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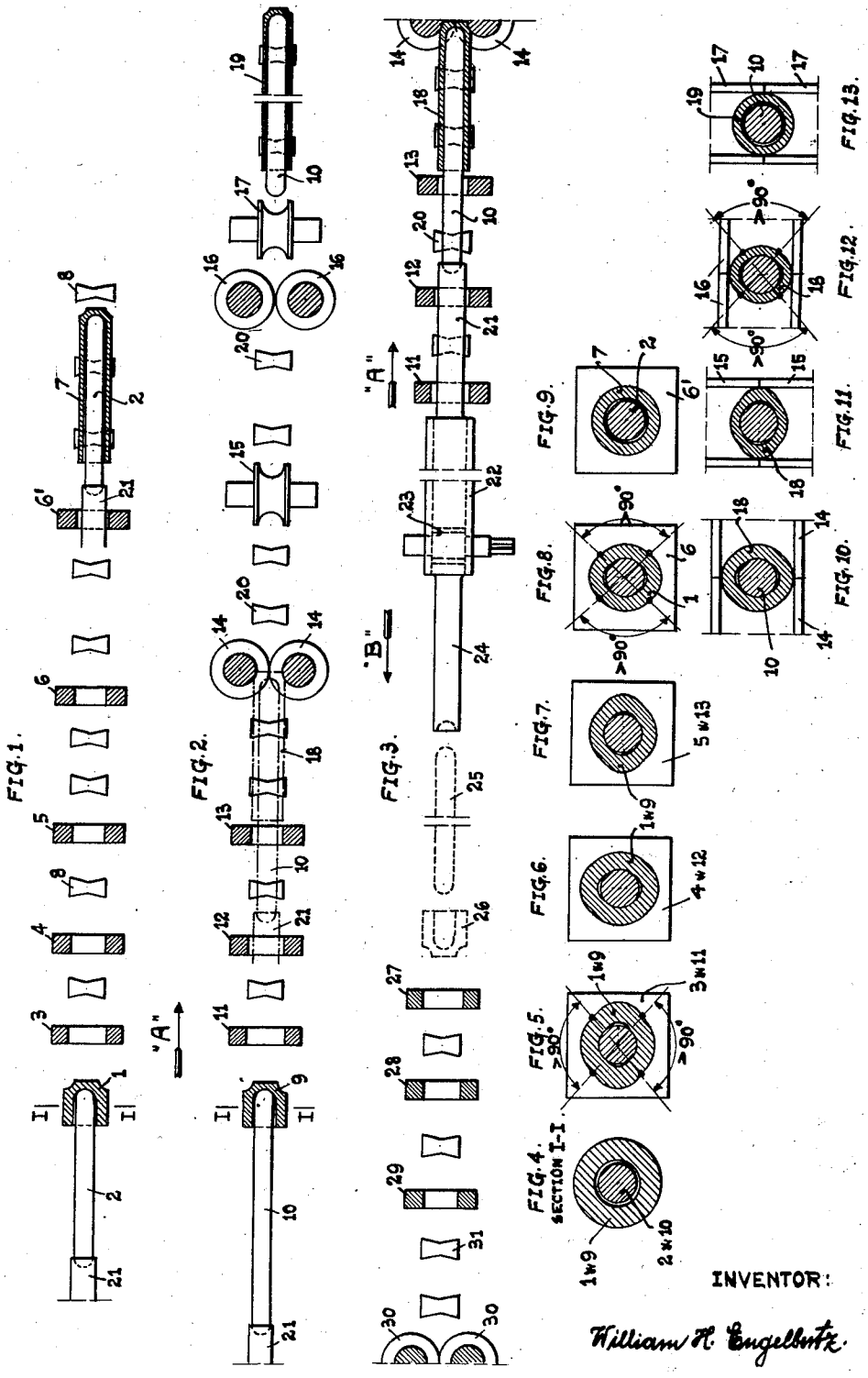

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PUSH BENCH METHOD AND APPARATUS

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8 Claims. (Cl. 205—4)

This invention has relation to the manufacture of seamless tubes and other tubular articles from cupped work-pieces upon apparatus of the pushbench type, or by the use of a new system comprising a pushbench cooperating with a rolling mill.

The process of manufacturing tubular articles from cupped work-pieces upon apparatus of the pushbench type was originated by Ehrhardt, United States Patent No. 495,245 of April 11, 1893, and consisted in first bringing a solid billet to a hollow form closed at one end, and then forcing it, whilst upon the forward end of a mandrel, through reducing means until a tube was formed along the mandrel from the hollow billet or work-piece. Then the tube had to be deformed slightly by pressure rolls or the like to loosen its hold upon the mandrel, to permit the necessary tube-and-mandrel stripping operation to be performed.

Since its origination, this process has been further developed, for instance, the loosening of the tube on the mandrel by a reeling machine of old and well known design was added. The tube, adhering tightly to the mandrel, is slightly increased in diameter while passing the cross-rolls of the reeling machine, thus making its removal from the mandrel easier than devised by Ehrhardt. Then, the tube, after being separated from the mandrel, is conveyed through truing means which shape its cross-section into circular form.

The manufacture of tubes from cupped work-pieces, originated by the above mentioned Ehrhardt patent, is still today in practical use and is performed in the following steps: first, pushing a short, thick-walled and cupped work-piece, placed on the forward end of a mandrel, through means which gradually reduce the cross-section of the work-piece along the mandrel, thereby elongating and forming the work-piece into a tube; second, conveying the mandrel with the tightly adhering tube through the cross-rolls of a reeling machine to loosen the hold of the tube upon the mandrel while leaving the structure of the metal in the tube substantially unchanged; third, passing the tube, after the same has been separated from the mandrel, through the rolls of a sizing machine which true and shape the tube to the required circular cross-section.

Practice reveals the setbacks of this necessity of reeling the tube to enlarge its diameter sufficiently to allow the stripping of the tube from the mandrel. For instance, when the tube-wall varies in thickness, a tube of varying diameter is obtained due to the irregular amount of pressure exerted by the reeling rolls. Therefore, the tube, after leaving the reeling machine, must be brought to the exact diameter by passing the sizing machine. Such unfavorable factors naturally result in additional labor and operating expenses.

The principal object of this invention is to simplify the production of tubes and other tubular articles on the pushbench type of apparatus, or on apparatus of the said type in combination with a rolling mill by dispensing with the use of the reeling machine and the sizing machine, thus reducing the number of steps for the manufacture of such articles. In this manner, by obtaining quality products in larger quantities than heretofore, manufacturing costs will be reduced considerably because the omission of said machines in the tube-manufacturing process is also a time and power saving achievement which preserves the heat of the product, thereby permitting its further hot-treatment without reheating.

More specifically stated, the object of this invention is to improve the process of manufacturing tubular articles from cupped work-pieces over mandrels to the end that, while omitting both, the reeling and the sizing machine, the tubular product formed upon the mandrel will, after passing its forming dies in one continuous operation and in a straight forward direction, have: first, a slightly larger internal diameter than the diameter of the mandrel; second, a perfect circular cross-section, trued in diameter throughout; third, an even and smooth wall and a cylindrical form along its entire length.

Having in mind this brief introduction to the invention, these and other advantages comprehended by the same will be fully demonstrated as the description progresses, and will be particularly pointed out in the appended claims.

Reference may now be made to the accompanying drawing which illustrates several preferred embodiments of the invention. I desire to have it understood that I do not intend to in any way limit myself to any specific details of design and construction shown in the drawing, in which: Fig. 1 is a diagrammatic sectional view of the dies for stretching a cupped, thick-walled short work-piece into a tubular body by passing the work-piece, supported by the forward end of the mandrel, together with the mandrel through the dies. Fig. 2 is a diagrammatic sectional view of the work-piece-stretching dies and the tube-forming rolling means. Fig. 3 is a fragmentary layout of a further developed type of tube-forming apparatus according to this invention.

Fig. 4 is an enlarged cross-section of the cupped work-piece with the mandrel inside of it, taken on line I—I in Figs. 1 and 2. Figs. 5 to 13, inclusive, show enlarged cross-sections of the work-piece in the successive passes of the dies and rolls.

In the apparatus shown by Fig. 1, the work-piece 1, carried by the forward end of mandrel 2, will, together with the mandrel, be forced through dies 3, 4, 5, 6, 6' in arrow direction "A", thereby reducing the cross-section of, and elongating, the work-piece into a hollow body 7. During and after the forming operation the rollers 8 may support the mandrel with work-piece or hollow body, respectively. The work-piece, before passing the dies, is of circular cross-section and has a bore slightly larger than the diameter of the cylindrical mandrel, as shown in Fig. 4. The dies 3, 4, 5, 6, however, which gradually decrease in size, may be oval-shaped and, preferably, located alternately in horizontal and vertical planes as shown, whereby the work-piece may be subjected successively and alternately to pressure first from the top and bottom and then from the two sides.

The effect of the oval-shaped dies is to give the work-piece a somewhat elliptical cross-section with a larger internal circumference than the circumference of the mandrel, thus causing the work-piece to bulge laterally away from the mandrel, as shown in Figs. 5 to 8, inclusive. As the elliptically-shaped work-piece moves forward with the mandrel, it is converted into cylindrical form when passing the circular-shaped die 6', as clearly shown in Fig. 9. In this way a truly cylindrical hollow body 7, having an internal diameter slightly larger than the diameter of mandrel 2,—thereby dispensing with a reeling machine—is formed, with a smooth surface inside and out, trued in diameter—thereby omitting the sizing machine—and with a uniform wall-thickness throughout. The separation of mandrel and hollow body in the well known manner may follow immediately, after die 6' has been passed.

In the apparatus shown by Fig. 2, which comprises another embodiment of the invention, the work-piece 9, carried by mandrel 10, will, together with the mandrel, be forced by pushing means 21 through dies 11, 12, 13, which may be of the same size and caliber, and so arranged to act upon the work-piece as the dies 3, 4, 5, referred to before. The work-piece 9 may preferably have a circular cross-section with a slightly larger bore than the diameter of the mandrel 10, as shown in the drawing. The hollow body 18, being produced over the mandrel 10, by passing the oval-shaped dies 11, 12, 13, will, naturally, also be transformed into a somewhat elliptical cross-section with a larger internal circumference than the circumference of the mandrel.

While the mandrel-and-work-piece pushing means such as, for instance, items 21, 22, 24, in Fig. 3, may be stopped as soon as the hollow body with mandrel have passed the dies 11, 12, 13, the power-driven roll-sets 14, 15, 16, having oval-shaped calibers preferably arranged alternately in horizontal and vertical planes, as shown in the drawing, automatically take over and further reduce the wall of, and elongate, the hollow body 18 which is finally formed into a trued tube 19 over the mandrel by passing the circular-shaped caliber of the preferably driven rolls 17, which may be located immediately behind roll-set 16, as shown in the drawing.

Of course, the said pushing means may, if desired, be further advanced to feed the hollow body with mandrel into the grip of roll-set 14. The rollers 20 may serve as support for the work-piece, hollow body and tube with mandrel during and after the forming operation.

Figs. 10 to 13, inclusive, illustrate the successive actions of the roll-passes which gradually decrease in size, upon the hollow body 18, showing clearly the somewhat elliptical form of the alternately horizontally and vertically arranged roll-passes 14, 15, 16, as well as that of the hollow body, and the circular-shaped finishing roll-pass 17. Since the internal circumference of hollow body 18, while said body passes the oval-shaped calibers of roll-sets 14, 15, 16, is always larger than the circumference of mandrel 10 as the result of subjecting the hollow body successively and alternately to horizontal and vertical roll pressure, i. e. first from the top and bottom and then from the sides, or vice versa, it is natural that the final product, that is the tube 19, after passing the circular-shaped caliber of the roll-set 17, has the desired larger internal circumference than the circumference of mandrel 10 along which it has been produced from the work-piece 9 in one continuous operation. Therefore, the tube 19, coming from the finishing roll-set 17 with a true diameter and a circular cross-section throughout, has a slightly larger internal diameter than the diameter of mandrel 10.

Although no attempt has been made in the drawing to show the precise curvature of the dies and roll-passes, I prefer that in each of the reducing dies and reducing roll-passes a portion of at least 180 degrees of the circumference of the work-piece receives a uniform wall-thickness, as indicated in Figs. 5 to 8, inclusive, and Figs. 10 to 12, inclusive. Through this provision, the use of reshaping rolls or dies is dispensed with.

In using apparatus like that shown in Figs. 1, 2 and 3 to carry out my method, any suitable type and number of hollow body-forming dies and tube-forming rolls, respectively, may be employed, and each roll-set may consist of two or more rolls. Moreover, the fixed dies 3, 4, etc., may be replaced by idler or driven rolls. When using the latter, the action of the pushing means may be limited to the feeding of the work-piece with mandrel into the grip of the first roll-set. I prefer, however, to have all dies, rotating or non-rotating, so spaced to each other as to have only one die at a time acting upon the work-piece in order to keep the material stress within the work-piece during its transformation down to the best-possible minimum, and to secure the desired clearance between the mandrel and hollow body, and between the mandrel and tube, during and after the forming procedure, as specifically described before.

Another advantage of such die and roll arrangement is the elimination of upsetting the mandrel and tearing of the bottom of the work-piece, and the elimination of friction between work-piece and mandrel while passing the roll-sets. As shown in Fig. 2, the tube-truing roll-set 17 is placed close to roll-set 16. This is permissible because no reduction of the hollow body takes place in the tube-truing pass 17. Consequently, there is no friction between tube 19 and mandrel 10 while passing the circular-shaped caliber of roll-set 17.

In accordance with the invention, the tube

forming apparatus shown by Fig. 2 may be extended by the facilities indicated somewhat fragmentarily in Fig. 3, in order to obtain a great increase in the output rate of the apparatus, while, on the other hand, decreasing its power consumption relatively, thus operating the whole plant with the best-possible efficiency. Fig. 3 shows the mandrel-and-work-piece pushing means **21**, **22**, **24**, driven by pinion **23**, in a position after completion of the hollow body forming operation in direction of arrow "A", that is, just when roll-sets **14** etc. automatically take over the hollow body with mandrel to further reduce and elongate said hollow body into a tube **19**, as explained in detail before. The said pushing means, however, on their reverse stroke in direction of arrow "B", may feed mandrel **25** into the work-piece **26**, both of which are shown in dotted lines, and further advance and force the mandrel, with the work-piece at its forward end, through dies **27**, **28**, **29**, thereby forming a hollow body from said work-piece along the mandrel. Although it has become known to force a cupped work-piece, carried by a mandrel, through circular-shaped dies in the push bench by the forward motion of the pushing means and, subsequently, by their reverse stroke, each time producing a tube which adheres tightly to the mandrel, the present invention provides means for drawing of tubular articles which adhere loosely to the mandrel during and after the forming operation. Then, while the motion of the pushing means is again reversed, the hollow body with mandrel **25** is taken over by the roll-sets **30** etc. which transform the hollow body into a tube in the same manner as explained before. The rollers **31** may support the work-piece, hollow body and tube with mandrel during and after the forming operation.

The advantages of my invention will be apparent to those experienced in the art. By using my method, a heated, short and thick-walled cupped work-piece will be transformed into a tubular body or into a thin-walled finished tube, adhering loosely to the mandrel over which it was formed in a single heat and in one continuous operation by a straight forward pass, that is, without stopping or changing its direction of movement, and without passing a reeling and a sizing machine.

Modifications in the construction and arrangement of the apparatus for carrying out my method may be made without departing from this invention. For instance, the passes of the dies and rolls may have any suitable curvature, and the angular displacement of the successive passes may differ to effect the manufacture of the tubes and other tubular articles, set forth in this specification. If desired, the produced tubes or tubular articles may be further treated to adapt them for their particular purpose.

What I claim is:

1. The method of transforming cupped work-pieces into tubes over mandrels in machines of the push bench type in one operation, during which the work-piece remains partially clear of the mandrel while forcing said mandrel, with the work-piece upon its forward end, through a succession of oval-shaped reducing dies, thus obtaining a tubular body of oval cross-sectional form and of equal wall-thickness throughout; and, subsequently, forcing said oval-shaped tubular body while partially loose upon the mandrel, with said mandrel through finishing dies for reshaping said tubular body without reducing its cross-sectional area or wall-thickness, into a tube true in diameter while, simultaneously, completely clearing the tube from the mandrel along which it is produced.

2. Improved push bench for forming tubes from cupped work-pieces in one operation, comprising a mandrel carrying a cupped work-piece, a plurality of successively arranged oval-shaped reducing- and circular-shaped finishing dies having a common pass line with the mandrel and work-piece; a power-driven machine part for advancing and forcing the work-piece, while upon the mandrel, through the reducing dies alternately disposed to each other and successively decreasing in size, thereby alternately pressing the same parts of the circumference of the work-piece against the mandrel while, simultaneously, elongating the work-piece and forming a concentric cross-sectional portion of the same in contact with each die and the mandrel of at least 180 degrees, thereby forcing the remaining parts of the work-piece clear of the mandrel, thus gradually reducing the wall-thickness of the work-piece and transforming the same into a cupped tubular body of oval cross-sectional form, partially loose on the mandrel and of equal wall-thickness throughout; and means for further advancing and forcing said tubular body, while partially loose upon the mandrel, through the finishing dies for reshaping the same without reducing its cross-sectional area or wall-thickness, into a tube true in diameter while, simultaneously, completely clearing the tube from the mandrel.

3. Improved push bench for forming tubes from cupped work-pieces, comprising a mandrel carrying a cupped work-piece, a desired number of successively arranged oval-shaped reducing- and circular-shaped finishing dies having a common pass line with the mandrel and work-piece; a power-driven machine part for advancing and forcing the work-piece, whilst upon the mandrel, through the reducing dies alternately disposed to each other and successively decreasing in size, thereby alternately pressing the same parts of the circumference of the work-piece against the mandrel while forming a concentric cross-sectional portion of the work-piece in contact with each die and the mandrel of at least 180 degrees, thereby forcing the remaining parts of the work-piece clear of the mandrel, thus gradually reducing the wall-thickness of the work-piece and elongating the same into a cupped tube of oval cross-sectional form; means for further advancing and forcing said tube, whilst upon the mandrel, through the desired number of finishing dies for truing the tube in diameter and, simultaneously, completely clearing the tube from the mandrel; and means for reversing the direction of motion of the power-driven machine part after a tube has been formed, clear of the mandrel, to form a tube during its backward stroke; a mandrel located in the path of the reversing machine part, carrying a cupped work-piece on its forward end, oval-shaped reducing- and circular-shaped finishing dies located in the path of the reversing machine part which, during its backward stroke, forces the work-piece, whilst upon the mandrel, through said dies, whereby the work-piece is gradually reduced in wall-thickness and elongated into a cupped tube true in diameter and loose on the mandrel along which it is formed.

4. Improved method of forming a tube in machines of the push bench type from a cupped work-piece, comprising stretching of the work-piece over a mandrel by pushing the work-piece

with the mandrel in one stroke through a succession of reducing dies of oval shape, alternately disposed and preferably spaced to each other so as to have the work-piece pass through one die at a time, which embrace the circumference of the work-piece so as to partially reduce its wall-thickness alternately on opposite sides against the mandrel, thus causing the work-piece to bulge laterally away from the mandrel, thereby transforming the work-piece into a tube of oval cross-sectional form; and reshaping of the said tube into circular cross-section by passing the same through finishing dies after leaving the reducing dies, thereby truing the tube in diameter and, simultaneously, loosening the hold of the tube on the mandrel, thus forming a cupped tube of larger internal diameter than the diameter of the mandrel along which the said tube is being produced.

5. Method of forming a tube from a cupped work-piece in machines of the push bench type cooperating with rolling apparatus, which comprises stretching of the work-piece over a mandrel by pushing the work-piece with the mandrel in one stroke through a succession of reducing dies of oval shape alternately disposed to each other, which embrace the circumference of the work-piece in a manner to reduce its wall-thickness alternately on opposite sides against the mandrel while forming a concentric cross-sectional portion of the work-piece in contact with each die and the mandrel of the least 180 degrees, thus causing the work-piece to partially bulge laterally away from the mandrel, thereby elongating the work-piece and transforming the same into oval cross-sectional form; and conveying the work-piece, after leaving the dies, forward with the mandrel through a succession of roll-sets preferably spaced to each other so as to have the work-piece pass through one roll-set at one time, and having said roll-sets form oval passes alternately disposed to each other, embracing the surface of the work-piece in a manner to reduce its wall-thickness alternately on opposite sides against the mandrel while forming a concentric cross-sectional portion of the work-piece in contact with each roll-set and the mandrel of at least 180 degrees, thus causing the work-piece to partially bulge laterally away from the mandrel, thereby transforming the work-piece into a tube of oval cross-sectional form; and reshaping of the said tube into circular cross-section by passing the same through finishing rolls, thereby truing the tube in diameter and, simultaneously, loosening the hold of the tube on the mandrel, thus forming a cupped tube of larger internal diameter than the diameter of the mandrel along which the said tube is being produced.

6. Method of forming a tube from a cupped work-piece in machines of the push bench type cooperating with rolling apparatus, which comprises stretching of the work-piece over a mandrel by pushing the work-piece with the mandrel in one stroke through a succession of reducing dies of oval shape, alternately disposed and preferably spaced to each other so as to have the work-piece pass through one die at a time, which embrace the circumference of the work-piece so as to partially reduce its wall-thickness alternately on opposite sides against the mandrel, thus causing the work-piece to bulge laterally away from the mandrel, thereby elongating the work-piece and transforming the same into oval cross-sectional form; and conveying the work-piece, after leaving the dies, forward with the mandrel through a succession of roll-sets which form oval passes, alternately disposed and preferably spaced to each other so as to have the work-piece pass through one roll-set at a time, embracing the surface of the work-piece so as to partially reduce its wall-thickness alternately on opposite sides against the mandrel, thus causing the work-piece to bulge laterally away from the mandrel, thereby transforming the work-piece into a tube of oval cross-sectional form; and reshaping of the said tube into circular cross-section by passing the same through finishing rolls, thereby truing the tube in diameter and, simultaneously, loosening the hold of the tube on the mandrel, thus forming a cupped tube of larger internal diameter than the diameter of the mandrel along which the said tube is being produced.

7. Apparatus for forming tubes from cupped work-pieces, comprising in combination, a push bench having a mandrel supporting a cupped work-piece, a plurality of successively arranged oval-shaped reducing dies having a common pass line with the mandrel and work-piece; a power-driven machine part for advancing and forcing the work-piece, whilst upon the mandrel, through the reducing dies alternately disposed to each other and successively decreasing in size, thereby pressing only alternate portions of the surface of the work-piece at one time against the mandrel so as to have an angular contacting surface of the work-piece with each die and the mandrel of at least 180 degrees, thereby forcing the no-pressure portions of the work-piece clear of the mandrel, thus gradually reducing the wall-thickness of the work-piece and elongating the same; a plurality of roll-sets in alignment with said dies and preferably spaced to each other so as to have the work-piece pass through one roll-set at one time, having oval-shaped passes angularly disposed to each other alternately for further reducing the wall of the work-piece and elongating the same into a cupped tube partially clear of the mandrel; and rolls in line with said roll-sets, for truing the said tube in diameter and, simultaneously, completely clearing the tube from the mandrel.

8. In apparatus according to claim 7, means for reversing the direction of motion of the power-driven machine part after a tube has been formed, clear of the mandrel, to perform a tube-forming operation during its backward stroke; a mandrel located in the path of the reversed machine part, carrying a cupped work-piece on its forward end, a plurality of dies and roll-sets having oval-shaped passes angularly disposed to each other alternately, and located in the path of the reversed machine part which, during its backward stroke, forces the work-piece through said dies, thereby gradually reducing the diameter of the work-piece and elongating it along the mandrel; and further reducing and elongating the work-piece, whilst upon the mandrel, by passing said roll-sets; truing rolls, in alignment with said roll-sets, having circular passes for transforming the work-piece from oval cross-sectional form into a tube of circular cross-sectional form and, simultaneously, completely loosening the hold of the tube on the mandrel.

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