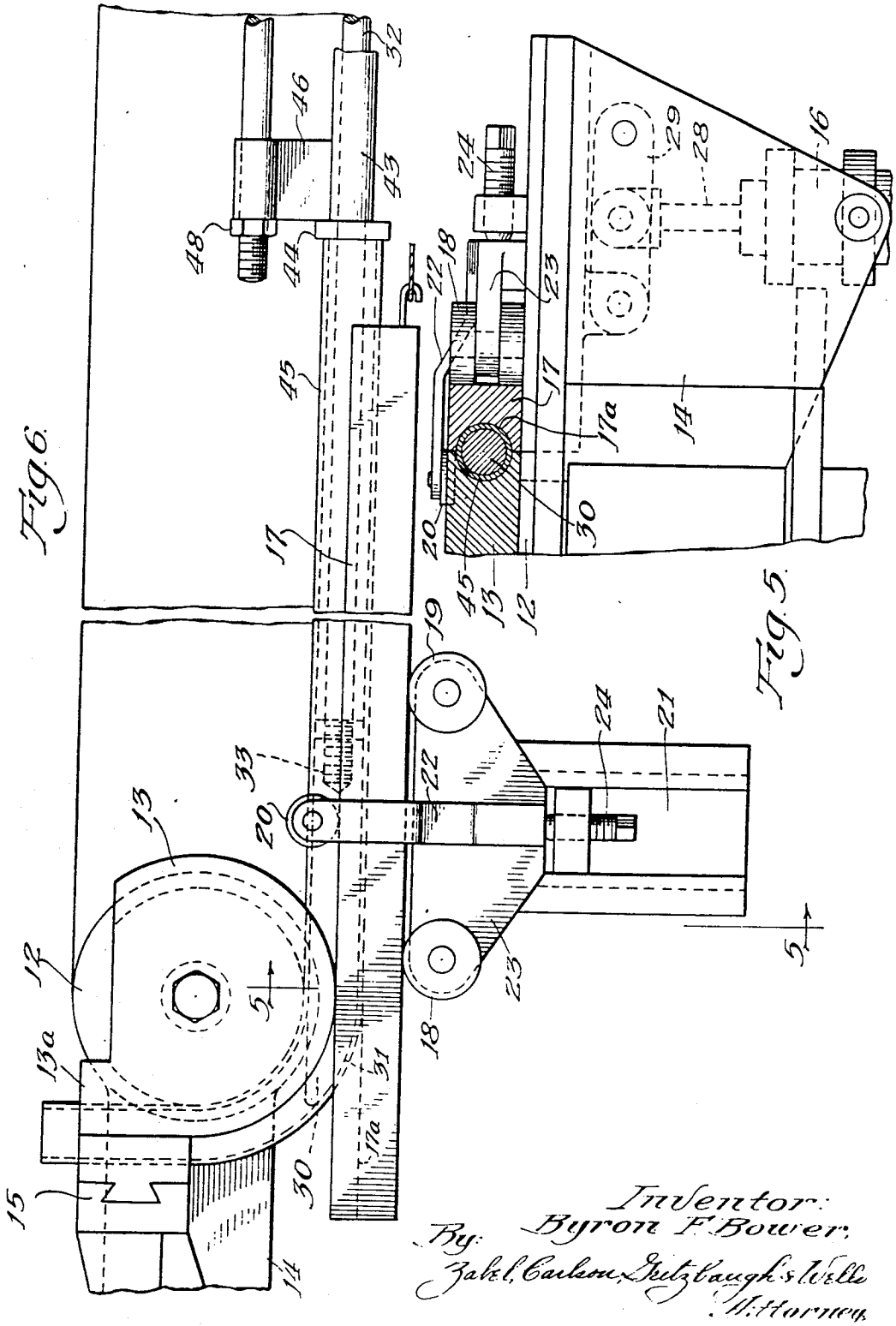


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TUBE BENDING MACHINE

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2,357,873

TUBE-BENDING MACHINE

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5 Claims. (Cl. 153—40)

The present invention relates to tube bending machines and is particularly directed to means for improving the actual bending operation so as to make it possible even in relatively thin walled tubing to make shorter radius bends and more perfect bends with the outer walls of the bends freer of distortion than has heretofore been possible. In the bending of tubing in accordance with my invention the tubing is usually bent around a bending die, a clamp block being used to hold the advancing end of the tubing against the bending die. In addition a back-up die presses the tube snugly against the bending die. A mandrel is placed inside the tube and is advanced to the proper position for bending, which is with its tip just right for the bend to take place about it when the clamp block and bending die start to turn about the axis of the bending die. As the bending die is rotated the tube is drawn along with it of course and the back-up die moving in a straight line does the actual bending of the tube against the approaching surface of the bending die. The mandrel of course does not advance after the bending is under way.

It will be appreciated that in a bending operation of this type the wall of the tube on the outside of the bend is subjected to a terrific tension and this tension increases as the radius of the bend is made smaller. In making shorter radius bends in thin wall tubing, in accordance with the prior art, mandrels have been used with several balls on the end thereof so that the tube in the bent portion could be rounded out after the bend actually took place. This however did not avoid the difficulty that the outer wall of the bend was subject not only to the bending stresses but to the force necessary to pull the tubing around the bending die. Oftentimes an attempt to make shorter radius bends has resulted in a large percentage of the tubing failing in the outer wall.

It is the principal purpose of the present invention to provide an improved tube bending means whereby I can make shorter radius bends with a plain rounded end mandrel or with a single ball end mandrel than have heretofore been possible even with the multiple ball mandrel.

It is also a purpose of this invention to provide a novel tube bending means whereby distortion of the metal in the tubing wall is controlled and a better all around strength is obtained in the bent portion of the tubing.

In the preferred form of the invention means are provided whereby tubing, as it is advanced in the bending operation, is pressed forward so that the tension that is ordinarily required to draw the tubing off the mandrel is relieved from the bending and bent portion of the tube. I prefer to apply this tension by means of a head sliding over the mandrel and engaging the rear end of the tube, the head being pressed forward by a suitable pressure device, such, for example, as a hydraulic or air cylinder and piston arrangement.

This apparatus has in addition a novel feature of unloading the tubing from the mandrel. The unloading is accomplished by relieving the clamp from the bent tubing and utilizing the pressure on the rear end of the tubing to force it out of the die. It is believed to be evident that in tube bending up to 180° this unloading can be accomplished as a final movement of the cross head that is pressing against the rear end of the tubing after the bending operation is completed.

A further advantage of this apparatus is that in a great many instances it eliminates the necessity for a mandrel extractor cylinder. The normal function of a mandrel extractor cylinder is to withdraw the end of the ball mandrel from the bent portion of the tube while the tube is still clamped in the bending die. When the tube is then unclamped, it is free to be removed without force. This attachment reverses the process by permitting the use of a fixed mandrel rod, and the pressure that is applied on the rear end of the tube and which unloads the tube from the die automatically forces the tube off the tip of the mandrel.

When a tube is bent over a bending die that is grooved to fit snugly over the outside of the tube, there is a tendency for the tube in the bent portion to flatten slightly and to increase its diameter which is at right angles to the bend. This tendency causes the bent tube to wedge itself into the groove of the die, requiring force to eject it. This attachment therefore overcomes this force to release the tube from the die, in addition to the releasing of the mandrel.

Other and more detailed advantages of the invention will appear more fully as the description proceeds, reference being made to the accompanying drawings wherein a preferred form of the invention is shown. It should be understood however that the drawings and description are illustrative only and should not be taken as limiting the invention except insofar as it is limited by the claims.

In the drawings:

Fig. 1 is a plan view of a tube bending machine embodying my invention;

Fig. 2 is a view in side elevation of the bending machine;

Fig. 3 is an enlarged end view of the machine showing the parts with the clamp open;

Fig. 4 is an enlarged fragmentary view in side elevation of that portion of Fig. 2 at the lefthand end;

Fig. 5 is a view similar to Fig. 3 but showing the tubing in clamped position;

Fig. 6 is an enlarged fragmentary plan view showing the bending operation completed; and

Fig. 7 is a diagrammatic view illustrating the control apparatus by which the several operations are carried out in the proper sequence.

Referring now in detail to the drawings, my invention is shown as embodied in a tube bending machine wherein the numeral 10 represents the base of the machine and the numeral 11 is the frame of the machine. At one end of the frame 11 I mount for rotation a bending die supporting head 12 upon which a bending die 13 is mounted. The supporting head 12 also carries with it a framework 14 that supports a clamp 15 for clamping the end of a piece of tubing to the die 13. The framework 14 also supports an operating cylinder 16 that is adapted to close the clamp 15 against the corresponding portion 13a of the bending die.

The tube bending machine includes what is commonly termed a back-up die 17 which cooperates with the bending die 13 to bend the tubing as the die is rotated. This back-up die is free to travel with the tubing and is guided by two sets of rollers 18 and 19 engaging the back side thereof and a small guide roller 20 engaging the edge thereof directly over the tube engaging portion 17a of the back-up die (see Fig. 5). The rollers 18, 19 and 20 are carried by a slide 21, there being a bar 22 carrying the roller 20 and a plate 23 carrying the rollers 18 and 19. The plate 23 and the bar 22 preferably are adjustable with respect to the slide 21. An adjusting screw 24 is provided for this purpose.

The back-up die slide 21 is carried by a pair of spaced side frames 25 and 26 and is adapted to be moved in the side frames to advance the back-up die by means of a cylinder 27 having a piston rod 28 that is connected by a set of links and pins indicated at 29. The cylinder 27 as well as the cylinder 16 which operates the clamping unit 15 are desirably supplied with a suitable fluid under pressure (either liquid or air). The details of the control of this mechanism form no part of my invention and therefore such details have not been shown.

Tubing to be bent is placed over a mandrel 30 that has its end rounded as indicated at 31. This mandrel is supported upon a mandrel actuating rod 32 which is threaded into the mandrel as indicated at 33 in Fig. 6. The rod 32 extends lengthwise of the frame 11 to a connecting block 34 near the rear end of the frame where it is coupled to a piston rod 35 that projects from a piston within a hydraulic cylinder 36. The cylinder 36 is mounted on a block 37 that in turn is arranged for horizontal adjustment along a dovetailed guide bar 38 that is mounted at the rear of the machine. The cylinder 36 and the back-up die supporting and guiding rollers 18, 19 and 20 have to be adjustably mounted to take care of different sizes of bending dies 13 and different sizes of tubing. It will be appreciated that when the radius of the bending die 13 is changed the mandrel and the back-up die must move to the new radius. This makes it desirable to also adjust the hydraulic cylinder 36 for any substantial change in size of die. The rod 32 and the mandrel 30 may of course be adjusted in length to put the tip of the mandrel, when it is advanced, at the proper position for bending the tube about its rounded end 31. The present invention is not at all limited to this particular type of mandrel as the ball end mandrel may be used as well, and in fact a multiple ball end mandrel can be used.

The normal operation of a bending machine such as has just been described comprises a sequence of operations as follows: first the tubing is placed over the mandrel and set into the proper position with respect to the clamping unit 15 and the die 13. The clamping unit is next caused to close on the die and the mandrel is advanced to the proper position. Also, the back-up die 17 is closed into position against the tubing. Next the bending die is started to rotate. The bending die and the clamping unit 15 pull the tubing around the axis of the bending die. The back-up die 17 prevents the rearwardly extending part of the tubing from swinging so that the tubing is actually bent by the back-up die. The tubing, as it is drawn around the bending die, is subjected to a terrific strain, particularly at the point where it is being bent and pulled around the nose of the mandrel. The rounded mandrel nose is necessary to prevent the tube from flattening under this strain in order to reduce the distance around the curve and thus reduce the amount that the metal must stretch.

It has been found that the strain placed on the tubing practically limits the sharpness of the bend that can be given to tubing by drawing it around a bending die. However, I have developed a mechanism whereby it is possible to eliminate a substantial portion of the strain to which the tubing is subjected and thus get sharper bends by means of a bending die operating in the manner hereinbefore described. In accordance with my invention I push the tubing as it is being drawn by the bending die so as to relieve the tubing itself of a substantial portion of the strain necessary to draw the tubing around the die. This pushing of the tubing is carried out in such a fashion as to eliminate the drag of the tubing so that the principal strain placed on the tubing is that necessary to bend it. This means of course that the metal in the outer half of the tubing bend will be stretched, but it will be stretched only the amount necessary to provide the additional length that is found at the outside of the bend. The weakening of the metal due to its reduction in cross section makes it subject to danger of fracture if the weakened metal is then subjected to further drawing strain, as has been the case in tube bending machines of this type in the past. In accordance with my invention I avoid the extra stresses that would disrupt the tubing.

I provide on the frame of the machine a cylinder 40 in which a piston 41 is mounted, the piston having a double ended shaft or rod 42 that projects through the opposite ends of the cylinder 40. This rod carries a tubular sleeve 43 through which the mandrel carrying rod 32 extends. The tubular member 43 has a head 44 thereon which is adapted to engage against the rear end of the piece of tubing 45 that is to be bent (see Fig. 1). The tubular member 43 is connected to the rod 42 by two plates 46 and 47 which are welded to

the tubular member 43 and bent around the rod 42. Two nuts 48 and 49 hold the members 46 and 47 in place. It is believed to be obvious that when desirable the sleeve 43 and the piston rod 42 may be combined as a hollow piston rod through which the mandrel carrying rod extends.

In order that suitable adjustment of the cylinder and the cross head carried by its piston rod 42 may be had to accommodate various sizes of bending dies, the cylinder 40 is mounted on two guides 50 and 51 that are formed on the top of the frame 11, the guides being arranged so that transverse movement of the cylinder with respect to the frame is possible. Movement of the cylinder 40 toward and away from the axis of the bending die is not necessary because filler lengths of tubing may be inserted between the head 44 and the end of the tubing 45 where the length of the tubing is such that when it is bent the pressure could not be applied by the travel permitted the rod 42.

The cylinder 40 may utilize either air or a hydraulic fluid as the means for moving the piston 41. In either case control means are provided whereby the cylinder can be put into operation at the desired time. In the present instance the control means comprises an electrically responsive control valve which is adapted to be turned on when the piston rod 35 is advanced to move the mandrel carrying rod into operative position. This operation, in accordance with the sequence hereinbefore outlined, occurs after the clamp 15 has clamped the end of the tubing 45 in place against the bending die.

A normally open switch 52 has a lever 53 which is adapted to be operated by a projection 54 on the connector 34 of the rod 32. When closed the switch 52 moves the valve above referred to into position to feed fluid through a pipe 55 from a source of pressure (not shown) so as to move the piston of the cylinder 40 and with it the rod 42 toward the bending die 13. This brings the head 44 up against the end of the tubing 45, or against a separate piece that may have been inserted, and pressure is applied to the tubing at the beginning of the bending operation. At the end of the bending operation a stop projection 56 engages an operating lever 57 on a control switch 58. When this occurs the control switch 58 opens the circuit for the valve hereinbefore mentioned causing the valve to assume a position wherein the pressure is released from the conduit 55 and this conduit is connected to a drain on the exhaust. It will be appreciated that by adjusting the nuts 48 and 49 on the rod 42 which is threaded for a substantial distance, the relative positions of the piston within the cylinder 40 and the head 44 may be varied within a sufficient range for all practical purposes.

The amount of pressure applied to the tubing 45 in the bending operation is of course a function of the pressure to which the piston in the cylinder 40 is subjected during its advance stroke. This pressure may be varied to suit the particular operation by using a variable pressure pump or other means for supplying the fluid under pressure to the cylinder, or conversely it may be accomplished by having a bleed valve in the line that supplies the cylinder 40 from a constant pressure source. The arrangement must be such however that sufficient pressure can be applied to the tubing to relieve that part of the tubing between the die 17 and the clamping unit 15 substantially from the strain of pulling the tubing around the die. Too much pressure is also to be avoided since this would tend to cause the tubing to buckle outward on the inner side of the bend as the bending takes place.

In order that the operation of the controls for the cylinder 40 will be more clearly understood reference is made to Fig. 7 of the drawings wherein a diagrammatic showing is made for a typical control circuit. In this Fig. 7 the switch 52 and the switch 58 are shown as simple, normally open and normally closed switches. The switch 52 closes the circuit from a source of current indicated at 60 to a relay 61 and through the normally closed switch 58 and this causes the relay to attract its armatures 62 and 63. The initial effect of attracting the armature 62 is the closing of a circuit through its front contact 64 for a holding circuit for the relay 61 so as to maintain it energized until the switch 58 is opened. Another effect of energizing the relay 61 and the attraction of its armature 63 is to close a circuit through a contact 65 to energize a solenoid 67 which attracts its armature 68. The armature 68 is connected to a stem 69 of a control valve 70 that controls the supply of liquid or air to the cylinder 40.

From the foregoing description it will be seen that as soon as the switch 52 is closed by the stop 54 engaging its lever 53 the relay 61 will be energized. The relay locks itself energized by closing a circuit at the contact 64. It also closes a circuit at the contact 65 to energize the solenoid 67 which in turn operates the valve 70 to direct fluid through the pipe 55 into the cylinder 40. When the rod 42 has advanced far enough it brings the stop 56 against the lever 57 of the switch 58, thus opening the normally closed switch 58. When the switch 58 is opened the holding circuit for the relay 61 is broken and the relay thus becomes de-energized, its armature 63 falling back to de-energize the solenoid 67. This allows the valve 70 to resume its normal inactive position where fluid is cut off from the supply source indicated at 71 and where the conduit 55 is open to an exhaust conduit 72. By this same operation the supply conduit 71 may be connected to a return conduit 73 to return the piston in the cylinder 40 to its starting position.

In the normal operation of the device hereinbefore described the tube bending is completed before the stop 56 engages the lever 57 of the switch 58 to open this switch. The reason for this is that it is desirable to utilize the pressure being applied to the tubing to push the tubing off the bending die after the bending operation is completed. This is particularly advantageous where 180° bends are being made because the tubing has a tendency to stick to the bending die and be difficult to remove. With the present apparatus no difficulty is encountered in removing the tubing because of the pressure that can be applied by the head 44.

The particular advantages of my invention reside in the method of taking the entire load of mandrel resistance off of the bent and bending portion of the tube. As shown in the diagrammatic view of Fig. 7 I utilize a pressure reducing valve 74 in the line to the cylinder 40 in order to control the power applied against the end of the tube. Once the pressure is set for a particular size of tubing and sharpness of bend the rotation of the bending die has only the load of the actual bending to take care of. It is not necessary with my invention to use a multiplicity of balls on the end of the mandrel in order to round out the tube in the bent portion. In fact I find

that I can use a plain rounded end mandrel or a single ball mandrel and make shorter radius bends than I am able to make without my invention on the same machine as that shown in the drawings with a multiple ball mandrel. The use of the multiple ball mandrel slows down the production of the machine substantially since it involves a long stroke for the mandrel pulling cylinder and a loss of time in threading the balls into the tube when the tube is being placed over the mandrel. The increased efficiency of the machine however is not such an important factor as the balancing of the pressures on the tubing so that the tension on the bent portion of the tubing is kept at a safe level.

From the foregoing description it is believed that the nature of my invention and the manner in which it is to be carried out will be readily apparent to those skilled in this art.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a tube bending machine, a rotatable bending die, a gripping means adapted to grip tubing to the die and turn with the die, a mandrel for supporting tubing against the die and preventing its collapse at the point of bending, a back-up die supporting the mandrel and the tubing thereon against the pressure developed in bending the tubing, a mandrel rod operable to advance the mandrel and to hold the mandrel stationary as the tubing advances due to the turning of the die, a cylinder, a piston in said cylinder, a piston rod, means on said piston rod engaging the rear end of a tube on said mandrel for pushing the tubing forwardly as the bending die turns, valve means for causing a supply of fluid under pressure to be delivered to said cylinder, and control means for said valve operable by movement of the mandrel rod.

2. In a tube bending machine, a rotatable bending die, a gripping means adapted to grip tubing to the die and turn with the die, a mandrel for supporting tubing against the die and preventing its collapse at the point of bending, a back-up die supporting the mandrel and the tubing thereon against the pressure developed in bending the tubing, a mandrel rod operable to advance the mandrel and to hold the mandrel stationary as the tubing advances due to the turning of the die, a cylinder, a double acting piston in said cylinder, means connected to the piston for pressing tubing on said mandrel forwardly as it is being bent, and control means for directing fluid to opposite sides of said piston in the cylinder comprising, means operable by advance of the mandrel rod to cause fluid to be applied to one side of the piston for causing it to press the tubing forwardly, and means operable by advance of the piston to cause fluid to be applied to the other side of said piston to retract it.

3. In a tube bending machine, a rotatable bending die, a gripping means adapted to grip tubing to the die and turn with the die, a mandrel for supporting tubing against the die and preventing its collapse at the point of bending, a back-up die supporting the mandrel and the tubing thereon against the pressure developed in bending the tubing, positioning means for said back-up die comprising a block mounted for movement transversely of the mandrel and rear and front guide rollers on said block holding the back-up die between them so it may move with the tubing as the bending die rotates, means for moving said block to press the back-up die into engagement with tubing on said mandrel, a mandrel rod secured to the mandrel, means operable to advance the mandrel rod and to hold the mandrel stationary as the tubing advances, and means for pressing tubing forwardly on said mandrel as the tubing is bent whereby to overcome the friction between the mandrel and the tubing comprising reciprocating power means having a part positioned to engage tubing on said mandrel, control means, operable upon advance of the mandrel rod and mandrel to operative position, to cause the power means to press the tubing forwardly, said control means being operable upon advance of the tubing a predetermined distance to cause the power means to move the engaging part back to starting position.

4. In a tube bending machine, a bending die, a mandrel, means to position the mandrel in bending position with respect to said die, comprising a mandrel rod, power means comprising a cylinder, a double acting piston in said cylinder, means connected to the piston for reciprocation therewith and having a head thereon for engaging the rear end of tubing threaded on said mandrel and rod for bending, and means controlling the supply of liquid under pressure to said cylinder whereby to actuate said piston, said controlling means comprising means actuated by advance of said mandrel rod to bending position for supplying liquid to one end of the cylinder and thereby causing the piston to press said head against the end of the tubing, and means actuated by advance of the head to a predetermined point to direct the supply of liquid to the other end of the cylinder and thereby return the head to original position.

5. In a tube bending machine, a rotatable bending die, a gripping means adapted to grip tubing to the die and turn with the die, a mandrel for supporting tubing against the die and preventing its collapse at the point of bending, a back-up die supporting the mandrel and the tubing thereon against the pressure developed in bending the tubing, positioning means for said back-up die comprising a block mounted for movement transversely of the mandrel and rear and front guide rollers on said block holding the back-up die between them so it may move with the tubing as the bending die rotates, and means for positioning the block against tubing on the mandrel comprising a sliding plate on which the block is mounted, means to adjust the block on the plate, and power means for reciprocating the plate.

BYRON F. BOWER.