May 19, 1959 B. F. BOWER ET AL 2,887,141

TUBE BENDING MACHINE WITH PIVOTALLY MOUNTED ADJUSTABLE PRESSURE DIES

Filed March 16, 1955 3 Sheets-Sheet 1

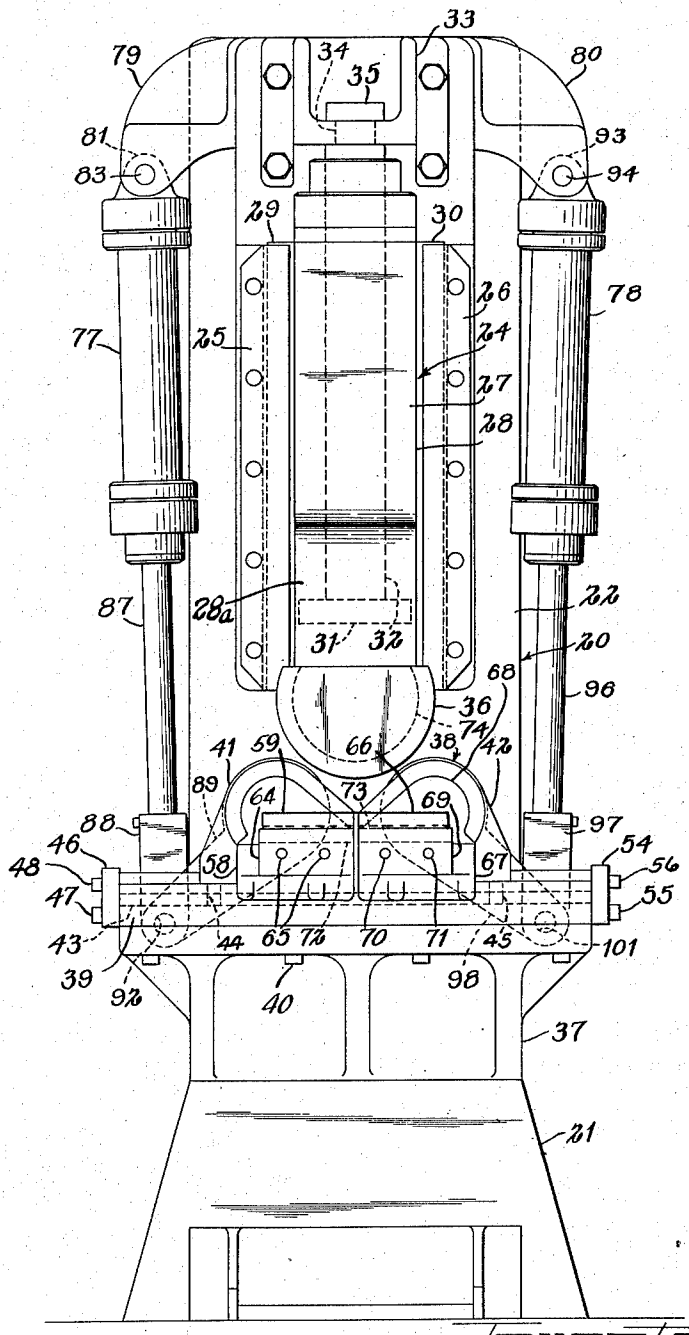


Fig. 1

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Filed March 16, 1955 3 Sheets-Sheet 2

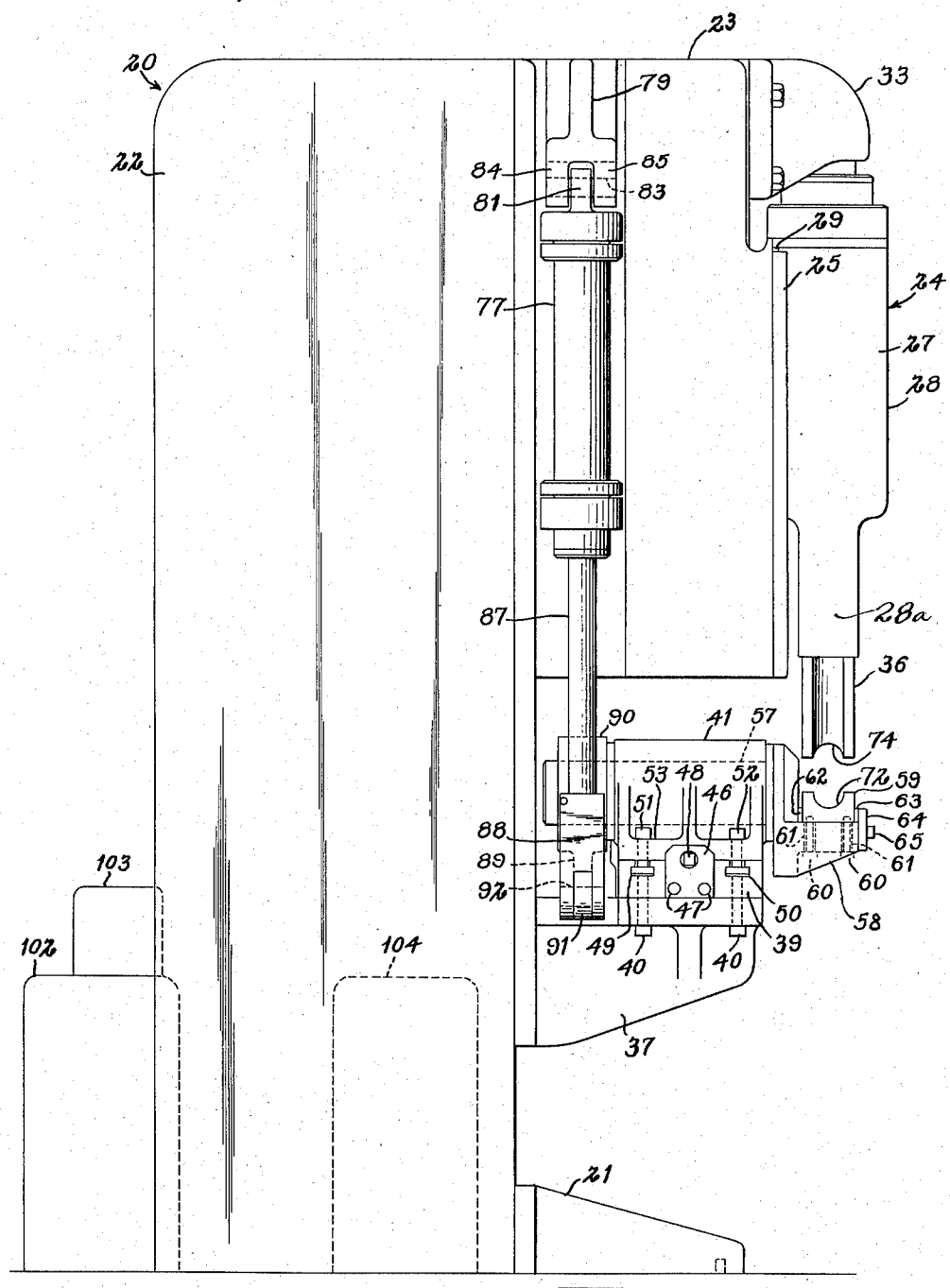


Fig. 2

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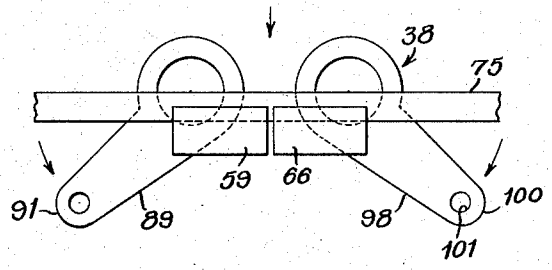
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TUBE BENDING MACHINE WITH PIVOTALLY MOUNTED ADJUSTABLE PRESSURE DIES

Filed March 16, 1955 3 Sheets-Sheet 3

Fig. 4



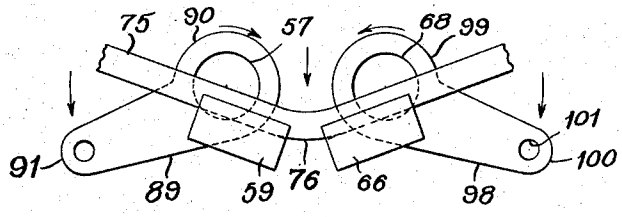


Fig. 5

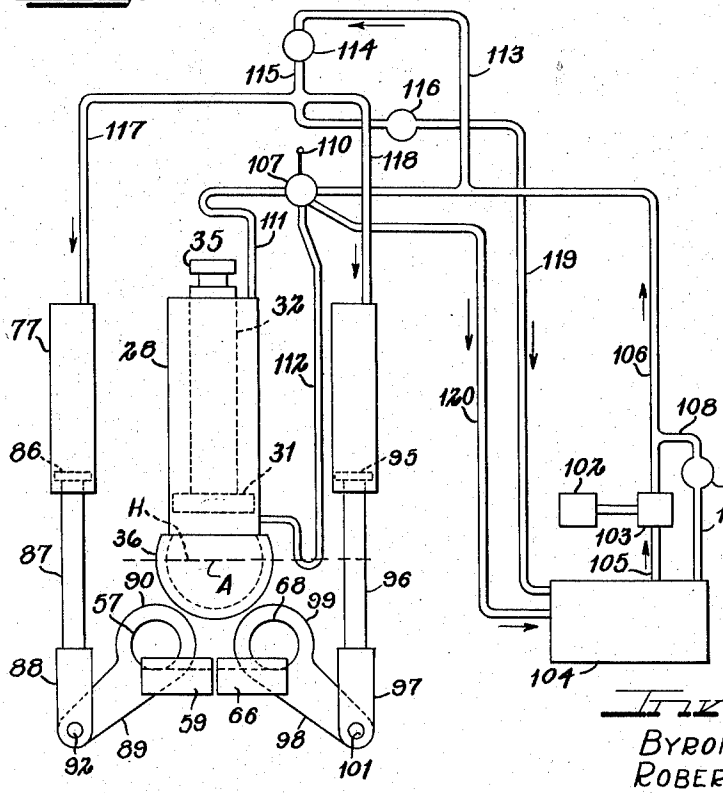


Fig. 6

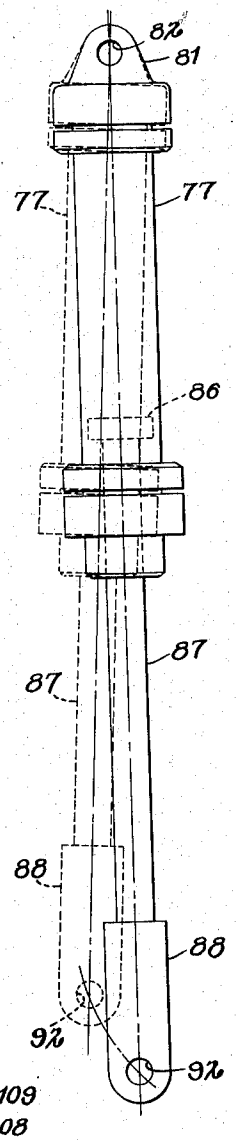


Fig. 3

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2,887,141

TUBE BENDING MACHINE WITH PIVOTALLY MOUNTED ADJUSTABLE PRESSURE DIES

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Application March 16, 1955, Serial No. 494,750

3 Claims. (Cl. 153—33)

This invention relates to improvements in tube bending apparatus and more particularly to a tube bending machine having relatively movable pressure and bending dies of the type described in the specification of the co-pending application Serial No. 469,338, filed November 17, 1954, now Patent No. 2,837,928 of which this application is a continuation-in-part.

Usually, tube bending machines are provided with a stationary bending die against which a length of tubing is clamped. A pressure die is so mounted as to move along the clamped tubing and thereby bend the tubing to the contour of the bending die.

In the present invention, there is provided a pair of pressure dies mounted for rotation toward and away from each other. A predetermined pressure is exerted on the dies to normally maintain them in aligned position to receive a length of tubing to be bent. The dies are mounted in adjacent relation to swing away from each other when a reciprocating bending die is moved against the tubing in alignment with an axis between the pressure dies. When the pressure exerted by the movable bending die exceeds the opposed predetermined pressure exerted on the pressure dies, the pressure dies swing away from each other thereby effecting a bending of the tubing between the dies.

This arrangement of a single set-up of dies permits the forming of bends up to angles of 180°, effects a greater working clearance by locating the dies in spaced relation to obstructions on the bending machine frame, and allows for multiple bends in various planes by the manual lengthwise shifting and rotation of a length of tubing in the pressure dies between strokes of the bending die.

It is, therefore, an important object of this invention to provide a tube bending machine having dies so constructed and arranged as to effect a wide range in the angularity of bends which may be accomplished.

Another object of the invention is the provision of a tube bending machine having a bending die arrangement which lends itself to a location to provide maximum working clearance for tubing to be worked on.

A further object of the invention is the provision of a tube bending machine having bending dies which, with but one relative adjustment, permit the accomplishment of multiple bends in various planes in a single length of tubing.

A still further object of the invention is the provision of a tube bending machine having a bending die arrangement which is simple in design, rugged in construction, simple in operation and highly efficient in use.

Other and further objects and advantages of the invention will become apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings, which disclose preferred embodiments of the invention.

On the drawings:

Figure 1 is a front view in elevation of a tube bending machine embodying our invention of relatively movable pressure and bending dies and the pressure operating mechanisms therefor;

Figure 2 is a side elevational view of the tube bending machine construction shown in Figure 1;

Figure 3 is an enlarged fragmental view in elevation of a pressure die cylinder, shown in normal position in full lines and shown in a position to which it is swung, during operation of its connected pressure die, in dotted lines;

Figure 4 is a diagrammatic view of the rotatable pressure dies when in normal position at the start of a bending cycle and showing a length of tubing to be bent;

Figure 5 is a view, similar to Figure 4, illustrating the rotation and cooperation of parts when the dies have been moved to a tube bending position; and,

Figure 6 is a diagrammatic view of the tube bending dies and the operating and control mechanisms therefor, shown in normal position at the start of a bending cycle.

Referring now in detail to the drawings, and as explained in the specification of the said co-pending application for patent, our invention is shown as being embodied in a tube bending machine **20**. It is, of course, to be understood that the bending die arrangement of this invention may be used in association with any reciprocating device, whether vertical or horizontal.

The tube bending machine **20** includes a base **21** and a main frame **22**. A secondary frame **23** is mounted on the face of the main frame and supports a bending ram construction **24**. Spaced guide members **25** and **26**, on the secondary frame **23**, form a slide for receiving a reciprocating ram **27**. The ram has a body **28** including a hollow parallelepipedon extension **28***a* with wing slides **29** and **30** seated between the frame **23** and the guide members **25** and **26**. This construction permits the ram to slide lengthwise of the guide.

A piston **31**, within the extension **28***a*, has a piston rod **32** extending through body **28** and depending from a support **33** attached by bolts or other suitable means to the frame **23**. It will be noted in Figure 1 that a reduced end **34** of the piston rod extends through the support, and a nut **35** or other suitable attaching means holds the piston and rod against vertical movement. This is for a purpose to be described more fully later.

A bending die **36** of generally semi-circular shape is carried at the end of the body extension **28***a*. It is preferred that the die be removably attached.

In the structure so far described, the body **28** moves relative to the stationary piston when fluid under pressure is introduced at an end of the cylinder.

A support table **37**, mounted on the main frame **22** of the machine and located beneath the secondary frame **23**, carries a pressure die mechanism **38**. A supporting bed member **39** is secured to the table by means of bolts **40**, **40**, or the like. A pair of housings, a left hand housing **41** and a right hand housing **42**, are mounted for sliding adjustment along the bed member **39** laterally across the tube bending machine. A slot, **43** extending lengthwise of the bed member, receives therein an adjusting nut **44** on the housing **41** and an adjusting nut **45** on the housing **42**. At the end of the bed member **39**, supporting the housing **41**, is a bearing plate **46** attached to the bed member by means of bolts **47**, **47**, or the like. The operating end of an adjusting screw **48** is retained in the bearing plate and the screw extends through the housing adjusting nut **44** whereby to adjust the housing **41** toward and away from the housing **42**. As best shown in Figure 2, inverted T-shaped slots **49** and **50** are provided lengthwise of the bed member to receive therein bolts **51** and **52** which extend through a foot portion **53** of the housing **41** to secure the housing in an adjusted position. Similarly, a bearing plate **54** is attached to the opposite end of the bed member by means of bolts **55**, **55**, or the

like. The operating end of an adjusting screw **56** is retained in the bearing plate and the screw extends through the housing adjusting nut **45** whereby to adjust the housing **42** toward and away from the housing **41**. Although not shown, bolts are provided to engage in the T-shaped slots **49** and **50** and extend through a foot of the housing **42** to secure the housing in an adjusted position on the bed member.

The housing **41** has a cylindrical bore to rotatably receive a journal **57**. At its forward end, the journal carries a die support **58**. A pressure die **59** seats on the support and is adjustably secured thereto. Bolts **60, 60** extend through slots **61, 61** in the die support to clamp the die to the support. The slots are enlarged in a direction normal to the die in order to provide lateral adjustment of the die on its support. Lengthwise adjustment of the die is provided through the adjusting screw **48**. Wedges **62** and **63**, or similar means, provided either at one or both sides of the die, effect a desired lateral adjustment. A bearing plate **64**, bolted to the die support **58** by means of bolts **65, 65** secures the adjusted die in position on the support. Similarly, a pressure die **66** is adjustably mounted on a die support **67**, carried by a journal **68** extending into the housing **42**, by means of wedges or other similar means (not shown) and secured or locked thereto by a bearing plate **69** with locking bolts **70** and **71**.

As best shown in Figure 1, the pressure dies **59** and **66** are adjusted along the die support **58** so as to be located on opposite sides of and preferably equally spaced from the vertical axis of the bending die **36**. Also, as shown in Figure 2, the pressure dies are adjusted laterally to align the tubing receiving grooves **72** and **73** with a similar groove **74** in the bending die.

In Figures 4 and 5 are shown the cooperation of the bending and pressure dies by which a length of tubing **75** has a bend **76** formed therein. As the ram cylinder **28** moves the bending die **30** downwardly (as shown by arrows) against the tubing and in alignment with the space between the pressure dies, the tubing bends around the bending die. The depth of the bend is determined by the distance the bending die moves in its association with the tubing and pressure dies. However, it is desirable that the bending die movement be so limited that the lines of contact between the tubing and the bending die do not extend above the horizontal plane H through the horizontal axis A of the bending die.

To insure the proper bending of the tubing **75** by the downward movement of the bending die **36**, it is necessary to provide each of the pressure dies **59** and **66** with a backing pressure. The pressure provided should be such as to give when exceeded by the pressure exerted through the bending die **36**. This backing pressure is exerted through means to maintain fluid pressure provided in cylinders **77** and **78**.

A pair of wing supports **79** and **80** are attached to the secondary frame **23** at the upper end and on opposite sides thereof. The wing support **79** extends laterally to locate the lower end of the attached cylinder **77** spaced from the housing **41**. As shown in Figures 1, 2 and 3, the upper end of the cylinder is provided with a pivot hanger **81** having therein an opening **82**. A pivot pin **83** extends through the spaced sidewalls **84** and **85** of the wing support member **79** and through the opening **82** of the pivot hanger **81** which is located between the wing sidewalls. This arrangement permits the cylinder **77** to swing on the pivot pin **83** in directions toward and away from the housing **41** and the vertically movable reciprocating ram **27**. A piston **86**, within the cylinder **77**, has extending therefrom a piston rod **87** with a clevis **88** attached to its free end. An actuating arm **89** has one end **90** embraced on and secured to for co-rotation with the journal **57** at the rear of the housing **41**. The opposite end **91** of the actuating arm is arranged between the legs of the clevis **88** and pivotally secured thereto by a pin **92**.

As shown in Figures 4 and 5, the bending of tubing **75** effects a rotation of the journal **57** in a clock-wise direction, as shown by the arrow. As the free end **91** of the actuating arm **89** swings upwardly the connected clevis **88**, the cylinder **77**, piston rod **87** and the piston **86** swing outwardly and upwardly. The piston **86** thereby moves against any fluid in the cylinder **77**.

A similar arrangement is provided with the cylinder **78**. A pivot hanger **93** on the upper end of the cylinder is connected to and between spaced sidewalls (not shown) of the wing support **80** by means of a pivot pin **94**. A piston **95**, within the cylinder, has extending therefrom a piston rod **96** with a clevis **97** at its free end. An actuating arm **98** has one end **99** embracing that portion of the journal **68** to the rear of the housing **42** and is secured to the journal for co-rotation therewith. The opposite end **100** of the actuating arm is pivotally connected to and between the sides of the clevis **97** by means of a pin **101**. As the bend **76** is formed, the pressure die **66**, together with its connected journal **68**, is rotated within the housing **42** thereby effecting a counter-clockwise rotation of the actuating arm **98**. As the arm rotates, the cylinder **78**, rod **96**, and piston **95** swing outwardly with the piston being moved into the cylinder against fluid therein.

Figure 6 diagrammatically illustrates the general operating and control mechanisms of the tube bending machine. A motor **102** drives a pump **103** that draws fluid, preferably a liquid such as oil, from a reservoir **104** through a suction line **105**. The fluid is then pumped through a conduit line **106** to a 4-way directional control valve **107**. This system is intended to operate at a predetermined pressure which is maintained by bleeding sufficient fluid through a by-pass line **108** and a pressure relief valve **109** into the reservoir **104**.

The directional control valve **107** is of well known construction and is shown as being manually operated by a handle **110** to direct the flow of fluid either to the upper end of the ram cylinder **28** through a conduit **111** or to the lower end of the cylinder through a conduit **112**. By this manual control, the movable ram cylinder **28** is operated relative to the stationary piston **31**. This movement controls the operation of the bending die **36** both relative to and in cooperation with the pressure dies **59** and **66**.

A conduit line **113** is in fluid flow connection with the line **106**, between the by-pass valve **109** and the manually operated directional control valve **107**, and extends into connection with an adjustable pressure control valve **114**. A conduit **115** connects the pressure control valve **114** to an adjustable maximum pressure valve **116**. Both pressure valves are of the one-way type, that is, pressure is exerted through each valve in but one direction. Conduit lines **117** and **118** are in fluid flow communication with the conduit **115**, between the pressure valves **114** and **116**, and extend, respectively, into connection with the upper ends of the cylinders **77** and **78**. A return conduit **119** connects the maximum pressure valve **116** and the reservoir **104**.

When the operating handle **110** of the directional control valve **107** is manually actuated to open the conduit **112** to fluid flow from the pressure line **106**, the ram cylinder **28** actuates the bending die **36** into engagement with a length of tubing seated on the pressure dies **59** and **66**. As a bend is formed in the tubing, the pressure dies rotate with their respective journals thereby rotating the actuating arms **89** and **98**.

Assuming, for purposes of example only, that a constant pressure is exerted through the conduit **106** to provide a bending pressure of 150 p.s.i. at the bending die **36**, and, that a constant back pressure of 50 p.s.i. is desired at the pressure dies **59** and **66** to resist rotation during the bending operation. The pressure control valve **114** is so adjusted as to provide a constant pressure through the conduits **117** and **118** to the cylinders **77** and **78** above their respective pistons which, in turn, trans-

mit the pressure through the piston rods, clevises, actuating arms, and journals to the pressure dies **59** and **66**. Accordingly, the tubing is bent under opposed and unequal pressures.

As the bending pressure exerted by the bending die is greater than the resisting pressures of the pressure dies, a rotation of the pressure dies is transmitted to the operatively connected pistons **86** and **95**. Movement of the pistons toward the ends of their respective cylinders effects an increase in the pressure in conduits **117** and **118**. By adjusting the effective operating pressure of the maximum pressure valve **116** slightly higher than that of the pressure control valve **114**, there is effected a pressure bleeding into the return conduit **119**.

There is thus insured, during the bending operation, the application of constant pressures on the pressure dies **59** and **66**.

After a bend **76** is accomplished, the valve **107** is manually actuated to connect conduit lines **106** and **111** whereby to operate the ram cylinder and the bending die **36** away from the pressure dies **59** and **66**. Release of pressure exerted by the bending die against the pressure dies effects a reverse movement of the pistons **86** and **95** as the maximum pressure valve **116** closes and pressure is again exerted through the pressure control valve **114**.

It will be noted that a return flow line **120** connects the valve **107** and the tank **104**. When the valve is positioned to direct flow through lines **106** and **111**, the lines **112** and **120** are opened to flow to the tank. Similarly, when the valve is positioned to direct flow between lines **106** and **112**, the lines **111** and **120** are opened to flow to the tank.

As many bends, in the same or different planes, in a tubing may be accomplished as desired by manually moving an unbent portion of the just bent tubing into bending position and rotating the tubing to a new angle of bend.

Although the tube bending machine **20** is shown in preferred vertical position, it may, if desired, be constructed to reciprocate horizontally.

While I have shown certain preferred embodiments of my invention and described them more or less precisely as to details, it is to be understood that the invention is not to be limited thereby, as changes may be made in the arrangement and proportion of parts, and equivalents may be substituted, without departing from the spirit and scope of the invention except as required by the terms of the claims.

We claim as our invention:

1. In a tube bending machine, the combination of an upstanding frame, a support table adjacent to the lower end of said frame, a hydraulic bending die mechanism on said frame reciprocable toward and away from the support table, means regulating reciprocation of said mechanism, a pair of housings mounted on said support table, said housings being arranged in a common plane spaced from the path of said mechanism, means to adjust said housings toward and away from each other in said plane, a journal received in each housing and mounted for rotation about axes perpendicular to the said plane, said journals carrying die supports and positioned for swinging movement in the path of the bending die mechanism, pressure dies mounted one on each die support for adjustment relative to said supports in the direction of the journal axes, an actuating arm on each journal extending laterally from the journal axes, a piston rod operably connected one to each arm, and a hydraulic cylinder for each piston rod, said cylinders being pivotally mounted on the frame and above said table one on each side of the bending die mechanism for self adjustment upon adjustment of the housings.

2. In a tube bending machine, the combination of, an upstanding frame, a support table adjacent to the lower end of said frame, a hydraulic bending die mechanism on said frame reciprocable toward and away from the support table, means regulating reciprocation of said mechanism, a pair of housings mounted on said support table, said housings being arranged in a common plane spaced from the path of said mechanism, means to adjust said housing and mounted for rotation about an axis perpendicular to the said plane, said journals carrying die supports and positioned for swinging movement in the path of the bending die mechanism, pressure dies mounted one on each die support for adjustment relative to said supports in the direction of the journal axes, an actuating arm on each journal extending laterally from the journal axes, hydraulic means each including a piston and a cylinder operably connected one to each arm and each extending upwardly from the table on opposite sides of the frame and said bending die mechanism axis, and means pivotally mounting the cylinders at their upper ends to the frame above the table.

3. In a tube bending machine, the combination of, an upstanding frame, a support table adjacent to the lower end of said frame, a hydraulic bending die mechanism on said frame above and reciprocable toward and away from the support table, means regulating reciprocation of said mechanism, a pair of housings mounted on said support table and spaced apart in a common plane spaced from the path of said mechanism, means to adjust said housings toward and away from each other in said plane, a journal received in each housing and mounted for rotation about an axis perpendicular to said plane, said journals carrying die supports positioned for swinging movement in the path of the bending die mechanism, pressure dies mounted one on each die support for adjustment relative to said supports in the direction of the journal axes, a radially extending actuating arm on each journal, a piston rod operably connected one to each arm, a hydraulic cylinder for each piston rod, means pivotally connecting said cylinders to the frame and above said table for self adjustment upon adjustment of the housings, and means to maintain fluid pressure in the cylinders to resist pressure on the pressure dies under the influence of the hydraulic bending die mechanism.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,887,141 May 19, 1959

Byron F. Bower et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 16, after "plane," insert -- journals mounted one in each housing for rotation on axes perpendicular to the axis of the bending die mechanism, --.

Signed and sealed this 29th day of December 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents