Jan. 16, 1934. L. W. SNELL 1,943,700

METHOD OF AND MEANS FOR BENDING TUBES

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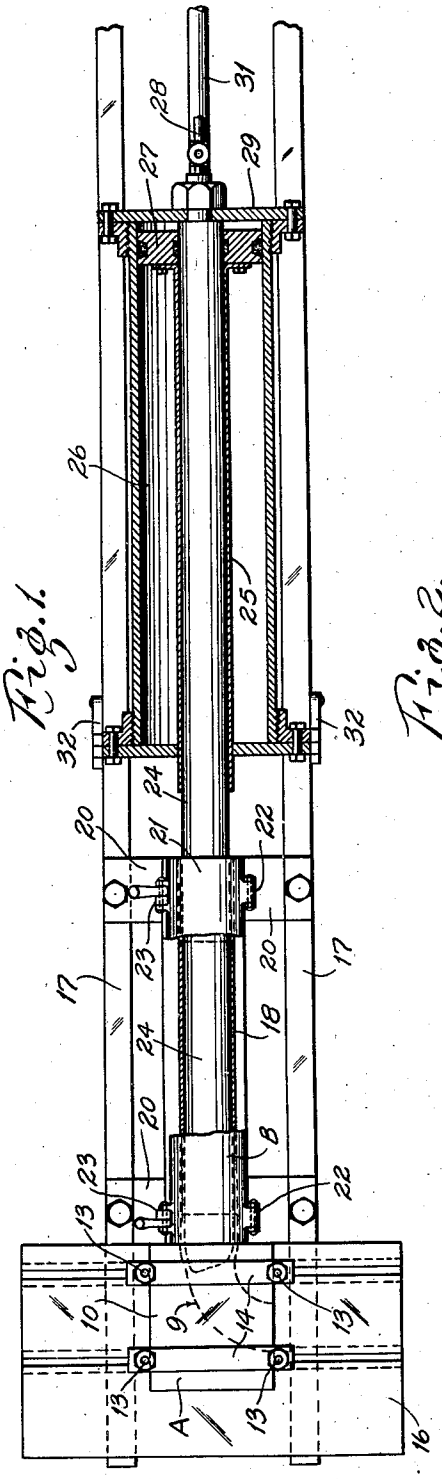


Fig. 1.

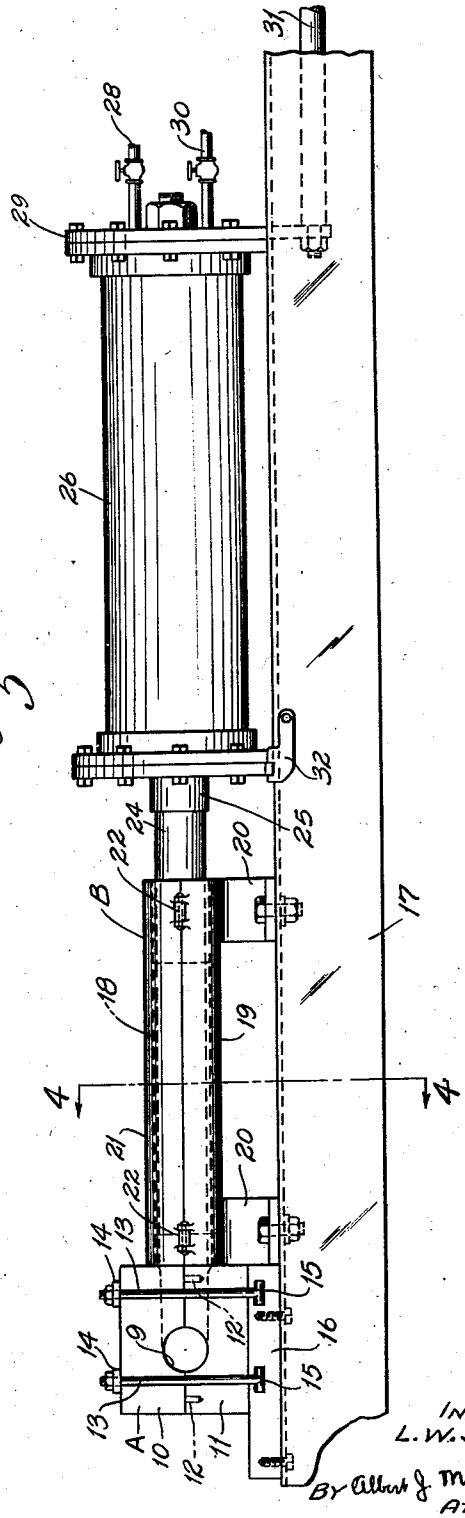


Fig. 2.

INVENTOR
L. W. SNELL.
By Albert J. McCauley
ATTORNEY.

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Fig. 3.

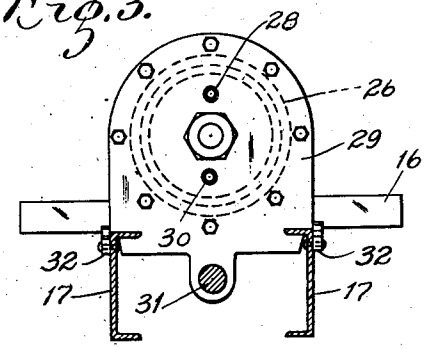


Fig. 4.

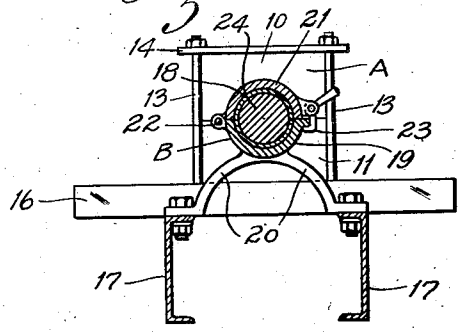


Fig. 5.

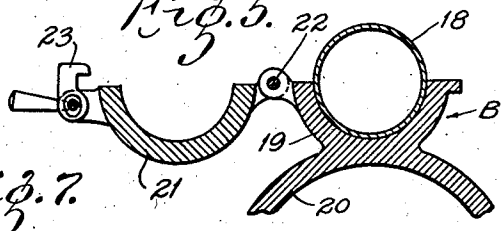


Fig. 8.

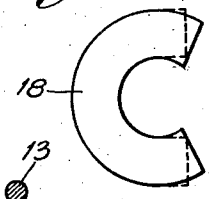


Fig. 7.

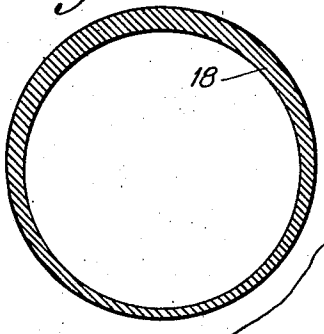


Fig. 6.

INVENTOR:
L. W. SNELL.

By Albert J. McCauley

ATTORNEY.

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UNITED STATES PATENT OFFICE

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METHOD OF AND MEANS FOR BENDING TUBES

Lester W. Snell, Alton, Ill.

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17 Claims. (Cl. 153—32)

This invention relates to methods of and means for bending tubes, and the novel features may be advantageously used in making pipe fittings, such as U-shaped return bends, and elbows with tangential end portions at various angles to each other.

One of the objects is to accurately bend the tubes in a simple manner whereby the bending operations can be performed easily and quickly.

More specifically stated, an object is to bend the tubes in a die having a curved passageway through which the tubes are forced. The bending occurs in the curved passageway which preferably conforms to the external diameter and the curvature desired in the bent tube. I have shown how this may be easily accomplished without requiring the use of cores in the curved portion of the bending die.

Another object is to prevent undue variations in the thickness of the material in the bent products. In performing the ordinary simple bending operation, a metal tube is stretched at the arc of greatest radius, which is sometimes regarded as the outer portion of the bend, while the metal is compressed at the inner portion of the bend where the radius of the curve is shorter. The stretching reduces the thickness of the metal at the outer portion of the bend, while the compression increases the thickness at the inner portion of the bend. As a consequence, the ordinary simple bending operation results in a bent tube that is non-uniform in thickness.

One of my objects is to produce a bent tube that is substantially uniform in thickness. This may be accomplished by deflecting portions of the tube, as will be hereafter described, to increase the delivery of metal to the outer portion of the bend, where the radius of the curve is relatively large, and if desired, the metal passing to the inner portion of the bend may be reduced in thickness.

In the preferred form of the invention, the tube is contracted to reduce its diameter before it is subjected to the bending operation, and this contracting operation may be performed by deflecting the material that is to form the arc of relatively large radius in the bent tube, thereby increasing the thickness of said material, so as to compensate for the stretching and thinning which occurs during the bending operation.

With the foregoing and other objects in view, the invention comprises the novel method, construction, combination and arrangement of parts hereinafter more specifically described and illustrated in the accompanying drawings, wherein is shown the preferred embodiment of the invention. However, it is to be understood that the invention comprehends changes, variations and modifications which come within the scope of the claims hereunto appended.

Fig. 1 is a top view, partly in section, illustrating a bending apparatus embodying the features of this invention.

Fig. 2 is a side elevation of the apparatus.

Fig. 3 is an end view of the same.

Fig. 4 is a section on the line 4—4 in Fig. 2.

Fig. 5 is a transverse section, on a larger scale, showing the cylindrical housing whereby the tube is guided to the die, said housing being open in Fig. 5 to receive the tube.

Fig. 6 is an enlarged section showing how the tube may be contracted at the entrance to the die.

Fig. 7 is a section of the tube, taken on the line 7—7 in Fig. 6, showing how the thickness of the tube is modified as it passes through the entrance of the forming die.

Fig. 8 shows the shape of the tube as it leaves the die, the dotted lines indicating that the end portions of the tube may be bent to lie tangential to the curves.

The apparatus shown to illustrate one form of the invention comprises a die A provided with a curved, or arcuate passageway 9 between upper and lower die members 10 and 11. This passageway 9 conforms to the external diameter and curvature desired in the bent tube. The tube to be bent is forced through said passageway 9, as will be hereafter described.

The upper die member 10 may be provided with dowel pins 12 extending into the lower die member, as shown in Fig. 2. These die members are secured together by means of bolts 13 extending through bars 14 on the upper die member, and having heads 15 (Fig. 2) at their lower ends arranged in T-shaped slots in a base 16, the latter being mounted on and secured to a pair of beams 17.

The tube to be bent is shown at 18 in Figs. 1, 4 and 5. While in a hot condition, this straight tube is placed in a cylindrical guide, or housing, B including a lower section 19 provided with legs 20 secured to the beams 17, and an upper section 21 which may be hinged to said lower section as shown at 22. Latch members 23, pivoted to the upper section 21, are adapted to engage lugs on the lower section 19 when the housing is closed, as shown in Fig. 4.

A mandrel, or core, 24 may be inserted through the straight tube 18 in the housing B, so as to extend into the forming die A, as shown in Figs.

1 and 6. The tube 18 is thus closely confined between the mandrel 24 and the housing B. The mandrel conforms to the internal diameter of the tube. The straight passageway formed by the housing B conforms approximately to the external diameter of the straight tube.

The means for pushing the tube from the housing B comprises a cylindrical ram 25 surrounding the mandrel 24. This ram conforms to the diameter and thickness of the tube to be bent, and during the bending operation it engages one end of said tube and moves longitudinally to force the tube into the die A.

To illustrate a means for operating the ram 25, I have shown a cylinder 26 provided with a piston 27 to which the ram 25 is secured, as shown in Fig. 1.

Any suitable fluid under pressure may be introduced into the cylinder to force the piston to the left from the position shown in Fig. 1. As a simple illustration of this, I have shown in Fig. 2 a valved inlet pipe 28 connected to the cylinder head 29, and a valved exhaust pipe 30 extending from said head. However, it is to be understood that any other suitable means may be employed to control the admission and discharge of the fluid through which power is transmitted to the piston 27.

The cylinder 26 is slidable on the beams 17 and it may be moved longitudinally of said beams through the medium of an operating rod 31 shown in Figs. 2 and 3. Latches 32 may cooperate with one of the cylinder heads, as shown in Figs. 1 and 2, to prevent displacement of the cylinder 26 during the bending operation.

The operation of the parts so far described will be briefly set forth as follows.

A hot tube 18 is placed in the lower section 19 of the sectional housing while the upper section 21 is open, as shown in Fig. 5. The housing is then closed and locked by means of the latch devices 23, to confine the tube. It is to be understood that when the tube is placed in the apparatus, the movable cylinder 26 occupies a position considerably to the right from that shown in Fig. 1. The mandrel 24 is secured to the cylinder head 29, so it is shifted with the cylinder to a position in which it will not interfere with the delivery of the tube to the housing B.

After the tube is placed in said housing, the cylinder is moved to the position shown in Fig. 1 to insert the mandrel 24 through the tube and into the entrance of the die A. The piston 27 is then operated to force the ram 25 to the left, and the outer end of said ram engages the tube 18 and forces it into the die A. The next step consists in withdrawing the mandrel and ram, and another hot tube is then placed in the housing B. When this second tube is forced into the die, it will engage the first tube and push it from the die. The successive operations are carried out continuously, and each tube, excepting the first, pushes the preceding tube from the die.

In making U-shaped return bends, the tubes are bent to the shape indicated by full lines in Fig. 8, the curved faces being true arcs drawn from a common center. In this connection it may be observed that the bending operation is completed near the entrance of the die A, and that the bent portion of the tube passes on through the arcuate passageway in the die without substantial friction and without being bent at any point remote from said entrance. In other words, the shape and radii of the bent tube are determined by the curvature of the portion of the passageway near the entrance to the die, and since the other portion of this passageway merely conforms to the said radii, the tube passes freely through said other portion without being subjected to any additional bending.

If a very long tube were forced through the die, it would tend to assume the shape of a true and complete circle, and by deflecting the long tube as it passes from the die it could be made to form a helix.

It will, therefore, be understood that in making pipe fittings, the ends of the curved tube are preferably bent as suggested by dotted lines in Fig. 8, to lie tangential to the curve. This bending may be done in any suitable manner after the tube passes from the die, and the extended ends of the tube may be suitably shaped, or threaded, to receive pipes.

Fig. 8 illusrates a U-shaped return bend, but 45° elbows and the like, can be made by bending shorter pipe sections in the die A, and finishing the end portions of said sections to provide the desired pipe connections.

An important feature of the invention lies in the manner in which the metal in the tube is distributed to compensate for changes in thickness which occur in bending metal tubes. The ordinary bending operation reduces the thickness of the metal that is to form the arc of relatively large radius in the bent tube, while the metal at the arc of shorter radius is increased in thickness as a result of compression during the bending operation.

In the preferred form of the present invention, the material that is to form the arc of larger radius is increased in thickness before the tube is bent, and this increase in thickness may occur at the entrance to the die A. For example, the diameter of the tube may be reduced at the entrance to the die, as shown in Fig. 6, and the metal displaced during this operation may be distributed as shown in Fig. 7.

The entrance to the die is offset as shown at 33 in Fig. 6 to reduce the diameter of the tube 18 before it enters the arcuate passageway 9. The mandrel 24 extends into this entrance, and said mandrel is offset at 34. At this point, the mandrel is eccentric to the entrance, and it is separated from the walls of said entrance to provide an annular space through which the tube passes to the arcuate passageway 9. This annular space is eccentric, as indicated in Fig. 7 which is a section illustrating the portion of the tube in said space. This annular space is widest at the portion of the entrance leading to the arc of largest radius in the arcuate passageway 9, and said annular space is narrowest at the portion of the entrance leading to the arc of the shortest radius. Fig. 7 shows how the metal in the tube is distributed while passing through said annular space, the metal being thickest at the top of Fig. 7 and gradually tapered toward the thin lower portion in the same view.

This gradual change in thickness compensates for the changes in thickness which occur at different portions of the arcuate passageway 9. The curvature at different portions of this passageway conforms to arcs of numerous radii drawn from a common center, and during the bending operation the metal in the tube is reduced in thickness at the arc having the longest radii, but the extent of this reduction in thickness will gradually decrease from a maximum at the arc of largest radius. On the other hand, during the same bending operation, the metal will be in-

creased in thickness at the arcs of relatively small radii, and this increase will be greatest at the arc of shortest radius.

Therefore, the variations in thickness shown by Fig. 7 will result in a bent tube approximately uniform in thickness.

The entrance to the curved passageway 9 may be offset as shown at 35 in Fig. 6 to forcibly reduce the thickness of the metal passing to the arc of shortest radius in said passageway. However, it is to be understood that the invention is not limited to the specific details herein disclosed to illustrate one form of the invention.

I claim:

1. The method of bending tubes which comprises imparting longitudinal movement to a tube while increasing the thickness of the material that is to form the arc of relatively large radius in the bent tube, and at the same time bending portions of said tube that have been subjected to said thickening operation.

2. The method of bending tubes which comprises increasing the thickness of the material that is to form the arc of relatively large radius in the bent tube, also decreasing the thickness of the material that is to form the arc of small radius, and at the same time bending portions of said tube that have been subjected to the aforesaid operations.

3. The method of bending tubes which comprises forcing a tube onto a bending element conforming to the curvature desired in the bent tube, and at the same time increasing the thickness of the material that is to form the arc of relatively large radius in the bent tube, while discharging the bent portion of the tube from said bending element.

4. The method of bending tubes which comprises forcing a tube in a direction longitudinally of the tube while bending it to the desired curvature, and at the same time contracting the tube by deflecting the material that is to form the arc of relatively large radius in the bent tube, so as to increase the thickness of that portion of the tube before it is bent to the desired curvature.

5. The method of bending tubes which comprises forcing a tube through a curved passageway conforming to the diameter and curvature desired in the bent tube, so as to bend the tube in said curved passageway, discharging the curved portion of the tube from said curved passageway, and at the same time contracting the portion of the tube entering said curved passageway.

6. The method of bending tubes which comprises forcing a tube through a curved passageway conforming to the diameter and curvature desired in the bent tube, so as to bend the tube in said curved passageway, at the same time discharging the bent portions of the tube from said passageway, and contracting the tube as it enters said curved passageway, by deflecting the material that is to form the arc of relatively large radius in the bent tube, thereby increasing the thickness of said material at the entrance to said curved passageway.

7. The method of bending tubes which comprises forcing a tube through a curved passageway conforming to the diameter and curvature desired in the bent tube, so as to bend the tube while it is surrounded by and in contact with the walls of said curved passageway, and reducing the thickness of the material that is to form the arc of relatively short radius in the bent tube before said material enters into the curved passageway.

8. The continuous method of bending successive tubes which comprises confining a straight tube in a straight passageway, pushing the tube from said straight passageway and into a curved passageway conforming to the diameter and curvature desired in the bent tube, so as to bend the tube in said curved passageway, and thereafter pushing another tube through said passageway to discharge the first mentioned tube therefrom.

9. The method of bending tubes which comprises confining a straight tube in a straight passageway, pushing the tube from said straight passageway and entirely through a curved passageway conforming to the diameter and curvature desired in the bent tube, so as to bend the tube in said curved passageway, and contracting the tube as it passes from said straight passageway to said curved passageway by deflecting the material that is to form the arc of relatively large radius in the bent tube, thereby increasing the delivery of material to last mentioned portion of the tube, without increasing the delivery to the portion that is to form the arc having the shortest radius.

10. The method of bending tubes which comprises closely confining a straight tube in a straight passageway, pushing one end of said tube and thereby forcing the opposite end from said straight passageway and then through a curved passageway conforming to the diameter and curvature desired in the bent tube, contracting the tube as it passes from said straight passageway to said curved passageway by deflecting the material that is to form the arcs of relatively large radii in the bent tube, thereby increasing the thickness of said material at the entrance to said curved passageway, and at the same time reducing the thickness of the material that is to form the arcs of shorter radii, so as to produce a bent tube wherein the material is substantially uniform in thickness.

11. In a tube bending device, a bending die having a curved passageway conforming to the external diameter and curvature desired in the bent tube, and means whereby the tube is forced through said passageway, said passageway having an entrance of larger diameter, a portion of said entrance being offset to reduce the diameter of the tube as it passes into said curved passageway, and said offset being merged into the portion of said curved passageway having a relatively large radius.

12. In a tube bending device, a bending die having a curved passageway conforming to the external diameter and curvature desired in the bent tube, a mandrel in the entrance to said curved passageway, said mandrel being separated from the walls of said entrance to provide an annular space through which the tube passes to said curved passageway, and said space being relatively narrow at the part of the entrance leading to the part of said curved passageway having a relatively short radius, so as to reduce the thickness of the material to be bent to said short radius, and means for forcing the tube through said entrance and into said curved passageway.

13. In a tube bending device, a bending die having a curved passageway conforming to the external diameter and curvature desired in the bent tube, a mandrel in the entrance to said curved passageway, said mandrel being separated from the walls of said entrance to provide an annular space through which the tube passes to

said curved passageway, a portion of the mandrel at said annular space being eccentric to said entrance and so arranged that said annular space is widest at the part of the entrance leading to the arc of largest radius in said curved passageway and narrowest at the part of the entrance leading to the arc of shortest radius in said curved passageway, and means whereby the tube is forced through said annular space so as to conform to the shape and dimensions thereof before it is bent in said curved passageway.

14. In a tube bending device, a die having a curved passageway conforming to the external diameter and curvature desired in the bent tube, a cylindrical housing communicating with said curved passageway, said housing having a straight passageway conforming to the external diameter of the tube to be bent, the last mentioned diameter being larger than the first mentioned diameter, a mandrel in said straight passageway, a portion of the entrance to said curved passageway being offset to reduce the diameter of the tube as it passes into said curved passageway, said offset being at the part of the entrance leading to the portion of said curved passageway having a relatively large radius, a cylindrical ram confined between said housing and mandrel, and means whereby said ram is operated to force the tube into said curved passageway.

15. In a tube bending device, a die having a curved passageway conforming to the external diameter and curvature desired in the bent tube, a cylindrical housing communicating with said curved passageway, said housing having a straight passageway conforming to the external diameter of the tube to be bent, the last mentioned diameter being larger than the first mentioned diameter, a mandrel in said straight passageway, the diameter of said mandrel being approximately equal to the internal diameter of the tube to be bent, and a portion of said mandrel being extended into the entrance of said curved passageway, a portion of said entrance and the portion of the mandrel therein being offset to reduce the diameter of the tube as it passes into said curved passageway, said offset portions being at the part of the entrance leading to the portion of said curved passageway having a relatively large radius, a cylindrical ram confined between said housing and mandrel, the thickness and diameter of said ram being approximately equal to that of the tube to be bent, and means whereby said ram is operated to force the tube into said curved passageway.

16. The method of bending a series of separate tubes to produce continuous uniform bends extending from end to end of each tube which comprises feeding successive tubes into a curved passageway conforming to the diameter and curvature desired in the bent tubes, and transmitting longitudinal motion from a tube approaching the bending zone in said passageway to a tube undergoing the bending operation therein, so as to push the tubes entirely through said bending zone.

17. In a tube bending device, a bending die having a curved passageway conforming to the external diameter and curvature desired in the bent tube, and means whereby the entire tube is forced through and discharged from said passageway so as to form a continuous and uniform bend extending from end to end of the tube.

LESTER W. SNELL.