ABSTRACT OF THE DISCLOSURE

An apparatus for cold bending of tubes wherein the tubular blank is supported by mandrels disposed in the leading and trailing tube end portions. A grooved forming roller is mounted on a carriage which is movable on beds to adjust for different bend radii. The roller is rotatably supported by opposed pedestals, one of which is slideably on the carriage for removal and replacement of the roller. The trailing mandrel is slideably connected to a ram and is guided within a cylindrical way. A stripper device includes a dog for engaging the workpiece and stripping it from the leading mandrel after forming. The dog is spring biased to inoperative position, and engages the workpiece when the rim of a hat-shaped member engages striker plates on the machine. A positive roller drive is provided and is co-ordinated with the ram drive so that the circumferential speed of the outer radius fibers of the tube is the same as the linear ram speed during forming.

This invention relates to improvements in cold bending of tubes, and is an improvement on the concepts disclosed in the present inventor's United States Patents 3,243,873 and 3,243,982, issued Apr. 5, 1966. As disclosed in one or both of these patents, a forming roller is rotatably mounted in a frame and has a peripheral groove therein. A back-up member forming a groove is disposed adjacent the roller and forms with the roller groove a passage through which the tube moves during bending. The central axis of the forming passage is fixed. During forming a first mandrel forming part of a pressure plunger enters the trailing end of the tube, and a second mandrel enters the leading end of the tube. The second mandrel is so formed that it progressively supports the outer wall of the leading portion of the tube against flattening as the tube is bent, and is mounted as to provide a yield resistance to movement of the tube during forming. A stripper mechanism is utilized to strip the formed tube from the second mandrel.

The present invention utilizes some of the concepts described above, but provides improvements therein. The structures disclosed in the aforementioned patents are capable of handling only a single size tube, unless major reconstruction of the device is undertaken. The axis of the forming passage must change with a change in the bending radius, as must the size of the forming roller groove, back-up and mandrels. The structures of the aforementioned patents cannot adapt to such changes.

In accordance with the invention, a forming press is provided which has structural parts which can be adjusted or easily replaced to accommodate different tube sizes and/or to change the bend radius. An improved stripping mechanism is also provided.

In order to provide the best possible results in all forming, it is desirable that the thickness of the outer bend wall of the finished product be uniform throughout its length and substantially identical to the thickness of the same wall before forming. While the yielding resistance mentioned heretofore assisted in this regard, it has been found that thickness variations throughout the length of the formed wall were still evident. Further in accordance with the invention, means are provided to confine the outer bend wall of the tube in such a manner during forming that the circumferential speed of the outer radius fibers of the bend is the same as the linear speed of the pressure plunger. A constant thickness is thus maintained.

The accompanying drawings illustrate the best mode presently contemplated by the inventor for carrying out the invention.

In the drawings:
FIGURE 1 is a perspective view of a press constructed in accordance with the invention;
FIG. 2 is a generally central vertical section taken generally on line 2—2 of FIGURE 1 and schematically showing the positive drive and speed control means;
FIG. 3 is a front elevation of the apparatus-
FIG. 4 is an enlarged fragmentary vertical section of the tube forming apparatus with parts removed for clarity and with the blank in initial feeding position and showing the stripper details;
FIG. 5 is a view similar to FIG. 4 showing the relative position of the parts at the beginning of the forming stroke;
FIG. 6 is a view similar to FIG. 4 and showing the parts in position after the blank is formed and prior to stripping; and
FIG. 7 is a view similar to FIG. 4 and showing the position of the parts at the conclusion of stripping.

As best shown in FIGS. 1—4 of the drawings, the concept of the invention may be utilized in a press having a bed 1 and an upstanding framework 2 which supports a ram mechanism 3.

In accordance with the invention, bed 1 is provided with a pair of ways 4 which support a carriage 5 for sliding movement thereon. Carriage 5 includes a pair of spaced base plates 6 and 7, which support respective pedestals 8 and 9 thereon. A forming roller 10 extends transversely to the axes of ways 4, between pedestals 8 and 9, and is rotatably mounted in suitable bearings therein. Roller 10 is provided with a generally centrally disposed circumferential groove 11 for receiving the workpiece tube 12 during forming.

The lower end of ram mechanism 3 includes a vertically disposed arcuate support 13, which will be described in greater detail hereinafter. Support 13 includes a vertical groove 14 which, during tube forming, is disposed oppositely from groove 11. The two grooves thereby form a restricted passage through which tube 12 moves during forming. The central axis 15 of the passage conforms to the central axis of tube 12.

In order to form bends of differing radii, it is necessary to shift the relative positions of axis 15 and the axis of rotation of roller 10. For this purpose, and in the present embodiment, a handwheel 16 is associated with screw 17 which are fixedly mounted on the rear portion of bed 1, with screw 17 being threaded through a lug 18 mounted on the rear portion of carriage 5. Turning of handwheel 16 will thus cause carriage 5 to move along ways 4, and thus shift forming roller 10 laterally toward or away from support 13.

Further in accordance with the invention, means are provided to permit replacement of roller 10 with a roller having a groove of different diameter. For this purpose, and in the present embodiment, plate 6 is provided with an elongated groove 19 which is transverse to the axes of ways 4, and which receives an elongated spline 20 which extends downwardly from the base of pedestal 8. Pedestal 8 can thus be slid along groove 19 and axially away from pedestal 9 and roller 10. Roller 10 can then be removed from its bearings in pedestals 8 and 9 and
replaced with a roller having the desired size groove 11, and pedestal 8 then returned to its original position.

It is desirable to provide means to lock carriage 5 and pedestal 8 in the desired positions. For this purpose, a T-head bolt 21 moves in the slot of each way 4 and may be tightened when carriage 5 is in the desired position. Likewise, a locking bolt 22 threadably extends downwardly through the base 23 of pedestal 8 and may be used to tighten pedestal 8 into plate 6.

Still further in accordance with the invention, means are provided to permit replacement of support 13 with another support having a groove 19 of different diameter. For this purpose, ram mechanism 3 comprises a suitable hydraulic cylinder 24 mounted on framework 2 and a piston-like ram 25 extending downwardly therefrom. Ram 25 is adapted to threadably receive the upper end of a plunger holder 26 which is vertically slideable co-axially in a cylindrical tubular guide or way 27. Way 27 is secured in any suitable manner to framework 2, and the lower end thereof is cut back, as at 28 to provide a cut away portion permitting exposure of support 13 adjacent fountain during 8.

Holder 26 is provided with a socket 29 for receiving the upper end of a pressure plunger 30, which may be locked into position by a set screw 31. The lower end of plunger 30 includes a trailing mandrel 32 which is shaped similarly to those in my previously identified patents and extends downwardly into groove 14. Support 13 forms a downward extension of holder 26 and is positioned with groove 14 behind mandrel 32 for purposes of supporting the outer fibers of the trailing end of a tubular blank 12 which is disposed over the mandrel.

To replace support 13 with one having a different diameter groove 14, and to also replace mandrel 32 with one of a different size, holder 26 is merely removed from ram 25 and a new, properly sized holder 26 substituted therefor. This permits accommodation of tubes of different sizes. The outer diameters of all replacement holders 26, and the inner diameter of way 27 remain constant.

For purposes of supporting the leading end portion of blank 12, the device includes a leading mandrel sub-assembly, which comprises a support 33 which is secured in any suitable way to roller 10 and adapted to pivot therewith about the roller axis. Support 33 includes a suitable socket 34 for receiving a leading mandrel 35 which is held in position by a bolt 36. The detail construction may be similar to that disclosed in my aforementioned patents. An arcuate guide 37 is secured to a portion of way 4, as by a bolt 38, and supports the tube 12 as it is fed into roller 10. The forming operation is generally similar to that disclosed in the aforementioned patents. Suffice it to say at this point that, during forming, leading mandrel 35 acts as a cantilever to progressively support the outer wall of the leading portion of the tube, and trailing mandrel 32 supports the trailing end of the inner tube wall.

As ram 25 moves downward, roller 10 and support 33 pivot about the roller axis so that blank 12 is progressively bent. The intermediate and end positions of the apparatus are shown in sequence in FIGS. 4, 5, and 6. At the end of forming, ram 25 returns to its uppermost position, but roller 10 and support 33 continue pivoting for purposes of stripping the formed tube 12 from mandrel 35. Compare FIGS. 6 and 7.

The improved stripping apparatus comprises an elongated housing 39 formed in the embodiment shown as an integral part of support 33. Housing 39 is normally disposed vertically, as shown in FIG. 4, and has a generally hat-shaped member 40 slideably disposed over its lower end. A plunger 41 is fixed at its lower end to member 40 and extends upwardly through housing 39. A stripper dog 42, having tooth means 43 disposed closely adjacent the forward end of the outer wall of a tube 12, is fixedly keyed to the upper end of plunger 41.

Plunger 41 and dog 42 are normally biased downwardly away from the tube 12, as by a spring 44 which extends between seats 45 and 46 in housing 39 and member 40 respectively. This biased position is limited by a stop 47 on housing 39 which is engaged by the lower end of dog 42.

The relative positions of the stripper mechanism remain as shown in FIG. 4 until the tube forming operation is completed. As roller 10 and housing 39 continue to rotate about the roller axis, a rim 48 on member 40 finally engages fixed strike plates 49 which are disposed on the machine such as on the inner ends of pedestals 8 and 9. The biasing action of spring 44 will be overcome, and plunger 41 moved toward the workpiece so that dog 42 engages the leading end thereof and strips it from mandrel 35. See FIG. 7.

By spacing rim 48 inwardly from the end of member 40, the stripper actuating striker plates 49 can be positioned so as not to interfere with the loading operation.

As mentioned heretofore, it is desirable to obtain a finished product wherein the thickness of the outer radius fibers of tube 12 is constant throughout the tube's length. In accordance with the invention, this can be accomplished if the circumferential speed of the outer radius fibers is substantially the same as the linear speed of ram 25 and trailing mandrel 32 throughout forming. The ends of the outer radius fibers of the tube are confined to maintain the original length of the outer radius fibers.

For this purpose, as shown in FIGS. 2 and 3, roller 10 is shown as rotatably driven through a shaft 50, pinion 51 and rack 52. Pinion 51 is fixed, except for rotation, and rack 52 is driven by a piston unit 53 slideably disposed within a suitable hydraulic cylinder 54. While the arrangement appears similar to that in the aforementioned Patent 2,434,982, the system there was pneumatic and merely provided a yielding resistance to roller movement. In the present instance, the system is hydraulic, and the substantially incompressible fluid in cylinder 54 provides a positive drive for the roller.

The invention contemplates a variable control for piston unit 53 to provide the desired equality of circumferential outer radius fiber speed relative to ram speed for workpieces of different diameter. For this purpose, cylinder 54 is connected through suitable hydraulic lines 55 to a variable control valve 56. Valve 56, in turn, is connected via lines 57 to a pump 58, which connects through lines 59 to a pump 60. A valve control handle 61 is used in conjunction with a suitable calibrated dial 62 to provide the setting necessary to obtain the desired constant circumferential speed of the pipe's outer radius fibers.

It is, of course, necessary to correlate the positive drive of roller 10 with the positive drive for ram 25. If the apparatus is provided with a ram of fixed speed, only valve 60 need be adjusted to give the desired circumferential outer radius fiber speed. If a tube of different size is to be formed, valve 56 will have to be adjusted to compensate for the change in angular velocity of roller 10, due to the change in radial distance from the roller axis to the outer pipe wall.

In some instances, it may be desirable to provide different constant speeds of ram stroke during forming of different size tubes. In this instance, a control for cylinder 24 may be provided which is similar to the control for cylinder 54. This control is shown as having a suitable valve 63, pump 64 and suitable hydraulic lines 65, 66 and 70 to cylinder 24. A similar control handle 68 and calibrated dial 69 is also provided. In this instance, the setting of dials 62 and 69 must be mutually coordinated to give the desired results.

The device of the present invention provides substantial improvements over prior similar devices. Not only can tubes of different sizes be formed and stripped, but the finished product is more uniform than heretofore.

Various modes of carrying out the invention are contemplated as being within the scope of the following
3,440,851

5 claims and particularly pointing out and distinctly claiming the subject matter.

I claim:

1. In an apparatus for cold bending of tubes,
   (a) a bed,
   (b) a carriage mounted on said bed,
   (c) a grooved forming roller,
   (d) support means on said carriage and rotatably mounting each end of said roller,
   (e) a leading mandrel mounted for rotation with said roller and adapted to enter the forward end of a tube and progressively support the outer fibers thereof during forming,
   (f) a tubular way mounted above said roller and being cut away adjacent the roller,
   (g) a ram mounted for movement co-axially relative to said way,
   (h) a holder disposed at the lower end of said ram and being disposed for sliding movement within said way, the lower end of said holder having a socket,
   (i) a groved support extending downwardly from the socket end portion of said holder for supporting the outer wall of the tube during forming,
   (j) and a trailing mandrel member mounted in said socket and extending downwardly into the groove of said support and disposed for entering and supporting the interior of the trailing end portion of a tube during forming,
   (k) the grooves in said roller and said support forming a passage through which the tube moves during forming.

2. The apparatus of claim 1 which includes: means to provide relative lateral movement between said roller and said support to vary distance between the axis of said passage and the axis of rotation of said roller to thereby permit a change in the bend radius.

3. The apparatus of claim 2 wherein said means comprises: means to move said carriage on said bed.

4. The apparatus of claim 1 in which: the said support means for at least one end of said roller is mounted for sliding movement on said carriage in a direction axially of said roller.

5. The apparatus of claim 1 which includes stripper means for removing a formed tube from said leading mandrel, said stripper means comprising:
   (a) a housing mounted adjacent said leading mandrel and rotatable with said mandrel and roller about the roller axis, said housing having a seat,
   (b) a housing shaped member and a rim disposed inwardly from the end of the member, said member being slideably mounted on the outer end of said housing,
   (c) a plunger attached to said member and extending into said housing,
   (d) a stripper dog on said plunger,
   (e) and means to bias said member, plunger and stripper dog outwardly so that said dog engages said seat,
   (f) said engageable part being adapted for engagement by a fixed part of the said apparatus upon rotation of said housing about said roller axis to thereby unseat said dog and move it into stripping engagement with a formed tube.

7. The apparatus of claim 6 in which said member is a hat-shaped, and said engageable part comprises a rim disposed inwardly from the end of the member.

8. The apparatus of claim 1 which includes:
   (a) a first positive drive device for moving said ram and connected trailing mandrel lineally,
   (b) a second positive drive device for drivingly rotating said roller and associated leading mandrel circumferentially about the roller axis,
   (c) and means to relatively correlate said drive devices to provide a circumferential speed of the outer radius fibers of a workpiece being bent which is substantially equal to the lineal speed of said ram and trailing mandrel during forming.

9. The apparatus of claim 8 wherein:
   (a) at least one of said drive devices includes a hydraulically operated cylinder and piston,
   (b) and said drive device correlating means comprises a variable control valve system connected through hydraulic lines to said cylinder.

10. In an apparatus for cold bending of tubes wherein a trailing mandrel is disposed within the trailing end of a tube, and wherein a leading mandrel is disposed within the leading end of the tube and rotates with a tube-supporting roller about the roller axis during forming:
   (a) a first positive drive device for moving said trailing mandrel lineally,
   (b) a second positive drive device for drivingly rotating said roller and associated leading mandrel circumferentially about the roller axis,
   (c) and means to relatively correlate said drive devices to provide a circumferential speed of the outer radius fibers of a workpiece being bent which is substantially equal to the lineal speed of said trailing mandrel during forming.

11. In the method of cold bending of tubes wherein a trailing mandrel is disposed within the trailing end of a tube and wherein a leading mandrel is disposed within the leading end of the tube and rotates with a tube-supporting roller about the roller axis during forming, the steps comprising:
   (a) positively driving said trailing mandrel lineally while positively driving said roller and said leading mandrel circumferentially,
   (b) while maintaining the circumferential speed of the outer radius fibers of the tube substantially equal to the lineal speed of said trailing mandrel as the tube moves around the bend.

12. In the method of cold bending of tubes wherein a trailing mandrel is disposed within the trailing end of a tube and wherein a leading mandrel is disposed within the leading end of the tube and rotates with a tube-supporting roller about the roller axis during forming, the steps comprising:
   (a) positively driving said trailing mandrel lineally while positively driving said roller and said leading mandrel circumferentially,
   (b) while maintaining the circumferential speed of the outer radius fibers of the tube substantially equal to the lineal speed of said trailing mandrel as the tube moves around the bend,
   (c) and while confining the ends of the outer radius fibers of the tube to maintain the original length of the outer radius fibers.
13. The method of forming bends in tubes wherein the thickness of the outer wall of the completed bent tube is substantially constant throughout its length, comprising the steps of:
   (a) applying positive force to the trailing end of the tube by means of a linearly movable member;
   (b) simultaneously moving the tube around a bend and supporting the inner tube wall on a rotatable roller;
   (c) while rotating said roller at such a speed that the circumferential speed of the outer tube wall is substantially equal to the speed of linear movement of said member.