Aug. 29, 1961 G. G. MALLY ET AL 2,998,047

METHOD OF MAKING TUBE FROM STRIP METAL STOCK

Filed March 5, 1958 2 Sheets-Sheet 1

FIG. 1

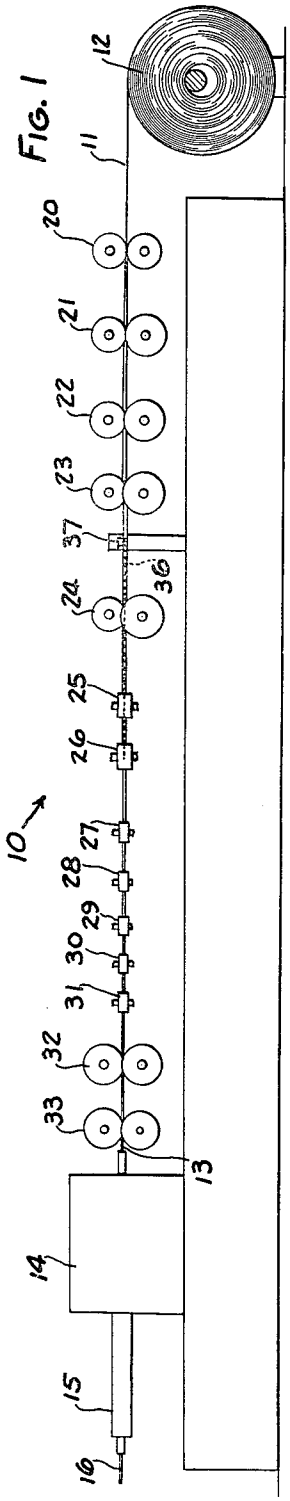
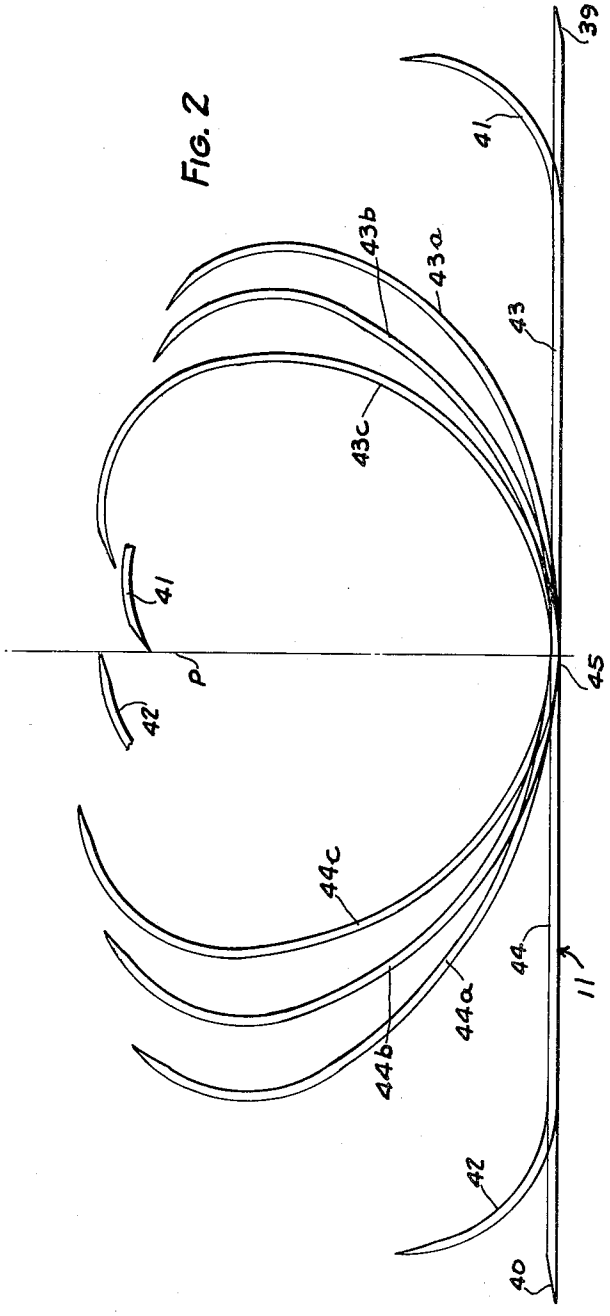


FIG. 2



INVENTORS
GEORGE G. MALLY, PETER LALLI
& ZBIGNIEW GNIADOWSKI
BY
Barnes, Kisselle, Raisch & Choate
ATTORNEYS

Aug. 29, 1961 G. G. MALLY ET AL 2,998,047

METHOD OF MAKING TUBE FROM STRIP METAL STOCK

Filed March 5, 1958 2 Sheets-Sheet 2

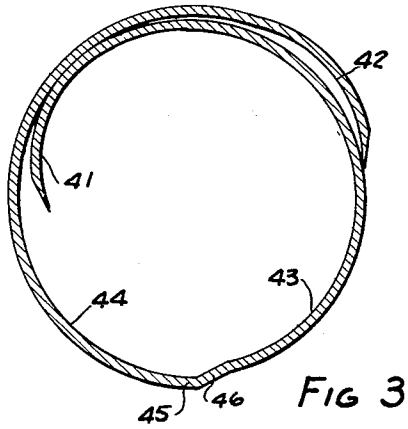


FIG 3

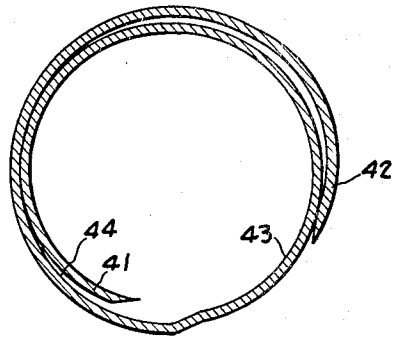


FIG. 4

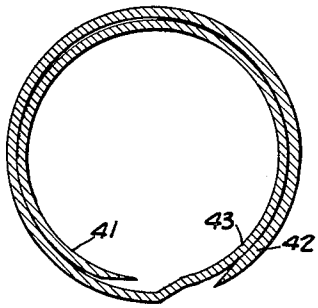


FIG. 5

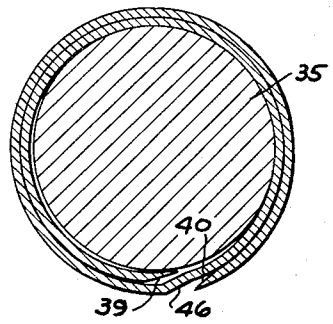


FIG. 6

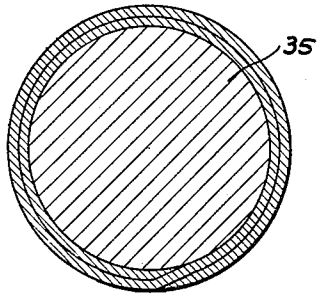


FIG. 7

INVENTORS
GEORGE G. MALLY, PETER LALLI
& ZBIGNIEW GNIADOWSKI
BY
Barnes, Kisselle, Raich & Choate
ATTORNEYS

United States Patent Office

2,998,047

Patented Aug. 29, 1961

2,998,047

METHOD OF MAKING TUBE FROM STRIP METAL STOCK

George G. Mally, Peter Lalli, and Zbigniew Gniadowski, Birmingham, Mich., assignors to Bundy Tubing Company, Detroit, Mich., a corporation of Michigan

Filed Mar. 5, 1958, Ser. No. 719,416

9 Claims. (Cl. 153—54)

This invention relates to making tubing from strip metal stock and is especially concerned with the manufacture of tubing having walls formed of a number of layers of stock.

United States Patent No. 2,292,810 to E. O. Woeller dated Angust 11, 1942, discloses a method of fashioning metal strip stock transversely through about 720° while the strip is moving lengthwise to form tubing having two-ply walls. Billions of feet of excellent tubing for hydraulic and other purposes have been made by use of the Woeller disclosure. However, the Woeller method gives rise to certain difficulties of manufacture which it is the object of the present invention to eliminate.

According to the Weoller method, a portion of the strip metal stock near one edge is bent abruptly upwardly through about 90°. The outer edge of the strip is then rolled or wrapped toward the bent up portion which provides a guide for the strip as it moves lengthwise and which supports the strip against the lateral forming pressure involved in rolling up or wrapping the strip. After the strip has been wrapped through about 1½ turns the portions of the stock containing the abrupt L-shaped bend is ironed out to provide this portion with a curvature approximately that of the outer ply of the tube wall. The latter part of the stock is then wrapped around the previously rolled up portion to complete the roll forming procedure per se.

During this process the portions of the strip which are first rolled through 1½ turns are stretched considerably more than the portions which are merely wrapped through about the remaining half turn around the tube exterior. This results in uneven stresses tending to cause the tube to spiral and to twist on its longitudinal axis during subsequent treatment such as when it is subjected to heat to bond the wall plies together. Moreover, the portion which was first bent to L-shape and then ironed out is work hardened more than other portions of the tube, making it difficult to wrap the outer portion to complete the formation of the tube. In addition, the edge of the strip stock adjacent the abrupt L-shaped bend is stretched to such an extent during formation of the L that it contains ripples downstream of the L-forming rolls which must be smoothed out by further rolling, thus work hardening this edge portion of the strip more than adjacent portions.

Heretofore, these and similar factors have necessitated passing the tubing over a mandrel and subjecting it to severe compressive forces to set the plies in contiguous relationship to prevent the tubing from unwrapping and to prevent it from spiraling or twisting unduly after leaving the tube mill. The tubing passes over the mandrel at the rate of between 300 and 400 feet per minute. Various circumferential portions of the tubing are work hardened to materially different degrees. Consequently, wear on the mandrel is severe and uneven and the mandrel must be frequently replaced, necessitating frequent tube mill stoppages which are expensive in mill hours production time lost, and in man hours required for changing the mandrel.

The present invention provides a simple method of rolling tubing from strip stock which is improved to eliminate these disadvantages. The invention generally contemplates rolling longitudinal halves of the strip transversely in opposite directions in a generally symmetrical manner so that in wrapping the stock through about 720° each longitudinal half is wrapped through about 360°. The stresses and work hardening of the stock are generally uniform throughout the circumferential extent of the tubing thus formed and the tendency of the tube to unwrap, twist, or spiral is minimized or eliminated entirely.

In the drawings:

FIGURE 1 is a diagrammatic representation of a tube mill arranged to utilize the present invention.

FIGURE 2 is a composite partially diagrammatic elevational view illustrating the conformation of the strip stock in various early stages of its formation.

FIGURES 3, 4, and 5 are sectional views illustrating conditions of the strip metal stock during further progressive stages of its formation.

FIGURES 6 and 7 are sectional views illustrating the final stages of forming the tube and illustrating the tube as being passed over a mandrel.

Shown in FIGURE 1 is a tube mill **10** which may be of a generally conventional type and which draws flat strip metal stock **11** from a coil **12** and passes the stock through a series of forming rolls to fashion the stock transversely to form tubing **13** which is then passed through a suitable furnace or heater **14** for heating the tubing and sealing or bonding its interfaces. The tubing is then passed through a cooler such as a water jacket **15** from which it emerges as completed basic tube **16**. Tube mill **10** is shown as including a number of sets of vertically aligned forming rolls **20—24**, a series of horizontally aligned forming rolls **25—31**, and two sets of finishing rolls **32** and **33**. It will be understood that this arrangement of rolls is illustrative only and that the rolls can be arranged in any desired manner according to the requirements of the particular tubing being rolled. In some cases, a mandrel **35** is utilized in the tube interior between finishing rolls **32** and **33**. This mandrel is anchored through a long rod **36** inserted into the partially formed tube as at **37** before the tubular form is closed.

The first set of rolls **20** bevels the edge portions of the stock in opposite directions as at **39** and **40** for a purpose to be described. Portions **41** and **42** of the strip adjacent opposite edges thereof are then fashioned transversely counter-clockwise and clockwise respectively as the drawings are viewed through about 90° on radii of curvature which closely approximate the radii which they will have in the tubing to be formed. In some instances, the radii of portions **41** and **42** may be the same and in other cases they may be slightly different to facilitate wrapping one longitudinal half of the strip around the other longitudinal half and to facilitate the latter forming stages in making the tube. This step may be accomplished at vertical rolls **21** and it will be noted that the portions **43** and **44** of the strip lying between the longitudinal central portion **45** thereof and the curved edges remain generally flat.

As the strip passes through vertical rolls **22**, **23**, and **24**, intermediate portions **43** and **44** of the strip are fashioned transversely on progressively diminishing radii of curvature which are greater than the radius of the initial radii at portions **41** and **42**. Portions **43** and **44** are formed respectively counterclockwise and clockwise to bring the side edges of the strip stock toward each other and the changing radii of these portions of the stock are represented in FIGURE 2 generally at **43***a–c* and **44***a–c*. The radii of portions **41** and **42** remain generally unchanged during the forming of portions **43** and **44**, though there may be some variation in shape resulting from the stresses in the strip set up by this fashioning of the strip.

The strip then passes through horizontal rolls **25** and

26 where intermediate portions 43 and 44 of the strip are further transversely fashioned so that the strip assumes generally tubular form with the side edges of the strip intersecting a common plane P as represented in FIGURE 2. Intermediate portions 43 and 44 have been formed on radii of curvature which are sufficiently unlike to cause portion 42 to lie radially outwardly of portion 41 by at least the thickness of a side edge of the strip so that upon continued rolling portion 42 will overlap portion 41.

In rolling the stock from its flat condition to the generally tubular condition illustrated by the last stage of FIGURE 2, the curved portions of the strip lying on opposite sides of the longitudinal central portions 45 have provided abutments for suppotring the strip against the lateral forming pressures applied to the opposite half of the strip.

The strip is then passed through horizontal rolls 27 and 28 in which portion 42 of the stock is lapped over the exterior of portion 41 and intermediate portions 43 and 44 of the stock are further formed transversely so that the longitudinal halves of the stock on opposite sides of the longitudinal central portion 45 begin to wrap mutually around each other. The half containing portions 41 and 43 of the stock conforms generally to the interior of the half containing portions 42 and 44 while the latter half conforms generally to the exterior surfaces of the half containing portions 41 and 43. The condition of the stock at this time is illustrated generally in FIGURE 3. It will be noted that the stock has been provided adjacent its longitudinal central portion with a step 46 for a purpose to be described. This step may be provided at any convenient stage in formation of the tube such as at vertical rolls 22.

As the partially formed tube passes through horizontal rolls 29 and 30, the radii of curvature of the outer and inner halves are progressively diminished so that the halves continue to wrap mutually to each other as illustrated in FIGURES 4 and 5. The tube is then passed through horizontal roll 31 where the halves are further wrapped and diminished in radius to bring bevels 39 and 40 into close proximity to opposite faces of stepped portion 46. The tube is passed through finishing rolls 32 and 33 which further constrict the wrapped halves to set the bevels on the step as illustrated in FIGURE 7. As pointed out, it may be advantageous to use an internal mandrel in conjunction with the finishing rolls though a mandrel may not in all cases be necessary.

In the stages illustrated in FIGURES 3–5, portions 41 and 42 tend to retain their original radii of curvature but may change somewhat in shape because of stresses in the stock incident to the wrapping. In particular, outer portion 42 may be stressed to somewhat flatter condition in the intermediate stages (FIGURE 4) but this portion springs back and tends to resume its original radius in the latter stages (FIGURE 6) to facilitate relatively snug wrapping of the outer ply around the inner.

In the latter forming stages as well as in the earlier forming stages, curved portions of the stock on one side of the tubular form provide abutments for supporting the stock against lateral forming pressures applied to the opposite side. Both the inner half and the outer half of the stock are rolled through about 360° and the rolling is so nearly symmetrical that the stresses set up in the longitudinal halves of the stock are substantially similar. The fact that the inner ply is formed on a slightly smaller radius of curvature than the outer ply does not give rise to objectionable difference in stresses.

The tendency of the inner ply to spring back radially outwardly and the resistance thereto by the outer ply tends to hold the plies in snug uniform interfacial engagement when the tube emerges from tube mill 10. There is little or no tendency for the tube to unwrap. The seam at the interfaces of bevels 39, 40 and step 46 is generally uniform along the length of the tubing. Since the stresses throughout circumferential portions of the tube are uniform, there is little or no tendency for it to twist or spiral.

These factors minimize the pressures required at the region of finishing rolls 32 and 33 and if a mandrel 35 is used, it has very long life, thus minimizing the man hours and tube mill hours lost in mandrel replacement. Moreover, since the portions of the tube which engage the mandrel are generally uniformly work hardened, there is little or no uneven wear on the mandrel. More generally, the symmetrical rolling of the various circumferential portions of the tube facilitates gradual, generally equal deformation of all circumferential portions of the tube stock and makes roll forming of the tube relatively trouble free.

One example of tubing made by the present method is as follows: The strip stock is of a relatively low carbon steel .014" thick and 2.250" wide. This stock is rolled to a two-ply tubular form having a ⅜" outer diameter and a wall thickness of .028". It has been found by experimentation that in forming ⅜" tubing by the present invention the stock stretches circumferentially about .050" less than the stock stretches utilizing the Woeller method discussed above.

The present invention makes it possible to roll tubing having heavier or thicker walls than was possible with prior methods. One reason for this is that the present method employs no abrupt bends of the stock during the rolling which must subsequently be ironed out. Methods utilizing the abrupt bending and ironing out feature can not feasiably be used to roll thick materials to form thick walled tubing because as a practical matter it is too difficult to iron out these sharp bends and then wrap the work hardened, ironed out portions around the inner ply.

Another advantage of the present invention is that a tube mill utilizing the invention can handle stock having greater tolerances of thickness and temper than was possible by mills utilizing prior methods. This decreases the machine and man hours spent in effecting proper adjustments to handle different batches of stock.

We claim:

1. The method of forming tubing which comprises, moving a strip of metal stock lengthwise and while so moving said strip, fashioning a portion of a longitudinal half of said strip on one side of the longitudinal central portion thereof transversely in a clockwise direction and on a radius of curvature closely approximating the radius which it will have in the tubing to be formed, fashioning a portion of the longitudinal half lying on the other side of said central portion of said strip transversely in a counterclockwise direction and on a radius of curvature closely approximating the radius which it will have in the tubing to be formed, fashioning other portions of said longitudinal halves respectively in a clockwise and counterclockwise direction and on radii of curvature which are larger than the first mentioned radii of curvature to bring the side edges of the strip toward each other, lapping the side edge of one longitudinal half over the side edge of the other half, then, while leaving the first mentioned radii of curvature substantially unchanged, fashioning said other portions of said one longitudinal half on predetermined progressively diminishing radii of curvature, and simultaneously therewith, fashioning said other portions of the other longitudinal half transversely on slightly smaller progressively diminishing radii of curvature so that said first half overlies and generally conforms to the curvature of said other half, and continuing so to fashion said other portions of said halves until said edges are adjacent opposite faces of said longitudinal central portion.

2. The method of forming tubing which comprises, moving a strip of metal stock lengthwise and while so moving said strip, fashioning a portion of a longitudinal half of said strip lying a predetermined distance laterally of the longitudinal central portion thereof transversely in

a clockwise direction and on a radius of curvature which closely approximates the radius which it will have in the tubing to be formed, fashioning a portion of the longitudinal half lying generally an equal transverse distance on the opposite side of said central portion of said strip in a counterclockwise direction and on a radius of curvature closely approximating the radius which it will have in the tubing to be formed, fashioning portions of said halves lying intermediate the first mentioned portions thereof respectively in a clockwise and counterclockwise direction on radii of curvature which are larger than the first mentioned radii of curvature and which are different from each other, thereby bringing the side edges of the strip toward each other with the side edge of one of said halves lying radially outwardly of the side edge of the other half, then, while leaving the first mentioned radii of curvature substantially unchanged, fashioning the intermediate portions of said one longitudinal half transversely on predetermined progressively diminishing radii of curvature, and simultaneously therewith, fashioning the intermediate portions of said other longitudinal half on slightly smaller progressively diminishing radii of curvature so that the said first half overlaps and generally conforms to the curvature of the exterior of said other half, and continuing so to fashion said intermediate portions of said halves until said side edges are adjacent opposite faces of said longitudinal central portion.

3. The method of forming tubing which comprises, moving a strip of metal stock lengthwise and while so moving said strip, fashioning a portion of said strip lying adjacent one side edge thereof transversely in a clockwise direction and on a radius of curvature closely approximating the radius which it will have in the tubing to be formed, fashioning a portion of said strip lying adjacent the other side edge transversely in a counterclockwise direction and on a radius of curvature closely approximating the radius which it will have in the tubing to be formed, fashioning the portions of said strip lying between the first mentioned portions thereof respectively in a clockwise and counterclockwise direction on radii of curvature which are greater than the first mentioned radii and thereby bringing the side edges of said strip toward each other, lapping one of said side edges over the other, then, while leaving the first mentioned radii of curvature substantially unchanged, simultaneously fashioning said intermediate portions of said strip transversely on predetermined progressively diminishing radii such that one longitudinal half of the strip overlaps and generally conforms to the curvature of the exterior of the other half, and continuing so to fashion said halves until said edges are adjacent opposite faces of said longitudinal central portion.

4. The method of forming tubing which comprises, moving a strip of metal stock lengthwise and while so moving said strip, transversely fashioning portions of said strip adjacent its side edges respectively clockwise and counterclockwise through about 90° on radii of curvature closely approximating the radii which they will have in the tubing to be formed, then transversely fashioning intermediate portions of said strip respectively clockwise and counterclockwise on radii of curvature which are initially greater than the first mentioned radii, and thereby bringing said side edges toward each other, lapping one side edge over the other, and while leaving the first mentioned radii of curvature unchanged, simultaneously fashioning said intermediate portions transversely on progressive diminishing radii of curvature until said side edges lie adjacent opposite faces of a generally central longitudinal portion of said stock,

5. In a method of forming tubing by fashioning strip stock to tubular form while the strip is moved lengthwise, the improvement which comprises, first fashioning edge portions of the strip respectively clockwise and counterclockwise on radii of curvature closely approximating the radii which they will have in the tube to be formed, then, without changing substantially said radii,

fashioning intermediate portions of said strip respectively clockwise and counterclockwise on radii of curvature initially larger than the first mentioned radii and progressively diminishing, lapping one side edge of said strip over the other, and simultaneously continuing so to fashion said intermediate portions until the radii thereof are diminished substantially to the radius of said tube and said side edges are disposed adjacent opposite face portions of the longitudinal central portion of said strip.

6. The method of forming tubing which comprises, moving a strip of metal lengthwise and while so moving said strip applying to longitudinal halves of said strip on opposite sides of the longitudinal central portion thereof of lateral forming pressure, controlling said pressure so that the portions of said halves adjacent their free edges are fashioned transversely in clockwise and counterclockwise directions respectively on radii of curvature closely approximating the radii which they will have in the tubing to be formed, then applying further transverse forming pressure to said halves and controlling the latter said forming pressure so that the portions of said halves intermediate said edge portions and central portion transversely fashioned in clockwise and counterclockwise directions respectively on radii of curvature larger than the first mentioned radii, lapping the side edge of one half outside of the side edge of the other half, simultaneously applying further lateral forming pressure to said intermediate portions of said longituidnal halves while leaving the first mentioned radii of curvature substantially unchanged, controlling the latter said pressure so that said halves wrap simultaneously relative to each other with said one half conforming generally to the exterior surface of said other half and said other half conforming generally to the interior surface of said one half, and continuing the latter said forming pressure until said side edges are disposed adjacent opposite faces of said longitudinal central portion.

7. The method defined in claim 5 wherein said edge portions of said strip are fashioned on radii of curvature which are substantially equal.

8. The method of forming tubing which comprises, moving a strip of metal stock lengthwise and while so moving said strip, fashioning in directions respectively clockwise and counterclockwise and on radii of curvature closely approximately their radii in the tubing to be formed, portions of said strip spaced in opposite directions from the longitudinal central portion of said strip and thereby bringing the edges of said strip toward each other, further bringing said edges toward each other by fashioning others of said portions respectively clockwise and counterclockwise on radii of curvature larger than the first mentioned radii, lapping the side edge of one-half of said strip over the side edge of the other half, and, while leaving the first mentioned radii of curvature substantially unchanged, further and simultaneously fashioning said other portions of the longitudinal halves clockwise and counterclockwise respectively on progressively diminishing radii with the radius of curvature of said one-half being slightly greater than the radius of curvature of the other half so that said one-half overlaps and generally conforms to the curvature of the exterior of the other half, and continuing so to fashion said other portions of said halves until said side edges are adjacent opposite faces of said longitudinal central portion.

9. The method of forming tubing which comprises, providing a strip of substantially flat metal stock, moving the strip lengthwise, and while leaving the longitudinal central region of said strip substantially flat fashioning portions of said strip adjacent its edges respectively clockwise and counterclockwise on radii of curvature closely approximating the radii which they will have in the tubing to be formed, then while leaving said radii substantially unchanged fashioning portions of said central region respectively clockwise and counterclockwise on radii of curvature which are larger than the first mentioned radii of curvature to bring the side edges of the strip toward

each other, lapping one of said side edges over the other, then while leaving the first mentioned radii of curvature substantially unchanged simultaneously continuing so to fashion said portions of said central region until the radii thereof are diminished substantially to the dimensions of said tube and said side edges are disposed adjacent opposite face portions of the longitudinal central portion of said strip.

References Cited in the file of this patent

UNITED STATES PATENTS

909,644	McCloud	Jan. 12, 1909
1,476,796	Bundy	Dec. 11, 1923
2,038,600	Quarnstrom	Apr. 28, 1936
2,234,450	Quarnstrom	Mar. 11, 1941
2,292,810	Woeller	Aug. 11, 1942