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TUBE BENDER

Filed Jan. 25, 1947

2 Sheets-Sheet 1

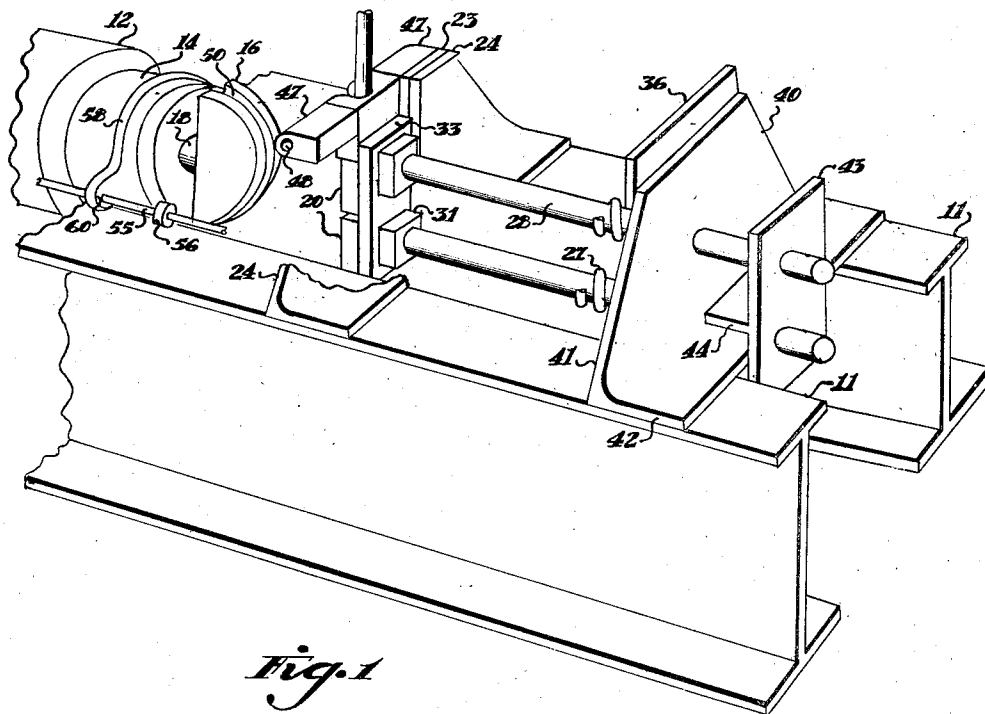


Fig. 1

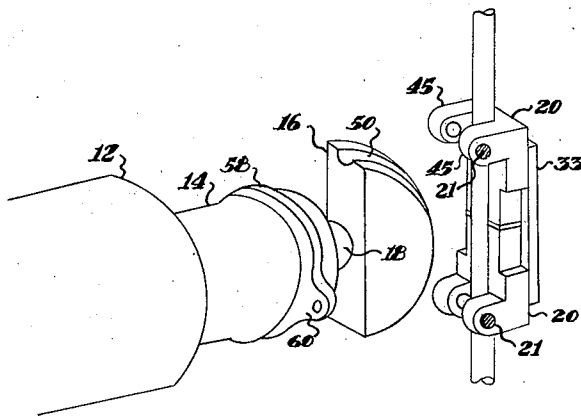


Fig. 2

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2 Sheets-Sheet 2

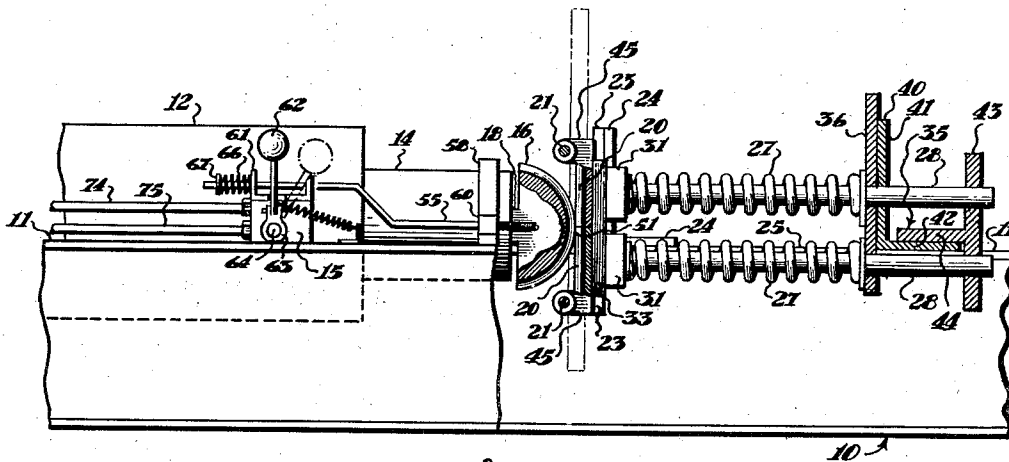


Fig. 3

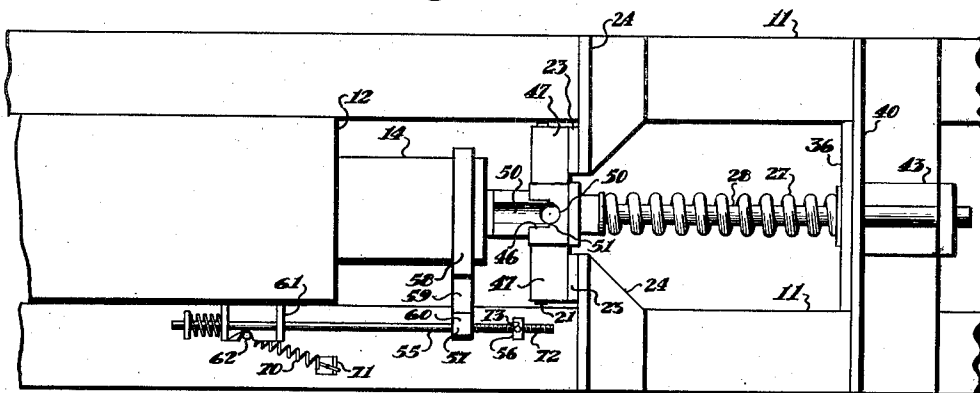


Fig. 4

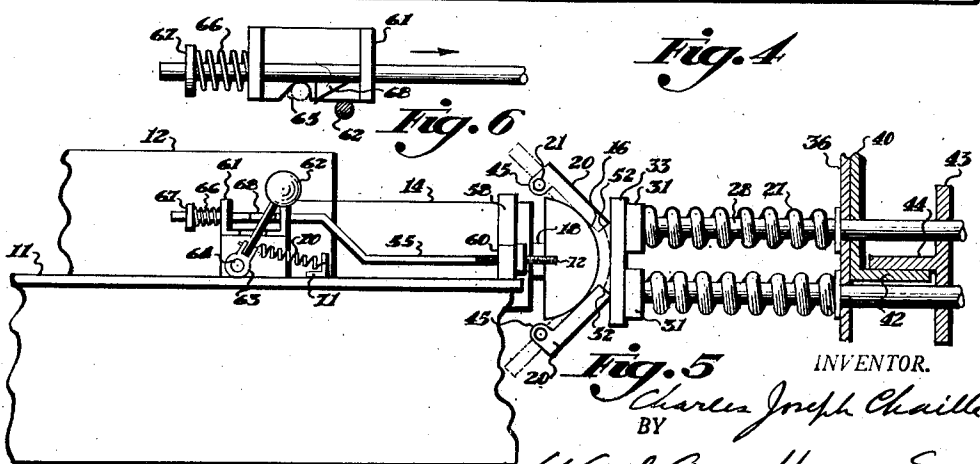


Fig. 5

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TUBE BENDER

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2 Claims. (Cl. 153—33)

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This invention relates to tube bending apparatus and has particular reference to improvements in a hydraulically operated mechanism designed automatically to bend the work to a predetermined radius and degree of angularity within close limits and at a production scale of operation.

Briefly, it is the concept of the inventor to provide a tube bending apparatus having a hydraulic ram which carries an interchangeable swaging or forming die having a convex curved face cooperating with a pair of straight spring loaded rocking jaws, the work being engaged between the convex face and jaws and swept tangentially and progressively around the curved face as the forming die advances relative to the jaws, the angle of the bend being determined by the distance advanced by the forming die and the radius of the bend corresponding to the curve radius of the forming die face.

In order to provide a machine capable of volume production, the apparatus is arranged to operate automatically in a controlled cycle, each cycle being initiated by manual operation of a control valve after which the apparatus completes the bending operation automatically then returns to its starting position.

The bending of the tubes is facilitated by the arrangement of the dies which provides an open throat into which the tubes may be inserted conveniently. The control valve is then tripped manually to cause the ram and forming die to advance to an adjustable stop to bend the tube to its predetermined shape. The ram then retracts automatically to its initial starting position after which the formed tube is conveniently removed from the dies. The apparatus is capable of being adjusted to form any desired bend, in stepless increments from minimum to maximum without collapse or wrinkling of the tubing and without marking or scratching it.

After having been properly adjusted, the machine will produce a uniform quality of work within closely established limits as to angle of bend and radius. It has therefore been a primary object of the invention to provide an automatic hydraulically operated tube bending machine by means of which the bending operation is simplified and produces work of improved quality and of uniform consistency.

It has been another object to provide a tube bending machine which increases the bend progressively from the center of the radius outwardly as the forming die advances, and one which has dies which completely encircle the tube at the line

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of bend to maintain the circular cross section of the tube and prevent collapse or wrinkling of the tube.

It has been still another object of the invention to provide a hydraulically operated bending machine having a simplified control system by means of which the bending operation may be initiated manually to cause the ram to advance relative to the work, perform its bending function and retract to its starting position automatically so as to facilitate feeding the machine, and eliminate the requirements of skill in regulating the machine.

Further objects and advantages of the invention will be more fully described in the following detailed description with reference to the drawings in which a typical embodiment of the improved structure is illustrated.

In the drawings:

Figure 1 is a diagrammatic perspective view generally illustrating the bending apparatus in its starting position.

Figure 2 is a diagrammatic fragmentary perspective view showing the relationship of the dies with the work positioned, therein at the starting position of the apparatus.

Figure 3 is a fragmentary side elevation partially broken away showing the ram advancing toward the work preliminary to bending the tube.

Figure 4 is a top plan view of the apparatus in the position shown in Figure 3.

Figure 5 is a diagrammatic fragmentary view similar to Figure 3 showing the relationship of the dies at the completion of the stroke.

Figure 6 is a fragmentary top plan view detailing the release mechanism which trips the control valve at the end of the forming stroke of the ram to cause the same to retract to its initial starting position.

Referring specifically to the drawings, the apparatus comprises a base indicated generally at 10 formed preferably of a pair of spaced I-beams 11—11 upon which is mounted a hydraulic unit 12, which includes a ram 14 regulated by means of a control valve 15. The forward end of ram 14 carries a swaging or forming die 16 which is mounted preferably by means of a shank 18 extending into a bore formed in the ram so as to be removably mounted therein.

Forming die 16 cooperates with a pair of opposed spring loaded bending dies or jaws 20—20 hingedly mounted on sets of pivot pins 21—21. These pins are carried by a plate 23 mounted upon I-beams 11 by means of angle brackets 24, welded or otherwise secured to the upper web 25 of

the respective I-beams. The bending dies 20—20 are designed to swing open in opposite directions as the forming die 16 advances, and the rocking motion of the dies is resisted by a pair of compression springs 27—27, one for each bending die.

Compression springs 27 are carried respectively upon shafts 28, the forward end of each shaft including a block 31 forming part of the shaft. These blocks in turn are secured to a backing plate 33, which plate bears against the rear surface of dies 20. Plate 33 thus forms a bearing block which, as the bending dies are forced open, engages the swinging edges of the respective dies to spring load them. In this manner the dies back up the tube against the pressure of the advancing forming die.

In order to stabilize and guide the plate 33 and shafts 28, the rearward ends of the respective shafts are slidably engaged in a bearing element generally indicated at 35. This element constitutes spaced bearing flanges each having a pair of aligned holes to slidably sustain a respective shaft 28. As shown in Figure 1, element 35 includes an angle bracket 40 having a vertical limb 41 and a horizontal limb 42 seated and secured upon the upper web of the respective I-beams 11. A T-shaped member 43 having a horizontal web 44 secured by welding or other means to the web 42 of angle member 41, supports the rearward ends of the shaft 28, while the vertical flange 41 of angle piece 40 supports the forward portion of the shafts. It will be apparent that the spaced relationship of the bearing plates 41 and 43 prevents binding of the shafts 28 therein which otherwise might occur due to lateral forces against the forward ends of the shafts developed in the sliding of plate 33 relative to the hinged bending dies 20—20.

The compression springs 27 have their rearward ends seated against a plate 36 secured to flange 41 of the angle piece 40 while their opposite ends are seated against the blocks 31. Upon advance of the ram 14 carrying forming die 16, as shown in Figure 5, plate 33 will be forced rearwardly thereby compressing springs 27 between the blocks 31 and the plate 36. When the ram reaches the limit of its stroke it trips control valve 15 as hereinafter described, stops automatically and retracts to its starting position. When this occurs the springs 27, bearing against bending dies 20, cause the bending dies to follow the forming die to return them to their normal position as shown in Figure 3. This causes the formed tube to be ejected automatically from the dies. The tube may be permitted to drop into a chute or container or it may be grasped by the operator for manual removal.

As viewed in Figure 2, each bending die 20 includes at one end a pair of lugs 45—45. The inner end of the respective pivot pins 21 are engaged in these lugs and the lugs thus provide an open throat 46 to receive the tube without interference with the pivot pins. In other words, the pivot pins 21 do not extend across the dies since this would interfere with the placing of work in the dies or in its removal therefrom. Referring to Figure 1, the outer ends of the pivot pins 21 are engaged in lugs 47, the lugs being secured to the plate 23, preferably by welding. Lugs 47 each include a bore 48 to receive the pivot pins and to permit the pivot pins to be withdrawn when it is necessary to remove the bending dies from the machine to be interchanged with dies of a different size as hereinafter described.

It will be noted that the forming die 16 is of

semi-circular face contour as viewed in Figure 3 and that the flat faces of the bending dies 20—20 contact the periphery of the forming die when it advances. The advance of forming die 16 causes the bending dies 20—20 to rock open in opposite directions by means of their pivotal mounting studs 21 as shown in Figure 5. As viewed in cross section (Figure 4) the forming die and bending dies each are provided longitudinally with a semi-circular groove 50 complementary to each other to provide a circular recess conforming to the diameter of the tube to be bent and closely embracing it. Since the swinging dies 20 contact the periphery of forming die 16 at a moving tangential line of contact during the stroke, the tube is completely enclosed in the bending zone. In other words, the tangential line of contact, as indicated at 51, is located in the bending zone and since the bending operation is progressive, starting at the parting line 52 of dies 20 and working outwardly in opposite directions, the line of contact progresses with the bending zone. It has been found that this arrangement substantially eliminates distortion and flattening of the tube. Since the dies completely encircle the tube in the bending zone, it is prevented from expanding laterally of the bend as normally occurs. Apparently this causes the metal to flow sufficiently to accommodate the differential between the inside and outside radius of the bend, producing a swaging effect greatly improving the quality of the work.

It will be apparent that during the bending operation the tube is rigidly supported at its opposite ends by the pivot pins 21, which support the bending dies 16, although the ends of the dies are yieldable. As the forming die advances, the tube begins to bend at its center outwardly in opposite directions progressing toward the pivot pins as the bending dies 16 swing in opposite directions. Therefore, the major bending force is resisted by the pivot pins while the pressure exerted by springs 27 serves to maintain the bending dies against the forming die to enclose the tube in the bending zone.

The apparatus is capable of bending tubing or pipes of the several standard commercial sizes ranging for example from $\frac{1}{4}$ " to $1\frac{1}{2}$ " in diameter and in wall thickness up to $\frac{1}{8}$ ". This is accomplished by interchanging the bending and forming dies which are supplied with appropriate grooves 50 corresponding to the desired pipe or tube diameters. Likewise, should it be desired to bend the tube to a smaller or larger radius, an appropriate forming die 16 having the desired face radius may be installed in the ram. It will be apparent of course that the radius of the finished bend will conform to the radius of forming die 16 as shown in Figure 5.

As previously noted the angle of the bend is regulated by adjusting the advance or forward stroke of the forming die 16 relative to the bending dies. In other words, a complete return or U-shaped bend may be formed by causing the ram to advance sufficiently to cause the line contact of the bending dies to reach the center line of the semi-circular forming die, and conversely, the angle of the bend may be reduced by limiting the advance of die 16. Adjusting means are provided which may be regulated to stop the advance accurately at a predetermined position.

For this purpose a control rod 55 extends forwardly from the control valve 15, having a stop collar 56 adjustably secured on its forward end. This collar cooperates with a stop 57 carried by

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ram 14. Stop 57 constitutes a ring 58 engaged on the forward end of the ram and includes a laterally extending arm 59, the outer end of which includes a boss or hub 60 having a bore through which rod 55 is slidably projected. The rearward end of control rod 55 is slidably mounted in a U-shaped bracket 61 secured to the top of the hydraulic control unit 15.

The hydraulic control unit serves as a reversing valve to control the supply of hydraulic pressure to the cylinder 12 and includes a hand operated control lever 62. As shown in Figure 3, the control lever is shown in dotted lines in its normal or ram retracting position and is shown in full lines in its ram advancing position. This lever is pivotally mounted as at 63 upon control shaft 64 so as to permit the lever to be rocked in a lateral direction with respect to the U-shaped bracket 61. Bracket 61 includes a notch 65 along its side edge into which the control lever 62 may be engaged. When the lever is swung to the position shown in Figure 3, in engagement in the notch 65, hydraulic pressure is conducted to the cylinder 12 to cause the ram to advance. The advance of the ram continues until stop hub 60 engages collar 56 secured to the end of control rod 55. Upon engaging the stop collar, the control rod is caused to move forwardly with the ram, compressing spring 66 which is seated between bracket 61 and collar 67 secured to the rear end of the control rod. Forward movement of the rod causes the cam segment 68, secured to control rod, to engage control lever 62 and move the same laterally out of engagement with notch 65. When this occurs, tension spring 70, having one end anchored upon bracket 71 and its opposite end anchored to control lever 62, causes the control lever to snap forwardly to its reversing position whereupon the supply of fluid pressure to the cylinder is reversed causing ram 14 to retract. This motion will continue until ram 14 reaches its fully retracted position as shown in Figure 1 whereupon the cycle of operation is ended. It will be apparent, therefore, that adjustment of collar 57 relative to the control rod 55 limits the bending motion of the ram and by so doing regulates the angle to which the tubing is bent. In order to provide a fine adjustment the control rod 55 may be screw threaded at its forward end as at 72 to permit the collar to be adjusted accurately with respect to the rod and may be locked in adjusted position by means of set screw 73.

The machine is operated by placing the pipe or tubing in position in the bending dies as shown in Figure 1, preferably by the provision of a suitable fixture or stop to position the tubing lengthwise relative to the dies. Valve control lever 62 is then rocked manually in a rearward direction to engage the shank of the lever 62 in notch 65 to cause the ram 14 to advance. The cycle will then continue until hub 60 engages collar 56 to trip the control rod and cause reversal of the ram. Hydraulic pressure is conducted to the valve 15 from a pressure supply system and from the valve to the forward and rearward ends of the hydraulic unit 12 by means of the tubes 74 and 75. Valve 15 is arranged alternately to supply one or the other of these lines to cause the appropriate ram motion.

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It will be noted that having once been adjusted, each succeeding work piece will be identical as to angularity and radius since the advance of the die is uniform for each work piece as controlled by the stop collar 56. Therefore, the apparatus produces work of uniform proportions to meet the required production standards.

Having described my invention, I claim:

1. A tube bending apparatus comprising, a frame, a hydraulic cylinder and ram unit mounted upon said frame, a forming die carried by said ram and adapted to be advanced and retracted by said ram, a pair of stationary bending dies yieldably mounted upon said frame and cooperating with said forming die, a valve for controlling the advance and retraction of said ram and forming die relative to the bending dies to bend the work to a predetermined angle, a manually operated lever on said valve for initiating the advance of the ram, an adjustable trip mechanism associated with said manually operated lever, and a stop element carried by said ram cooperating with said trip mechanism and arranged to actuate the trip mechanism to reverse the position of said manually operated lever and cause the ram to retract when the forming die bends said work to a predetermined angle.

2. A tube bending apparatus comprising; a frame, a hydraulically actuated ram carried by said frame, a forming die carried by the ram and adapted to be advanced and retracted by the ram, a pair of stationary bending dies mounted on said frame and arranged to engage the opposite ends of a tube to be bent, said die disposed in alignment and having their respective opposite ends pivotally mounted and adapted to open in opposite directions, said forming die having a curved face to determine the radius of a bend and adapted to engage an intermediate portion of the tube, said bending dies having straight faces adapted to engage the curved face of the forming die to provide a progressive bending zone starting at the center of the forming die and progressing outwardly in opposite directions, whereby distance advanced by the forming die relative to the bending dies determines the angle between the opposite ends of the tube, spring loading means on said bending dies to exert a bending pressure against said forming die, a reversing valve having a control lever and adjustable stop means adapted to be contacted by said ram at the end of its stroke, said stop means carrying a cam for engaging said lever and actuating said reversing valve whereby said ram is automatically reversed when said tube is bent to a predetermined angle.

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