

[54] METHOD OF FABRICATING CURVED TUBING AND PRODUCT THEREOF

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[52] U.S. Cl. 72/369

[51] Int. Cl. B21d 7/00

[58] Field of Search 29/423, 455; 72/369, 701

[56] References Cited

UNITED STATES PATENTS

2,401,542	6/1946	Booth	29/455
3,110,754	11/1963	Witort et al.	29/455
3,841,138	10/1974	Zinnbauer et al.	72/369

FOREIGN PATENTS OR APPLICATIONS

264,366	1950	Switzerland.....	29/455
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[57] ABSTRACT

A method of bending a metal tube including providing an elongated unitary multiwalled metal tube having an internally disposed elongated web with transverse ends connected to generally opposed walls of the tube and dividing the internal hollow into generally equal sections. The tube is then bent in a direction generally perpendicular to the elongated web to establish a predetermined tube curvature. The tube may be of generally rectangular cross sectional configuration with the tube curvature (ratio of height to width) being about 22 to 50 percent. The web will preferably be positioned at or adjacent the neutral axis of the tube in bending. The rectangular tube sidewalls preferably have a maximum wall thickness at or adjacent their upper and lower extremities and a minimum wall thickness at or adjacent the middle thereof.

The curved tube product of the above method devoid of appreciable undesired wall collapse resulting from the bending operation.

10 Claims, 7 Drawing Figures

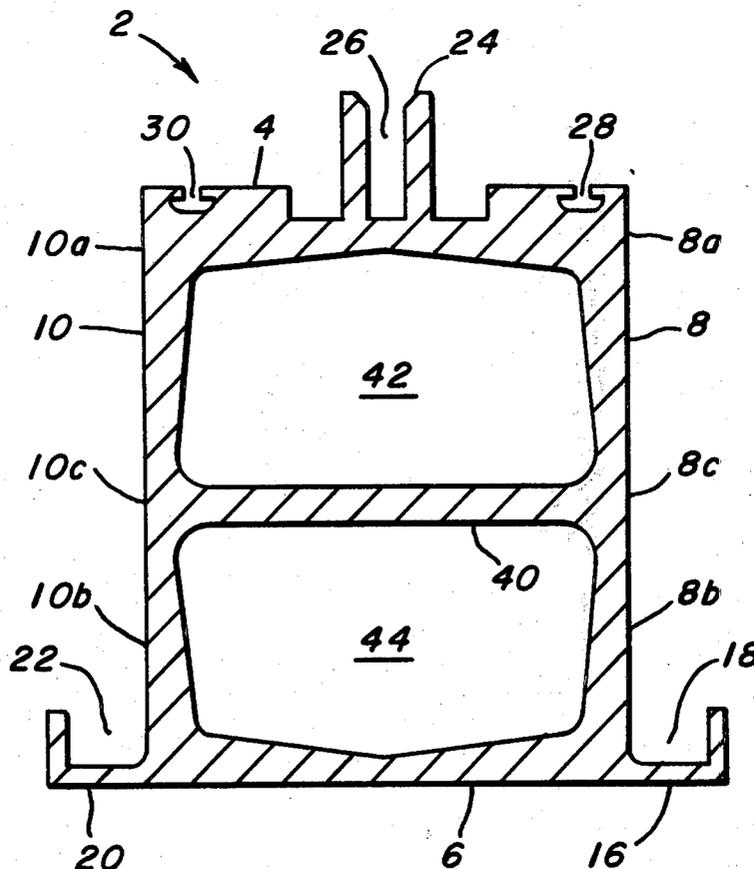


FIG. 1.

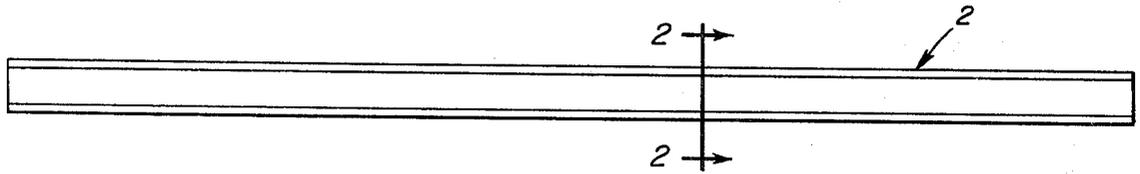


FIG. 3.

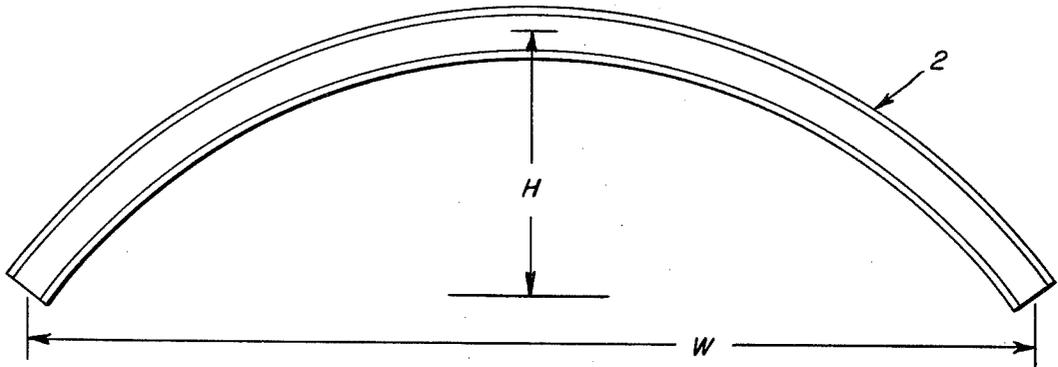


FIG. 2.

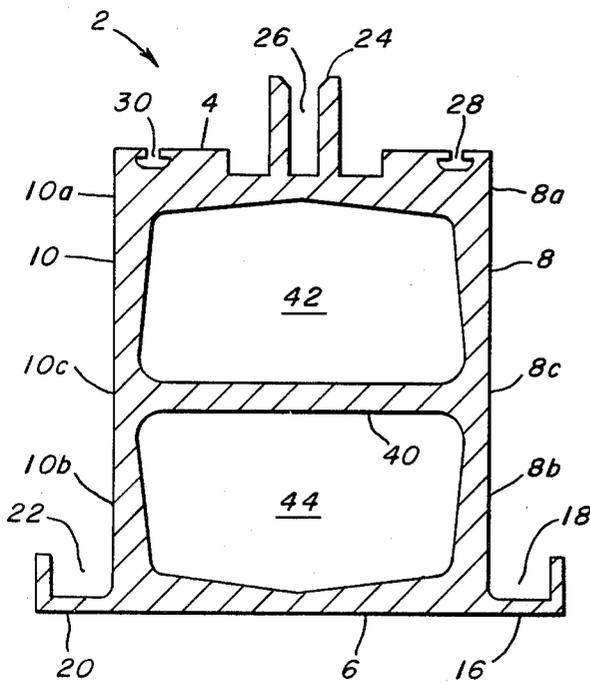


FIG. 4.

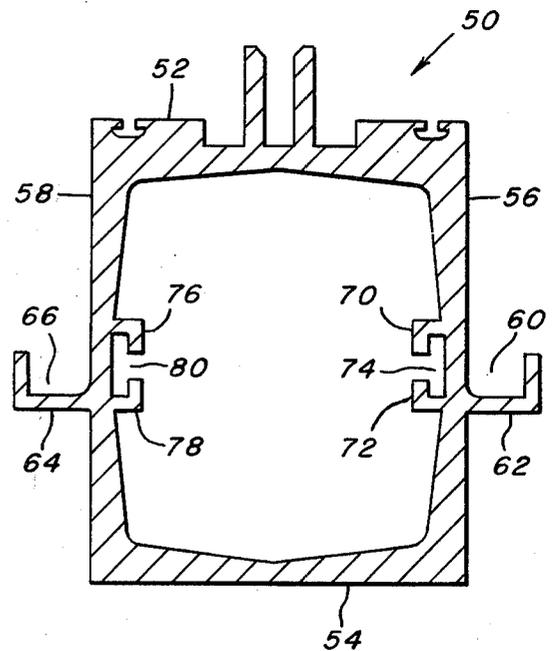


FIG. 6.

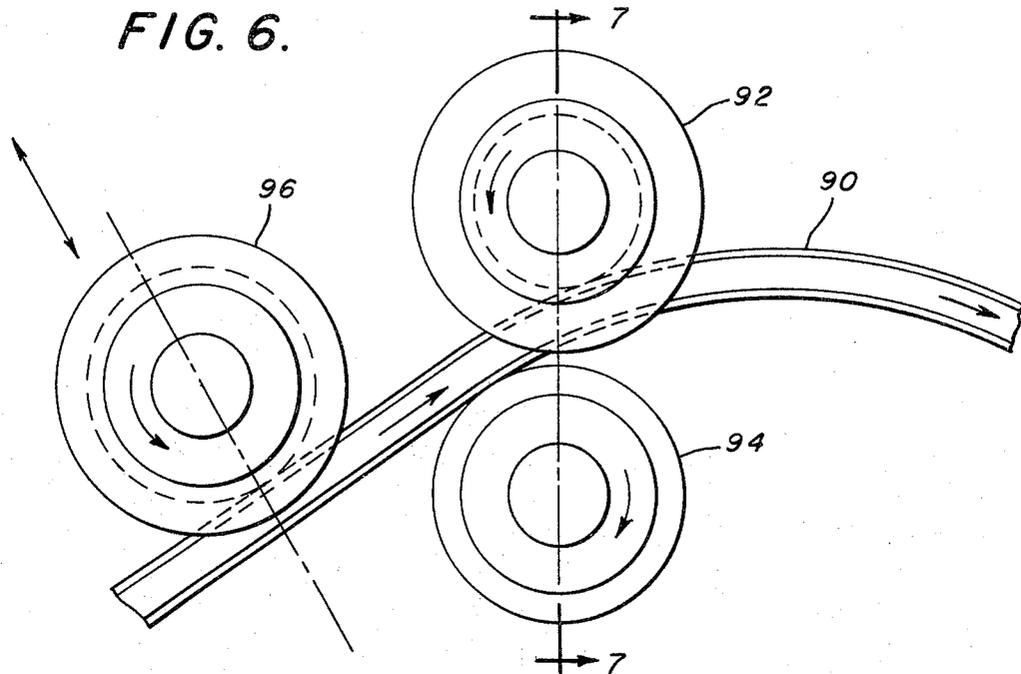


FIG. 5.

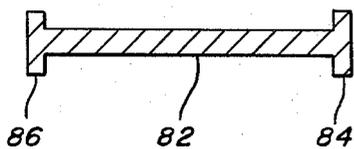
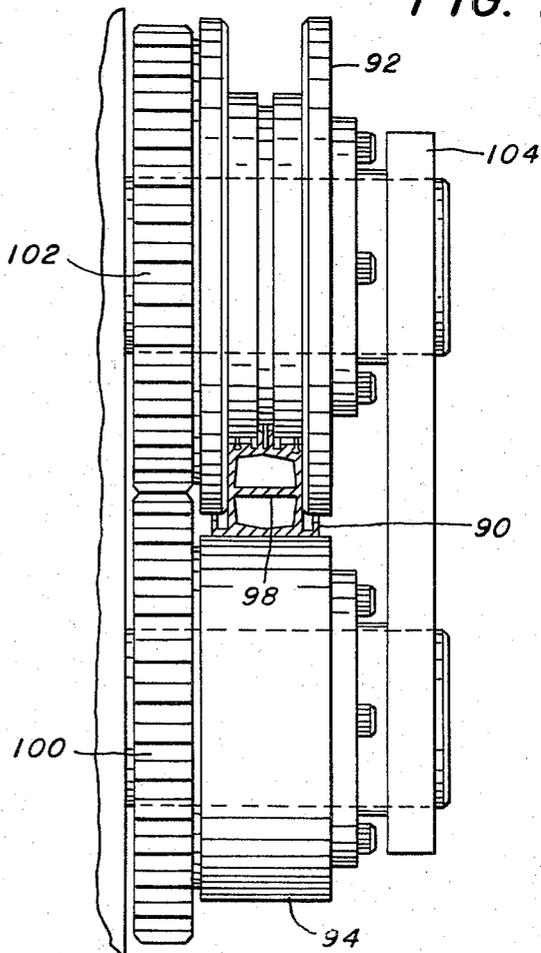


FIG. 7.



METHOD OF FABRICATING CURVED TUBING AND PRODUCT THEREOF

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improved method of bending a multiwalled metal tube into a curved shape and the product thereof and, more specifically, this invention relates to such a method and product wherein appreciable undesired distortion of one or more tube walls during bending is resisted.

2. Description of the Prior Art

In prior art practices where it has been necessary to bend a hollow multiwalled metal tubular product, difficulty has frequently been encountered as a result of undesired, inherent inward collapse of one or more walls of the tube during the bending operation. See generally U.S. Pat. Nos. 1,913,417 and 3,081,795. As such tubular products are frequently needed or desired in numerous end use environments, including architectural uses, it has been known to adopt practices which will resist undesired inward deformation of one or more walls of such tubular products when they are bent along a curved path. For example, it has been known to fill the interior hollow of the tube with sand, shot or similar materials in order to provide internal support during bending. Such systems are undesirable as they require the use of additional material not required in the end products and the additional labor involved in introducing and removing the support material.

In general, such problems have not been encountered in the bending of cylindrical tubing in a curved path as such tubing possesses symmetry about the circumference and ready access for uniform positioning of external rollers is permitted. While it has been suggested to provide various forms of integral support for such tubes, such supports have not been necessitated by problems such as those which arise in multiwalled tubes. See generally U.S. Pat. Nos. 1,930,285, 2,196,708 and 3,110,754.

U.S. Pat. No. 3,105,522 discloses a multipiece tube having a divider web and being adapted to be bent in a direction aligned with the orientation of the divider web. The tube is adapted to withstand internal pressures generated by the passage of a coolant material therethrough. Bending of this tube is said to be facilitated by a reduction in tube width at certain regions, with the divider web not serving any particular function during the fabricating stages.

There remains, therefore, a very substantial need for a method which will effectively provide desired predetermined curved bending of a metal multiwalled tubular product while resisting undesired wall deformation during the bending operation. There remains the further need for such a process wherein the desired bending may be effected without the use of inefficient and expensive tube filling and emptying processes of the prior art.

SUMMARY OF THE INVENTION

The above-described problems have been solved by the method of the present invention and the product resulting from the practice of such method.

In the present invention an elongated unitary multiwalled metal tube is provided with an internally disposed elongated web having transverse edges or ends connected to generally opposed walls of the tube and

dividing the internal hollow into generally equal sections. The tube is then bent into a predetermined curvature in a direction generally perpendicular to the elongated web. Bending is preferably effected to establish a curvature of about 22 to 50 percent. In a multiwalled tube of rectangular configuration the sidewalls to which the elongated web is attached are preferably of non-uniform thickness with the sidewalls having a maximum wall thickness adjacent the upper and lower extremities thereof and a minimum thickness generally midway therebetween in the region where the web is connected thereto. Bending is preferably effected progressively in order to establish a uniform curvature of about 22 to 50 percent. The tube may be provided with either an elongated web which is formed as a unit with the tube as by extrusion or, in the alternative, it may be provided with a web which is separately formed and subsequently joined to the tube.

The product of the method of this invention will have the desired degree of curvature, will preferably be substantially devoid of meaningful undesired tube wall deformation resulting from the bending operation and will generally preserve the original cross sectional configuration of the tube.

It is an object of this invention to provide a method of bending a unitary metal multiwalled tube along a predetermined path in order to provide a predetermined curvature without meaningful undesired tube wall deformation.

It is another object of this invention to provide such a method and the product thereof wherein the need to employ filler material such as sand, shot and the like is eliminated.

It is a further object of this invention to provide such a method and the product thereof wherein the multiwalled tube may be progressively curved by means of conventional bending techniques and apparatus with the avoidance of undesired tube wall deformation being provided by means integral with the workpiece.

It is yet another object of this invention to provide such a method and product which may be adopted economically and readily without requiring major changes in equipment and procedures for producing the workpiece.

These and other objects of the invention will be more fully understood from the following description of the invention, on reference to the illustrations appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevational view of an elongated multiwalled metal tube of a type employed in this invention;

FIG. 2 is a cross sectional view of the metal tube of FIG. 1 taken through 2—2 of FIG. 1;

FIG. 3 is a front elevational view of the tube of FIG. 1 after fabrication in accordance with this invention;

FIG. 4 is a cross sectional view of an elongated multiwalled metal tube showing a modified form of the invention;

FIG. 5 is a cross sectional illustration of a modified form of web member adapted for use with the tube of FIG. 4;

FIG. 6 is a partially schematic representation of a form of apparatus usable in the practice of this invention; and

FIG. 7 is a cross sectional view of the apparatus of FIG. 6 taken through 7—7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As used herein, the term "multiwalled" as employed in describing a metal tube shall refer to a tube having a non-cylindrical cross sectional configuration and having a cross sectional configuration defined by three or more wall sections which cooperate to define the internal hollow of the tube. The term would encompass, but not be limited to, metal tubes having triangular, rectangular, pentagonal and hexagonal cross sectional configurations. The term, in the preferred form of the invention, shall refer to tubes having a cross sectional configuration in the shape of a polygon of n sides wherein n equals three to ten.

Referring now more specifically to FIGS. 1 and 2, there is shown an elongated seamless multiwalled metal tube 2 which may be of any desired length and preferably has a substantially uniform cross sectional configuration throughout its length. In the particular form shown, the tube 2 is of generally rectangular configuration having an upper wall 4, a lower wall 6 and a pair of sidewalls 8, 10. It will be seen that the sidewalls 8, 10 are of varying thickness. The sidewalls 8, 10 have a maximum wall thickness generally in the regions of the upper and lower extremities 8a, 8b, 10a, 10b and have a minimum wall thickness generally in the regions 8c, 10c midway therebetween. It is noted that there is preferably a generally uniform taper between the extremities 8a, 8b, 10a, 10b and the regions 8c, 10c, respectively, for reasons which will be stated below. It is also noted that upper wall 4 and lower wall 6 have varying wall thicknesses with the maximum wall thickness being adjacent transverse ends thereof and the minimum thickness being generally midway therebetween.

In the particular form of tube shown, the profile is adapted for use in architectural systems, such as by use as a skylight mullion. It will, therefore, be noted that sidewall 8 has a flange 16 which is integrally formed and extends outwardly and then upwardly in order to cooperate with another portion of the sidewall 8 in defining moisture receiving gutter 18. Similarly, flange 20 of sidewall 10 extends outwardly and then upwardly and cooperates with another portion of sidewall 10 to define upwardly open moisture receiving gutter 22. The upper wall 4 is provided with channel 24 which defines screw receiving slot 26. Upper wall 4 also defines a pair of upwardly open gasket receiving recesses 28, 30.

Referring now to FIGS. 2 and 3, the bending process of the present invention will now be considered in greater detail. FIG. 3 illustrates the seamless tube 2 of FIG. 1 after bending to a desired degree of curvature has been accomplished. As used herein a reference to "curvature" or words of similar import shall refer to the ratio of height H to width W of a curved tube wherein height H is measured between the level of the longitudinal axis at the tube ends and the longitudinal axis at the center of the tube and width W is measured between the tube ends at the longitudinal axis. As is shown in FIG. 2, tube 2 has a generally centrally located integrally formed elongated web 40 which has its transverse ends connected to sidewalls 8, 10. Web 40 is preferably positioned generally parallel to upper wall 4 and lower wall 6 and is disposed generally midway

therebetween. Web 40 serves to divide the interior hollow of the tube 2 into two generally equal sections 42, 44. Web 40 is preferably substantially continuous and substantially coextensive with tube 2. During the bending operation of the present invention, bending will be effected in a direction generally perpendicular to web 40. As a result, the portion of tube 2 disposed at a level above web 40 will be placed in tension during the bending operation and the portion of the tube disposed below the level of web 40 will be placed in compression during the bending operation. The web 40 will preferably be disposed generally along the neutral axis, i.e., will not be under appreciable tension or compression during the bending operation.

In general, it will be preferred to provide a web 40 which has a wall thickness less than the maximum wall thickness of sidewalls 8, 10 and preferably in the range of about 20 to 80 percent of the maximum wall thickness of sidewalls 8, 10. In general, great wall thickness of web 40 is not required in order to provide the strength needed for the process of the invention and where the web 40 is provided as an integral extruded portion of the tube 2, it may be made in the minimum thickness which the state of the extrusion art permits. This serves to reduce metal costs and product weight. In the preferred practice of the invention, bending will be effected to establish a generally uniform tube curvature of about 22 to 50 percent.

It has been found that the normal tendency for tube sidewalls to collapse inwardly during bending can be resisted by providing the irregular sidewall thickness described above. Providing the above-described taper may result in the sidewalls 8, 10 experiencing some outward distortion during the bending operation. It has been found that positioning the web 40 along or adjacent to the sector of maximum expected bending will result in resisting such undesired distortion. To the extent to which the sidewalls 8, 10 would normally deform transversely inwardly during the bending operation, the web 40 is believed to serve as a column which resists such deformation by its compressive strength and the extent to which outward deformation would normally result from bending, the tensile strength of the web 40 resists such undesired distortion. As a result, one may effectively produce the desired curved tube by means of the present invention without experiencing undesired deformation of one or more tube walls.

Referring now to FIGS. 4 and 5 another embodiment of the invention will be considered. While in general the tube may advantageously be formed as a unitary seamless unit of a suitable metal such as aluminum or bronze, for example, by an extrusion process and web 40 may be formed during such an extrusion process, an alternate approach may be taken if desired. While the embodiment wherein the web is formed integrally during the extrusion process is preferred, if desired, the embodiment shown in FIGS. 4 and 5 may be employed as an effective alternative. As is shown in FIG. 4, tube 50 is of generally rectangular configuration having an upper wall 52, a lower wall 54 and a pair of sidewalls 56, 58. Sidewall 56 is provided with a moisture receiving gutter 60 which is defined by flange 62 in cooperation with a portion of sidewall 56. Similarly, flange 64 cooperates with a portion of sidewall 58 to define gutter 66. It will be appreciated that gutters 60, 66 may be provided in any desired elevation along sidewalls 56,

58. It is noted that sidewall 56 has a pair of inwardly projecting flanges 70, 72 which cooperate to define restricted throat recess 74. Similarly, sidewall 58 has inwardly directed flanges 76, 78 which cooperate to define restricted throat recess 80. As is shown in FIG. 5, a web 82 has a pair of generally T-shaped ends 84, 86. Web 82, which is preferably substantially continuous and substantially coextensive with tube 50, is adapted to be secured to tube 50 by axial insertion of the web 82 into the tube interior in such fashion that end 84 is received within recess 74 and end 86 is received within recess 80. While this embodiment does not provide the advantage of automatic creation and connection of the web member within the tube interior, there may be certain uses for which such an approach may advantageously be employed.

Referring now to FIGS. 6 and 7, one form of bending operation which may be employed in the present invention will now be considered. As is shown in FIG. 6, a tube 90 is moving through a group of roller dies 92, 94, 96 in the direction indicated by the arrow. The relative positions of the three dies 92, 94, 96 will determine the degree of curvature imparted to the tube 90 as it moves progressively through the dies. In the form shown roller 94 is a driver die, roller 92 is a driven die and roller 96 is an idler die which is adjustable in the direction indicated by the double arrow. All of the rollers rotate in the directions indicated by the arrows.

As is shown in FIG. 7, the roller dies 92, 94 have configurations which will permit ready engagement of the tube 90 without undesired deformation thereof during the bending operation. It is also noted that the web 98 disposed within the tube 90 as described above will serve to resist undesired meaningful inward or outward deformation of the tube sidewalls. In the form shown, a suitable power source will cause gear 100 to drive roller 94 and through the operative connection with gear 102 to drive roller 92. A suitable thrust collar 104 is provided.

While the present invention is adapted for use on a wide range of metals employed in tube construction, it will generally be most advantageous to employ the method on metal tubes of a gauge and material designed for both structural and decorative architectural uses. For example, metal tubes made out of extruded aluminum or bronze may frequently be advantageously employed in the practice of the invention. Aluminum alloys of the 6063 and 6061 types are exemplary of those which may be employed. In general, such tubes will have a wall thickness within the zones of minimum thickness 8c, 10c in the range of about 0.080 to 0.250 inch.

While for simplicity of description above, reference has been made to a rectangular multiwalled tube, it will be appreciated that the invention is applicable to other multiwalled tubes. In uses where the tube has more than four walls, the reference to the transverse ends of the web being connected to "generally opposed walls" shall be deemed to include connections between an end of the web and a point where two adjacent walls meet. Also, while it is preferred that the web be positioned on the neutral axis of the tube, the web may be displaced from this neutral axis a distance which does not result in excessive undesired tube wall deformation during the bending operation. Finally, while for convenience of description herein there has been reference to a unitary web, it will be appreciated that, although not pre-

ferred, two or more webs which function to provide the benefits of the unitary web may be substituted therefor if desired and such substitution shall be deemed to be encompassed within the scope of this invention.

While for convenience of description herein reference has been made to various relative directions such as "upper," "lower," "side" and the like, these words are not, in the absence of express indications to the contrary, to be deemed limitations on the invention.

It will, therefore, be appreciated that the method and product of the present invention provide for efficient bending of a multiwalled metal tube along a predetermined curved path, while avoiding undesired meaningful tube wall deformation during bending. The general original cross sectional configuration of the tube can be preserved during bending. This is accomplished in an economical fashion without requiring meaningful modification to bending equipment and techniques and without requiring the use of inefficient prior art tube filler material, such as sand and shot. The method employs means integral with the workpiece to effect such curved bending, either uniformly or nonuniformly, without undesired wall distortion and permits advantageous use of modern metal extrusion techniques in creating the workpiece.

Whereas particular embodiments of the invention have been described above for purposes of illustration, it will be evident to those skilled in the art that numerous variations of the details may be made without departing from the invention as defined in the appended claims.

I claim:

1. A method of bending a metal tube comprising providing an elongated unitary multiwalled seamless metal tube, providing said elongated metal tube with an internally disposed elongated web having transverse ends connected to generally opposed walls of said tube and dividing the internal hollow into two generally equal sections, and bending said tube in a direction generally perpendicular to said elongated web to establish a predetermined tube curvature.
2. The method of claim 1 including said multiwalled metal tube having a cross sectional configuration in the shape of a polygon of three to ten sides.
3. The method of claim 2 including bending said tube progressively by passing it through a series of roller dies to establish a curvature of about 22 to 50 percent.
4. The method of claim 3 including providing said tube as a tube with a generally rectangular configuration defined by an upper wall, a lower wall and a pair of spaced sidewalls, and establishing said elongated web generally parallel to and generally midway between said upper and lower walls.
5. The method of claim 4 including providing said sidewalls with a maximum wall thickness at or adjacent the upper and lower extremities thereof and a minimum thickness at or adjacent the middle thereof.
6. The method of claim 5 including providing said sidewalls with a generally uniform taper extending generally from the upper and lower extremities thereof toward the middle thereof.
7. The method of claim 4 including

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providing said upper and lower walls with a maximum wall thickness at or adjacent the transverse outer extremities thereof and a minimum thickness generally midway therebetween.

8. The method of claim 4 including forming said elongated seamless metal tube and said elongated web as a unitary extrusion having generally the same cross sectional configuration throughout its length, and establishing said internally disposed web with a wall thickness less than the maximum wall thickness of said tube sidewalls.

9. The method of claim 4 including forming said elongated web as a separate member

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from said tube with flanges at or adjacent the transverse edges thereof,

providing said tube sidewalls with inwardly projecting flanges defining recesses for receiving said web flanges, and

securing said web to said sidewalls by introducing said web flanges into said sidewall flanges.

10. The method of claim 4 including providing said sidewalls with exteriorly disposed generally outwardly and upwardly directed flanges which cooperate with other portions of said sidewalls to define moisture receiving gutters.

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