May 1, 1934. J. H. WILLIAMS 1,956,604

METHOD AND MEANS FOR MAKING TUBE BENDS

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Fig.1

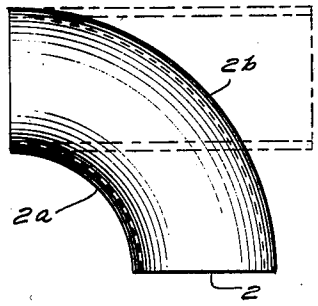


Fig.2

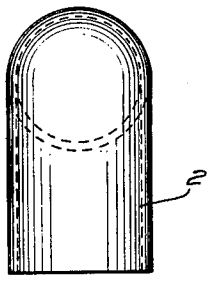


Fig.3

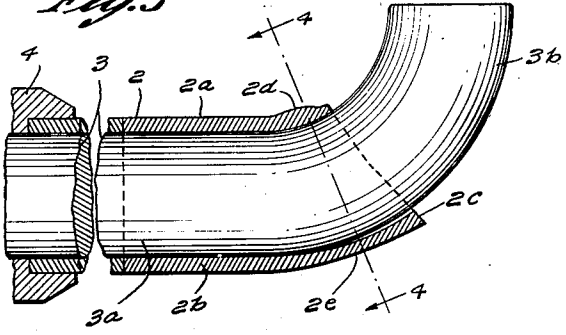


Fig.4

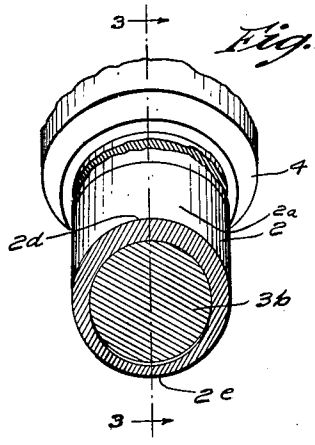


Fig.5

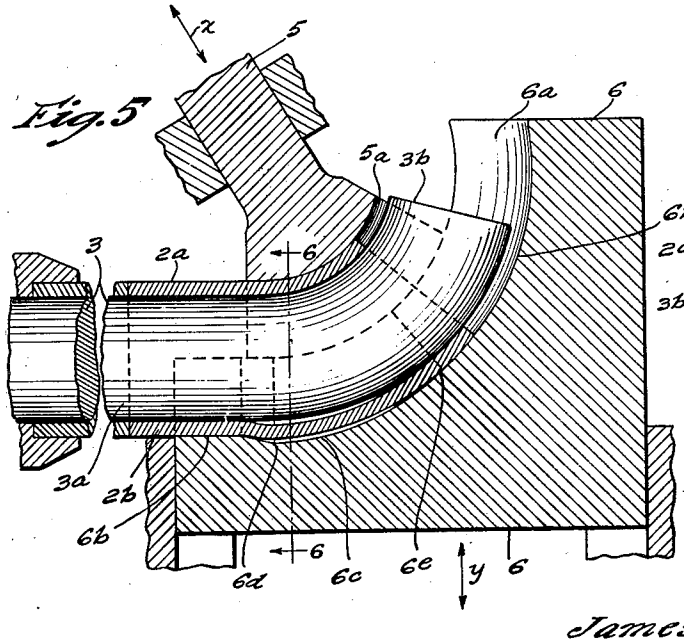
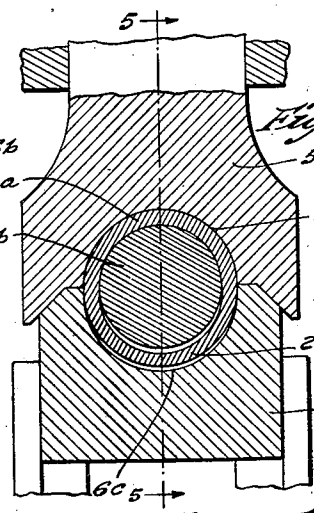


Fig.6



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METHOD AND MEANS FOR MAKING TUBE BENDS

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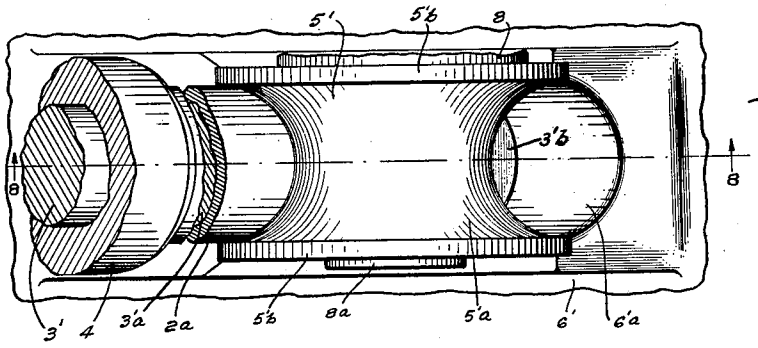


Fig. 7

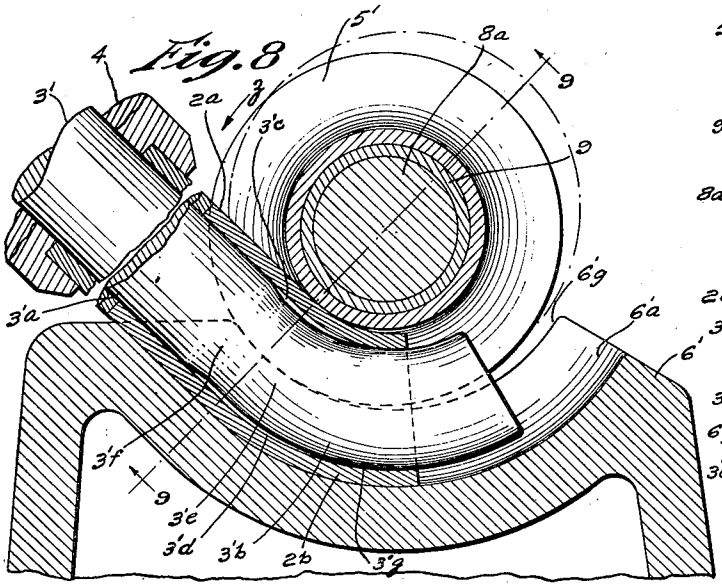


Fig. 8

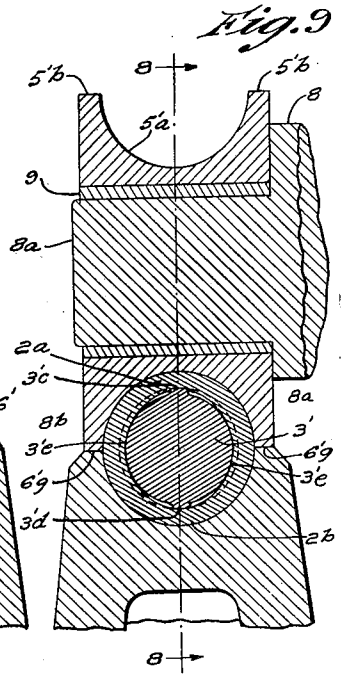


Fig. 9

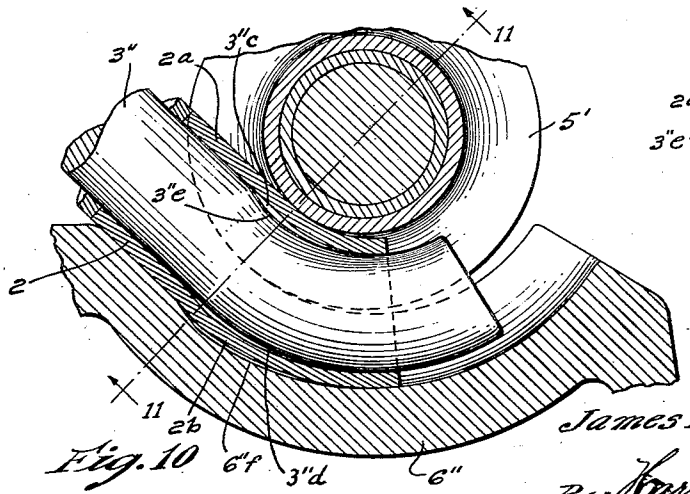


Fig. 10

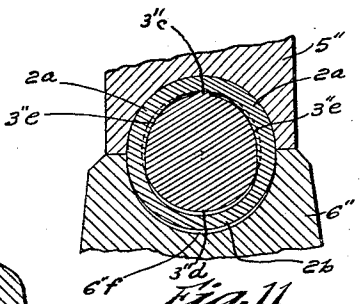


Fig. 11

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UNITED STATES PATENT OFFICE

1,956,604

METHOD AND MEANS FOR MAKING TUBE BENDS

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Application January 20, 1932, Serial No. 587,626

33 Claims. (Cl. 153—32)

This invention relates to improvements in methods and means for making tube bends. More especially it has to do with the production of bends having a controlled wall thickness.

It is a major object of this invention to produce bends of relatively short radius from tubes of ordinary stock sizes and to effect and control the distribution of the material in the tube wall to the end that the wall of the finished bend will be of desired thickness.

It is a further object to produce bends of controlled wall thickness by applying a vibratory force externally to a tube as it progresses along a mandrel having a curved portion corresponding to the desired curvature of the bend.

In carrying out the principles of my invention I employ a mandrel having a portion, curved as aforesaid, from which the bend is discharged in its bent shape. Coacting with this mandrel are externally positioned elements, one or both of which is movable intermittently to impart a forging pressure to the tube. These elements, together with the mandrel, effect both the bending of the tube and the control of the wall thickness of the bend.

In the accompanying drawings I have shown somewhat diagrammatically how my invention may be practiced and means for so doing but these showings are merely illustrative and it is intended that the patent shall cover by suitable expression in the appended claims whatever features of patentable novelty exist in the invention disclosed.

In the drawings:

Figures 1 and 2 are side and end views respectively, showing in dot and dash lines a straight tube, and in full lines a bend made therefrom in accordance with this invention;

Figure 3 is an elevation in section as on line 3—3 of Figure 4, which is intended to show what the effect is of pushing a tube along the mandrel in the practice of my invention;

Figure 4 is an elevation in section on line 4—4 of Figure 3;

Figures 5 and 6 are elevations, similar to Figures 3 and 4, respectively, but showing the combined effects of the mandrel, and external formers;

Figure 7 is a plan view of the same group of elements as shown in Figures 5 and 6 but embodying the preferred forms thereof;

Figure 8 is an elevation in section as on lines 8—8 of Figures 7 and 9;

Figure 9 is an elevation in section as on line 9—9 of Figure 8;

Figure 10 is an elevation showing modified forms of the elements; and

Figure 11 is a cross sectional view thereof as on line 11—11 of Figure 10.

Referring now more particularly to the drawings there is shown in full lines in Figures 1 and 2, a tube 2, bent in accordance with the principles of my invention. This bend has the same wall thickness as the straight tube (seen in dot and dash outline) from which it was formed but this is merely illustrative because it is possible in the practice of my invention to have the inner wall 2*a* of the bend thicker than the outer wall 2*b*, or vice versa, it being a feature of the invention to control the distribution of the tube material and consequent wall thickness as desired.

It should be stated initially that in what follows it must be assumed that the material of the tube when operated upon is in a ductile or malleable condition, this being either an inherent characteristic of the metal (copper, lead or the like) or a state produced by proper heating. And it should be also borne in mind that if the tubing be of such metal as requires heating, proper consideration must be given to the variations in sizes which occur because of expansion or contraction.

One of the elements which I employ in carrying out by invention is a cylindrical mandrel 3 having a straight portion 3*a* and a curved portion 3*b* whose radius of curvature is that of the desired bend. If the finished bend is to have approximately the same diametric dimensions as the tube operated upon, this mandrel is substantially the same size as the inside of the tube, the latter being movable along the straight portion 3*a* without undue friction. Any suitable propelling means may be employed which will exert a push on the end of the tube, such means being represented by pusher 4.

In Figures 3 and 4 is shown what I deem to be the effect on a tube if it is merely pushed along the mandrel. The moving force exerted by the pusher 4 acts upon one end of the tube 2 in directions parallel to its center line and tends to move all the material of the wall straight ahead. When the leading end 2*c* of the tube encounters the curved portion 3*b* of the mandrel, the inner wall 2*a* of the tube, or wall nearer the axis of curvature is urged inward while the outer wall 2*b* which is remote from said axis still tends to move straight forward. The resulting effect is a slight enlargement of the tube end 2*c* with the outer wall retaining its initial thickness and the inner wall thinning slightly immediately adjacent its leading edge. Very

promptly, however, the resistance exerted upon the inner wall of the tube by the inner curved face of the mandrel acts with retarding effect on the forward movement of this inner wall and causes it to become upset or thickened as at 2*d*. When this occurs, the strength of the inner wall of the tube becomes greater and partly overcomes the tendency of the outer wall to move straight forward, thereby causing the latter to bend inward and become curved. This deflection of the outer wall coupled with its own tendency to move straight forward results in an elongation of this wall and consequent thinning thereof as at 2*e*. If the tube is thus pushed fully around the curved portion 3*b* of the mandrel, the wall of the completed bend will be thicker on the side of the bend having the shorter radii of curvature and thinner on the side of the bend having the greater radii of curvature than the wall of the original tube; and the bend will have an enlarged cross section somewhat analogous in shape to the longitudinal section of an egg shell.

The above described action on the tube by the mandrel is taken advantage of in my invention and the tendency of the material to continue straight forward and around the curved portion of the mandrel is augmented by the coaction of elements adapted to impose force externally on the tube during its progress along the mandrel.

One of these elements, hereinafter called formers, is positioned to act upon the part 2*a* of the tube which forms the inner wall of the bend, or wall having the smaller radius of curvature and the other element acts upon that part 2*b* of the tube which forms the outer wall of the bend, or wall having the greater radius of curvature. As shown in Figures 5 and 6, the inner former 5 is represented as being movable toward and from the former in the directions indicated by the double-ended arrow *x* and the outer former 6 is similarly movable in the directions represented by the arrow *y*. Suitable means (not shown) may be provided for moving these formers and for determining the end of their respective travel toward the mandrel. As shown their limits of movement toward the mandrel are such that the bend will have practically uniform thickness of wall throughout, but if these limits were to be changed to permit the inner former to move closer and the outer former less near to the mandrel than the inner wall of the bend would be thinner than the outer wall thereof, and reversely, if the outer former were to move closer to the anvil than the inner former.

In Figures 5 and 6 the working face 5*a* of the inner former 5 is shaped parallel to the surface of the section of the mandrel toward which it moves and the working face 6*a* of the outer former is, at its end portions 6*b*, similarly parallel to the surface of the mandrel. Between these end portions the working face 6*a* is provided with a recess 6*c* which begins very abruptly, as at 6*d*, near the entrance end and then gradually lessens in the direction of tube movement to finally merge at some point, such as 6*e*, into parallelism with the surface of the mandrel.

In operation, the tube is moved along the mandrel with consequent thickening of the inner side as heretofore described (see 2*d* in Figure 3). As the inner former moves toward the tube the portion of the latter which has been thickened as aforesaid is thinned by the blow of the former. This forging action causes the material of the tube to move toward the outer side of the mandrel and causes the outer wall 2*b* to move into the space provided by the recess 6*c* as seen in Figure 5. As the forward movement of the tube continues, this outer wall 2*b* is moved back toward the mandrel by the outer former 6. It is understood, of course, that the movements of the latter are simultaneous with those of the inner former 5 but opposite in direction. Accordingly as the tube moves forward, the combined actions of the tube, mandrel, and formers effect a transfer or distribution of the material which results in a bend of the desired curvature and controlled wall thickness.

In Figures 7, 8 and 9 the preferred form and shape of elements is disclosed. The outer former 6′ is here shown as stationary and has a groove 6′*a* throughout its entire length which is of uniform cross section and corresponds in shape to the outer wall of the bend. Here the mandrel 3′ differs from that previously described by having its lateral sides recessed to provide the desired clearance for the ready transfer of the tube material. The mandrel at its innermost and outermost faces 3′*c* and 3′*d* respectively, is unchanged, but near the end of the straight portion 3′*a*, and partly along the curved portion 3′*b* the sides are rather abruptly recessed as at 3′*f*, and then gradually restored to full size at a point, such as 3′*g*, farther along on the curved portion, from whence the mandrel continues as a ring.

The inner former 5′, shown in Figures 7, 8 and 9, is illustrated as a roller mounted eccentrically on a rotating shaft 8, with a suitable bearing 9 interposed between them. As the shaft and its eccentric crank 8*a* rotate about the axis of the shaft, the outer edges 5′*b* of the roller ride on the curved edges 6′*g* of the stationary former with the curved or grooved face 5′*a* of the roller acting on the tube. This movement of the roller has the same effect upon the tube as does the reciprocating inner former 5 of Figures 5 and 6. The roller shaft may be rotated about its axis in either direction, but I prefer to turn it in the direction indicated by the arrow *z*.

As the roller moves toward the tube, its grooved face 5′*a* encounters the thickened portion formed by the action of the unchanged inner face 3′*c* of the mandrel. Between this latter face 3′*c* and the roller the tube is thinned and the material which accounted for the previous thickening is forced around the mandrel on both sides. Since the face 6′*a* of the groove in the former corresponds to the outer wall of the bend, the tube does not leave the outer unchanged face 3′*d* of the mandrel, as it does when a former 6 like that of Figure 5 is used, but continues along in contact therewith. The transferred material causes the lateral sides of the tube to be thickened where the recesses 3′*e* of the mandrel are greatest, but this thickness is gradually reduced as the tube continues on past the recess, and the final distribution results in a wall of desired thickness.

It is to be noted that the curved portion 3′*b* of the mandrel shown in Figures 7 to 9 is shortened and is less than a quarter turn. This has been found suitable because the distribution of the material and shaping of the bend begins very promptly after the tube encounters the curved portion and is completed shortly after the recesses are passed.

The modification illustrated in Figures 10 and 11 is characterized by the clearance being provided by both the mandrel and a former. The innermost face 3″*c* and the outermost face 3″*d*

are unchanged but the mandrel is recessed on both sides as at 3''*e* similar to the upper half of the mandrel 3'' of Figures 7 to 9. Instead of continuing nearly around the mandrel the recess 3''*e* on each side tapers circumferentially and merges into the circular surface 3''*d*. The outer former 6'' is recessed at 6''*f* as was the former 6, Figure 5, but not to as great a depth because when the thickened part of the tube is acted upon by the roller 5', the material that is transferred around the mandrel causes some thickening of the wall 2*a* which is opposite the recesses 3''*e*. Consequently the outer wall 2*b* moves a less distance from the outer side of the mandrel. As the tube is fed forward and passes beyond the recess, it is shaped by the elements to the desired bend.

As regards the speed of action of the formers, it is dependent in part upon the rate of travel of the tube. If the latter is moved continuously, then the strokes of the reciprocating formers or the rotations of the roller should be very rapid. If the tube is moved intermittently, the forging action of the formers may be timed to occur when the tube is at rest. This vibratory action of the formers or intermittent application of force externally to the tube is important because there is thus provided a period of relief, as it were, when the tube can be fed forward free of intimate contact with the formers and because it enables the mandrel to effect its thickening influence on the tube.

Although I have shown only a 90° bend in the drawings it is evident from the foregoing description that a bend of lesser or greater arc may be made in precisely the same manner, and indeed the principles of the invention may be applied to the production of a continuous bend, it being only necessary to so shape the formers and mandrel as to permit the bent tube to pass out and by them as the bending continues.

I claim:

1. The method of making a tube bend which comprises moving a tube having a uniformly thick wall along a curved mandrel and intermittently applying force externally to the tube to control its wall thickness.

2. The method of making a tube bend which comprises moving a tube having a uniformly thick wall along a curved mandrel and between coacting external formers adapted to apply pressure intermittently to the tube for controlling the wall thickness thereof.

3. The method of making a tube bend which consists in moving a tube having a uniformly thick wall along a curved mandrel, applying a vibratory force externally to the inner wall of the bend and applying a restraining force externally to the outer wall of the bend.

4. The method of making a tube bend which consists in moving a tube having a uniformly thick wall along a curved mandrel, applying a vibratory force externally to the outer wall of the bend and applying a restraining force externally to the inner wall of the bend.

5. The method of making a tube bend which comprises moving a tube having a uniformly thick wall along a curved mandrel and thereby thickening the wall of the tube on the side toward the axis of curvature followed by a thinning of the thickened portion and distribution of the material to produce the desired wall thickness.

6. The method of making a tube bend which comprises moving a tube along a curved mandrel to cause bending of the tube and initial thickening of the wall thereof at the inner side of the bend, applying force externally to the tube to thin said thickened wall and effect distribution of the wall material, and guiding said distribution to produce the desired shape of wall.

7. The method of making a tube bend which comprises moving a tube along a cylindrical mandrel having its end curved to the radius of curvature of the desired bend, applying force to the inner side of the bend to effect transfer of the material toward the outer side, and controlling the distribution of the material thus transferred to produce a desired wall thickness.

8. The method of making a tube bend which comprises moving a tube having a uniformly thick wall along a curved mandrel and during the course of said movement intermittently applying external force to the tube to effect controlled distribution of the material thereof.

9. The method of making a tube bend which comprises moving a tube having a uniformly thick wall along a curved mandrel and between external formers, and during the course of said movement first thickening a portion of the tube wall and then thinning the said thickening portion.

10. In the method of making a tube bend by moving a tube along a curved mandrel and between external formers, the steps of first thickening and then thinning that part of the tube wall which forms the inner portion of the bend.

11. In the method of making a tube bend by moving a tube along a curved mandrel and between external formers, the steps of first thickening the wall forming the inner side of the bend, then thinning said wall and effecting displacement of the wall forming the outer side of the bend, followed by a replacement of the last said wall in predetermined relation to the mandrel.

12. In the method of making a tube bend by moving a tube along a curved mandrel and between external formers, the steps of first thickening the wall forming the inner side of the bend, then thinning said wall and thickening the walls forming the lateral sides of the bend, followed by a thinning of the last said walls to effect transfer of the material to the wall forming the outer side of the bend.

13. In the method of making a tube bend by moving a tube along a curved mandrel and between external formers, the steps of first thickening the wall forming the inner side of the bend, then thinning said wall and causing the material thereof to thicken the walls forming the lateral sides of the bend and effect displacement of the wall forming the outer side of the bend, followed by a thinning of the last said thickened walls and a replacement of the outer wall in predetermined relation to the mandrel.

14. The method of making a tube bend which comprises moving a tube along a curved mandrel and between external formers, and during the course of said movement changing the cross-sectional area of the tube and then again changing said area in a reverse manner.

15. In the method of making a tube bend by moving a tube along a curved mandrel and between external formers, the steps which comprise transferring material from the wall which forms the inner side of the bend to the walls forming the lateral sides thereof whereby the latter are thickened and then transferring material from said thickened sides to the wall forming the outer side of the bend.

16. In the method of making a tube bend by

moving a tube along a curved mandrel and between external formers, the steps which comprise increasing the internal cross-sectional area of the tube and then restoring said area to its original size.

17. The method of making a tube bend which comprises moving a tube along a curved mandrel and between external formers, and during the course of said movement reducing the internal cross-sectional area of the tube and then increasing the said reduced area.

18. The method of making tube bends which comprises moving a tube having a uniformly thick wall along a curved mandrel of changing cross-sectional area, and applying force externally to the tube to effect a flow of the wall material from that portion of the tube which forms the inner curve of the bend toward that portion of the tube which forms the outer curve of the bend; the said transfer being accomplished in the region of said changing cross-section.

19. Apparatus for making tube bends with walls of controlled thickness, comprising a mandrel having its end curved to the desired radius of curvature; means for moving a tube along said mandrel and off its curved end; and coacting formers arranged to apply force to the tube during its progress along the mandrel whereby the wall thickness of the bend is controlled.

20. Apparatus for making tube bends with walls of controlled thickness, comprising a mandrel having a portion curved to the desired radius of curvature; means for moving a tube along said mandrel; a former adapted to be positioned with its working face spaced from the surface of said mandrel a distance equal to the desired wall thickness of the bend; and another former adapted to be moved toward and from said mandrel for applying force to said tube to effect distribution of material in the tube wall, whereby the wall thickness of the bend is controlled.

21. Apparatus for making tube bends with walls of controlled thickness, comprising a curved mandrel having a recess; means for moving a tube along said mandrel; and coacting formers arranged and constructed to apply force externally to said tube during its progress along said mandrel.

22. Apparatus for making tube bends with walls of controlled thickness, comprising a curved mandrel having a recess; means for moving a tube along said mandrel; and coacting formers arranged and constructed to apply force externally to said tube during its progress along said mandrel; the said recess lessening in the direction of movement of the tube whereby the thickened wall is subsequently thinned.

23. Apparatus for making tube bends with walls of controlled thickness, comprising a curved mandrel; means for moving a tube along said mandrel; a former having a working face with end portions adapted to be positioned parallel to the face of the mandrel and with a recess in said face between said portions; and another former adapted to apply force to a tube as it progresses along said mandrel and cause the wall thereof to be forced into said recess; the said recess lessening in the direction of movement of the tube whereby the said wall is forced back toward said mandrel.

24. Apparatus for making tube bends with walls of controlled thickness, comprising a mandrel having a curved portion corresponding to the curvature of the desired bend and having a recess in its face near the beginning of the curved portion; means for moving a tube along said mandrel; a former adapted to impart force externally to a tube as it progresses along said mandrel and effect at the region of said recess displacement of material from the side of the tube nearer the axis of curvature and emplacement of material on the side of the tube remote from said axis; and means adjacent said remote side for controlling the thickness thereof.

25. Apparatus for making tube bends with walls of controlled thickness, comprising a curved mandrel having a recess in its face; means for moving a tube along said mandrel; a former on the side of said mandrel remote from the axis of curvature having a working face and a recess therein; and means for applying force externally to said tube as it progresses along said mandrel to effect at the region of said recesses displacement of material from the side of the tube nearer the axis of curvature and emplacement of material on the side of the tube remote from said axis.

26. Apparatus for making tube bends with walls of controlled trickness, comprising a mandrel having a curved portion corresponding to the curvature of the desired bend; means for moving a tube along said mandrel; a former adapted to be positioned with respect to the side of the mandrel adjacent the axis of curvature to provide a space therebetween corresponding to the inner part of the bend; and another former adapted to be positioned with respect to the side of the mandrel remote from the axis of curvature to provide a space therebetween corresponding to the outer part of the bend; the said formers being relatively movable to apply force externally to a tube as it progresses along the mandrel and thereby effect controlled distribution of material throughout the space defined by said mandrel and said formers.

27. Apparatus for making tube bends with walls of controlled thickness, comprising a curved mandrel; a stationary external former adjacent the side of the mandrel having the greater radius of curvature; and a movable external former adjacent the side of the mandrel having the lesser radius of curvature; both formers having working faces corresponding to the external surface of the bend and there being a recess in the said face of the stationary former.

28. Apparatus for making tube bends with walls of controlled thickness, comprising a mandrel having a curved portion; a stationary external former adjacent the outer side of said portion; and a movable external former adjacent the inner side of said portion; the mandrel having a recess in its surface near the beginning of said curved portion.

29. Apparatus for making tube bends with walls of controlled thickness, comprising a mandrel having a curved portion; a stationary external former adjacent the outer side of said portion; and a movable external former adjacent the inner side of said portion; the mandrel having a recess in each of its lateral faces near the beginning of said curved portion.

30. Apparatus for making tube bends with walls of controlled thickness, comprising a mandrel having a curved portion; a stationary external former adjacent the outer side of said portion; and a movable external former adjacent the inner side of said portion; the last said former being a roller mounted to rotate eccentrically about an axis.

31. Apparatus for making tube bends with walls of controlled thickness, comprising a curved

mandrel having recesses on its surface arranged to permit movement of the material from the side of the bend nearer the axis of curvature toward the side of the bend remote from said axis as the tube progresses along the mandrel; means for effecting said progress of the tube; means for pressing the wall of the tube which forms the said nearer side against the mandrel and thereby effect said movement of the material; and means controlling the extent of said movement.

32. Apparatus for making tube bends with walls of controlled thickness, comprising coacting elements forming a curved annular passageway having a recess in its wall, and means for moving a tube through said passageway.

33. Apparatus for making tube bends with walls of controlled thickness, comprising coacting elements forming a curved annular passageway having a recess in its wall, and means for moving a tube through said passageway and past said recess to effect distribution of the wall material thereof.

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