

April 10, 1945.

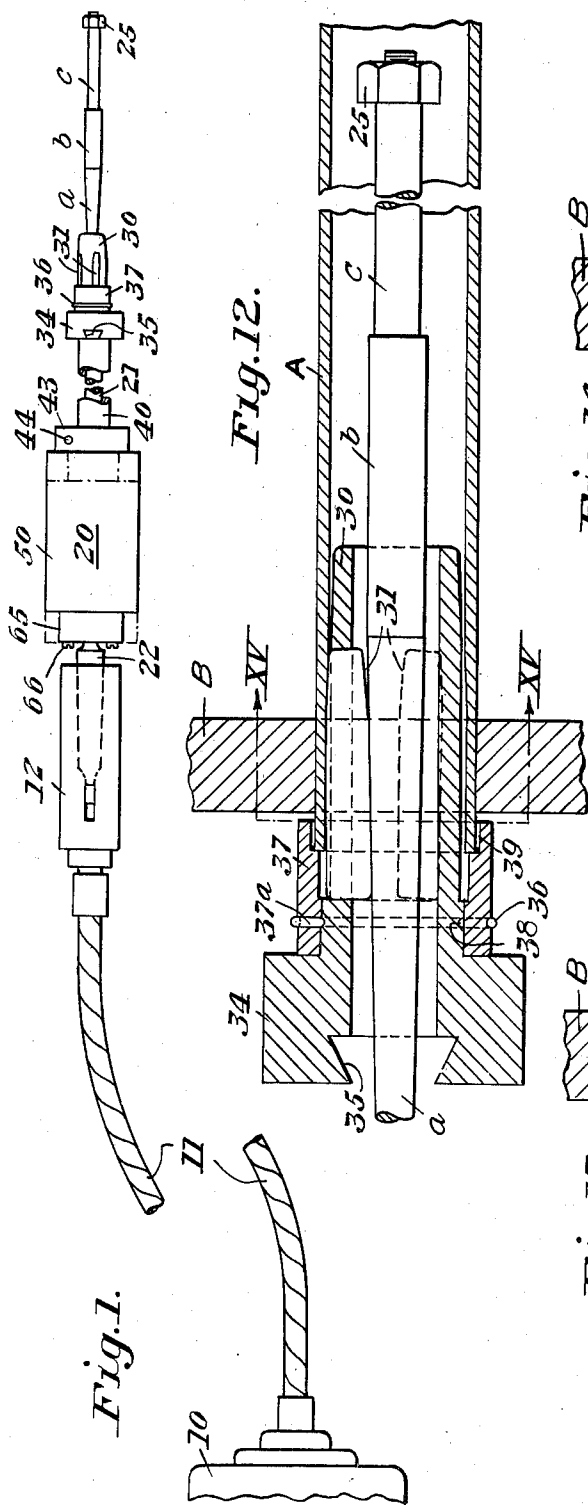
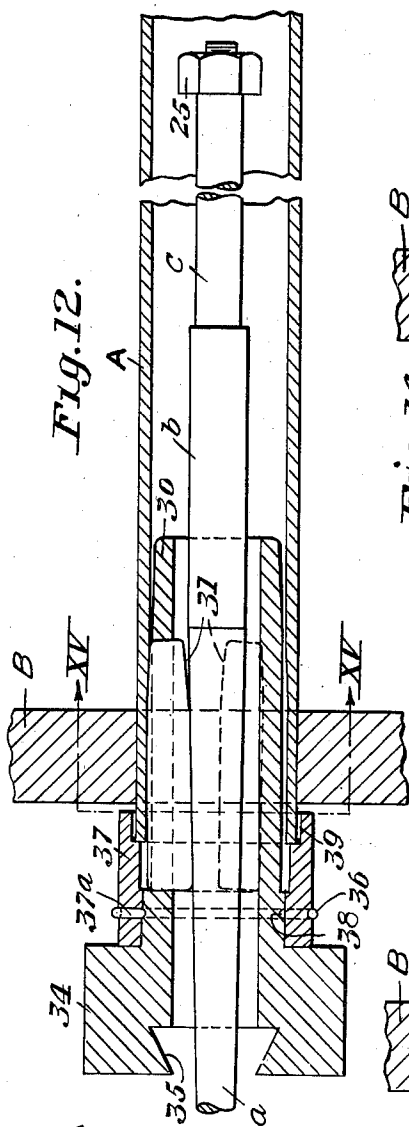
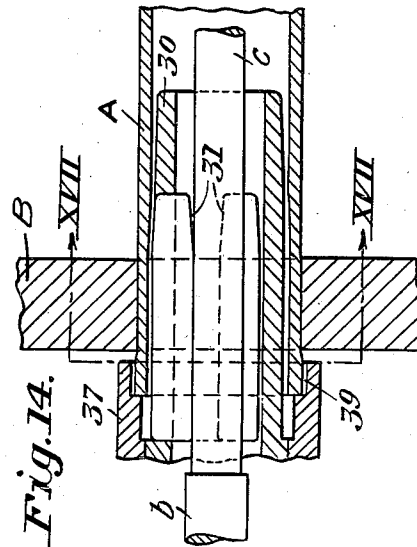
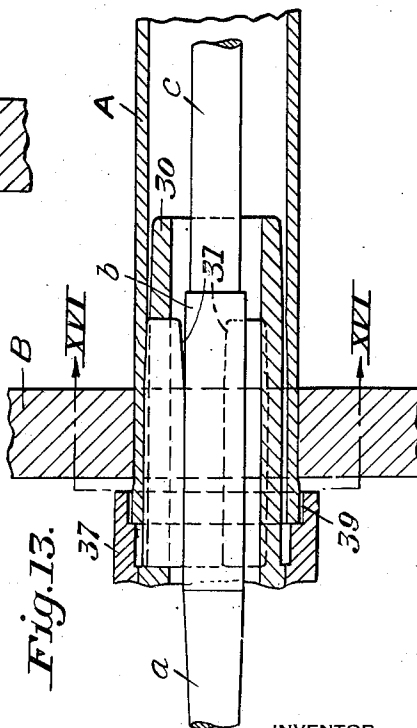
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2,373,097

APPARATUS FOR EXPANDING TUBES

Original Filed Feb. 8, 1940

3 Sheets-Sheet 1



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APPARATUS FOR EXPANDING TUBES

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3 Sheets-Sheet 2

Fig. 2.

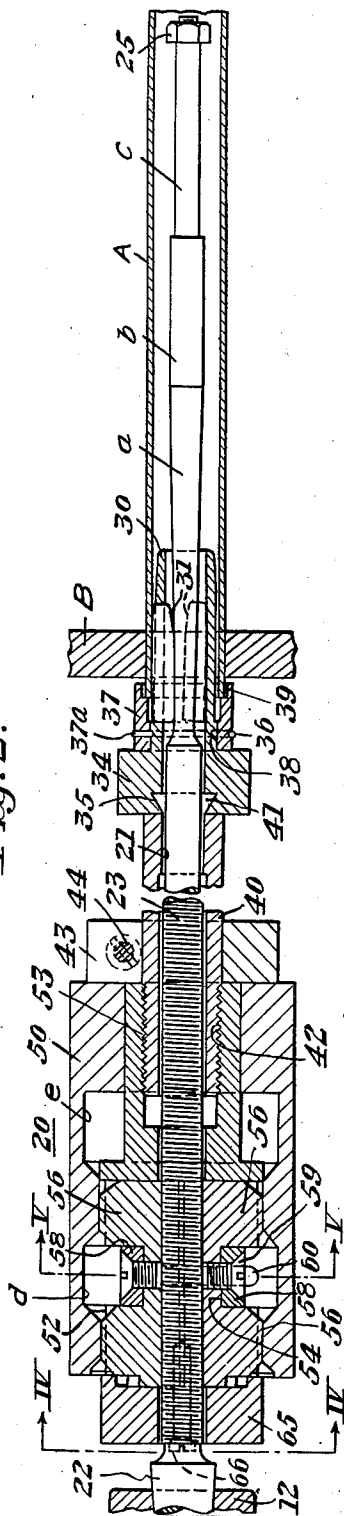


Fig. 3.

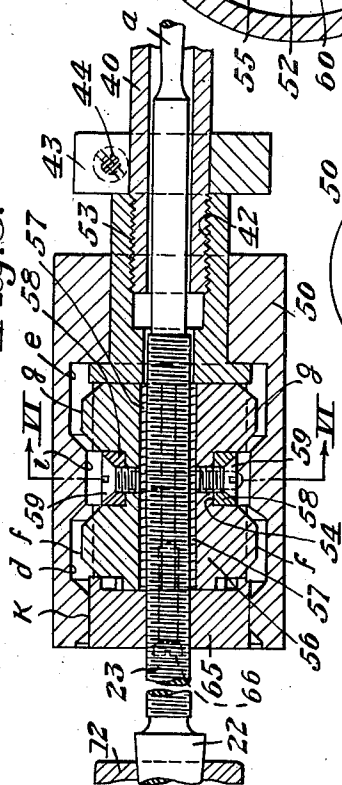


Fig. 5.

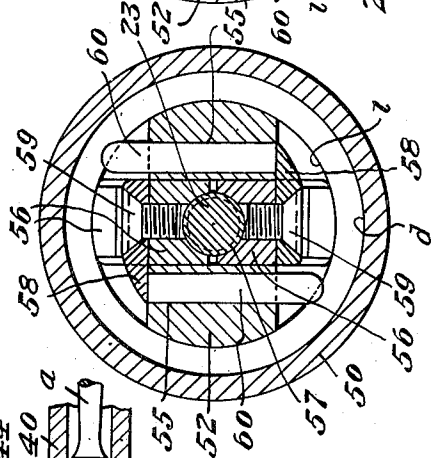


Fig. 6.

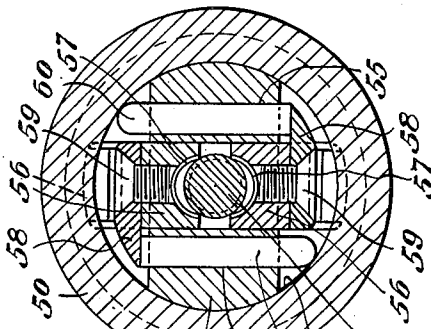
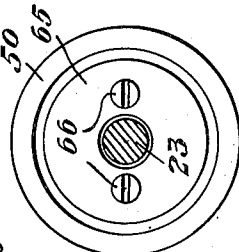


Fig. 4.



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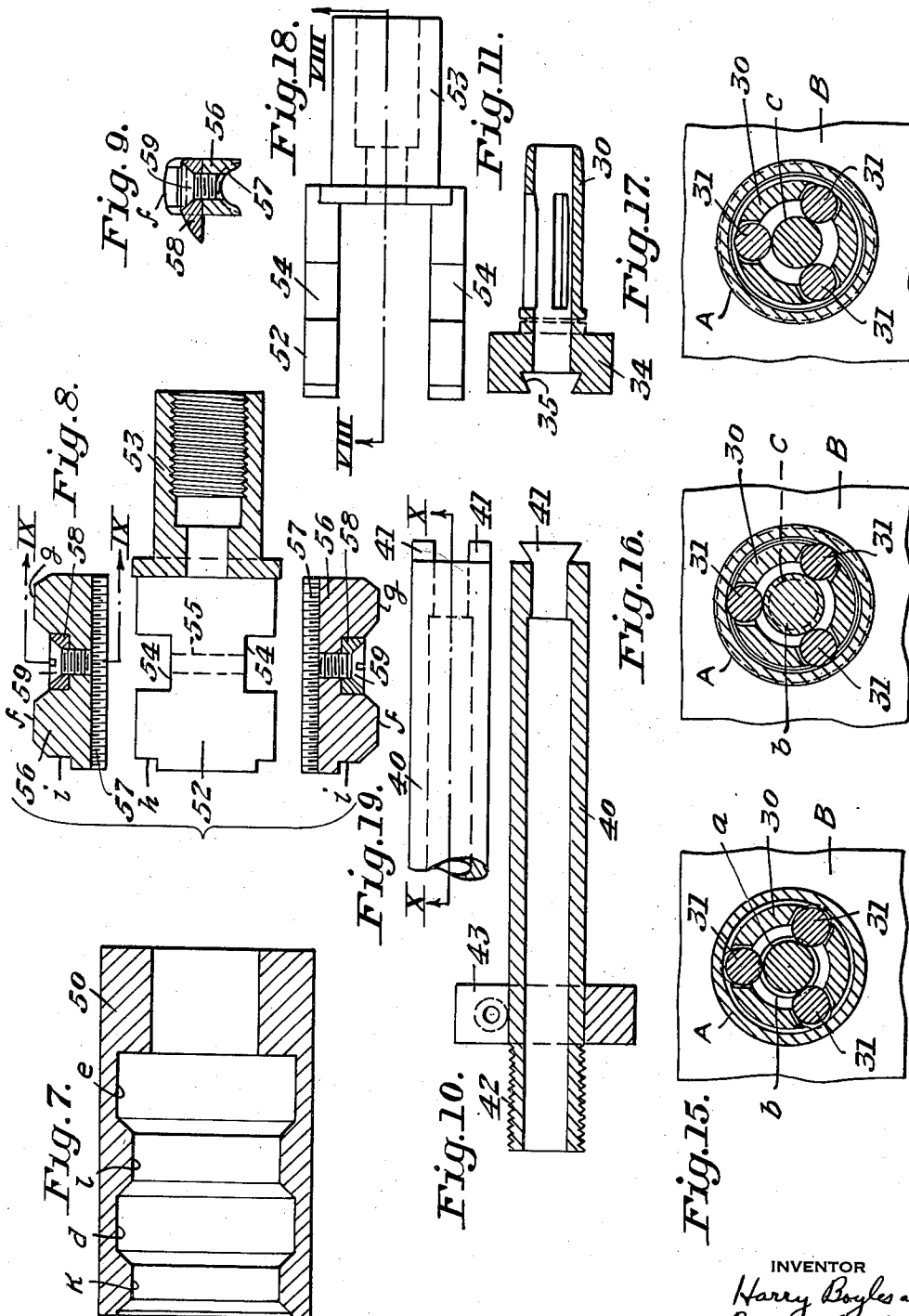
H. BOYLES ET AL

2,373,097

APPARATUS FOR EXPANDING TUBES

Original Filed Feb. 8, 1940

3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,373,097

APPARATUS FOR EXPANDING TUBES

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Original application February 8, 1940, Serial No.
317,876. Divided and this application Septem-
ber 11, 1941, Serial No. 410,416

9 Claims. (Cl. 153—82)

This invention pertains to apparatus for expanding tubes, and particularly, for expanding heat exchange tubes such as employed in a condenser, boiler, or feed water heater.

This application is a division of our copending application Serial No. 317,876, filed February 8, 1940, entitled "Method and apparatus for expanding tubes."

In the manufacture of boilers, condensers, and similar apparatus, tubular heat exchange members are mounted in suitable tube sheets or baffles that support or hold them in position. The tube sheet or baffle is holed-out to provide openings to receive the tubular members. The tubular members are inserted in or through such holes and their wall portions expanded to press them tightly against the bounding edges of the holes provided. After the tubes have been mounted within the holes in the tube sheets, their edge portions are rolled in.

Particularly due to the temperature changes and conditions to which apparatus of this type is subjected, considerable difficulty has arisen in providing a suitable type of connection or mounting construction between the tube sheets and the heat exchange tubes. In the first place, it is customary, and in many cases advisable, to provide sheets of one type of metal and tubes of another type. For example, the heat exchanger shells may be of iron, while the tubular surfaces of some suitable material such as an alloy of copper. Consequently, due to the different coefficients of expansion, the tubes will expand more than the shell when the condenser is heated up. In some heat exchange apparatus, the exterior of the condenser may be less severely heated than the interior portions and the shell and the tubes may have different thicknesses, all of which contribute to the different coefficients of expansion and to differences in temperature between the shells or sheets and the tubes, themselves.

As a result of the different temperature conditions and different coefficients of expansion as above outlined, the tubes may break away from their mounted relationship with respect to the shells and vice versa, as many tons of pressure may be exerted between such portions of the apparatus. Some have attempted to alleviate these conditions by providing a form of flexible packing for the tubes or by making the entire tube sheet in which one end of all the tubes is mounted subject to movement in a floating head. It will be apparent that such methods have their difficulties and limiting features, particularly due

to the high temperature conditions involved. For example, a flexible packing has a tendency to leak and its life is limited.

In view of conditions such as above outlined, we have endeavored to develop a new method of attack which will meet the problems presented. In our development, heavy tube sheets are employed and an initial bow is made in the tubes so that there is a slight arc along the tube length. As expansion occurs, the tube length may vary with the curvature of the arc. The present invention deals particularly with procedure and apparatus for enabling a new and improved utilization of such a construction.

It will be noted that a small amount of expansion may produce a great change in curvature, and that a very moderate change in temperature may produce a very great change in tube deflection. In longer tubes, it is difficult to initially secure straightness of the tube, and to hold the initial deflection due to weight in the same direction. Consequently, with varying temperatures the deflection of the tubes is not only variable in amount, but differs in direction. We have also found it advisable to provide a tube construction that will not fail due to the stresses and strains involved even if the apparatus is overloaded beyond its normal capacity for a period of time; this will give the vent or other safety devices full opportunity to operate.

If the apparatus such as a condenser or heater is rolled with the tubes heated, the differential expansion upon cooling puts the tubes under a partial tension, at least in theory. If the tension becomes heavy enough, the tubes may elongate within their elastic limits due to the stresses imposed. We have found the structure is more flexible with the tubes in tension as water boxes normally are of heavy section of cast iron or welded steel to provide corrosion-resistance. Such boxes tend to prevent the tube sheets from expanding outwardly and hold them in place more positively than if the tube sheets are pulled inwardly by contracting tubes. It is also apparent that due to differences in temperature between the top and bottom of the apparatus and other parts thereof, some of the tubes may be under tension and others under compression. In accordance with this method, both tube ends were rolled in the tube sheet and the tube sheets were fixed slightly further apart in position than they would normally be if the tube sheets were to be positively held in position.

In rolling the tubes, holes in the tube sheet were drilled out and then reamed to a controlled

size. The tube, itself, is manufactured with a predetermined diameter and within a closely held tolerance. As the tube materials are somewhat ductile, the wall portions were expanded by a tool inserted in the interior of the tube and revolved. This tool rolled the tube metal to a larger diameter until tight contact was made between the tube exterior wall and the inner edges of the hole in the tube sheet. In order to insure suitable contact and provide holding power, it was found necessary to continue the expansion, the equivalent of several thousandths of an inch on a one inch diameter of the tube, for example, beyond the point where actual contact was made, in order to provide a mechanical and continuous contact between such surfaces. This last operation after contact was made tends to extrude metal of the tube and heavy pressures and plastic flow of the tube material results.

In carrying out the operation, it is obviously necessary to have the workmen on the outer side of the tube sheet away from the tubes. Heretofore, it has been the customary practice in the art to extrude the tubular wall towards the spacing between tube sheets or towards the interior of the condenser or away from the open end through which the tool was inserted. This extrusion, even when a few thousandths of an inch, was significant enough to produce a considerable change in the deflection of the tube.

We have been able to meet the problems involved in this type of operation as well as in the general operation of securing or mounting a tubular member in tube sheets, by certain new and improved operative methods. In this connection, we prefer to extrude the metal, if the tube is to be rolled from the inside, towards the operator and to avoid superimposing the extruded portion upon the tube to, in effect, stretch rather than compress the metal. As above intimated, the tool should have a tapered head so that it may be inserted and withdrawn from the tube; previous constructions had a tendency to anchor about the point at which they first came into contact with the inner wall of the tube and to extrude away from this point.

In accordance with the present invention, we determined the advisability of beginning the tube rolling or expanding operation at a portion of the tube farthest from the end which is to be mounted, or in other words, farthest removed from the operator, and to cause the extrusion to take place in direction towards the end of the tube that is to be mounted and thus towards the operator. We have also been able to develop a tool that will effect such a result in an improved manner.

Although as above intimated, our invention has particular value in expanding heat exchange tubes for suitably mounting them in tube sheets or header constructions, it will be apparent that the present invention may also be applied with efficacy in other cases where walled members are to be expanded outwardly.

Thus, it has been an object of our invention to provide a solution to the problems encountered in suitably mounting tube members in their header sheets.

Another object of our invention has been to provide new and improved procedure and apparatus for suitably securing or mounting tubular members in tube sheet members, particularly adjacent end portions thereof.

A further object has been to expand or extrude walled members in a new and improved manner.

A still further object has been to provide a new and improved type of mounting construction for tubular members such as employed in heat exchangers, condensers, and the like.

These and many other objects of our invention will appear to those skilled in the art from the drawings, the description thereof, and the appended claims.

In carrying out our invention, we preferably insert a suitable mandrel-like roller device into the end of a tube and then actuate the device in such a manner as to begin the rolling operation at the far end of the device and to move it, while increasing the expanding pressure, in a direction towards the operator, or in other words, towards the end of the tube through which the tool has been inserted. After this preliminary operation, we preferably automatically change the angle (decrease the angle of application) of the device to roll the inside of the tube substantially parallel, and finally, to provide a gradually or smoothly tapered transition between the balance of the tube and the portion which has been expanded, all with a minimum of stress and strain upon the tube and without leaving sharp areas or rings and without overstressing any portion of the inside of the tube.

Previously, apparatus of this type produced a sharp thin edge at the point where the rolling was discontinued. This edge, of course, tended to initiate corrosion. We have found that a projection on the inner wall tends to increase turbulence and to aid the forming of cavities and the ultimate collapse of the tube at such a point. The tool is also employed in such a manner that the extent of each step of the rolling or extruding operation is automatically controlled and such that it automatically releases itself upon completion of the work, permitting its removal by the operator, all without damaging the quality of the tube and additionally producing an improved outer surface from the standpoint of holding the tube in position with respect to its tube sheet.

The drawings show a preferred apparatus embodiment of the present invention:

Figure 1 is a longitudinal side view in elevation of apparatus for expanding tubular members in accordance with our invention;

Figure 2 is a longitudinal view in side section through a tool constructed in accordance with our invention and shown in Figure 1; in this view, the device is shown in an initial or starting position with respect to a tubular member A that is to be expanded in a tube sheet B;

Figure 3 is a vertical longitudinal section of the apparatus of Figure 2, but showing it in a final position after it has completed the expanding operation and is ready for removal from the tube member;

Figure 4 is a front section taken along the line IV—IV of Figure 2;

Figures 5 and 6 are transverse sectional views taken along the lines V—V and VI—VI of Figures 2 and 3, respectively.

Figure 7 is a side sectional view of a clutch sleeve of the apparatus shown, for example, in Figure 2; Figure 8 is an exploded sectional view of chuck-like clutch jaws and their associated parts;

Figures 9, 10, and 11 are sectional views of other details of the apparatus of Figure 2;

Figures 12, 13, and 14 are all longitudinal sectional fragments of the expander portion of the apparatus shown in Figures 2 and 3, in different positions; in Figure 12, the apparatus is near the

end of its so-called inner extruding operation; in Figure 13, it has finished the inner extruding operation and is rolling a substantially parallel surface; and in Figure 14, the rolling operation has been completed, and the apparatus automatically released from rolling contact with the inner wall portions of the tubular member A; the position of Figure 14 is also the position of Figure 3;

Figures 15, 16, and 17 are cross-sectional views taken along the lines XV—XV, XVI—XVI, and XVII—XVII of Figures 12, 13, and 14, respectively;

Figure 18 is a longitudinal sectional view showing the yoke or clevis-like nature of the mount structure illustrated in Figure 8 and taken at 90° with respect thereto;

Figure 19 is a partial sectional detail showing the two dovetailed tangs on the end of the sleeve shown in Figure 10 and taken at 90° with respect thereto.

As shown, for example, in Figure 1, the device of the present invention includes an operating shaft 21 that at one end has mandrel-like portions *a*, *b*, and *c*, that are operatively engaged by a tube-expanding unit 30. The shaft 21 also has a threaded portion 23 operably mounted within a clutch unit 20 and terminating at one end in a connecting shank portion 22. The device may thus be rotated by a motor 10 through a shaft 11 and connector 12.

In using the device, the operator grips sleeve 50 of clutch unit 20, retains the clutch in a released position (see Figure 3), and inserts the tool in the tube A in a position for rolling. The operator then pushes or slides the threaded portions 23 to their extreme forward relationship with respect to the clutch 20; sleeve 50 is moved forwardly with respect to part 65 (from the position shown in Figure 3 to that shown in Figure 2, for example) to engage the clutch (see Figure 2). The motor 10 then rotates the entire device including the unit 20 within the hands of the operator. During such rotation the mandrel portions *a*, *b* and *c* move backwardly and effect the desired expanding or swaging operation through rollers 31 of the roller or cage expanding unit 30. Friction between the rollers 31 and the inside of the tube during the rolling operation produces a progressive backward turning of the screw portions 23 of the shaft 21 within the clutch member 20, moving the mandrel portions backwardly and automatically advancing the various steps of the expanding operation until the operation has been completed and the apparatus has been moved to the position shown in Figures 3 and 14.

Referring particularly to Figures 1, 2, and 3, the object of the tapered ends of rolls 31 is to blend the large rolled diameter of the tube A to the small unrolled diameter of the tube to avoid sharp shoulders that, in turn, produce eddy currents in the liquid stream. The roller cage 30 is provided with openings adapted to receive rollers 31 whose front ends are somewhat beveled to correspond to the forward bevel of the cage 30. As will be noted, the cage 30 is inwardly drilled out to receive the mandrel portions of the shaft 21 and to permit the rollers 31 to suitably operably engage between the mandrel portions *a*, *b*, and *c*, and the inner wall portions of the tube A being rolled. A tube sheet is represented by B.

As shown, see Figure 11, the cage portion 30 terminates in a base portion 34 having a grooved

female slide portion 35 adapted to removably receive a complementary male slide or stud portion 41, see Figures 1 and 10, of a mandrel shaft enclosing tube 40. That is, the portions 35 and 41, are, in effect, slidably and removably dovetailed. The dovetailed connection serves both as a key to cause the connected parts to rotate and as a detachable coupling. It is desirable to separate the two members 40 and 34 to substitute one cage for another when the tool is to be used upon a tube of a different diameter or where it is necessary to substitute one cage for another. Separation may be effected by unscrewing tube 40 from the member 50 and then sliding the cage and tube together off the innermost end of the mandrel, after which one member may be moved transversely with respect to the other to disengage the dovetailed parts. The base 34 has a forward ledge portion for receiving a sleeve-like stop element 37 thereover. As will be noted, this sleeve-like element is held in position by a circular lock spring 36 having an inwardly depending finger 37a that engages an annular groove 38 of the base member 34. The sleeve stop 37 is provided with an offset inner front edge portion 39 for receiving an end of the tube A to be expanded and for thus governing the distance the tool is inserted within the tube. This sleeve-like stop 37 being removable, may be interchanged with other stops having different depth of ledge portions 39 as desired, depending upon the desired depth of insertion of the tool within the tube A.

The clutch member 20 comprises an outer sleeve member 50 having a pair of inwardly-offset annulus-like portions *d* and *e*. A pair of chuck-like jaws or follower elements 56 are slidably positioned within bifurcated end portions of a mount element 52, see Figure 8. The clutch mount element 52 has a portion 53 threaded to receive and be secured to a like threaded portion 42 of the mandrel shaft enclosing sleeve 40.

The elements 52 and 56, shown particularly in Figures 2, 3, 5, 6, 7, and 8, are operably mounted within the clutch sleeve 50 and are held in position by a removable cap 65, see Figure 4, that has a flange portion engaging offset portions *h* and *i* of the elements 52 and 56, respectively. The cap 65, itself, is removably held in position by set screws 66.

As shown, for example, in Figures 8 and 9, each of the threaded followers or chucks 56 is provided with a shoe 58 removably mounted as shown by a set screw 59. Each shoe 58 is beveled as shown and extends over upon one offset ledge portion 54 of the bifurcated core or mount element 52.

A pair of follower-positioning pins 60 slidably extend through holes 55, see Figure 5, 6, and 8, and in the core element 52 and have a flat surface that contacts the lower surface portion of the shoes 58. The other end of each pin 60 is rounded off to engage, as shown in Figures 5 and 6, the inner wall portions of the sleeve 50. When the clutch sleeve 50 is moved forwardly against a slip-sleeve stop 43 (see Figure 2), projecting ledge portions *f* and *g* of the screw followers 56 abut against inwardly-extending ledge portions *k* and *l* of the sleeve 50, see Figures 2 and 3, holding or locking them against the threads 23 of the mandrel shaft 21. At the same time, the pins 60 enter the offset portion *d* of the sleeve 50 and are released, permitting the above-explained follower or clutch engagement.

When the sleeve 50 is moved backwardly to the position shown in Figure 3, it will be noted that the ledge portions *f* and *g* of the followers

56 enter the offset portions *d* and *e* of the sleeve 50, and that the pin elements 60 abut against the annular ledge *l* to effect an outward separation (spreading apart) of the followers 56 by pressing against and moving the shoes 58 outwardly, see Figures 3 and 6.

As will appear, the stop 43 is adjustably mounted on the mandrel-enclosing sleeve 40 by means of a set screw 44.

As will be noted particularly in Figures 1 and 2, the mandrel portion proper of the shaft 21 includes an outwardly beveled portion *a*, a parallel portion *b*, and a dropoff, or a portion of less diameter *c*.

As shown in Figure 12, the rolling expanding operation upon the inner wall of tube A begins with the rollers 31 and at the inner or lesser diameter beveled portion of mandrel *a*, to effect an initial outward expansion, beginning at the forward end portions of the rollers 31. As the portion *a* of the mandrel moves outwardly toward the open end of the tube with respect to the roller cage 30 and associated rollers 31, the expanding operation is progressively effected as the diameter of the part *a* increases toward the inner end of the mandrel. This causes the part of the tube most remote from the operator to be first engaged and the expanding operation then progresses outwardly toward the free end of the tube, tending to induce the flow of the metal of the tube toward its free end. When the cage 31 and its associated rollers engage the mandrel portion *b*, see Figure 13, the rollers 31 operate parallelly to even out the previous extrusion and make the inner walls of the tube A substantially parallel, with a gradual bevel that marks a transition point between the original surface of the tube and the portion that has been extruded. Later, when the cage 30 and its associated rollers 31 are engaged by the mandrel portion *c*, such rollers move inwardly and are thus released. The result is that the tool speeds up and the operator is warned that the operation has been completed and to withdraw the tool.

The outward feed of the mandrel shaft 21 relative to the roller cage 31, is effected by the planetary action of the rollers 31 in contact with the tube wall A. The screw thread 23 on the mandrel is made lefthand for conventional rotation of a motor and, of course, would be made righthand if the direction is reversed. The principle may be termed that of a sun and planet gear, that is, the small diameter rollers 31 are compressed against the tube wall which is stationary while the mandrel shaft 21 rotates. Thus, equal pressure is exerted upon the rollers on opposite sides of their diameter, one surface, the tube surface, being stationary, the other, namely, the mandrel surface, being rotated. The frictional contact is such that the rollers 31 rotate with substantially the surface speed of the mandrel 21 and rotate upon the tubular wall A in such a manner that the cage 30 revolves, as its diameter is less than the diameter of the tube wall.

Driving force is transmitted from the mandrel 21 which is driven by the motor 10 through the tube rollers 31 and tube wall back to the roller cage 30, and from the roller cage 30, backward to the clutch unit 20 and its controlling mechanism. As a result, a relative rotation is effected between the clutch 20 which carries the female follower elements 56 and the portion 23 of the mandrel which constitutes the male element. The rolls 31, themselves, determine the relative difference in speed between the mandrel 21 and the cage

30, and thus, between male and female portions 23 and 56 of the clutch 20. This relative difference in speeds results in a progressive backward movement of the mandrel screw 23 with reference to the clutch unit 20; and, this in turn, moves the mandrel portions *a*, *b*, and *c* progressively backwardly with respect to the roller cage 30, forcing the rollers 31 against the inner walls of the tube A in the manner previously outlined.

The entire apparatus can be readily dismantled and taken apart for replacement and repair purposes or for adapting it to various sizes of tubes, etc. The clutch sleeve 50 is pulled backwardly over the cap 65, as shown in Figure 3, to effect a release of the clutch followers 56 prior to initiating the tube expanding operation, in order that the threaded mandrel shaft 21 may be pushed forwardly to its extreme forward position as shown in Figure 2 before inserting the roller cage 30 within the tube A. At the time of insertion of the roller cage, the sleeve 50 is moved forwardly as shown in Figure 2, or to the position shown in full lines in Figure 1 (the previous position being shown in dotted lines in the same figure), to in effect, lock the female clutch follower portions 56 in threaded engagement with the male screw portion 23 of the mandrel shaft 21, and to initiate when actuated by the motor 10, the progressive expanding action previously explained.

Expanding the tube A outwardly towards its ends in mounting it within tube sheets B also prevents buckling as the force is applied away from the center of the tubing.

As will appear to those skilled in the art, the procedure of the present invention may be accomplished by other suitable apparatus, and the present preferred apparatus construction may be modified and suitable subtractions, additions, etc., thereof may be made without departing from the spirit and scope of the invention as indicated by the appended claims.

We claim:

1. A tube expander of the class described comprising a mandrel having an inner end adapted to be entered into a tube and having an outer end adapted to be engaged by actuating means, the inner end portion of the mandrel having a cylindrical section of small diameter at the innermost end thereof, there being a cylindrical section of larger diameter next to said section of smaller diameter, there being also a conical section of the mandrel tapering from the said larger cylindrical section in a direction which diminishes toward the outer end of the mandrel, a cage around the inner end portion of the mandrel having a plurality of radially movable rollers therein which rest on the periphery of the mandrel, the said rollers also having a cylindrical section and a conical section, the cylindrical section of the rollers being positioned at the beginning of the tube-expanding operation, adjacent to the conical section of the mandrel, at which time the conical section of each of the rollers is positioned adjacent to the cylindrical section of the mandrel, the mandrel being longitudinally movable relative to the cage to present the periphery of any of said three sections for engagement by the rollers, means for rotating the mandrel, and means for moving the mandrel outwardly with respect to the tube in which it is entered and with respect to the cage to successively engage said rollers by the cone section, the section of larger diameter, and the section of smaller diameter, in the order named, to ex-

pand the inside of the tube and induce the resulting flow of metal in the tube outwardly toward the free end of the tube, the said section of smaller diameter enabling the rollers to move inwardly to release the tool after the portion of the larger diameter has passed through the rollers.

2. A tube expander of the class described comprising a mandrel having an inner end adapted to be entered into a tube and having an outer end adapted to be engaged by actuating means, the inner end portion of the mandrel having a cylindrical section of small diameter at the innermost end thereof, there being a cylindrical section of larger diameter next to said section of smaller diameter, there being also a conical section of the mandrel tapering from the said larger cylindrical section in a direction which diminishes toward the outer end of the mandrel, a cage around the inner end portion of the mandrel having a plurality of radially movable rollers therein which rest on the periphery of the mandrel, the said rollers also having a cylindrical section and a conical section, the cylindrical section of the rollers being positioned at the beginning of the tube expanding operation, adjacent to the conical section of the mandrel, at which time the conical section of the rollers is positioned adjacent to the cylindrical section of the mandrel, the mandrel being longitudinally movable relative to the cage to present the periphery of any of said three sections for engagement by the rollers, means for rotating the mandrel, and means for moving the mandrel outwardly with respect to the tube in which it is entered and with respect to the cage to successively engage said rollers by the cone section, the section of larger diameter, and the section of smaller diameter, in the order named, to expand the inside of the tube and induce the resulting flow of metal in the tube outwardly toward the free end of the tube, the said section of smaller diameter enabling the rollers to move inwardly to release the tool after the portion of larger diameter has passed through the rollers, the said rollers having conical terminal portions directed toward the inner end of the mandrel whereby the expanded part of the tube merges into the unexpanded part of the tube through a portion which increases in wall thickness toward the unexpanded part of the tube.

3. A tube expanding tool of the class described comprising a mandrel having an inner portion and an outer end portion, the inner end portion being provided with a section that increases in diameter toward the inner terminal of the mandrel, a cage through which the mandrel passes, said cage having radially movable rollers therein, the said rollers also having a cylindrical section and a conical section, the cylindrical section of the rollers being positioned at the beginning of the tube-expanding operation adjacent to the conical section of the mandrel, at which time the conical section of each of the rollers is positioned adjacent to the cylindrical section of the mandrel, means for rotating the mandrel and imparting a planetary movement to said cage, and means on the outer end portion of the mandrel utilizing the planetary motion of the cage for effecting endwise travel of the mandrel relative to the cage and proportionately to the speed of rotation of the cage.

4. A tube expander of the class described comprising a mandrel having an inner end portion adapted to be entered into a tube and an outer end portion, the inner end portion having a tapered

section thereon of inwardly increasing diameter, a cage surrounding said inner end portion of the mandrel, said cage having a plurality of radially movable rollers therein which engage the periphery of said mandrel, and also engage the inner wall of the tube to be expanded, means for rotating the mandrel, rotation of the mandrel imparting planetary rotation to the rollers engaging the mandrel, the resulting rotation of the rollers setting up planetary rotation of the cage at a speed slower than the rotation of the mandrel, the outer end of said mandrel having a threaded section thereon, and nut means on the threaded part of the mandrel connected with said cage whereby said nut means rotates in the same direction as the mandrel but at a slower speed than the mandrel to effect longitudinal movement of the mandrel through the cage.

5. A tube expander of the class described comprising a mandrel having an inner end portion adapted to be entered into a tube, and an outer end portion, the inner end portion having a tapered section thereon of inwardly increasing diameter, a cage surrounding said inner end portion of the mandrel, said cage having a plurality of radially movable rollers therein which engage the periphery of said mandrel, and also engage the inner wall of the tube to be expanded, means for rotating the mandrel, rotation of the mandrel imparting planetary rotation to the rollers engaging the mandrel, the resulting rotation of the rollers setting up planetary rotation of the cage at a speed slower than the rotation of the mandrel, the outer end of said mandrel having a threaded section therein, and nut means on the threaded part of the mandrel connected with said cage whereby said nut means rotates in the same direction as the mandrel but at a slower speed than the mandrel to effect the longitudinal movement of the mandrel through the cage, and means for disengaging the nut means from the mandrel to enable the mandrel to be freely moved in a longitudinal direction through the cage.

6. A tube expander of the class described comprising a mandrel having an inner end portion adapted to be entered into a tube, and an outer end portion, the inner end portion having a tapered section thereon of inwardly increasing diameter, a cage surrounding said inner end portion of the mandrel, said cage having a plurality of radially movable rollers therein which engage the periphery of said mandrel, and also engage the inner wall of the tube to be expanded, means for rotating the mandrel, the resulting rotation of the rollers setting up planetary rotation of the cage, the outer end of said mandrel having a threaded section therein, and nut means on the threaded part of the mandrel connected with said cage whereby said nut means rotates in the same direction as the mandrel but at a slower speed than the mandrel to effect longitudinal movement of the mandrel through the cage, said nut means having radially movable portions thereon for engagement with the threaded mandrel, and manually operable means for selectively effecting radial movement of said sections to release or engage the threaded portion of the mandrel.

7. A tube expanding tool of the class described comprising a mandrel having an inner end portion adapted to be entered into a tube to be expanded, said inner end portion having sections of different diameters there along, a cage through which the inner end of the mandrel extends longitudinally an relative to which the mandrel is

movable in a longitudinal direction, said cage hav-

ing a plurality of radially movable rollers therein which bear against the periphery of the mandrel and which are adapted to bear against the interior of the tube into which the cage is inserted, and adapted to impart planetary rotation of the cage relative to the mandrel, the rotation of the cage being at a slower speed than the rotation of the mandrel, means for rotating the mandrel, said mandrel having a section which is threaded, a sleeve surrounding the threaded section of the mandrel, radially movable thread-engaging elements in the sleeve movable into and out of operative engagement with the threads on the mandrel, cooperating means on the sleeve and elements for effecting the radial movement thereof, and means for transmitting rotary motion between the thread-engaging elements in the sleeve and the cage, whereby the planetary movement of the cage caused by rotation of the mandrel effects a rotation of the thread-engaging elements relatively to the mandrel and in the same direction as the mandrel, whereby, when the said thread-engaging elements are in position to engage the threads on the mandrel, the mandrel will be moved longitudinally through the cage and at a rate proportional to the difference in the speed of rotation of the cage and the speed of rotation of the mandrel.

8. Apparatus for expanding the tube, having an open end, which comprises, in combination, a mandrel for insertion into the tube through the said open end, actuating means for the mandrel including means for retracting the mandrel through the said open end, and means for rotating the mandrel, a cluster of expanding rollers disposed around the said mandrel for expanding a portion of the tube from a point remote from the open end to the said open end, the said rollers being cylindrical through a portion thereof, the remaining portion of the rollers being conical, the conical portion including the inner end of each roller, a complementary configuration on the mandrel, the complementary configuration of the mandrel being a tapered portion followed by a cylindrical portion of a diameter equal to the largest diameter of the tapered portion, whereby longitudinal movement of the mandrel

to the tube causes first an expanding action of the rollers on the tube to expand the said portion of the tube and then to cause an automatic shifting of the rollers relative to the tube to roll the expanded portion of the tube substantially parallel interiorly, thereby providing a smoothly tapered transition between the expanded portion of the tube and the remainder thereof, and means for retaining the rollers in position on the surface of the tube.

9. Apparatus for expanding a tube having an open end, which comprises a mandrel having an outer end and an inner end, the mandrel comprising three sections, which are, in order from the outer end; a conical section enlarging from the outer end of the mandrel towards the inner end thereof, a first cylindrical section and a second cylindrical section, the first cylindrical section abutting against the larger end of the conical section and having a diameter substantially equal to the diameter of the said larger end of the conical section, the second cylindrical section of the mandrel being of relatively small diameter, a cage around the mandrel, a plurality of radially movable rollers in the cage bearing on the periphery of the mandrel, the said rollers having a cylindrical section and a conical section, the cylindrical section of the rollers being toward the outer end of the mandrel, and the conical section of the rollers being toward the inner end of the mandrel, and operating instrumentalities for the mandrel for rotating the mandrel in the tube and for moving the mandrel longitudinally relative to the tube, operation of the mandrel during longitudinal movement thereof, causing the rollers to expand the tube during an engagement of the conical section of the mandrel with the rollers, and then to shift the rollers relative to the tube upon engaging the first cylindrical portion of the mandrel incident to withdrawal of the mandrel, so that the expanded portion of the tube is rolled parallel interiorly to provide a smoothly tapered transition between the expanded portion of the tube and the remainder thereof.

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