Dec. 20, 1932. L. W. SNELL 1,891,338

METHOD OF AND MEANS FOR BENDING TUBES

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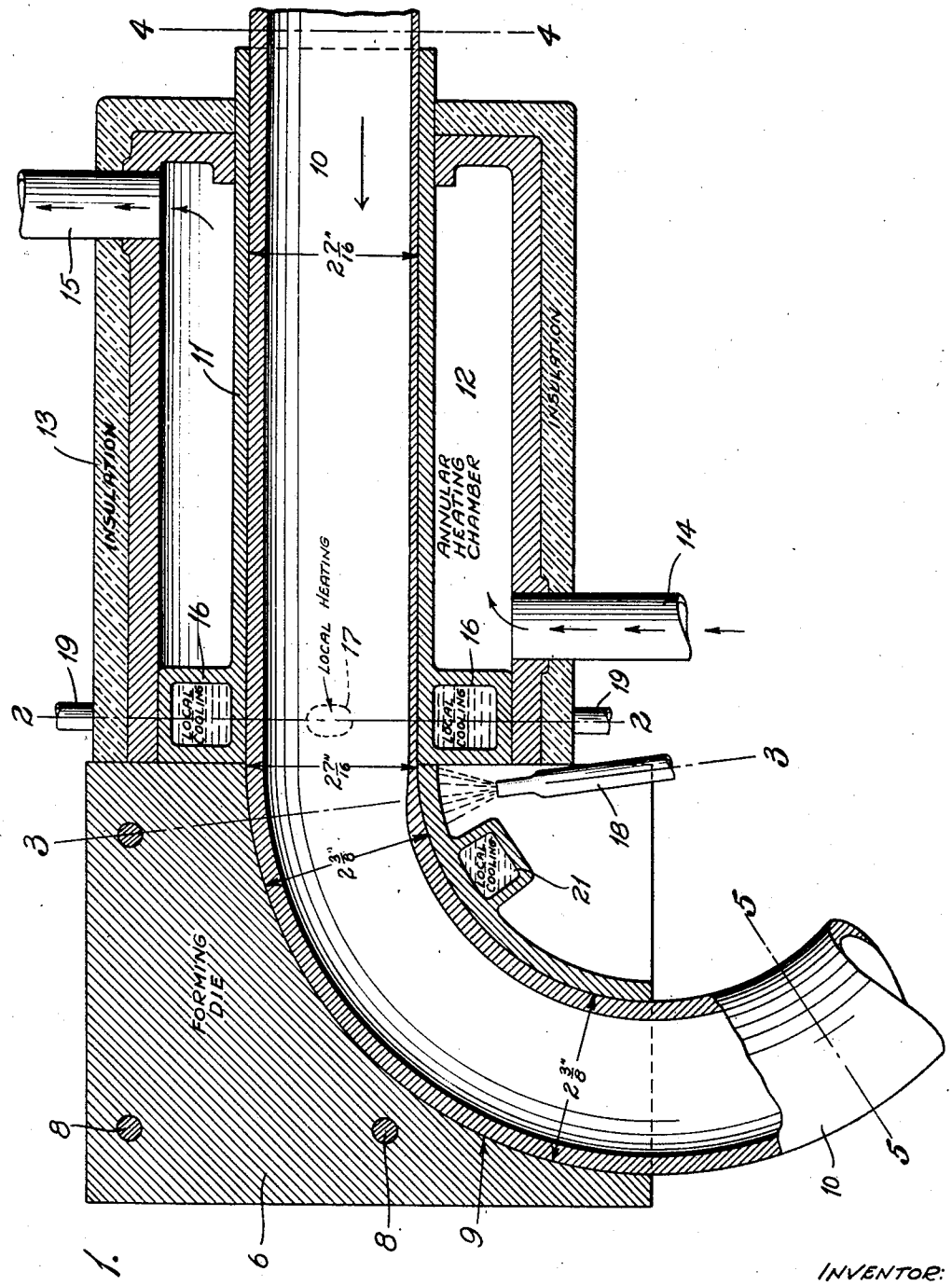


Fig. 1.

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Fig. 3.

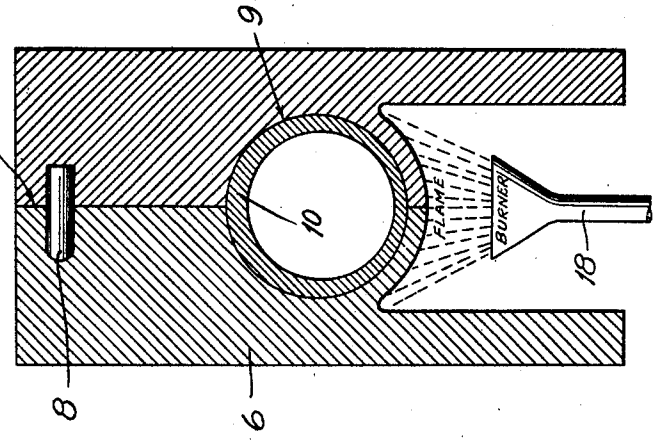


Fig. 5.

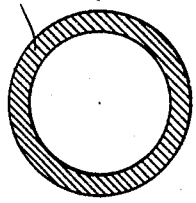


Fig. 2.

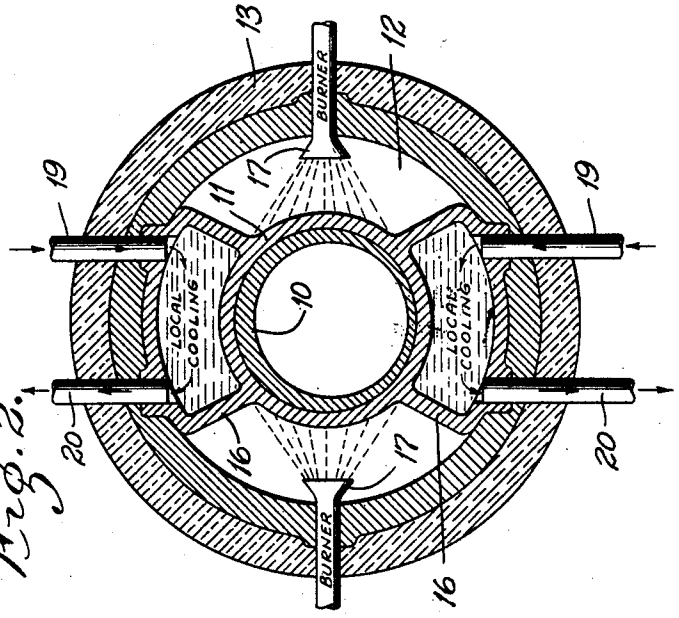
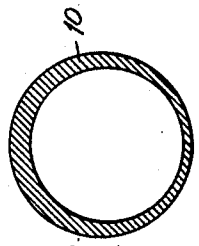


Fig. 4.



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METHOD OF AND MEANS FOR BENDING TUBES

Application filed February 9, 1931. Serial No. 514,348.

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, elbows with end portions at various angles to each other, and also in making long continuous coils of tubing.

One of the objects is to accurately bend the tubes to a predetermined curvature, while preventing undesirable variations in the thickness of the tube walls. A further object is to produce a strong and simple bent tube having a predetermined thickness which may be uniform throughout the tube.

In performing an ordinary simple bending operation, a metal tube is stretched at the arc of greatest radius, which is termed 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 in this old method 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.

In the preferred form of the present invention, the metal is of course subjected to varying changes in thickness during the bending operation, but these variations are so controlled that the bent tube is free from objectionable thick and thin portions. The tube is bent at high temperatures, and I preferably subject it to different temperatures, so as to control the changes in thickness and at the same time prevent objectionable distortion of the tube.

An important object is to accomplish all of these results in a very simple and inexpensive manner by merely pushing a continuous tube through a curved passageway without using cores or the like inside of the tube.

The simple pushing operation imparts a longitudinal motion to the tube and results in an upsetting action which causes a predetermined varying change in the thickness of the metal, thereby producing the desired thickness in the finished tube.

I will hereafter show how this can be accomplished without decreasing the thickness in any part of the tube during the bending operation. The upsetting operation causes a varying increase in thickness around the circumference of the tube, so the bending can be accomplished without undesirable stretching, or thinning, of the metal at the curve of largest radius in the bend.

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 section illustrating a bending system embodying the features of this invention,

Fig. 2 is a section on the line 2—2 in Fig. 1,

Fig. 3 is a section on the line 3—3 in Fig. 1,

Fig. 4 is a transverse section on the line 4—4 in Fig. 1, showing variations in the thickness of the tube to be bent, and

Fig. 5 is a section on the line 5—5 in Fig. 1 showing the uniform thickness of the bent tube.

I will now describe the apparatus which I have shown to illustrate one form of the invention.

6 designates a forming die made of two sections contacting with each other at the line 7 in Fig. 3, and alined by means of dowel pins 8, said die having a curved passageway 9 conforming to the curvature of the bent tube.

10 indicates a tube adapted to be forced through the passageway 9. In the preferred form of the invention, the first step consists in forming a continuous straight tube, of any desired length, having the cross-section shown by Fig. 4. This long straight tube has a relatively thick portion which extends longitudinally of the tube, and the thickness gradually decreases circumferentially to a

point diametrically opposite said thick portion.

In other words, as shown in Fig. 4, the thickest portion of the tube to be bent lies directly opposite the thinnest portion, and there is a gradual change in the thickness between these portions, the inner face of the tube being eccentric to the outer face.

After this tube has been forced through the curved passageway 9, it is curved as shown at the left of Fig. 1, and it has a uniform thickness as shown in Fig. 5. This uniformity in thickness is due partly to the initial non-uniformity in thickness, and partly to the upsetting operation which occurs when the tube is subjected to the different temperature conditions hereinafter described.

11 designates a stationary guide tube (Fig. 1) extending from the entrance of the curved passageway 9 and conforming to the outer face of the straight portion of the tube 10. A heating chamber 12, surrounding the guide tube 11, may be covered with insulation and provided with inlet and exhaust pipes 14 and 15 for the admission and discharge of the heating medium, which may be highly heated gases or other suitable heating agent. The heat transmitted from this chamber 12 may be great enough to subject the tube 10 to a uniform red heat while it passes through the guide tube 11.

The thickest portion of the tube 10 passes from the guide tube 11 to the curve of largest radius in the curved passageway 9, as shown in Fig. 1, while the thinnest portion of said tube 10 passes to the curve of shortest radius in said curved passageway.

As an illustration of one means to produce the variations in the temperature of the metal undergoing the bending operation, I have shown local coolers 16 and local heaters 17 at the entrance to the curved passageway, and a local heater 18 in the form of a burner projecting a flame onto the portion of the die 6 at points adjacent to the bending zone of the relatively thin portion of the tube 10. However, it is to be understood that the invention is not limited to these details.

The local coolers 16 lie at the thickest and thinnest portions of the tube to be bent, while the local heaters 17 are in the form of burners which project flames onto the guide tube 11 at points between said local coolers 16. As shown by Fig. 2, the local coolers 16 may be provided with inlet and discharge pipes 19 and 20 through which a cooling fluid is transmitted.

The tube 10 is pushed through the guide 11 by any suitable power, and is gradually heated to a uniform high temperature by the heat transmitted from the surrounding chamber 12.

However, instead of merely bending a simple hot tube, I preferably perform a complex upsetting action which thickens all parts of the tube, excepting the thickest portion in Fig. 4, and I preferably prevent any substantial stretching, or thinning, of said thickest portion. In other words, instead of performing a simple bending operation which stretches and thins the metal at the curves of relatively large radius in the bend, while compressing and thickening the metal at the curves of shorter radius, I preferably compact and thicken the metal at all points where there is any change in thickness. The bending can thus be performed by thickening all of the metal to the maximum thickness shown in Fig. 4, without reducing the thickness at any point.

The heat from the annular heating chamber 12 preheats the entire tube 10 to about a light red heat, and the preheated tube then passes the local coolers 16 and the local heaters 17 at the entrance of the curved passageway.

The relatively thick portions of the tube are thus cooled by one of the local coolers 16 and placed in a relatively firm condition. This prevents undue changes in the thickness of said thick portions, and also prevents undesirable displacement or distortion of said portions. At the same time, the other local cooler 16 reduces the temperature of the thin portions of the tube as they enter the curved passageway 9. The thin portions are thus stiffened to prevent crimping, or folding, of the thin metal near the entrance of the curved passageway. The action at this point may not be apparent, but one should understand that the longitudinal pressure on the tube 10 tends to force the thin portions away from the wall of the curved passageway, and that there is a tendency for these thin portions to fold, or buckle, at the beginning of their bending action. However, as the thin portions approach the curved bending zone in a relatively cool and firm condition, and since they are also reinforced by the firmer thick portions, the thin metal is not subjected to an undesirable displacement at the entrance of the curved passageway 9.

However, to provide for the intense upsetting and thickening of said thin metal, it is rapidly heated by the burner 18 which results in the desired union of this metal, and prevents folding or crimping of the thin metal as its particles are united to thicken the tube. A strong tube structure, free from laps or other defects is, therefore, produced at the arcs of relatively short radius in the bend.

The local heaters 17 transmit heat to opposite sides of the tube at points between the thickest and thinnest portions of the metal. The metal of the intermediate thickness is thus increased in temperature to permit the desired upsetting and thickening of these portions of the tube.

The temperature of the thinnest portions

of the tube is preferably higher than that of the intermediate portions, as the upsetting and thickening of the thinnest portions is most intense. A local cooler 21 may therefore be located in the bending die, as shown in Fig. 1, to rapidly cool the highly heated upset metal passing from the zone of the local heater 18. This highly heated metal, after being bent and thickened is accordingly placed in a relatively firm condition, so it will not be pushed away from the wall of passageway 9, nor otherwise distorted.

Attention is now directed to some of the peculiar actions which occur during the bending operation.

The longitudinal motion imparted to the straight portion of the tube very firmly pushes the thickest portion of the tube onto the curve of largest radius in the curved passageway 9. However, the same longitudinal motion tends to push the diametrically opposite thin portion of the tube away from the opposite wall of said curved passageway.

Nevertheless, the thick and relatively cool portion of the tube is positively pushed onto said curve of largest radius, and it is, therefore, positively bent to the desired curvature. This bending of the relatively cool and firm thick portion results in the transmission of compressive strains to all of the thinner metal. The displacement of the metal under this compression gradually increases from a minimum at the thick portion to a maximum at the thinnest portion. The temperature and firmness of the metal likewise increases from said thickest portion to said thinnest portion.

As a consequence, there is a varying upsetting and thickening action, the intensity of which gradually increases from the thick portion of the tube to the thinnest portion. The energy required for this upsetting operation is transmitted from the thick portion of the tube to the thinnest portion, and it will be important to observe that all of the varying factors contribute most effectively to the transmission of power required for the peculiar upsetting action.

The relatively cool thick portion of the tube is firm enough to transmit the high degree of upsetting power through the thinner and hotter intermediate portions, and these intermediate portions are firm enough to transmit the required degree of compression to the still hotter and thinner portions, where the greatest increase in thickness occurs.

In this connection it may also be noted that while the longitudinal thrust imparted to the straight portion of the tube has a tendency to push the thin portions away from the wall of the curved passageway 9, this tendency is firmly opposed by the transmission of the bending thrust from the relatively firm thicker portions to the hotter and more flexible thinner portions.

The thinner portions are, therefore, firmly forced onto the wall of the curved passageway, where they are positively upset and thickened while under a pressure which causes the entire outer face of the tube to conform precisely to the curved face of said wall. The finished tube has a smooth outer face of a predetermined diameter, and the peculiar combination of conditions prevents the formation of folds and other irregularities during the highly complex bending and upsetting operation.

It will now be understood that a tube having the non-uniform cross-section shown in Fig. 4 is bent while subjected to a non-uniform temperature which is highest at the thin portion of the tube, and decreases circumferentially to the relatively low temperature at the thickest portion of the tube. This method produces a strong tube structure, free from the defects which ordinarily occur in bending a tube, and while the invention can be employed to produce bent tubes of varying thicknesses, one of the advantages lies in producing a bent tube, as shown in Fig. 5, having a uniform thickness corresponding to the thickest portion of the tube shown in Fig. 4.

Moreover, the method can be very easily and quickly performed by maintaining the desired temperature conditions, while the tube is merely pushed through the curved passageway 9.

A further advantage lies in the continuous operation which permits a long continuous tube to be converted into a continuous bend, or coil, which may be used as a coil or cut into sections to produce elbows, return bends and the like.

The continuous bending operation can be carried out for an indefinite period upon a continuous succession of straight tubes, arranged end to end, so that an incoming tube will push the preceding tube through the tubular guide 11 and thence through the curved passageway 9.

This simple continuous operation eliminates the necessity of using removable cores inside of the bending die, and it provides the desired accuracy in the shape and thickness of the bent tube. The positive bending without distortion, and the freedom from weakening defects, are also important.

While the variations in temperature at the bending zone may be obtained by using any suitable heating, or heating and cooling, devices, it is usually important to push the tube at a uniform speed, so as to avoid undue increase or decrease in the predetermined temperatures resulting from the transmission of heat to the moving tube.

It is also advisable to form a slight taper in the passageway 9. For example, to produce a tube having an external diameter of

2⅜ inches, the curved passageway may have a diameter of 2 7/16 inches at the entrance, tapering to 2⅜ at a radial line where the combined bending and upsetting operation is completed.

In my copending application for patent on Methods of and Means for Bending Tubes, Serial No. 440,254, filed March 31, 1930, I have shown and more broadly claimed the method of bending tubes while forcing them through a curved passageway.

I claim:

1. The method of bending a tube having thick and thin portions which comprises imparting a longitudinal upsetting thrust to the thick and thin material undergoing the bending operation, maintaining said thin material at a relatively high temperature to permit free upsetting and thickening thereof, and maintaining said thick material at a lower temperature, so as to produce a bent tube having a substantially uniform thickness.

2. The method which comprises bending a tube having a varying thickness decreasing circumferentially from a relatively thick portion to a thinner portion diametrically opposite said thick portion, imparting a longitudinal upsetting thrust to the material undergoing the bending operation, heating the tube and controlling the upsetting action at the relatively thin portions by subjecting said thin portions to temperatures higher than that of the thicker portions, so as to produce the desired increase in the thickness of said thin portions.

3. The method which comprises bending a tube having a varying thickness decreasing circumferentially from a relatively thick portion to a thinner portion diametrically opposite said thick portion, imparting a longitudinal upsetting thrust to the material undergoing the bending operation, subjecting the thin portions to relatively high temperatures to permit free upsetting and thickening of said thin portions during the bending operation, while subjecting the thicker portions to lower temperatures to prevent undue thickening thereof.

4. The method of bending tubes which comprises forcing a tube through a curved passageway by pushing the outer face of the tube onto the wall of said passageway, so as to bend and at the same time change the thickness of the material forming different portions of the tube, heating the tube and producing different temperatures in different portions of the material undergoing the bending operation, so as to control the variations in thickness resulting from the heat and pressure to which the tube is subjected in said curved passageway.

5. The method of bending tubes which comprises forcing a continuous tube through a curved passageway by pushing the outer face of the tube onto the wall of said passageway, so as to bend and at the same time change the thickness of the material forming different portions of the tube, heating the tube and producing different temperatures in different portions of the material undergoing the bending operation, so as to control the variations in thickness resulting from the heat and pressure to which the tube is subjected in said curved passageway, and maintaining an approximately uniform speed in the longitudinal movement of the continuous tube so as to prevent substantial variations in the predetermined temperatures at different portions of the moving tube.

6. The method of bending a tube having thick and thin portions, which comprises forcing the tube through a curved passageway by pushing the outer face of the tube onto the wall of said passageway, so as to bend and at the same time change the thickness of the material forming different portions of the tube, heating the tube and producing relatively high temperatures in the thin portions of the material undergoing the bending operation, so as to permit relatively free upsetting and thickening of said thin portions in response to the heat and pressure to which the tube is subjected in said curved passageway, and at the same time maintaining lower temperatures in the thick portions undergoing the bending operation so as to prevent excessive change in the thickness of said thick portions.

7. The method of bending a tube having thick and thin portions, which comprises forcing the tube through a curved passageway by pushing the outer face of the tube onto the wall of said passageway, so as to bend and at the same time change the thickness of the material forming different portions of the tube, heating the tube and producing relatively high temperatures in the thin portions of the material undergoing the bending operation, so as to permit relatively free upsetting and thickening of said thin portions in response to the heat and pressure to which the tube is subjected in said curved passageway, at the same time maintaining lower temperatures in the thick portions undergoing the bending operation so as to prevent excessive change in the thickness of said thick portions, and maintaining an approximately continuous uniform speed in the longitudinal motion of said tube, so as to provide for the transmission of the different predetermined degrees of heat to different portions of the moving tube.

8. The method which comprises forming a tube having a varying thickness decreasing circumferentially from a relatively thick portion to a thin portion diametrically opposite said thin portion, forcing said tube through a curved passageway by pushing the outer face of the tube onto the wall of said passageway, so as to bend and at the same time

change the thickness of the material forming different portions of the tube, heating the tube and producing different temperatures in different portions of the material undergoing the bending operation, the highest temperature being in the thin portion of the tube to permit free upsetting and thickening of said thin portion in response to the heat and pressure in said curved passageway, the thick portions of said tube being maintained at a lower temperature in the bending zone to check the upsetting action in said thick portions.

9. The method which comprises forming a tube having a varying thickness decreasing circumferentially from a relatively thick portion to a thin portion diametrically opposite said thin portion, forcing said tube at a substantially uniform speed through a curved passageway by pushing the outer face of the tube onto the wall of said passageway, so as to bend and at the same time change the thickness of the material forming different portions of the tube, transmitting heat to said tube while it is moving at said uniform speed and producing different temperatures in different portions of the material undergoing the bending operation, the highest temperature being in the thin portion of the tube to permit free upsetting and thickening of said thin portion in response to the heat and pressure in said curved passageway, the thick portions of said tube being maintained at a lower temperature in the bending zone to check the upsetting action in said thick portions.

10. The method of producing curved tubes which comprises forming a tube with a relatively thick portion longitudinally of the tube, the thickness decreasing circumferentially to a point diametrically opposite said thick portion, heating and then bending said tube by upsetting the relatively thin portions while maintaining said thin portions at a temperature higher than that of the relatively thick portions, so as to permit relatively free upsetting and thickening of said relatively thin portions.

11. The method of producing curved tubes which comprises forming a straight tube with a relatively thick portion arranged longitudinally of the tube, the thickness decreasing circumferentially to a point diametrically opposite said thick portion, imparting a continuous, uniform longitudinal motion to the straight portion of said tube while heating and then gradually bending said moving tube by upsetting the relatively thin portions while maintaining said thin portions at a temperature higher than that of the relatively thick portions, so as to permit relatively free upsetting and thickening of said relatively thin portions.

12. The method of producing curved tubes which comprises forming a tube with a relatively thick portion arranged longitudinally of the tube, the thickness decreasing circumferentially to a point diametrically opposite said thick portion, heating and then bending said tube by locating the thickest portion at the curve of largest radius in the bend while maintaining the varying thinner portions, at relatively high temperatures, so as to freely upset and thicken said thinner portions without materially changing the thickness of said thickest portion.

13. The method of producing curved tubes substantially uniform in thickness, which comprises forming a straight tube with a relatively thick portion arranged longitudinally of the tube, the thickness decreasing circumferentially to a point diametrically opposite said thick portion, heating and then bending said straight tube by locating the thickest portion at the curve of largest radius in the bend and upsetting the varying thinner portions to the thickness of said thickest portion.

14. The method of producing curved tubes substantially uniform in thickness, which comprises forming a straight tube with a relatively thick portion arranged longitudinally of the tube, the thickness decreasing circumferentially to a point diametrically opposite said thick portion, heating and then bending said straight tube by pushing it longitudinally at a uniform speed through a curved passageway with the thickest portion of the tube in contact with the curve of largest radius in said passageway, at the same time transmitting heat to the moving tube and maintaining the relatively thin portions at relatively high temperatures, so as to upset all of said thin portions to a thickness corresponding approximately to the thickest portion of the straight tube.

15. The method which comprises bending a tube while a portion of the tube is subjected to a relatively high localized temperature so as to permit a relatively free change in the thickness of said relatively hot portion, and then rapidly cooling said portion to prevent distortion thereof.

16. The method which comprises moving a tube longitudinally at a substantially uniform speed, at the same time bending the tube and transmitting varying degrees of heat to different portions of said tube, so as to control the changes in thickness during the bending operation, providing the highest temperature in the portion at the curve of shortest radius in the bend to permit free upsetting and thickening of said portion during the bending operation, and then rapidly cooling said portion.

17. In a tube bending apparatus, a bending die having a curved passageway through which the tube is forced to form the desired bend, and means whereby different portions of the tube are subjected to different tempera-

tures during the bending operation, said means including a heater to increase the temperature of the tube as it passes to the bending die, and a local cooler adjacent to the course of the tube, so as to reduce the temperature in a local area extending longitudinally of the tube.

18. In a tube bending apparatus, a bending die having a curved passageway through which the tube is forced to form the desired bend, and means whereby different portions of the tube are subjected to different temperatures during the bending operation, said means including a main heater whereby the tube is heated as it moves toward the bending die, local heaters at opposite sides of the tube to increase the temperature at said opposite sides, local coolers to reduce the temperature between said opposite sides, and a local heater adjacent to the curve of shortest radius in said curved passageway.

In testimony that I claim the foregoing I hereunto affix my signature.

LESTER W. SNELL.