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Curry

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[54] **METHOD FOR MAKING CURVED TUBES**

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[51] **Int. Cl.** **B21d 53/00,** B21d 11/02

[58] **Field of Search** ..... 29/157 A; 72/367, 369, 72/379, 149, 150, 156, 159; 113/116 UT

[56] **References Cited**

UNITED STATES PATENTS

1,840,512	1/1932	Kling	29/157 A
2,335,887	12/1943	Smith	29/463
2,466,381	4/1949	Clouse	72/159
2,962,077	11/1960	Condiff	72/149
2,983,995	5/1961	Gresse	72/369
3,348,402	10/1967	Reistad	72/369

FOREIGN PATENTS OR APPLICATIONS

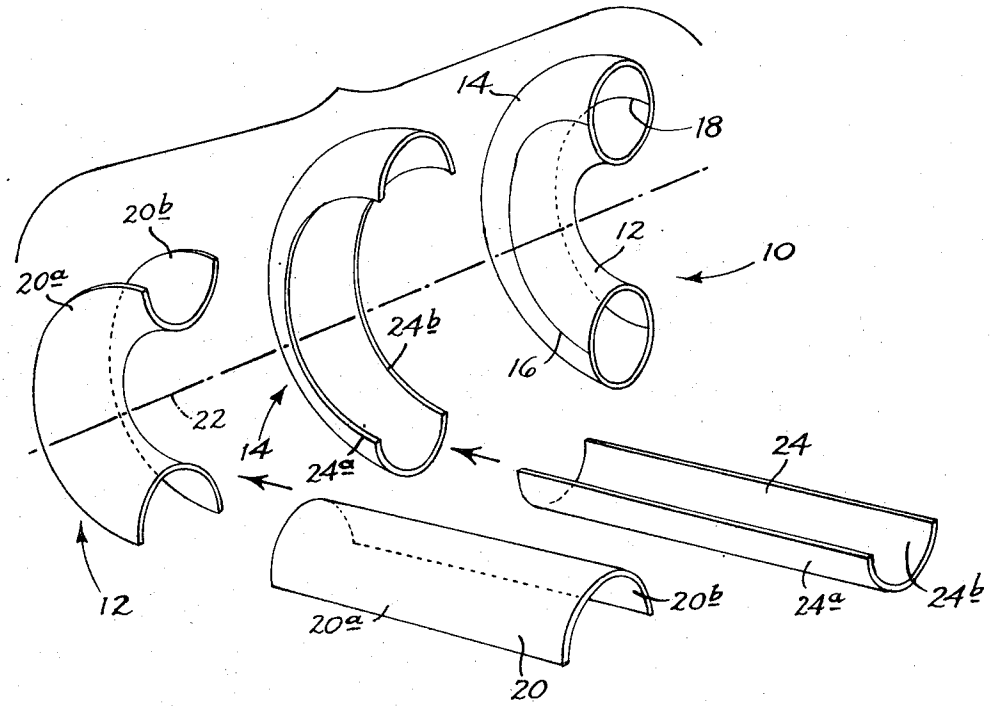
1,021	11/1882	Italy	29/157 A
70,795	4/1915	Switzerland	113/116 UT
123,927	10/1958	U.S.S.R.	29/157 A
214,827	5/1924	Great Britain	113/116 U
466,470	5/1937	Great Britain	29/157 A

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[57] **ABSTRACT**

A method of forming a curved tube. The method includes a first step of deforming a pair of sheets to form a pair of elongated semicylinders, each having opposed cheek regions extending longitudinally along its opposite sides. The semicylinders then are drawn around dies to bend them into curves in which their axes of curvature are normal to the cheek regions; with the cheek regions of one of the elements directed radially outwardly from the axis of curvature and the cheek regions of the other element directed radially inwardly toward the axis of curvature. The two elements then are joined to each other, as by welding, along edges bounding their cheek regions.

4 Claims, 4 Drawing Figures



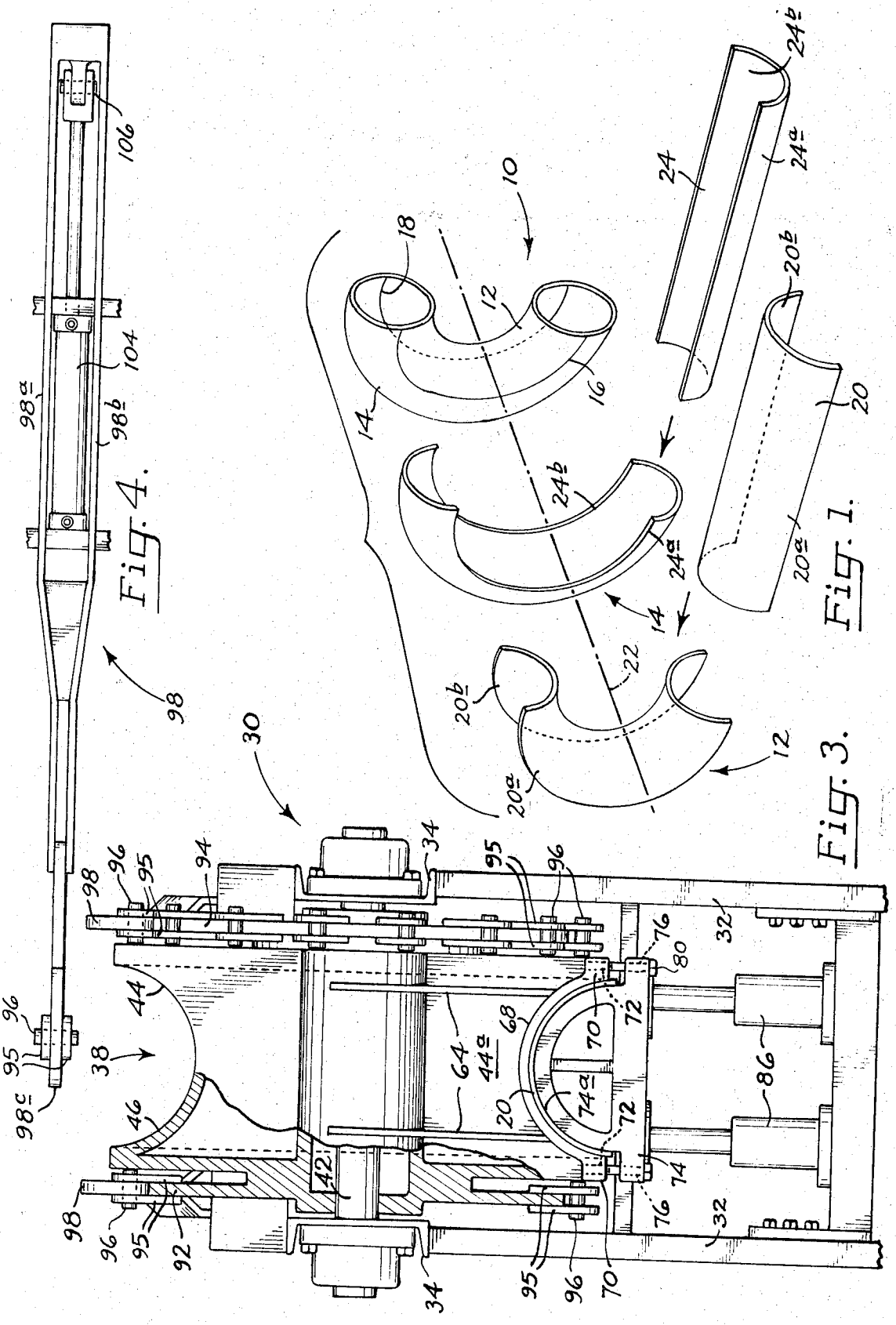


Fig. 1.

Fig. 3.

Fig. 4.

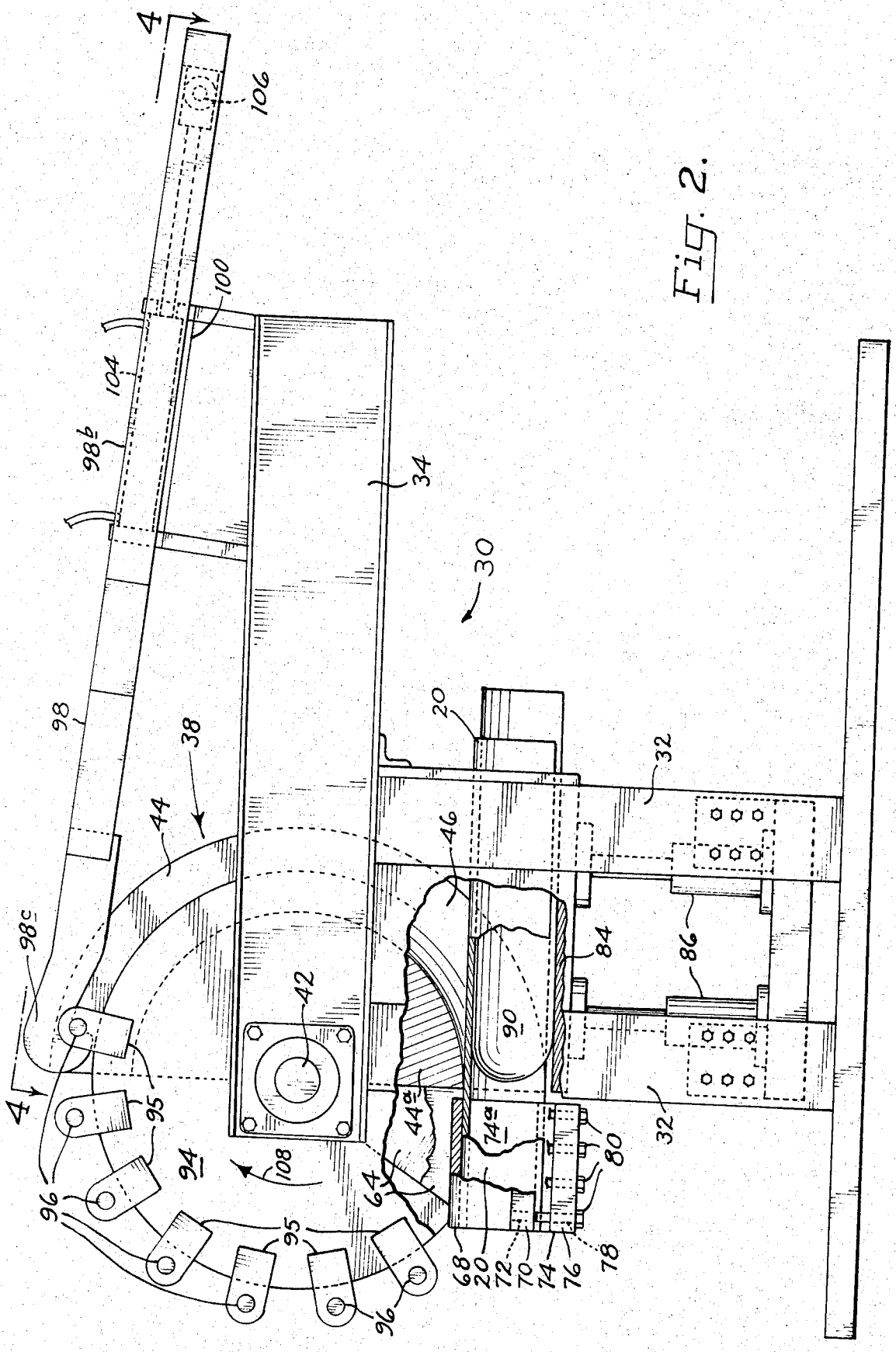

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106
100
104
98b
34
30
98
38
44
20
32
46
98c
84
86
42
90
95
94
108
44a
74a
80
64
96
68
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70
74
76
78

Fig. 2.

METHOD FOR MAKING CURVED TUBES

SUMMARY AND BACKGROUND OF THE INVENTION

This invention relates to the production of curved tube wall sections, and tubes constructed using such wall sections.

In the past, various methods have been used for producing curved tubes. Probably the most common is the simple bending of an elongated tube to the curve desired. This is not always satisfactory, however, since such bending often produces a tube which is out-of-round, with flat spots, or wrinkles, especially along the inner and outer walls of the curve. Further, such bending generally produces a great disparity in wall thicknesses, with the outer wall of the curve being substantially thinner than the inner wall.

Another previously known method for producing curved tubes, entails the steps of stamping sheets of metal into a pair of mirror-image, curved semicylinders, and joining them together along a mating set of their edges. A disadvantage of such method, however, is that a tube is produced in which the joining lines between the mating sections are disposed at throat and heel regions of the curved tube. These joints between the sections, which generally are the weakest regions in the tube, thus are positioned at the regions of maximum wear when material flows through the tube. Further, since these joints often are rough, they can create turbulence. Another disadvantage of such method is that the metal sheet in such a curved semicylinder when laid out in a plane is of an irregular rather than a rectangular shape, which means that the method tends to result in excessive trim waste. Further, stamping of sheets tends to induce wrinkling, and less than optimum grain direction in the wall of the final tube results.

A general object of the invention is to provide a novel method for forming a curved tube in a simple and inexpensive manner, and which overcomes the problems of previous methods noted above.

A further object is to provide a novel method for forming a curved tube, wherein the difference between the wall thicknesses at the inner and outer walls of the curve of the tube is minimized.

Another object is to provide a method for forming a curved tube which results in minimal waste of material and is adapted to produce a wide range of tube sizes.

A still further object is to provide a novel method for forming a curved tube wherein the grain of the metal forming the tube extends generally along the length of and substantially parallels the curvature of the tube, and thus is oriented in an optimum relationship to the bend in the tube.

More specifically, an object is to provide a novel method for forming a curved tube, wherein a first rectangular sheet is deformed to form an elongated semicylinder having opposed cheek regions extending longitudinally therealong, and drawing the element around a die to bend it into a curve around an axis of curvature which extends normal to the cheek regions, with the cheek regions directed radially outwardly from the axis of curvature; deforming a second rectangular sheet to form a second semicylindrical element having opposed cheek regions extending longitudinally therealong, and drawing the second element around a die to bend the same into a curve about an axis of curvature extending normal to the cheek regions of the element, with the cheek regions directed radially inwardly toward the axis of curvature; and joining the two elements, as by welding, along mating edges of their cheek regions.

A still further object is to provide a novel method for forming a tube wall section which may be used to produce a curved tube.

DESCRIPTION OF THE DRAWINGS

These and other objects and advantages will become more fully apparent as the following description is read in conjunction with the drawings, wherein:

FIG. **1** is a perspective view of materials in various stages of the production of a curved tube according to the invention;

FIG. **2** is a side elevation view of apparatus which is operable to draw a semicylindrical element into a curve according to the invention;

FIG. **3** is a front end elevation view of the apparatus illustrated in FIG. **2**; and

FIG. **4** is a top plan view taken generally along the line **4—4** of FIG. **2** of a part of such apparatus.

DETAILED DESCRIPTION OF THE INVENTION

Referring first to FIG. **1**, at **10** is indicated generally a curved tube constructed according to the invention. The tube includes an inner, or throat, wall section, indicated generally at **12**, and an outer, or heel, wall section indicated generally at **14**. The wall sections are joined together at mating sets of edges along lines **16, 18** at opposite sides of the tube.

Describing the method of producing such a curved tube, first a substantially rectangular sheet of ductile material, such as sheet steel, is deformed to form an elongated semicylindrical element, as indicated generally at **20**. In making element **20**, the sheet is curved about its longitudinal axis. The element has cheek regions **20***a*, **20***b* extending longitudinally along its opposite sides.

Element **20** then is drawn around a die, as will be explained more fully below, to bend the same in a curve, to form the throat section **12** in which the axis of curvature **22** of the element extends substantially normal to cheek regions **20***a*, **20***b*. Cheek regions **20***a*, **20***b* are directed radially outwardly from the axis of curvature.

To form a heel section **14**, a substantially rectangular sheet of ductile material, such as sheet steel, is deformed to form an elongated, semicylindrical element **24** having cheek regions **24***a*, **24***b* extending longitudinally along its opposite sides. Element **24** may be longer than element **20**. Element **24** then is drawn around a die, as will be explained more fully below, to bend it into a curve to form a heel section **14** in which the axis of curvature **22** of the element extends substantially normal to cheek regions **24***a*, **24***b*. Cheek regions **24***a*, **24***b* are directed radially inwardly toward the axis of curvature, and their inwardly facing edges curve in an arc which substantially conforms to the arc of the outwardly facing edges of cheek regions **20***a*, **20***b* on throat section **12**.

The heel and throat sections **12, 14**, thus formed are placed in mating positions, as illustrated for the completed tube at **10**, and are joined, as by welding, along their contiguous edges to produce fluid-tight joints along lines **16, 18**.

In the curved tube produced the joints between mating wall sections extend along the sides of the tube, rather than along the heel and throat regions. The joints thus are subjected to less wear and show less tendency to turbulence. Further, since the heel and throat sections are formed independently of each other, there is less variation in wall thicknesses at radially inner and outer regions of the tube curve.

Referring now to FIGS. 2 and 3, at 30 is indicated generally apparatus for drawing a semicylindrical elements, as illustrated at 20, into a desired curve.

Apparatus 30 includes four upright, laterally spaced support columns 32. A pair of laterally spaced, parallel, hoizontal support beams 34 are secured to the tops of columns 32. A rotatable die, indicated generally at 38, is disposed between beams 34. An axle 42 extends through the center of die 38 and is journaled adjacent its opposite ends on beams 34 to support the die for rotation about a horizontal axis.

The die includes a forming portion 44 which is half-moon shaped when viewed from a side (as seen in FIG. 2), and has a channel 46 formed in and extending along its curved periphery (as seen in FIG. 3). Channel 46 has a cross-sectional configuration which conforms to the outer surface of element 20. As seen in FIG. 2, channel 46 extends in a semicircular path about axle 42, and has a radius equal to the radius to which it is desired to bend element 20.

A pair of substantially parallel, laterally-spaced support plates 64 are secured along one set of their edges to, and project forwardly from the flat forward side 44*a* of portion 44 of the die. A semicylindrical mounting bracket 68 is secured, as by welding, to the lower set of edges of support plates 64, and thus is mounted for rotation with the die. The undersurface of mounting bracket 68 is concave, having a cross section which substantially conforms to the outer surface of element 20. As seen in FIG. 2, the mounting bracket is positioned to define a tangential extension of channel 46 on the die. A pair of lugs 70, extend laterally outwardly from opposite sides of bracket 68 and have threaded bores 72 extending vertically therethrough.

A locking member 74, having a semicylindrical upper surface 74*a* which conforms to the inner semicylindrical cross section of element 20, is received in bracket 68 with an end portion of element 20 therebetween, as illustrated. A pair of lugs 76 project laterally outwardly from opposite sides of member 74. Bolts 80, extend through bores 78 in lugs 76 and screw into bores 72 in lugs 70 to clamp mounting bracket 68 and locking member 74 against opposite faces of element 20 to secure the element to the die.

A support platform 84 is mounted for vertical shifting on a plurality of upright fluid-operated rams 86 beneath die 38. An elongated semicylindrical guide shoe 90, having an upper surface substantially conforming to the inner surface of element 20, is secured to platform 84 and is disposed substantially in line with mounting bracket 68.

A pair of laterally spaced disk-shaped portions 92, 94 are secured to opposite sides of forming portion 44 of die 38. A plurality of spaced apart lugs 95 are secured to the outer edges of portions 92, 94 and project radially outwardly therefrom. Each of lugs 95 has a pin 96 secured thereto which parallels axle 42.

An elongated operating arm, indicated generally at 98, is disposed above column 34 nearest the viewer in FIG. 2 and is substantially aligned with disk-shaped portion 94 of the die. A similar operating arm (not shown) is mounted adjacent the opposite side of the apparatus over the other one of beams 34 and in line with disk-shaped portion 92. Both arms and their operating mechanism are similar, and thus only the one illustrated in FIGS. 2 and 4 will be described in detail.

The rear end portion of arm 98, at the right in FIGS. 2 and 4, is formed of a pair of elongated, parallel, laterally spaced side members 98*a*, 98*b*. The forward end portion 98*c* of the arm is hook-shaped, and is adapted to hook onto a pin 96 at the top of die 38.

Side members 98*a*, 98*b* of the arm are slidably supported on an inclined support 100, secured to beam 34, for movement to the right and left in FIGS. 2 and 4. The cylinder end of an extensible-contractible ram 104 is secured to support 100 intermediate side members 98*a*, 98*b* and its rod end is pivotally connected at 106 to the rear end of arm 98.

With the arm in the position illustrated in FIG. 2, with its hooked end 98c engaging a pin 96, extension of ram 104 shifts the arm to the right, resulting in rotation of the die in the direction of arrow 108. Subsequent contraction of the ram shifts arm 98 to the left, and pivot connection 106 permits the arm to raise from support 100 with the hooked end of the arm riding up and over the pin on the lug immediately to the left of that previously engaged, and to hook onto such pin. The arm then is in a position to be shifted to the right again, by extension of the ram. to rotate the die further in the direction of arrow 108.

In operation of the apparatus, an end portion of a semicylindrical element, such as that illustrated at 20, is inserted between mounting bracket 68 and locking member 74. Bolts 80 are tightened to secure the element therebetween. Shoe 90 is elevated into close contact with the undersurface of element 20 as shown in FIG. 2. The die then is rotated in the direction of arrow 108 through movement of arm 98 produced by successive extension and retraction of ram 104, to cause the element to be drawn around channel surface 46 of forming portion 44. This bends, or draws, the element into a curve as illustrated for throat section 12 in FIG. 1. During such drawing process, substantially the entire wall of the element is supported by the die.

Somewhat similar apparatus may be used to form heel section 14 for the tube. To produce such heel sections, however, the supporting surfaces of the die, and mounting bracket 68 would be convex, instead of concave, while the supporting surfaces of locking member 74 and shoe 90 would be concave, as opposed to the convex curvatures illustrated.

While a preferred embodiment of the invention has been described herein, it should be apparent to those skilled in the art that various modifications may be made without departing from the spirit of the invention.

It is claimed and desired to secure by letters Patent:

1. A method of constructing a curved tube comprising the steps of

forming a first wall section by deforming a first sheet to form an elongated substantially semicylindrical element having laterally spaced cheek regions extending longitudinally along its opposite sides, and draw bending said semicylindrical element by clamping an end region thereof against a rotatable

form having a channel extending in a sweep thereabout which channel substantially matches in cross sectional profile the cross sectional profile of said semicylindrical element and then rotating such form to bend the element to conform to the curve of said sweep along the longitudinal axis thereof with drawing of the element across a shoe which confines said element in said channel with such confinement introductory to the bending of the element, the cheek regions in said first wall section facing inwardly toward the axis about which the wall section bends,

forming a second wall section by deforming a second sheet to form another elongated substantially semicylindrical element having laterally spaced cheek regions extending longitudinally along its opposite sides and draw bending said other semicylindrical element by clamping an end region thereof against a rotatable form having a channel extending in a sweep thereabout which channel substantially matches in cross sectional profile the cross sectional profile of said other semicylindrical element and then rotating such form to bend the element to conform to the curve of said sweep along the longitudinal axis thereof with drawing of the element across a shoe which confines said element in said channel with such confinement introductory to the bending of the element, the cheek regions in said second wall section facing outwardly from the axis about which the wall section bends, and

joining said sections together, with the edges bounding the cheek regions of the first section joined to the edges bounding the cheek regions on the second section.

2. The method of claim **1,** wherein said edges are joined to form a fluid tight joint therebetween.

3. The method of claim **2,** wherein said edges are joined by welding.

4. A method of manufacturing a curved tube comprising

forming first and second elongate complementary wall sections, each having a transverse curvature corresponding to the circumferential curvature of the final tube and the two wall sections over their length bending in sweeps along their longitudinal axes, one of the wall sections having cheek regions facing toward the axis about which the wall section bends and the other wall section having cheek regions facing outwardly from the axis about which the wall section bends,

each of the wall sections being produced by first forming an elongate sheet in the shape of a substantially semicylindrical element with laterally spaced cheek regions extending longitudinally along opposite side margins, and then draw bending the semicylindrical element, by clamping an end region thereof against a rotatable form having a channel extending in a sweep thereabout which channel substantially matches in cross sectional profile the cross sectional profile of the semicylindrical element and then rotating such form to bend the element to conform to the curvature of such sweep with drawing of the element across a shoe where confining of said element in said channel occurs introductory to the bending thereof,

the two wall sections so produced being joined to each other through the edges which bound the cheek regions to the elements.

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