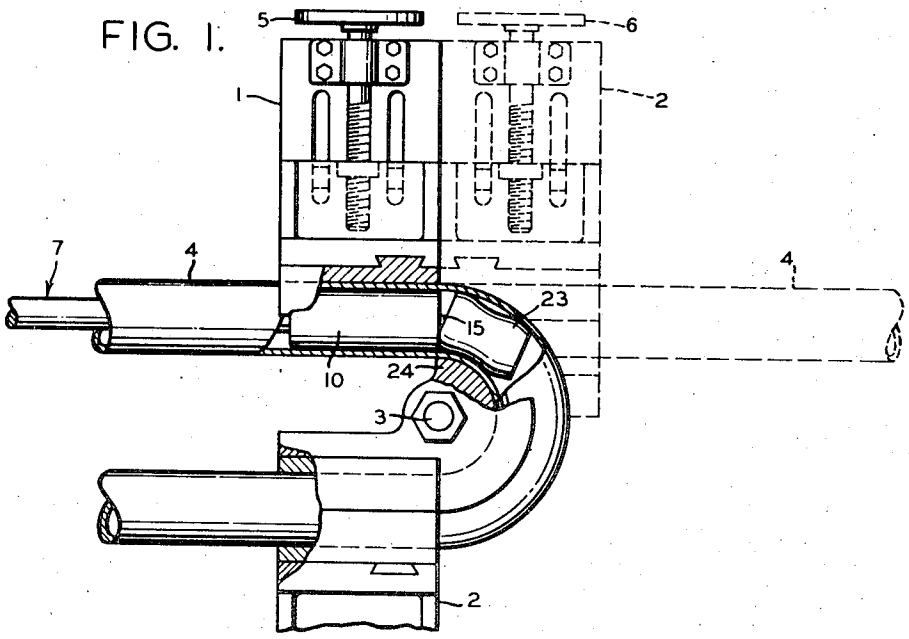
July 13, 1948. R. F. ATTRIDGE 2,444,907

TUBE-BENDING MANDREL

Filed May 3, 1945

FIG. 1.



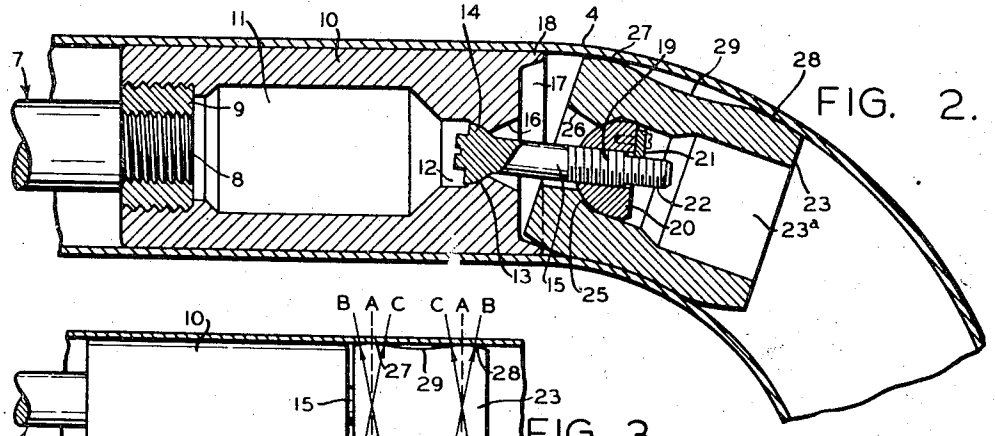


FIG. 2.

FIG. 3.

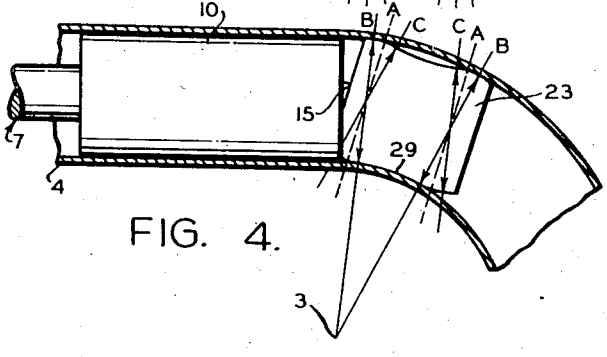


FIG. 4.

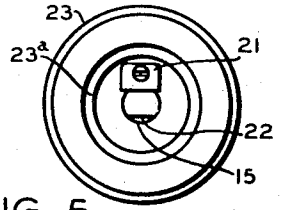


FIG. 5.

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TUBE-BENDING MANDREL

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3 Claims. (Cl. 153—63)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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My invention relates to a tube-bending mandrel. It has to do more particularly, with a mandrel adapted to be disposed within a tube and having a flexibly mounted bearing unit located where the tube is to be bent in order to maintain the cross-sectional shape of the tube during bending.

In bending thin-wall metal tubes at present, especially with short-radius bends, it is customary to pack the tube with sand or fill it with molten resin which is allowed to solidify in order to prevent collapse of the tube at the area of bending. In bending the tube, the tendency for the outer side of the tube to collapse is caused by the extreme tension developed in the material of the outer side during the bending operation. On the other or inner side there is a tendency for the material to ripple or wrinkle due to the extreme compression developed in the material of the inner side during the bending operation. The sand or resin used in an attempt to prevent collapse or wrinkling is removed after bending the tube. Obviously, this method is slow and cumbersome.

A mandrel has been designed and used in an attempt to maintain the cross-sectional shape of the tube at the bend. This mandrel includes a rod having a ball swiveled on its end. The ball is adapted to be disposed within the tube where it is bent to prevent collapse thereof. I have found that the ball does not keep the tube from flattening on the outer side of the bend, especially when the tube is being bent to a short radius. This is due to the fact that the ball does not afford a bearing surface of sufficient extent lengthwise of the bend. Consequently, the flattening of the tube on the outer side of the bend usually occurs beyond the ball. Furthermore, the single ball does not prevent the metal of the tube from rippling on the inner side of the bend, especially with short radius bends.

One of the objects of my invention is to provide a tube-bending mandrel having means associated therewith for effectively maintaining the cross-sectional shape of the tube at the bend.

Another object of my invention is to provide a mandrel of the type indicated having a bearing unit of such a nature that it will afford sufficient bearing surface to prevent flattening of the tube on the outer side of the bend.

Another object of my invention is to provide a mandrel of the type indicated wherein the bearing unit is of such a nature that it will iron out the ripples which tend to form on the inner side of the bend as the tube is being bent.

According to my invention, I provide a tube-

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bending mandrel which has a bearing unit swiveled on the end thereof. This bearing unit consists of a single member having a convex bearing surface at each end and an intermediate concave ironing surface.

The preferred embodiment of my invention is illustrated in the accompanying drawing wherein similar characters of reference designate corresponding parts and wherein:

Fig. 1 is a plan view, partly broken away, illustrating my tube-bending mandrel in position in a tube being bent.

Fig. 2 is a longitudinal sectional view illustrating in detail the bearing unit of my mandrel.

Fig. 3 is a longitudinal sectional view through the tube showing my mandrel in position in the tube before it is bent.

Fig. 4 is a similar view but showing the tube after it is bent.

Fig. 5 is an end view of the bearing member of my mandrel.

With reference to the drawing, I have illustrated in Fig. 1, clamping-units 1 and 2 of a tube-bending machine. These units 1 and 2 are of the usual type, the unit 1 being mounted in a fixed position and the unit 2 being mounted for swinging movement about a pivot point 3. This pivot point 3 is the center about which the tube 4 is to be bent. Initially, the clamping-unit 2 is disposed directly adjacent to the unit 1, as indicated by the dotted lines, so that these units are in side-by-side relationship. When the tube 4 is being bent, the unit 2 is swung about the point 3 and may, if desired, be swung through an angle of 180° to the full line position indicated in Fig. 1. The unit 1 and the unit 2 are provided with the usual tube-embracing dies which are opened and closed by handwheels 5 and 6, respectively.

A mandrel 7 is inserted in the tube 4 before it is bent. The mandrel is secured in a fixed position within tube 4, prior to bending the tube, by suitable means (not shown) attached to the bending machine and carries the bearing unit of my invention. Thus, the mandrel 7 includes a rod having its inner end 8 threaded into a bushing 9 which, in turn, is threaded into the end of a sleeve 10. This sleeve 10 is of the same diameter as the internal diameter of the tube 4 to be bent. The hollow chamber 11 within the sleeve communicates at its forward end with a reduced bore 12 in which is formed a ball seat 13. This ball seat 13 is adapted to receive a spherical or ball-like portion 14 formed on the inner end of a screw bolt 15. The bolt 15 is positioned by inserting it through the chamber 11, before positioning sleeve

10 on the mandrel rod, and passing it outwardly through the bore 12. The outer end of bore 12 is flared, as indicated at 16, to permit swinging of the bolt 15 in all directions relative to the sleeve 10. The forward end of the sleeve 10 is machined to form an annular recess 17 and thereby produce a peripheral flange 18.

The outer or forward end of the bolt 15 is threaded, as indicated at 19, and receives a threaded ball portion 20. The ball portion 20 is secured in the desired adjusted position on the bolt 15 by a lug 21 which is attached to the flat forward face of the ball portion. This lug 21 has a flat edge for cooperating with either of the flattened sides 22 (Fig. 5) of the outer end of bolt 15, to prevent rotation of ball portion 20 on the bolt.

The bolt 15 and ball portion 20 serve to connect the sleeve 10 flexibly to a bearing member 23. This bearing member is in the form of a sleeve having a bore 23a extending therethrough. The bore 23a has a ball seat 25 formed therein adjacent to its inner end for cooperating with the ball portion 20. The inner end of the bore, through which bolt 15 passes is flared, as indicated at 26, to permit free swinging of member 23 relative to bolt 15 in all directions. The recess 17 in the outer end of sleeve 10 will also facilitate this swinging action, preventing interference between the adjacent ends of members 10 and 23.

As shown best in Figs. 3 and 4, the bearing member 23 has convex bearing surfaces 27 and 28 formed on its outer surface adjacent to the ends thereof. Between these bearing surfaces is a concave ironing surface 29 which merges with both the surfaces 27 and 28. All of the surfaces 27, 28, and 29 extend completely around the member 23 which is of annular form. The diameter of the greatest transverse section of member 23, taken through either of the convex portions 27 or 28, will correspond substantially to the internal diameter of the tube 4 to be bent.

In bending the tube, the unit 2 is positioned in the dotted-line position indicated in Fig. 1 and the mandrel 7 is anchored in position on the machine. The mandrel will carry one of my bearing members 23 which will have convex portions 27 and 28 that have maximum outside diameters corresponding substantially to that of the internal curvature of the tube 4 to be bent. The sleeve 10, carried by the mandrel, also has an outside diameter corresponding to the internal diameter of the tube 4. The tube 4 will be in the straight-line position indicated by the dotted lines in Fig. 1. The mandrel will be so positioned that the outer or forward end of sleeve 10 will be substantially in alignment with the center of pivot 3.

The machine is now operated to swing the unit 2 around the pivot 3. In the example shown, the unit 2 is swung through 180° but it is to be understood that it may be swung through any selected angle to bend the tube to any desired extent. During the bending of the tube, the bolt 15 is free to rock relative to sleeve 10, due to the ball and socket connection 13—14. Also the member 23 will be free to rock relative to the bolt 15, due to the ball and socket connection 20—25. Thus, the member 23 will readily rock and move with the tube as it is being bent and it is also free to rotate about its axis. As the member 23 rocks, its inner end adjacent the inner side of the bend of the tube will swing into the recess 17, as indicated in Fig. 2.

As the tube is bent, the outer side of the bend

of the tube bears against the convex surfaces 27 and 28. These convex surfaces 27 and 28 are spaced apart longitudinally a considerable distance so that bearing surfaces will be provided at widely spaced longitudinal intervals. Furthermore, the surface 28 will be a considerable distance from the forward end of sleeve 10. Thus, flattening of the outer side of the bend of the tube, which tends to result from the tension created in the material, will be precluded.

As illustrated in Figs. 4 and 5, during the bending of the tube, the line of bearing contact between each of the surfaces 27 and 28 and that of the internal surface of the tube will shift longitudinally of member 23. The original line of contact between each of these convex surfaces and the tube is indicated by the broken line A in Figs. 3 and 4. As the tube is bent, the lines of contact shift through successive positions to the positions indicated by the full line B. Due to the fact that the member 23 is free to rotate on its axis, the contact between the surfaces 27 and 28 and the surface of the tube may occur on either side of line A, depending upon whether the contact is with the outer side or inner side of the bend, through a distance equal to the distance between lines A and B. Since the contact may be at any point between lines A and B and at any point between line A and the same distance on the opposite side thereof, that is, to the line C, it is important that the radius of curvature, longitudinally of member 23, of the surface extending from B to C be the same as that of the outer side of the bend of the tube. Thus, the radius of curvature of the surfaces 27 and 28, longitudinally of member 23, will correspond to that of the outer side of the bend of the tube. The center of the curvature of such surfaces, longitudinally of member 23, will be at the center of pivot 3, about which the tube is to be bent. The center of curvature of such surfaces, transversely of member 23, will be at the center of the tube. Thus, the convex surfaces 27 and 28 are toric surfaces.

The concave surface 29 is also a toric surface and will have a radius of curvature, longitudinally of member 23, corresponding to that of the inner side of the bend of the tube, with its center at the center of the point 3, as indicated in Fig. 4. The center of the curvature of such surface, transversely of member 23, will be at the center of the tube.

As the tube bends, the material thereof tends to ripple or wrinkle along the inner side of the bend, where it contacts with member 23, due to the compression of the material. However, the surface 29 will serve as an ironing surface which will iron out the wrinkles by keeping the material in firm contact with the curved portion 24 of the die unit 2. Such portion 24 will be of a radius of curvature corresponding to that to be produced on the throat or inner side of the bend.

After the tube is bent as indicated, the handwheels 5 and 6 are actuated to operate the dies to release the tube. Then it is merely necessary to grasp the curved portion of the tube and pull the tube out of the dies and off the mandrel.

It will be apparent from the above description that I have provided a bearing unit on a tube-bending mandrel having a number of advantages. The bearing unit will provide sufficient surface, properly located, to prevent flattening of the tube on the outer side of the bend. The bearing unit will iron out the throat of the tube and prevent wrinkling thereof. This will eliminate danger of

the die portion 24 cutting into the throat. Furthermore, it will prevent chattering or vibration of the machine and will relieve strain on the machine.

Various other advantages will be apparent.

The invention described herein may be manufactured and used by or for the Government of the United States of America for government purposes without the payment of any royalty thereon or therefor.

Having thus described my invention, what I claim is:

1. In a mandrel for bending a tube, a bearing member attached to the end of the mandrel by a universal connection and adapted to be located within said tube where it is to be bent, said bearing member having a plurality of convex bearing portions formed thereon at longitudinally spaced intervals and a concave ironing portion disposed therebetween, the surfaces of said bearing portions being curved longitudinally of said bearing member the same as the curvature of the outer side of the bend to be formed in the tube and said concave ironing surface being curved longitudinally with the same radius of curvature as that of the inner side of the bend to be formed in the tube, the surface of said ironing portion merging with the surfaces of said bearing portions, said bearing member being of annular cross section so that it will fit closely within the tube to be bent.

2. In a mandrel for bending a tube, a bearing member attached to the end of the mandrel and adapted to be located within said tube where it is to be bent, said bearing member having a plurality of convex bearing portions formed thereon at longitudinally spaced intervals and a concave ironing portion disposed therebetween, the surfaces of said bearing portions being curved longitudinally of said bearing member the same as the curvature of the outer side of the bend to be formed in the tube.

3. In a mandrel for bending a tube, a bearing member attached to the end of the mandrel and adapted to be located within said tube where it is to be bent, said bearing member having a plurality of convex bearing portions formed thereon at longitudinally spaced intervals and a concave ironing portion disposed therebetween, said concave ironing portion merging with the surfaces of said bearing portions and being curved longitudinally with the same radius of curvature as that of the inner side of the bend to be formed in the tube.

RICHARD F. ATTRIDGE.

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