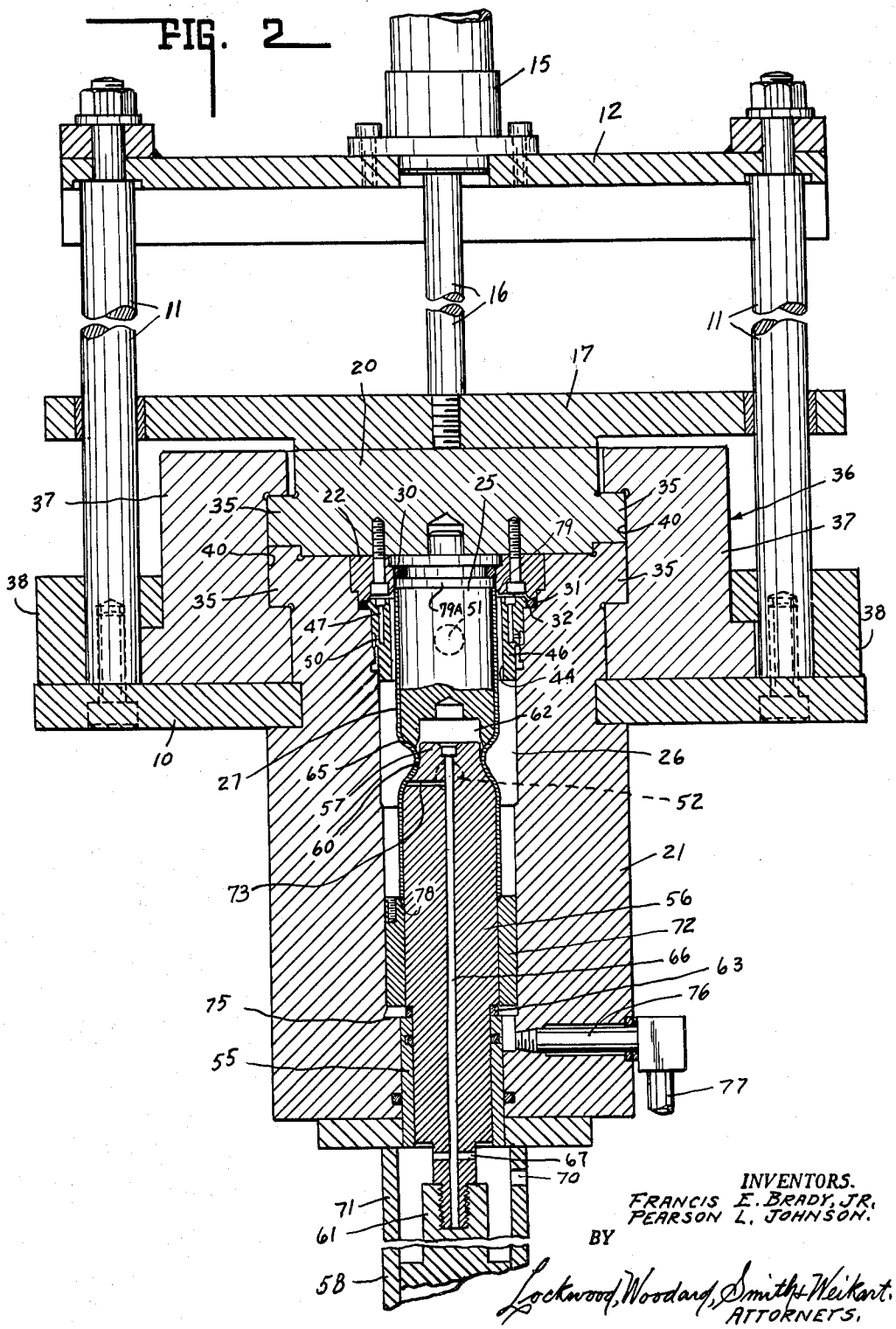
June 1, 1965 F. E. BRADY, JR., ETAL 3,186,203

METHOD OF AND APPARATUS FOR FORMING TUBULAR MEMBERS

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FIG. 2



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FIG. 3

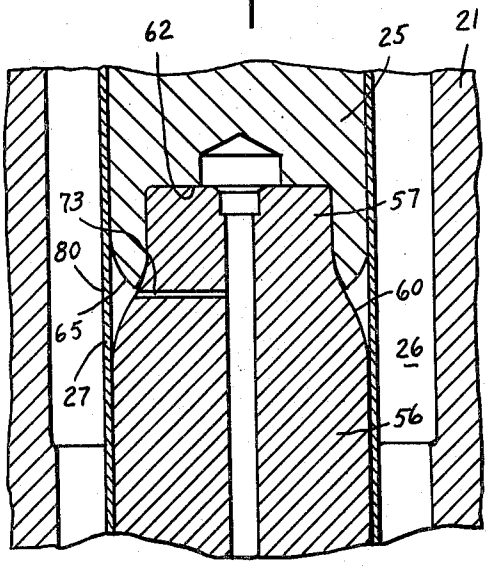


FIG. 4

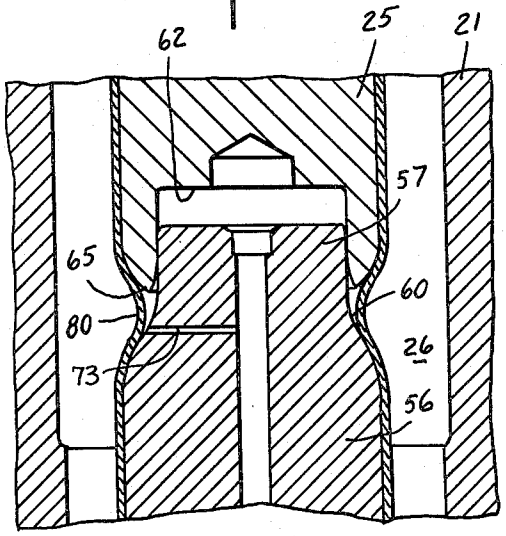


FIG. 7

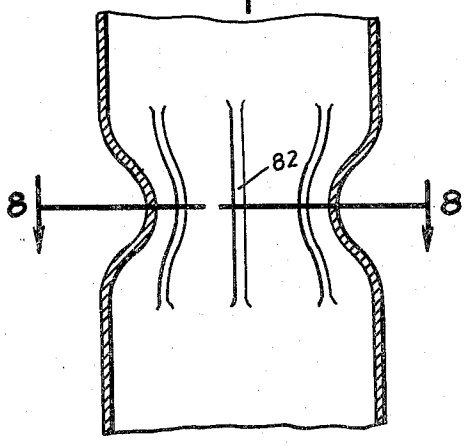
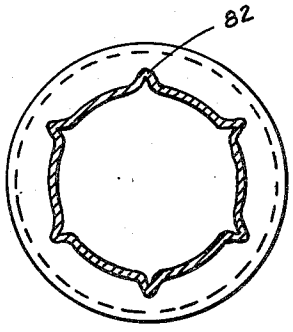


FIG. 8



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METHOD OF AND APPARATUS FOR FORMING TUBULAR MEMBERS

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FIG. 1

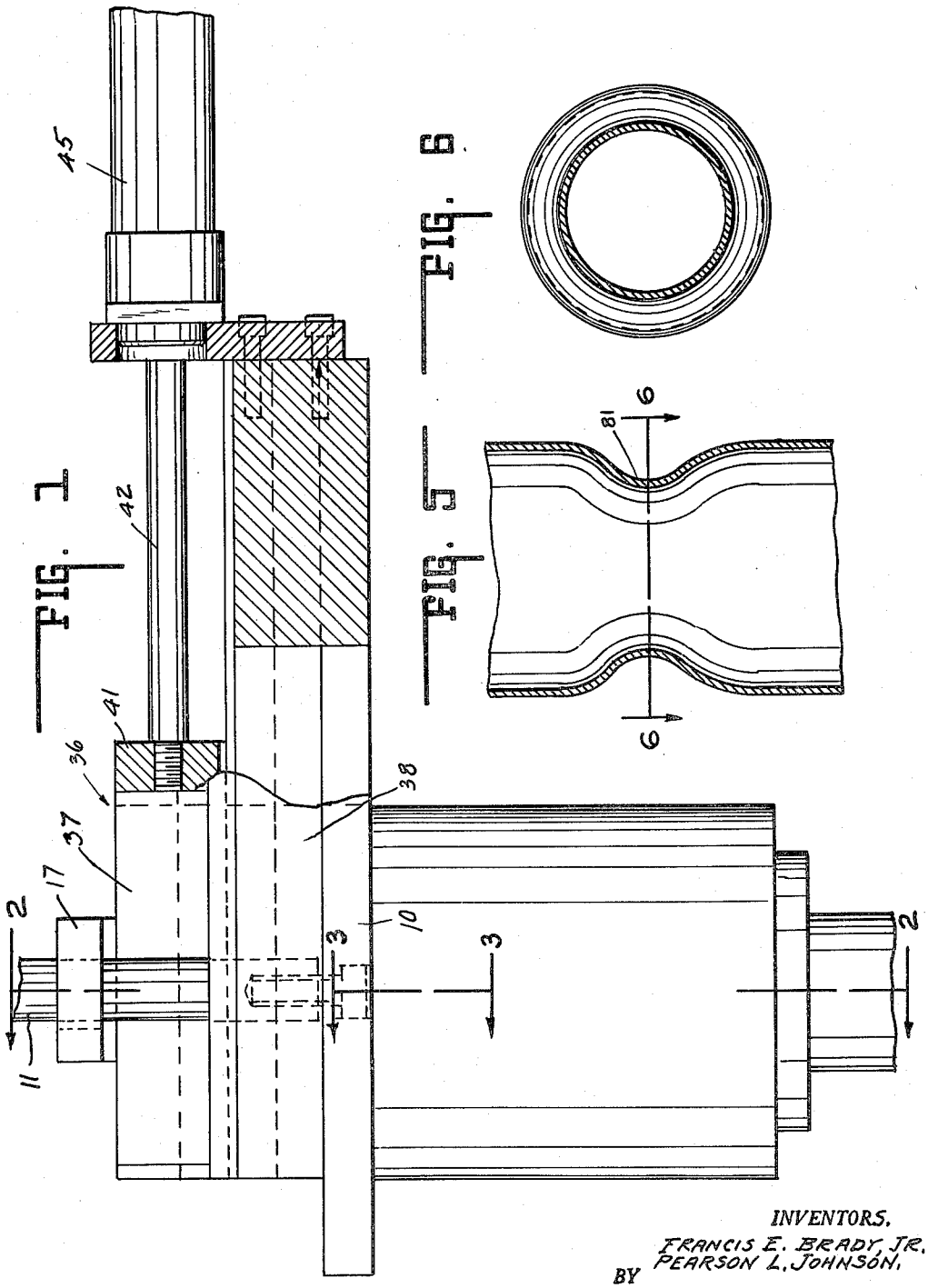


FIG. 6

FIG. 5

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3,186,203

METHOD OF AND APPARATUS FOR FORMING TUBULAR MEMBERS

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Filed May 9, 1960, Ser. No. 27,661
8 Claims. (Cl. 72—56)

This invention relates generally to metal working and forming methods and apparatus, are more particularly, it relates to a method of and apparatus for forming a neck or restriction in a tubular member.

According to conventional practice, restricted sections or neck portions are formed in tubular members by drilling bar stock to internal diameter such that a tubular member is formed having portions of relatively large diameter connected by a portion of relatively small diameter. Obviously, such an operation is time consuming and expensive. Another method of manufacturing such a product comprises a casting technique. Various methods and devices for deforming a tubular member to form a neck or restricted portion therein have been unsuccessful because such methods and devices do not cause uniform flow of metal to provide a neck or restricted portion of uniform curvature. The neck or restricted portion has what may be termed a "starred" shape which renders the tube unusable.

It is particularly desirable to provide a relatively simple and inexpensive method of deforming a tubular member for use in the manufacture of check valves of the type disclosed in Letters Patent of the United States, No. 2,827,922, granted to Paul A. Guinard. Such valves include a casing of tubular form having a neck or restricted portion formed therein.

The principal object of this invention is to provide a simple and inexpensive method of and apparatus for forming a neck or restricted portion in a tubular member.

Another object of this invention is to provide a hydraulically operated mechanism for forming or contracting a portion of a tubular member into a neck or restriction without decreasing the thickness of the walls of said member.

Related objects and advantages will become apparent as the description proceeds.

In accordance with the present invention, there is provided a method of forming a neck in a tube which includes internally supporting the tube, exerting pressure on the outer wall of the tube and simultaneously withdrawing support from a portion of the internal surface of the tube, this withdrawal of support being accomplished at a controlled rate and moving longitudinally of the tube.

The invention also contemplates an apparatus for forming a neck in a tubular member, the apparatus including a mandrel having a cavity opening at one end of the mandrel. There is also provided a second mandrel having a reduced end portion reciprocally received within the cavity. The mandrels are arranged in such a manner that a tube may be received about the mandrels whereby the mandrels will provide support to the tube during the exertion of pressure on the outer surface of the wall thereof. There is also provided means for withdrawing the second mandrel from the cavity whereby, upon the exertion of pressure on the outer surface of the tube, the wall of the tube will collapse toward the reduced end portion of the second mandrel and the collapse will move longitudinally of the tube.

The full nature of the invention will be understood from the accompanying drawings and the following description and claims.

FIG. 1 is a side elevation, partially in section, of an apparatus for forming a neck in a tube as embodied in the present invention.

FIG. 2 is a vertical section taken generally along the line 2—2 of FIG. 1 in the direction of the arrows.

FIG. 3 is an enlarged fragmentary section taken along the line 3—3 of FIG. 1 in the direction of the arrows and showing a portion of the structure illustrated in FIG. 2 in a different operating position.

FIG. 4 is a section similar to FIG. 3 showing the structure in still another operating position.

FIG. 5 is a longitudinal section of a tube having a neck formed therein by the use of the present invention.

FIG. 6 is a transverse section of the tube of FIG. 5 taken along line 6—6 of FIG. 5.

FIG. 7 is a longitudinal section of a tube having an improperly formed "star" shaped neck therein.

FIG. 8 is a transverse section of the tube of FIG. 7 taken along the line 8—8.

Referring more particularly to the drawings, there is illustrated a forming apparatus including a frame 10 having a pair of vertical stanchions or rods 11 fixed thereto and extending upwardly therefrom. Fixedly mounted upon the upper ends of rods 11 is a horizontally extending support 12 having a hydraulic cylinder 15 fixedly secured thereto. The piston rod 16 of the hydraulic cylinder is reciprocally received within the hydraulic cylinder in conventional manner, extends downwardly thereform and has fixed to its depending end a movable platen 17 which is vertically reciprocal upon the stanchions 11.

A lid 20 is fixed to the lower surface of the platen 17 and is arranged to close the upper end of a generally cylindrical container 21 which is fixedly mounted upon frame 10. The lid 20 has fixed to its lower surface an annular plate 22 which is suitably formed to retain and fix a depending mandrel 25 to the lower surface of the lid 20. When the lid 20 is moved downwardly by means of the hydraulic cylinder 15, the plate 22 and mandrel 25 are moved into a generally cylindrical chamber 26 extending longitudinally of the container 21.

In operation, hydraulic fluid is forced into the chamber 26 for deforming a tubular member 27 received therein. In order to prevent leakage of hydraulic fluid from the upper end of the chamber 26, an O-ring 30 is received between the plate 22 and the mandrel 25 and within a suitable peripheral recess in the mandrel. An O-ring 31 is received upon a shoulder 32 formed in container 21 adjacent the upper end of the cavity 26 and also functions to prevent leakage of hydraulic fluid from the chamber and more particularly between the plate 22 and the container 21.

In order to insure that the lid 20 is held securely against the upper end of the container 21, the lid and the container are provided with sidewardly projecting portions 35. When the lid is positioned upon the container in the position of FIG. 2, the projecting portions 35 may be engaged by a locking or clamping device 36 which includes a pair of members 37 which are slidable upon the frame 10 and have mutually facing recesses 40 adapted to move onto the projections 35 to prevent separation of the lid and container when hydraulic fluid is forced into the container.

The members 37 are slidable between guide members 38 fixed to the frame and are fixed in spaced relation by a connecting member 41 which is secured to the piston rod 42 of a hydraulic cylinder 45 mounted upon the frame 10. It can be seen that the function of the hydraulic cylinder 45 is to move the members 37 into and out of the locking position illustrated in FIGS. 1 and 2.

An annular member 46 is threadedly received within the container 21 and has an inner wall 44 having a some-

what greater diameter than the tube 27 whereby hydraulic fluid may pass therebetween. The annular member 46 is provided with a plurality of axially extending passages 47 which, when the apparatus is in the position of FIG. 2, communicate between the chamber 26 and an annular groove 50 on the outer periphery of the member 46. The container is provided with a suitable aperture 51 which provides communication between a suitable hydraulic line (not shown) and the annular groove 50. Thus, hydraulic fluid and air may pass from the chamber 26 between the annular plate 22 and annular member 46 into the passages 47 and groove 50 and out of the container 21 through the aperture 51.

The container 21 is also provided with an aperture 52 which opens directly into the chamber 26. The aperture 52 is connected to a suitable hydraulic line (not shown) wherein hydraulic fluid under pressure may be conducted into the chamber 26.

An insert 55 is fixed within the chamber 26 adjacent the lower end thereof and provides a bearing surface for a vertically reciprocal mandrel 56. The mandrel 56 has a reduced end portion 57 and a smoothly tapering surface 60 joining the reduced end portion 57 with the main body of the mandrel 56. A hydraulic cylinder 58 fixed with relation to the frame 10 has its piston rod 61 threadedly secured to the lower end of the mandrel 56 whereby the mandrel may be vertically moved within the container 21, the mandrel being reciprocal between a position wherein it is wholly seated within a cavity 62 in the lower end of the mandrel 25 and a position wherein it is partially withdrawn from the cavity 62 and seated on ring 63, as illustrated in FIG. 2, the ring 63 being received between a suitable shoulder on the mandrel and the insert 55.

It should be noted that the lower end of the mandrel 25 has a rounded surface 65 which smoothly decreases in diameter adjacent the distal end of the mandrel 25 until it joins the cavity 62. It should further be noted that the cavity 62 has a flaring shape adjacent its opening adapted to mate with the tapering surface 60 when the mandrel 56 is fully seated in the cavity 62.

The lower mandrel 56 is provided with an axially extending bore 66 which provides communication between the cavity 62 in the lower end of the upper mandrel and a radially extending bore 67 adjacent the lower end of the lower mandrel. In operation, atmospheric pressure is maintained within the chamber 62 through the bore 66 and 67 and through an aperture 70 in the wall of the sleeve-like member 71 surrounding the piston rod 61 and the lower end of the lower mandrel. The lower mandrel 56 is also provided with a plurality of uniformly spaced, radially extending bores 73 (only one of which is shown) which communicate between bore 66 and the outside of mandrel 56.

An annular chuck 72 is reciprocally received within the chamber 26 about the lower mandrel 56. The chuck 72 is movable into seating relation with an annular shoulder 75 formed adjacent the lower end of the chamber 26. A tube 76 is threadedly received within the wall of the container 21 and provides communication between the chamber 26 and a hydraulic conduit 77. In order to eject a finished tube, the chuck 72 may be moved upwardly by hydraulic fluid under pressure flowing into the lower end of the chamber 26 through the conduit 77 and tube 76.

It should be noted that the chuck 72 is provided with a chamfered surface 78 and the annular plate 22 is provided with a chamfered surface 79. These chamfered surfaces function to initially seal off the ends of the tube and to prevent leakage of hydraulic fluid from the chamber 26 into the cavity 62. The mandrel 25 is formed with a peripheral projection 79A which has a flat annular lower surface arranged to engage the tube 27 and to allow only a preferred amount of the chamfer to be upset on the upper end of tube 27. It should be noted that the chuck 72 is formed similarly at its upper end adjacent the chamfer 78.

In order to operate the apparatus of the present invention and to practice the process thereof, the clamping device 36 is moved out of clamping relation with the container and lid and the lid is moved upwardly by hydraulic cylinder 15 to allow access to the interior of the container 21. The hydraulic cylinder 58 is operated to raise the lower mandrel to its most upward position. The tube 27, which has an initial cylindrical shape, is placed over and around the lower mandrel 56 as illustrated in FIG. 3.

The lid 20 is lowered into the position of FIG. 2 so that the depending mandrel 25 is received within the upper portion of the cylindrical tube and the lower mandrel 56 is fully seated within the cavity 62 in the lower end of the upper mandrel 25. The hydraulic cylinder 45 is operated to position the members 37 in clamping relation about the projecting portions 35 of the lid and container as illustrated in FIG. 2. The length of the tube will be such that, in its initial cylindrical shape, it will be somewhat shorter than the distance between the chamfered surfaces 78 and 79.

Hydraulic fluid is caused to enter the chamber 26 through the aperture 52 flushing out the chamber 26 and removing air therein, the hydraulic fluid passing out of the chamber through the passages 47 and 50 and through the bore 51 in the wall of the container. It is preferred that this hydraulic fluid be heated prior to this flushing operation in order to remove air from the fluid. It is desirable to remove this air from the chamber and hydraulic fluid because the compressibility of the air would slow down the rate of pressure increase in later steps of the operation.

Hydraulic fluid is then caused to enter chamber 26 below the chuck 72 through conduit 77 and tube 76 moving the chuck 72 upwardly against the tube 27. The pressure of this hydraulic fluid is sufficiently great to cause the tube to be securely seated all around the annular chamfered surfaces 78 and 79 but not so great as to collapse the tube.

After the flushing operation, the passage of fluid from the aperture 51 is shut off by suitable valves and hydraulic fluid under high pressure is caused to enter the chamber 26 simultaneously through the bore 52 and through conduit 77 and tube 76. The pressure of the hydraulic fluid within the chamber should be increased at an extremely high rate by the fluid entering the chamber through the bore 52 and tube 76. In one embodiment of the invention, the pressure is caused to increase from zero p.s.i.g. to 6,000 p.s.i.g. in one-quarter of a second and to continue to increase to 10,000 p.s.i.g. in a total time of one and one-quarter seconds from the initial zero p.s.i.g. reading. It should be noted that because of the differential in area (wall thickness of tube) between the lower pressurized surface of the chuck 72 and the upper pressurized surface thereof, the chuck will not leave the end of the tube during the admission of high pressure fluid but rather will continue the firm seating of the tube against the chamfered surfaces.

As the pressure begins to increase, the fluid will, at first tend to flow around the ends of the cylindrical tube and to enter the cavity 62 even though the seating of the tube against the chamfered surfaces 78 and 79 will for the most part prevent such flow. However, as the pressure increases, the fluid will force against the walls of the tube causing them to contract and seal against the two mandrels and to prevent leakage of fluid around the ends of the tube. The pressure is allowed to increase until the walls at the unsupported central portion 80 of the tube begin to collapse toward the position illustrated in FIG. 4. In one embodiment of the invention, this reaction occurs at approximately 2,000 p.s.i.g.

At the instant the walls begin to collapse, the lower mandrel 56 is moved downwardly by the hydraulic cylin-

der 58. Because of the above mentioned pressure differential on the chuck, the tube 27 is prevented from downward movement with the lower mandrel 56. As the pressure within the chamber 26 increases, the collapse of the central portion 80 of the tube will continue and will move downwardly so as to follow the longitudinal movement of the lower mandrel 56 and, more particularly, so as to follow the tapered surface 60 of the mandrel 56. The bores 73 function to maintain atmospheric pressure on the inside of the tube and to bleed any trapped air or excess oil from between the tube 27 and the mandrel 56.

The mandrel will move downwardly until it seats against the ring 63 which in turn will bear against the insert 55 preventing further downward movement. The hydraulic pressure within the chamber 26 is caused to increase to a point which is somewhat greater than that necessary to collapse the central portion of the tube in order to insure that there will be no "spring-back" of that portion after the forming operation is completed and the tube is removed from the apparatus.

It should be noted that the withdrawal of the mandrel from the cavity 62 must be accomplished at a controlled rate which corresponds to the rate of collapse of the wall of the tube so that as the collapse occurs, the mandrel moves out of the way allowing the collapse to occur. Stated in another way, the mandrel must be moved at a rate sufficiently great so that the collapse of the wall moves longitudinally of the tube and follows the withdrawing mandrel. This rate varies for different wall thicknesses of the tube and should be determined by experiment.

Referring to FIGS. 5 and 6, the proper final shape of the finished tube is illustrated as including a smooth neck or restriction 81 having a uniform, wrinkle free, circular shaped cross section all along the neck. FIGS. 7 and 8 show the shape resulting from either too rapid a withdrawal of the mandrel or too slow a withdrawal thereof. It can be seen that the tube of FIGS. 7 and 8 does not have a neck which is circular in cross section but rather has a "star" shaped cross section with ribbed areas 82 referred to above.

After the mandrel 56 has completed its downward movement, the cylinder 45 may be operated to withdraw clamping device 36 and unlock the lid 20. Cylinder 15 may then be operated to lift mandrel 25 to the upper limits of its movement thereby to release the tubular member 27. Hydraulic fluid under pressure is then caused to enter the lower end of chamber 26 through conduit 77 and tube 76 to elevate the chuck 72 into contact with tubular member 27 for ejecting it from chamber 26.

The present invention not only provides a relatively simple and inexpensive method of forming a neck or restricted portion in a tubular member, but it also forms such neck or restricted portion without materially changing the wall thickness of the tubular member in the region of the restricted portion. By utilizing hydraulic pressure and by controlling the rate of movement of mandrel 56, the metal is controlled during its movement or flow so that the stress on all areas of the flow of metal is uniform. This prevents formation of ribbed areas or so-called "starring."

While the invention has been disclosed and described in some detail in the drawings and foregoing description, they are to be considered as illustrative and not restrictive in character, as modifications may readily suggest themselves to persons skilled in this art and within the broad scope of the invention. For example, the invention may be practiced to form a neck of non-circular right cross section and also of non-symmetrical right cross section. As a further example, the apparatus could be designed to form a neck which extends only around a portion of the periphery of the tube.

The invention claimed is:

1. A device for forming a neck in a tubular member comprising a mandrel having a cavity opening at one end, a second mandrel having a reduced end portion reciprocably received in said cavity, said mandrels being arranged in such a manner that the tube may be received thereabout, means for exerting pressure on the outer surface of said tube, and means for withdrawing said reduced end portion of said second mandrel from said cavity and for exposing said reduced end portion to the inside of said tubular member.

2. A device for forming a neck in a tubular member comprising a mandrel having a rounded end and a cavity opening at said rounded end, a second mandrel having a reduced end portion reciprocably received in said cavity, said mandrels being arranged in such a manner that the tube may be received thereabout, means for exerting pressure on the outer surface of said tube, and means for withdrawing said reduced end portion of said second mandrel from said cavity and for exposing said reduced end portion to the inside of said tubular member.

3. A device for forming a neck in a tubular member comprising an elongated mandrel having a rounded end and a cavity opening at said rounded end, a second elongated mandrel having a reduced end portion reciprocably received in said cavity, said mandrels being aligned in such a manner that the tube may be received thereabout, said second mandrel having a smoothly tapering surface between the reduced end portion and the second mandrel itself, said cavity being flared adjacent its opening to receive the tapering surface, means for exerting pressure on the outer surface of the tube, and means for partially withdrawing said reduced end portion of said second mandrel from said cavity.

4. A device for forming a neck in a tubular member comprising a mandrel having a cavity opening at one end, a second mandrel having a reduced end portion reciprocably received in said cavity, said mandrels being arranged in such a manner that the tube may be received thereabout, a chamber within which said mandrels are received, means for conducting hydraulic fluid under pressure into said chamber for exerting pressure on the outer surface of the tube, and means for withdrawing said reduced end portion of said second mandrel from said cavity and for exposing said reduced end portion to the inside of said tubular member.

5. A device for forming a neck in a tubular member comprising a mandrel having a rounded end and a cavity opening at said rounded end, a second mandrel having a reduced end portion reciprocably received in said cavity, said mandrels being arranged in such a manner that the tube may be received thereabout, said second mandrel having a passage communicating between said cavity and atmosphere, a chamber within which said mandrels are received, means for conducting hydraulic fluid under pressure into said chamber for exerting pressure on the outer surface of the tube, and means for partially withdrawing said reduced end portion of said second mandrel from said cavity at a controlled rate after said tube is forced in sealing relation against said mandrels by said hydraulic pressure.

6. A device for forming a neck in a tubular member comprising a base, an open topped container mounted on said base, a lid for said container reciprocably mounted on said base for opening and closing said container, a mandrel mounted on said lid in such a manner as to extend into said container when said lid closes said container, said mandrel having a rounded end and a cavity opening at said rounded end, a second mandrel having a reduced end portion reciprocably received in said cavity, said second mandrel arranged coaxially of said first mandrel and reciprocably mounted upon said container, said second mandrel having a passage communicating between said cavity and atmosphere, means for conducting hydraulic fluid under pressure into said container for exerting pressure on the outer surface of a tube received about said mandrels, and means for partially withdrawing said reduced end portion of said second mandrel from said cavity

at a controlled rate after said tube is forced in sealing relation against said mandrels by said hydraulic pressure.

7. A device for forming a neck in a tubular member comprising a base, an open topped container mounted on said base, a lid for said container reciprocably mounted on said base for opening and closing said container, a mandrel mounted on said lid in such a manner as to extend into said container when said lid closes said container, said mandrel having a rounded end and a cavity opening at said rounded end, a second mandrel having a reduced end portion reciprocably received in said cavity, said second mandrel arranged coaxially of said first mandrel and reciprocably mounted upon and extending through the wall of said container, said second mandrel having a passage communicating between said cavity and atmosphere, means for conducting hydraulic fluid under pressure into said container for exerting pressure on the outer surface of a tube received about said mandrels, means for partially withdrawing said reduced end portion of said second mandrel from said cavity at a controlled rate after said tube is forced in sealing relation against said mandrels by said hydraulic pressure, and an annular chuck surrounding said second mandrel within said container, said chuck being reciprocal within said container upon said second mandrel, and means for conducting hydraulic fluid under pressure into said container between said chuck and the portion of said wall of said container through which said second mandrel extends.

8. A device for forming a neck in a tubular member comprising a base, an open topped container mounted on said base, a lid for said container reciprocably mounted on said base for opening and closing said container, said lid and said container each having oppositely projecting portions, each of said portions on said lid being proportioned and arranged to extend in the same direction as a corresponding portion on said container when said lid closes said container, a clamping device having mutually facing recesses proportioned and arranged to receive said oppositely projecting portions, means for moving said clamping device onto and off of said oppositely projecting portions, a mandrel mounted on said lid in such a manner as to extend into said container when said lid closes said container, said mandrel having a rounded end and a cavity opening at said rounded end, a second mandrel having a reduced end portion reciprocably received in said cavity, said second mandrel arranged coaxially of said first mandrel and reciprocably mounted upon said container, said second mandrel having a passage communicating between said cavity and atmosphere, means for conducting hydraulic fluid under pressure into said container for exerting pressure on the outer surface of a tube received about said mandrels, and means for partially withdrawing said reduced end portion of said second mandrel from said cavity at a controlled rate after said tube is forced in sealing relation against said mandrels by said hydraulic pressure.

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