July 20, 1965 L. LANG 3,195,339

PIPE BENDING MACHINE

Filed Feb. 18, 1963 2 Sheets-Sheet 1

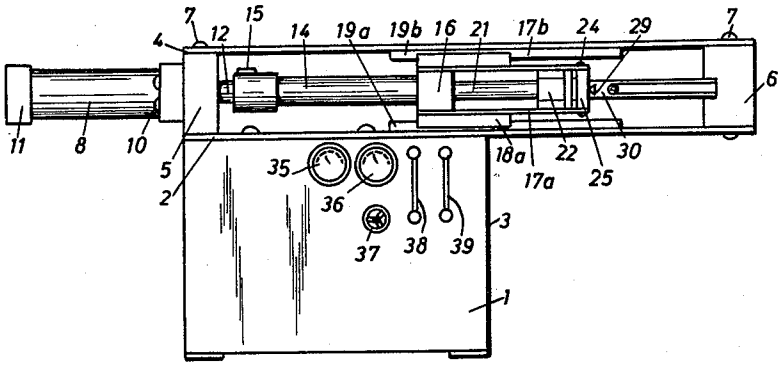


FIG.1.

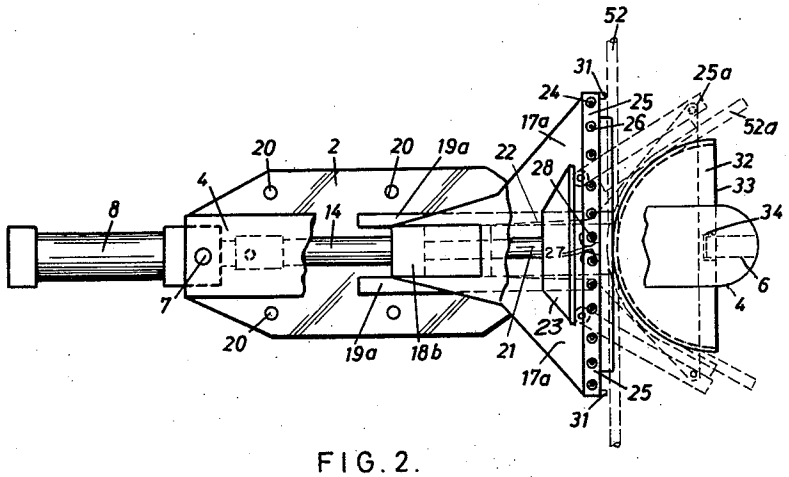


FIG.2.

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PIPE BENDING MACHINE

Filed Feb. 18, 1963 2 Sheets-Sheet 2

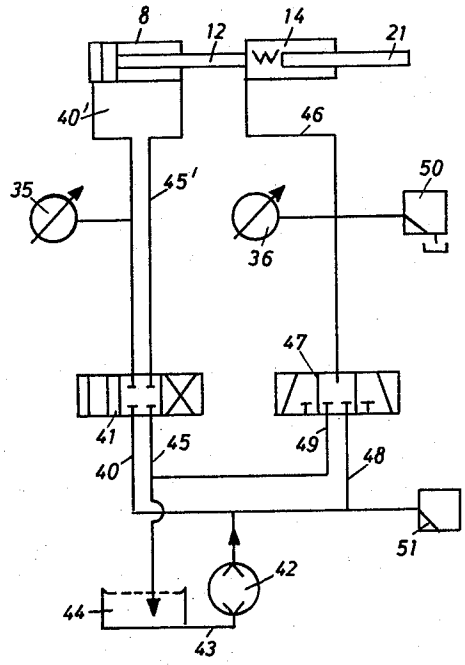


FIG. 3.

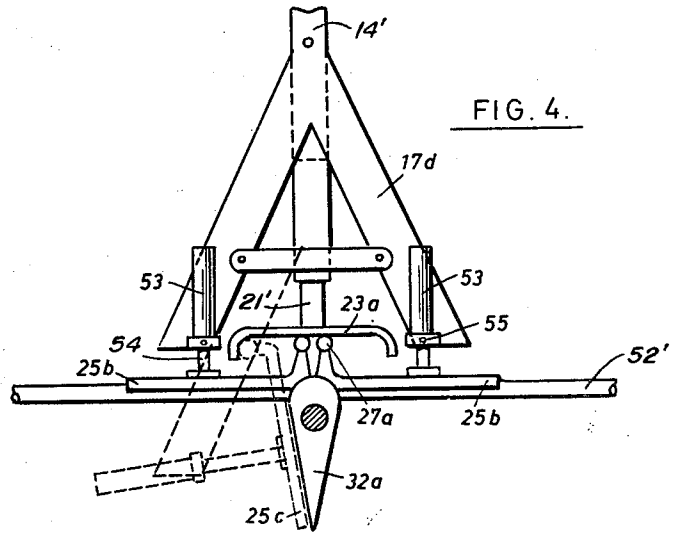


FIG. 4.

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3,195,339

PIPE BENDING MACHINE

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Claims priority, application Germany, Feb. 19, 1962, L 41,264
8 Claims. (Cl. 72—389)

This invention relates to the shaping of pipes and like elongated work pieces at ambient temperature, and more particularly to a pressure-fluid operated pipe bending machine.

An important object of the invention is the provision of a machine which permits pipes to be bent into complex shapes having small radii of curvature, bight portions extending over arcs of more than 180°, and a plurality of closely adjacent bends extending in different planes. Certain automotive exhaust pipes and rope eye thimbles are typical of the shapes for the forming of which the bending machine of the invention is of particular utility.

Another object of the invention is the provision of a bending machine in which the drive elements and associated motion transmitting members are limited to a small area on one side of the working area proper of the bending machine so as to leave the working area free of obstructions as is necessary for the bending of complex shapes.

A further object is the provision of a bending machine in which relative movement of all bending tools is in a horizontal plane, and all bends are therefore formed in this horizontal plane. This greatly facilitates the handling of a complex work piece.

Yet another object is the substantially uniform distribution of residual stresses generated in the work piece by cold working so that closely adjacent sections of the work piece may be subjected to bending in different directions without causing failure of the material under concentrated residual stresses.

Other features and advantages of the invention will become apparent to those skilled in the art as the disclosure is made in the following detailed description of preferred embodiments of the invention as illustrated in the accompanying drawing in which:

FIG. 1 is a side elevational view of a pipe bending machine of the invention;

FIG. 2 shows the machine of FIG. 1 in top plan view, some portions of the structure being broken away better to reveal others;

FIG. 3 is a diagram of the hydraulic circuit of the bending machine of FIG. 1; and

FIG. 4 shows a detail of a modified bending machine otherwise substantially identical with that illustrated in FIG. 1.

Referring now to the drawing in detail, and initially to FIGS. 1 and 2, there is seen a housing **1** on which the operating elements of the bending machine are supported. The housing encloses the hydraulic pump and other portions of the drive and control mechanism of the machine which will be described in more detail in connection with FIG. 3.

An elongated lower guide plate **2** is mounted directly on the top of the housing **1** and projects horizontally beyond the front face **3** of the housing. An upper guide plate **4** is spacedly parallel to the lower plate **2**. The longitudinal end portions of the plates **2, 4** are connected by posts **5, 6** to which the upper plate **4** is fastened by screws **7**. The upper plate **4** is relatively narrow as shown in FIG. 2. The lower plate **2** has a wider portion conforming to the top of the housing **1** and attached thereto by screws **20**. Its front end tapers, and the portion of the lower plate **2** overhanging the front face **3** of the housing **1** has the same shape as the corresponding portion of the upper plate **4**.

A double acting hydraulic cylinder **8** is attached to the post **5** by screws **10** which engage a flanged end portion of the cylinder **8** remote from the cylinder head **11**. The piston axially slidable in the cylinder **8** is integral with a piston rod **12** axially projecting from the cylinder **8** and guided in a conforming bore of the post **5**. The piston rod **12** is fixedly attached to the head **15** of a coaxial single acting hydraulic cylinder **14**. The front end of the cylinder **14** carries a block **16** provided with a bore in which a piston rod **21** is guided axially inward and outward of the cylinder **14**.

Flat brackets **17***a* and **17***b* are respectively fixedly fastened to the top and bottom of the block **16**, and thus to the cylinder **14** and the piston rod **12**. The brackets flare laterally in a forward direction. Guide members **18***a*, **18***b* respectively attached to the brackets cooperate with guide rails **19***a*, **19***b* on the plates **2, 4** to guide the brackets **17***a*, **17***b* in paths parallel to each other and to the common axis of the cylinders **8, 14**.

The piston rod **21** has a forked free end portion **22** on which a transverse abutment rail **23** is fixedly attached. The rail **23** is elongated in a horizontal direction perpendicular to the axis of the hydraulic cylinders. The front ends of the brackets **17***a*, **17***b* are connected by two pins **24** laterally spaced in opposite directions from the cylinder axis. The outer end portions of two bending rails **25** are respectively pivoted on the pins **24**. The inner end portions of the rails **25** carry rollers **27** arranged on pins **28** for travel on the transverse abutment rail **23**. Several apertures **26** are spaced along the length of each bending rail **25** for alternatively receiving the pin **24** as required by the bending work at hand. A dove-tail shaped guide bar **29** on the front face of each rail **25** is slidably received in a conforming groove in the rear face of a slide **30**. Longitudinal sliding movement of each slide in a laterally outward direction is limited by a stop **31** on the coordinated bending rail **25**. The front face of each slide **30** is formed with an open longitudinal groove of approximately semi-cylindrical shape.

A bending mandrel **32** is releasably mounted on the post **6** by engagement of the post with a groove **34** in the front face **33** of the mandrel. The arcuately shaped rear face of the mandrel **32** has an open, approximately semi-cylindrical groove in a common horizontal plane with the grooves of the slides **30** and facing the same.

The hydraulic system for the pipe bending machine is controlled by an operator standing on the side of the machine visible in FIG. 1. A pressure gauge **35** indicates the pressure in the cylinder **8** during forward movement of the piston rod **12**. The gauge **35** has a range from zero to nine thousand pounds per square inch. Another pressure gauge **36** having a range from zero to three thousand pounds per square inch indicates the pressure in the cylinder **14** during forward movement of the piston rod **21**. Switch levers **38, 39** control solenoid valves in the hydraulic circuits of the cylinders **8** and **14** respectively. A hand wheel **37** permits a pressure relief valve **50** for the cylinder **14** to be manually controlled as will presently become apparent.

FIG. 3 is a conventional diagram of the hydraulic system. The hydraulic fluid is supplied by a motor driven pump **42** which draws the fluid from a tank **44** through an intake pipe **43**, and discharges it under pressure into pressure lines **40** and **48** respectively connected to control valves **41** and **47**. A safety valve **51** vents the lines **40** and **48** to release excess pressure. The control valves **41, 47** are connected to the tank **44** by return lines **45, 49**.

The valve **41** is connected to the front and rear compartments of the cylinder **8** by lines **45'** and **40'** respec-

tively. The pressure gauge 35 communicates with the line 40'. A pipe 46 connects the cylinder 14, the pressure gauge 36, and the aforementioned manually controlled pressure relief valve 50 with the valve 47. As diagrammatically indicated, the piston rod 21 is spring biased in a direction outward of the cylinder 14.

In the position illustrated in FIG. 3, the valves 41, 47 block passage of fluid between the cylinders 8, 14, and the pump 42. When the pump operates, the hydraulic fluid is returned to the tank 44 in a conventional manner, not shown, through the safety valve 51.

The switch lever 38 has two operative positions for shifting the valve 41 into a first position in which pressure fluid is admitted from the pump 42 through the line 40' into the rear compartment of the cylinder 8, and the front compartment is drained through the line 45', and a second position in which pressure fluid is admitted to the front compartment and drained from the rear compartment. The actuating solenoids in electrical circuit with the switch of lever 38 are entirely conventional, and have not been shown. The sole compartment of the cylinder 14 is similarly arranged to be connected to the pump 42 or to the tank 44 when the lever 39 is manipulated. The pressure relief valve 50 is normally set for the lower pressure desired in the cylinder 14.

The afore-described apparatus is operated as follows: Pressure fluid is admitted to the rear compartment of the cylinder 8 and to the cylinder 14 to move the bending rails 25 from an inoperative position remote from the mandrel 32 into the position illustrated in fully drawn lines in FIG. 2 in which the slides 30 and the mandrel 32 engage a tubing length 52 from opposite sides, and the bending rails 25 extend longitudinally in a common straight line parallel to the transverse abutment rail 23.

The valve 47 is then set to connect the cylinder 14 with the tank 44, and additional fluid is admitted to the rear compartment of the cylinder 8, thereby further advancing the brackets 17*a*, 17*b*, and the hingedly attached outer end portions of the bending rails 25 while the inner end portions of the rails 25 travel laterally away from each other on their rollers 27 in abutting engagement with the rail 23. The bending operation is completed when the bending rails reach the position 25*a* indicated in broken lines, whereby the length of tubing is bent into an arcuate shape as shown by the broken outline 52*a*. The valve 41 is reversed, and the piston rod 12 is withdrawn inward of the cylinder 8 until the apparatus reverts to its inoperative position.

FIG. 4 shows the bending tools of a modified pipe bending machine of the invention otherwise closely similar to that illustrated in FIGS. 1 to 3. The front end of the cylinder 14' carries a V-shaped bracket 17*d*. Two auxiliary hydraulic cylinders 53 are respectively hingedly connected to the two forward ends of the bracket 17*d* by means of pins 55. A bending rail 25*b* is fixedly attached to the piston 54 of each auxiliary cylinder 53. The inner ends of the rails 25*b* are equipped with rollers 27*b*.

The free end of the piston rod 21' which is axially movable in the cylinder 14' carries a generally transversely elongated abutment rail 23*a* whose lateral ends are bent in a forward direction. The rollers 27*a* engage the rail 23*a* for lateral movement thereon, and such lateral movement is stopped when the rollers 27*a* reach the bent ends of the rail 23*a*.

The bending rails 25*b* are adapted to cooperate with a mandrel 32*a* having a horizontal cross section which is defined by a circular arc somewhat greater than 180° located opposite the rail 23*a*, and two flat sides extending from the ends of the arc and converging in a forward direction.

The bending apparatus illustrated in FIG. 4 is operated first to clamp the tubing length 52' between the rails 25*b* and the mandrel 32*a* in a position closely analogous to that illustrated in FIG. 2. The cylinder 14' is then connected to the return line leading to the storage tank for hydraulic fluid, and additional fluid under pressure is admitted to the high pressure or main cylinder corresponding to the cylinder 8, but not illustrated in FIG. 4. The resulting forward movement of the bracket 17*d* bends the tubing 52' about the arcuate rear face of the mandrel 32*a* in substantially the same manner as described in connection with FIGS. 1 to 3. The auxiliary cylinders 53 are last supplied with pressure fluid through valves analogous to the valves 41, 47, to urge the piston rods 54 outward of the cylinders. The tubing 52' is thereby bent to conform to the flat sides of the mandrel 32*a* and to assume the shape of a rope thimble including a bight portion extending over an arc greater than 180°. The ultimate position of one of the bending rails is indicated in broken lines at 25*c*, and the corresponding positions of the coordinated cylinder 53 and of a portion of the bracket 17*d* is also shown in broken outlines.

The bending machine of the invention is very convenient for the bending of automobile exhaust tubes and of similar complex shapes because of the compact arrangement of the bending tools and their drives which leaves the working area proper of the machine uncluttered by drive elements and by motion transmitting members. There is little relative movement of the work piece and of the contacting portions of the bending rails so that the bending deformation of all portions of the work piece is uniform. The residual stresses are therefore not concentrated in selected portions of the work piece, and several bends can be formed in closely adjacent longitudinal portions of a tube at ambient temperature without intermediate annealing. The movement of the bending rails from a position adjacent the machine axis in a laterally outward direction during the bending operation enhances stretching of the outer fibers in the tube which is being bent, and reduces the deformation of the inner fibers by compression. It is therefore possible to bend even open channels of semi-circular cross section into thimbles for insertion in rope eyes and similar shapes.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What I claim is:

1. A hydraulic device for bending pipes and like elongated work pieces comprising, in combination:

(a) a support;

(b) a bending mandrel fixedly mounted on said support;

(c) a first pressure-fluid operated motor including a cylinder member having an axis and a piston member axially slidable in said cylinder member, said cylinder member and said piston member constituting a first pair of members, one of said members of said pair being fastened to said support for axial movement of the other member of said pair;

(d) a second pressure-fluid operated motor including a cylinder member having an axis and a piston member axially slidable in the cylinder member of said second motor, said piston member and cylinder member of said second motor constituting a second pair of members axially aligned with said first pair, one member of said second pair being secured to said other member of said first pair for axial movement of the other member of said second pair toward and away from said mandrel;

(e) an elongated bending rail having two end portions, one of said end portions being secured to said other member of one of said pairs, and the other end portion engaging the other member of the other one of said pairs; and

(f) valve means for separately controlling flow of a pressure fluid to and from each of said cylinder members.

2. A device as set forth in claim 1, wherein said one end portion of said bending rail is pivotally secured to said other member of said first pair.

3. A device as set forth in claim 1, wherein said one end portion of said bending rail is pivotally secured to said one member of said second pair, and the other member of said second pair carries an abutment, said other end portion of said bending rail movably engaging said abutment.

4. A device as set forth in claim 1, wherein said cylinder member of said first motor is fastened to said support, and said cylinder member of said second motor is secured to the piston member of said first motor.

5. A device as set forth in claim 1, wherein said one end portion of said bending rail is secured to said other member of said first pair for pivoting movement, the device further including auxiliary pressure fluid operated motor means mounted on said other member of said first motor for actuating said pivoting movement.

6. A device as set forth in claim 5, wherein said auxiliary motor means include an auxiliary cylinder member pivotally attached to said other member of said first motor, and an auxiliary piston member slidable in said auxiliary cylinder member, said bending rail being attached to said auxiliary piston member.

7. A device as set forth in claim 1, wherein said other end portion of said bending rail movably engages said other member of said other pair, and stop means on the last-named other member for limiting movement of said bending rail.

8. A device as set forth in claim 1, wherein said axes extend in a horizontal direction.

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