Dec. 22, 1953 R. L. WHITING ET AL 2,663,206

METHOD AND MEANS FOR PRODUCING CLOSED END TUBING

Filed March 15, 1950 2 Sheets-Sheet 1

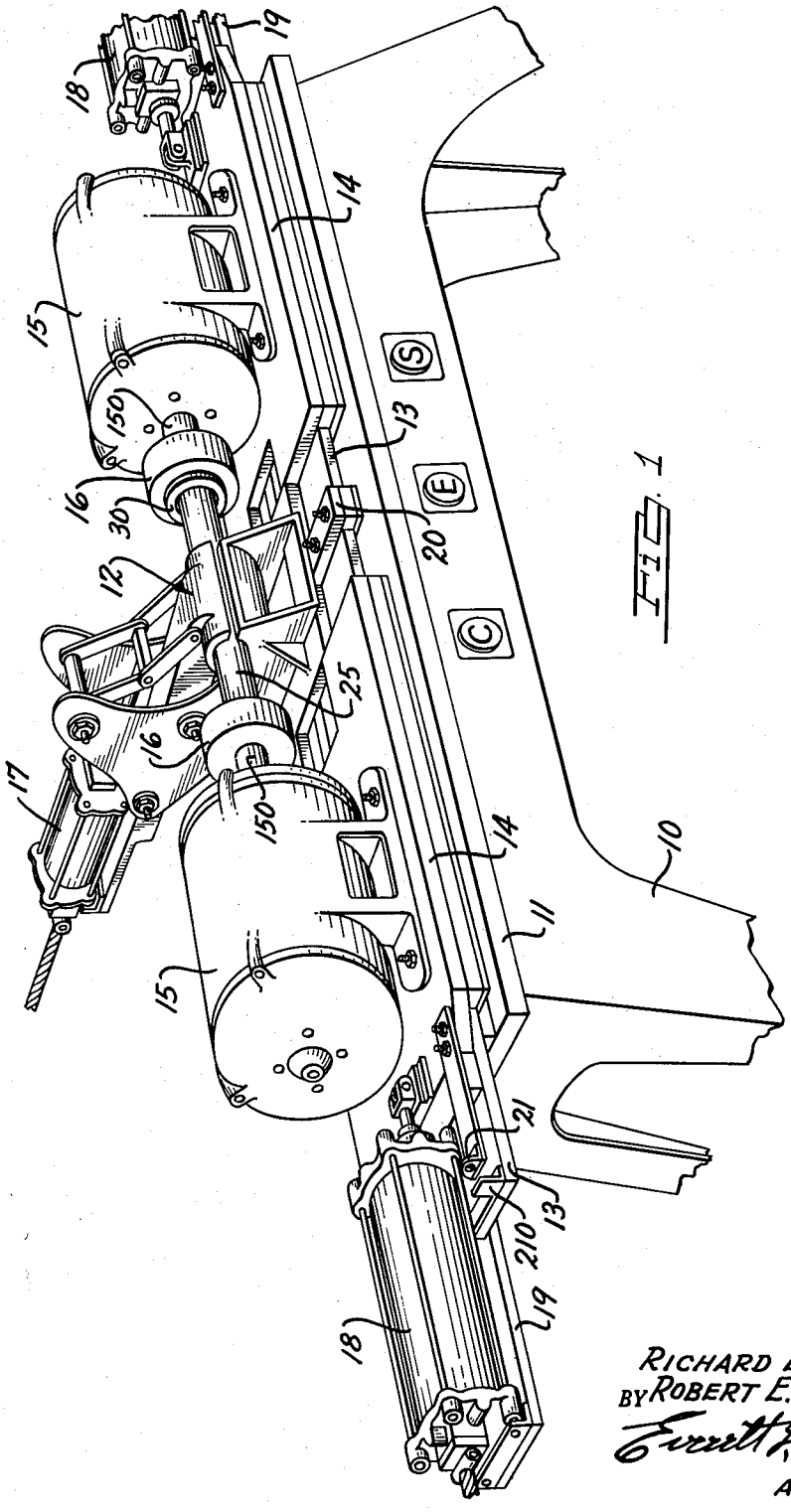


FIG. 1

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METHOD AND MEANS FOR PRODUCING CLOSED END TUBING

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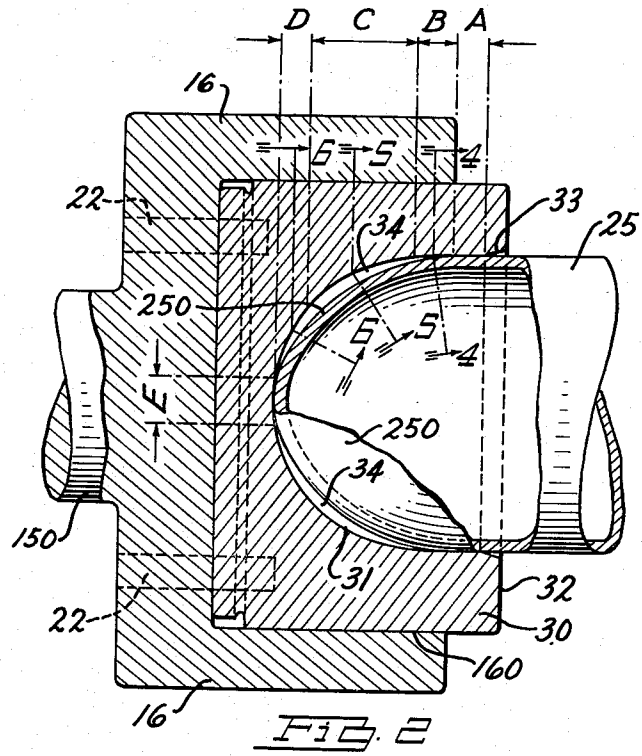


Fig. 2

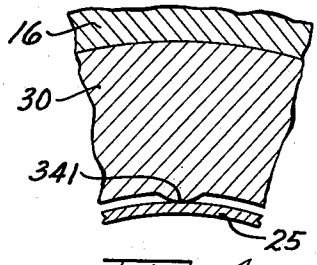


Fig. 4

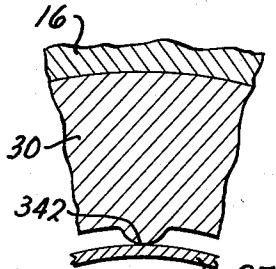


Fig. 5

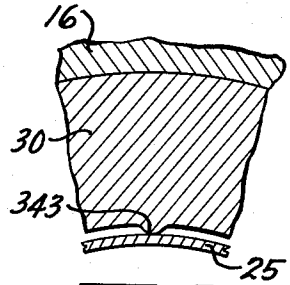


Fig. 6

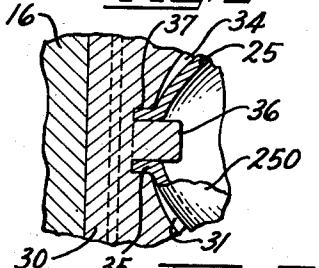


Fig. 7

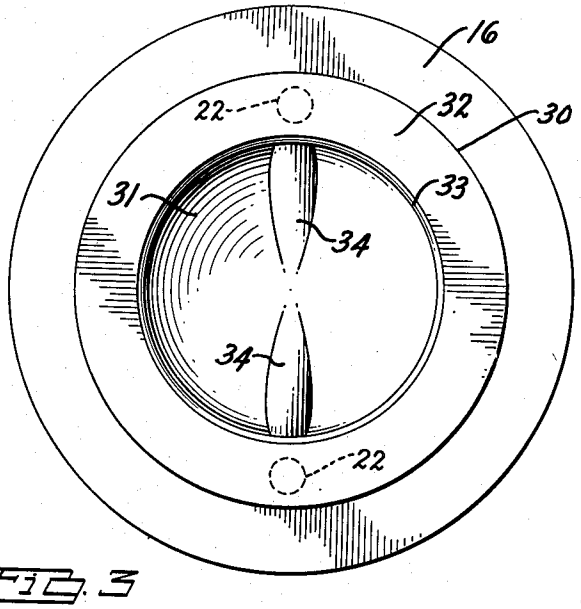


Fig. 3

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METHOD AND MEANS FOR PRODUCING CLOSED END TUBING

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Application March 15, 1950, Serial No. 149,709

2 Claims. (Cl. 78—89)

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This invention relates to an improved method and means for closing the ends of tubing.

In the prior art there have been many and divers methods and means employed for closing the ends of tubing, however, none has proven entirely satisfactory both in quality and uniformity of the finished product. Also, when high production is required many of the prior art methods and means employed result in an extremely high percentage of culls.

The primary object of the invention is to provide an improved, effective and positive method and means for producing closed end tubing by combined centrifugal and axial deformation further combined with extreme metal working at a critical portion of the forming operation and relatively minor metal working before and after the critical portion of the forming operation.

Another object of the invention is to provide an improved, effective and positive method and means for producing closed end tubing, including the steps of frictionally pre-heating the end of the tubing in a pre-heat ring, slightly working the tubing while frictionally increasing the temperature thereof in an initial heat and forming zone simultaneously with starting to close the end thereof, heavily working of the tubing while frictionally further increasing the temperature thereof in a forming heat and major forming zone simultaneously with nearly closing the end thereof, and then frictionally further increasing the said heat of the tubing in a final forming zone while gradually reducing the working thereof to zero working near the center of the tube, and frictionally increasing the temperature at the end of the tubing to a point of fusion while closing the end thereof in a finishing zone at the center of the tube without further working.

Other objects of the invention will become obvious by reference to the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a view in perspective showing a machine of the general type on which the method of producing closed end tubing may be practiced and which may employ the particular means and accomplish the method steps for closing the ends of tubing embodying the invention.

Fig. 2 is a vertical sectional view of a preferred and improved die employed for carrying out the method steps embodying the invention, a tube having had its end closed by the said die being positioned therein.

Fig. 3 is an end elevational view taken on the line 3—3 of Fig. 2 with the tube omitted showing a preferred form of ribbing of the die cavity.

Fig. 4 is an enlarged fragmentary sectional view taken on the line 4—4 of Fig. 2 showing the particular die ribbing preferred in the initial heat zone.

Fig. 5 is an enlarged fragmentary sectional view taken on the line 4—4 of Fig. 2 showing the particular die ribbing preferred in the critical forming heat zone.

Fig. 6 is an enlarged fragmentary sectional view taken on the line 6—6 of Fig. 2 showing the particular die ribbing preferred in the final forming zone.

Fig. 7 is an enlarged fragmentary sectional view of the construction shown in the dot and dash circle 7 of Fig. 2 modified to indicate how the center of the die would be formed to provide an open neck at the center of the closed end tubing.

The term "closed end tubing" as herein employed means the generally domed shape end formed on a metal tube of steel, copper, bronze or other material which will flow plastically responsive to frictional heat and metal working. The end of the tube need not be completely closed to come within the term "closed end tubing" as herein employed.

Referring now to the drawings wherein like numerals and reference characters refer to like and corresponding parts throughout the several views, the tube ending machine disclosed in Fig. 1 is illustrative of the type of machine that may include the means and carry out the method of producing closed end tubing embodying the invention. The particular machine for closing the ends of tubing disclosed for illustrative and not limiting purposes comprises a base 10, a bed 11, a hydraulically operated tube clamping fixture 12 fixed to the center of the bed 11, a pair of ways 13 onto which platens 14 are slidably mounted, a pair of oppositely disposed axially aligned electric motors 15 each mounted on one of the platens 14, each electric motor 15 having a chuck 16 mounted on the drive shaft 150 thereof, a tube closing die 30 fixed in each of said chucks 16 for rotation therewith, a hydraulic cylinder 17 for clamping a tube 25 to be closed at its ends in the tube clamping fixture 12, hydraulic cylinders 18 supported on an extension 19 of the bed 11 for advancing the platens 14 against a central stop 20 whereby to advance the dies 30 a predetermined distance against the open end of a tube 25 to close the same as hereinafter described in detail. Stops 21 on the platens 14 engage stops 210 on the ways 13 to limit the outward travel of the platens

14. Suitable adjustable means, not shown but well known in the art, are preferably employed to regulate the rate of advance of the platens 14 toward the central stop 20 which is necessary to adjust in setting up the tube ending machine inasmuch as the rate of attack of a tube closing die 30 on the end of a tube 25 to be closed must be such as will produce proper frictional heating and proper working of the tube end 250 as it is formed and closed.

To operate the tube ending machine the "Start" button S is pressed which starts both motors 15 which rotate the dies 30. The hydraulic tube clamping fixture 12 is open, a tube 25 to have its ends closed is placed therein, and the "Clamp" button C is pressed which causes the hydraulic cylinder 17 to clamp the said tube 25 and hold it in axial alignment and non-rotatably with respect to the rotating dies 30 while the hydraulic cylinders 18 advance the platen 14 toward the center of the machine and against the central stop 20 whereby to advance the dies 30 a predetermined distance onto opposite ends of the tube 25 in the process of having its ends closed. As soon as the foregoing cycle of operation is completed, the movement of the hydraulic cylinders 18 is reversed thereby reversing the platens 14 automatically, the tube clamping hydraulic cylinder 17 of the tube clamping fixture 12 is then reversed whereby to release the tube 25 having had its ends closed, and another tube 25 to have its ends closed is then placed in the machine and the cycle is repeated. The Emergency button E is pressed by the operator of the tube ending machine in the event it becomes necessary to stop the machine during its automatic operating cycle.

Inasmuch as the details of the construction of the tube ending machine illustrated in Fig. 1 and the controls therefor are obvious to those skilled in the art, the tube ending machine will not be described in detail. However, the improved method of producing closed end tubing and the novel means for accomplishing the said method is best illustrated in the construction, formation and function of the dies 30 and their application to tubing 25, all hereinafter fully described in detail.

Referring now particularly to Figs. 2–6 inclusive, the tube closing die 30 is seated in the die cavity 160 of the chuck 16 and is fixed in non-rotatable relationship with respect thereto by such means as the pins 22. The die 30 is provided with a generally semi-spherical shaped tube cavity 31 formed therein starting at the annular face 32 of the said die 30 with an annular tapered lead 33 for guiding the open end of tubing 25 to be closed into a pre-heat ring A which is substantially the same internal diameter as the external diameter of the tubing 25. Inwardly and blending from the pre-heat ring A is formed a pair of oppositely disposed ribs 34 contoured with their highest point disposed on the longitudinal axis of the tube 25 and describing the external domed shape of the closed end 250 of the tube 25 when closed, the said oppositely disposed ribs 34 blending into the base of the tube cavity 31 at the center or finishing zone E of the said die 30. It will be noted that the depth of the generally semi-spherical tube cavity 31 below the high point of the ribs 32 beginning at the inner edge of the pre-heat ring A and ending at the finishing zone E is such as to establish an initial heat and forming zone B, a forming heat and major forming zone C, and a final forming zone D adjacent the said finishing zone E. It will be further noted that the cross sectional configuration of the ribs 34 preferably varies gradually from a flat wide rib 341 in the initial heat and forming zone B, to a relatively deep wide rib 342 in the forming heat and major forming zone C, and to a narrower and shallower rib 343 in the final forming zone D fading out to an un-ribbed surface in the finishing zone E.

Obviously zones A to E inclusive are subject to variations as to the extent thereof as well as are the conformations of the ribs 32 at each of the zones B, C and D; however, the improved, effective and positive method and means for producing closed end tubing herein disclosed contemplates the generation of heat in the end or ends of tubing 25 being closed combined with limited working of the tubing 25 in a more or less degree at the several zones as the rotating die or dies 30 are pressed over the end or ends of the non-rotating tubing 25 as the said end or ends of the tube 25 are being closed.

The method and means for closing the end or ends of tubing embodying the invention will be better understood by describing that which takes place when a tube 25 to be closed at its end is attacked by a rotating specially formed die 30. In the particular example given as illustrative of the invention, the die 30 is preferably rotated at approximately 3600 R. P. M. The rate of advance of the die 30 onto the open end of the non-rotating tube 25 varies according to the type of material employed in and thickness of the tube 25, which rate of advance is adequate to provide sufficient heat in the end of the tube 25 when attacked by the inner half of the forming heat zone D to bring the temperature of the said tube 25 to just below melting point making the end of the tube 25 thereat substantially plastic and maintaining the temperature to maintain the substantial plasticity of the end of the tube 25 through the final forming zone D and the finishing zone E where the advance of the die 30 onto the tube 25 ceases whereupon the closed end of the tube 25 cools sufficiently to permit a final set of the metal thereof while the die 30 is still rotating but not advancing, the die 30 then being withdrawn from over the end of the tubing.

If complete closing of the end 250 of the tubing 25 is not desired, the rotating die 30 is advanced slightly less than normally required to fully close the end 250 of the tubing 25 whereupon an insufficient amount of metal is present at the center of the substantially closed end 250 of the tubing 25 to fully close the same. Also, as shown in Fig. 7, if an open neck 35 or any other annular form is required at the axial center of the closed end 250 of the tubing 25, the tube closing die 30 is formed to correspond by providing, as in the example given, a central slightly tapered cylindrical nib 36 and an annular well 37 adjacent thereto into which metal from the nearly closed end 250 of the tube 25 flows to form the said open neck 35.

Referring again particularly to Figs. 2–6 inclusive, when a straight tube 25 is attacked by the rotating tube closing die 30, the annular tapered lead 33 thereof encompasses the annular end of the said straight tube 25. As the rotating tube closing die 30 advances further, the end of the straight tube 25 is frictionally engaged by the pre-heat ring A which elevates the temperature of the end of the said tube 25 to a temperature somewhat below "cherry red." As the rotating tube closing die 30 advances further onto the end

of the straight tube **25**, the ribs **34** thereof at the initial heat and forming zone B further elevate the temperature of the end of the tube to slightly below "cherry red" as the end of the tube **25** takes its initial forming. As the rotating tube closing die **30** advances further onto the end of the tube **25**, the ribs **34** thereof at the forming heat and major forming zone C further elevate the temperature of the end of the tube to or sightly above "cherry red" but below the point of fusion as the end of the tube takes its major forming. As the rotating tube closing die **30** advances further onto the end of the tube **25**, the ribs **34** thereof at the final forming zone D maintain the temperature of the end of the tube at above "cherry red" but below the point of fusion as the end of the tube takes its final forming. As the rotating tube closing die **30** advances further and to its maximum advance onto and over the end of the tube **25**, the smooth surface thereof at the finishing zone E frictionally heats the end of the tube to a state of plasticity and fusion as the end of the tube is closed or is substantially closed.

The term "somewhat below cherry red," "slightly below cherry red," "cherry red," "above cherry red but below the point of fusion," and "a state of plasticity and fusion" as herein used are all relative heat terms employed because the actual specific temperatures to which the end of the tube **25** is elevated as the rotating tube closing die **30** is advanced onto and over the end thereof cannot be measured accurately; however, by observation of tubes **25** from which the rotating tube closing die **30** has been withdrawn quickly at check points in the advance of the said rotating tube closing die **30** thereover, indications are that the hereinbefore stated relative heating of the end of the tube **25** occurs during the formation of a completely or substantially completely closed end **250**.

As the rotating tube closing die **30** is advanced over the end of a tube **25** to be closed thereby, the said tube **25** is worked by the pressure of the oppositely disposed generally axially extending ribs **34** of the said tube closing die **30** being urged thereagainst, the resistance of the said tubing **25** against being deformed from a straight piece to a completely or substantially completely closed end **250** by the oppositely and axially disposed ribs **34** of the said die **30**, which resistance increases as the tubing **25** gradually becomes closed, permits the said ribs **34** to indent themselves minutely and progressively into opposite sides of the tubing **25** as the end of the said tubing **35** is closed by the advancement of the said rotating tube closing die **30** thereover and thereonto, thus working the tubing **25** closed at its ends. The pressure of the attack of the tube closing die **30** against the end of the tube **25** being closed and the rate of advance of the said tube closing die **30** over the said end of the tube **25** being closed depends upon the diameter and wall thickness of the tube **25**. The pressure of attack or thrust pressure of the tube closing die **30** always must be sufficient to maintain a constant or continuous pressure on the end of the tube **25** coupled with the proper rate of advance of the tube closing die **30** onto the end of the tube **25** to raise the temperature of the end of the said tube **25** during the tube closing operation to approximately those temperatures hereinbefore described.

It has been found that two ribs **34** in the tube

cavity **31** of the tube closing die **30** are preferable and all that are necessary for most tube closing operations on tubing below 2½" or 3" in diameter having up to ⅛" wall thickness. For some tube ending operations, particularly although not exclusively in larger diameter tubing, three or even four ribs **34** may be required to provide the proper working of the tube end during the closing of the tube. While it has been discovered that the ribs **34** preferably vary gradually in cross sectional configuration from a relatively wide flat rib as indicated in Fig. 4, to a relatively deep wide rib as indicated in Fig. 5, to a relatively shallower narrow rib as indicated in Fig. 6 which fades out in the finishing zone E as indicated in Fig. 2, it is contemplated that the rib configuration may be varied to suit particular conditions of various tube ending production operations where the problem is not normal, as for example, when the closed end **250** is required to be other than substantially dome shaped.

Although but a single embodiment of the invention and a single example of the method steps have been disclosed in detail, it is obvious that many changes may be made in the size, shape, detail and arrangement of the elements of the invention and that variations may be made in the method steps employed, all without departing from the spirit and scope of the invention as defined by the appended claims.

We claim:

1. A tube closing die comprising a die block having an annular substantially smooth pre-heat ring whose diameter is substantially the same as the diameter of a tube to be ended thereby and a generally semi-spherical shaped imperforate cavity inwardly of the said annular pre-heat ring, and a plurality of axially disposed straight ribs extending above the surface of the said cavity, each rib being deepest at approximately the center thereof and fading out at the pre-heat ring and near the center of the die, the said ribs being relatively flat and shallow beginning at a point inwardly of the face of the die, relatively deep and wide at the longitudinal central portion thereof, and relatively shallow and narrow at the portion thereof fading out near the center of the die.

2. A tube closing die comprising a die block having an annular substantially smooth pre-heat ring whose diameter is substantially the same as the diameter of a tube to be ended thereby and a generally semi-spherical shaped imperforate cavity inwardly of the said annular pre-heat ring, and a plurality of generally axially disposed straight ribs extending above the surface of the said cavity, each rib being deepest at approximately the center thereof and fading out at the pre-heat ring and near the center of the die.

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