Nov. 29, 1966 O. F. WIDERA 3,287,951

ART OF ROLL-REDUCING RING WALL THICKNESS

Original Filed June 4, 1962 2 Sheets-Sheet 1

Fig. 1.

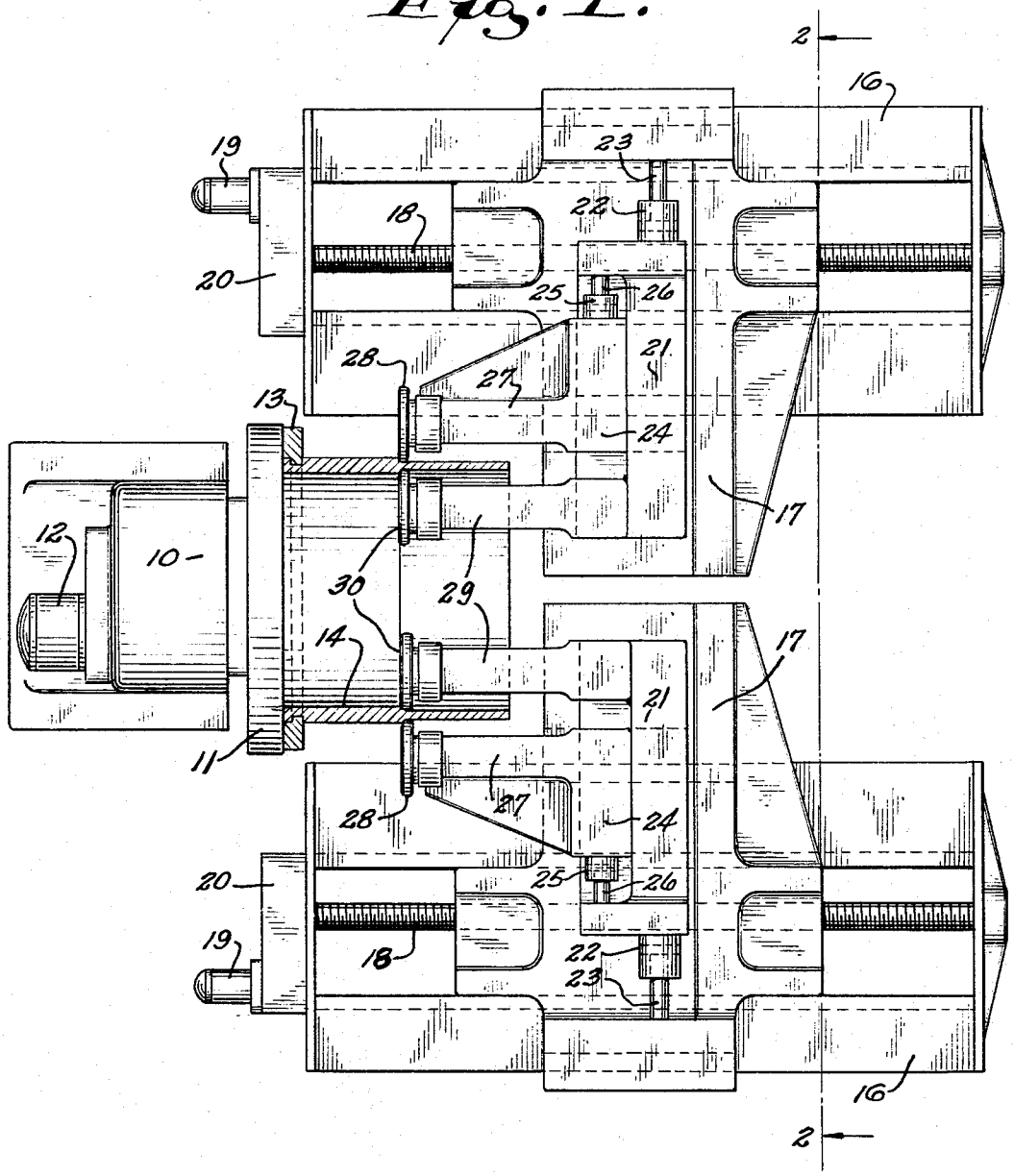

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Fig. 2.

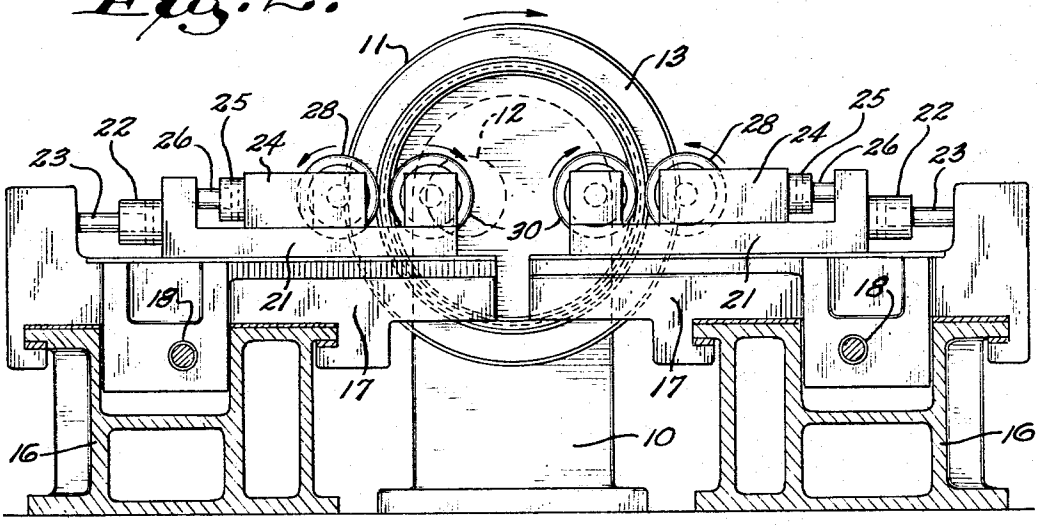

Fig. 3.

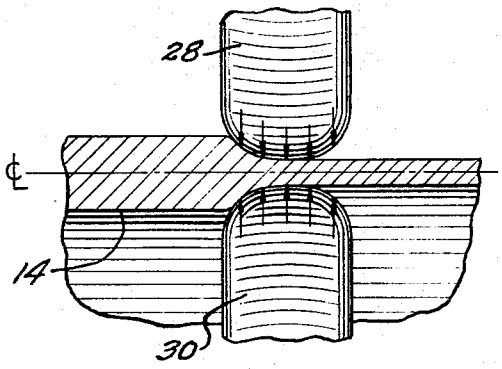

Fig. 4.

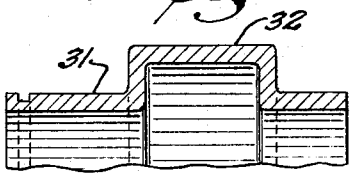

Fig. 5.

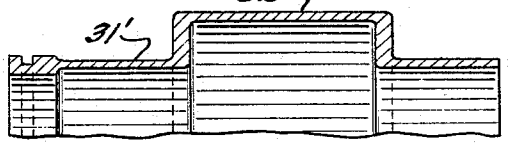

Fig. 6.

Fig. 7.

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ART OF ROLL-REDUCING RING WALL THICKNESS

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Continuation of application Ser. No. 199,956, June 4, 1962. This application Mar. 4, 1966, Ser. No. 538,438
8 Claims. (Cl. 72—85)

This invention relates to improvements in the art of roll reducing ring wall thickness, and is a continuation of application Serial No. 199,956, filed June 4, 1962.

In conventional methods of roll reducing rings, such as the method disclosed in Sporck Patent No. 2,932,890, it has been customary to employ very expensive heavy tooling in the form of a large generally cylindrical mandrel of substantially the same length as the work to hold and support the ring or cylinder throughout the inner surface of the area of the ring or cylinder being worked and to have the material of the ring or cylinder reduced from the outside diameter (O.D.) only. This is objectionable not only because of the expense and weight of the mandrel, but because the mandrel must be removable from the interior of the cylinder or ring being worked after completion of the rolling operation, which physically limits the geometry of the inside face of the ring. Furthermore, because only the fibers on the O.D. of the ring or cylinder are worked while the fibers on the inside diameter (I.D.) are not only worked, but are subjected to stretch, the properties of the metal of the finished product differ on the O.D. and I.D. In addition, it is not possible with these conventional methods to maintain a mean diameter.

Two additional conventional ring rolling methods generically described by the vague introductory comment that "It is known to make seamless pipe of a hollow block by rolling it both inside and outside, starting at a point, rolling it out and smoothing toward the end of pipe," are presented in an indefinite way in the introduction to the Roeckner Patent No. 1,610,593 for the alleged purpose of summarizing the art as it was supposedly known prior to Roeckner. The first appears to be the conventional and well known ring rolling method reflected at lines 4 through 14 of the Roeckner patent wherein the workpiece maintains a substantially constant length while it is engaged throughout its length on the I.D. and O.D. by revolving rolls which bring pressure against both the inner and outer surfaces of the workpiece, which support the workpiece, which are at least as long as the workpiece, and whose peripheries are generally flat in cross-section, to constantly give the work an increased diameter while decreasing its wall thickness. With this process, which is well known, the length of the finished product is substantially the same as the starting length and such length is necessarily limited to the length of the reducing rolls. In this conventional process there is no axial feed movement between the work and the reducing rolls. Such axial feed movement would be impossible with this prior process because the reducing rolls are in pressure engagement with the entire length of the workpiece from the inside and outside and this makes it impossible to cause axial feed movement, even if this was desired, because of the extreme forces which would be required. Of course, in the first well known ring rolling process which is discussed in the introduction to the Roeckner patent, axial feed movement is not desired because it is a feature of said process to impart an increased diameter to the work without increasing its length.

The second ring rolling method referred to in lines 14 through 29 of the Roeckner Patent No. 1,610,593 is so indefinitely described that it is impossible to ascertain sufficient details of the method to visualize an operative

procedure. For example, it is not stated whether the oppositely angled rolls both engage opposite portions of the O.D. of the work, and if so, whether an internal mandrel is used or whether one engages the I.D. and one the O.D., and it is not stated what the length or diameter of these rolls is compared to the length and diameter of the work. The only features that are clear is that the rolls are set at opposite angles arranged obliquely to the longitudinal direction of the workpiece, that they revolve around the cylinder or ring being rolled, and that the workpiece itself is "clamped fast so that it cannot turn on its own axis." It is also clear from the last sentence that the rolls produce helical grooves and that there must be additional smoothing which can be provided by additional rollers for smoothing the bulbs between grooves. This method, even if it were understandable, is complicated.

The structure claimed in the Roeckner patent advanced in the above described art by employing a plurality of sets of reducing rolls, each following set being wider than the preceding set, in which the roll sets are the sole support for the work and are arranged along a helical path. In Roeckner, the rolls of each set after the first are wider than the rolls of the preceding set so as to progressively widen the groove or nick which would be formed by a single set of rolls to thereby cause a step metal flow along the I.D. and O.D. of the workpiece toward the adjacent end of the work as shown in Figs. 1–4 of the Roeckner patent, it being necessary either to cause unproductive return movement of the roll sets at intervals, preparatory to starting a new step in the work, or to have the axes of the rolls arranged obliquely in order to cause a helical feed of the work. Of course, Roeckner found it essential to use a plurality of rolls, for if it were attempted to use only a single set of rolls with the Roeckner disclosure, this would not accomplish the desired metal flow, but instead would merely cut a thread unless one of the two prior methods hinted at in the introduction to Roeckner were employed to smooth the bulbs which would be formed between the turns of the groove or nick which would be formed by one narrow set of rolls. Roeckner, of course, recognized that relative longitudinal feed movement between workpiece and rolls might be desirable in place of the step by step nicking and smoothing action he describes wherein steps equal in length to the width defined by the leading edge of his first narrow set of helically displaced roll sets and the trailing edge of the last set are taken. To provide such longitudinal feed movement Roeckner referred to the conventional feed movement supplied by causing the axes of the roll sets, which he used as the sole support of the workpiece, to be oblique in relation to the axis of the workpiece. The Roeckner apparatus, in which a plurality of helically disposed roll sets are not only the sole support of the workpiece, but when arranged obliquely, also impart feed movement, is not suited to the practical application of any other feed means. Roeckner's plurality of ever wider roll sets present a substantial surface contact to the workpiece which would require a very substantial feed force to overcome and, if used, would tend to distort the workpiece away from its axis.

While the Roeckner type of apparatus is capable of maintaining substantially the same mean diameter while extending the longitudinal dimension of the workpiece, it not only is expensive, because it must employ the plurality of helically disposed sets of rolls which are progressively larger in cross-section, but the type of metal fashioning performed by Roeckner like other conventional processes is a nicking and smoothing operation on the workpiece surface rather than an extrusion process, which latter process is most desirable from a metallurgical standpoint. In addition, because of the helical arrangement and consequent path of the reducing rolls,

the Roeckner arrangement is impractical for forming circumferential ribs on the work which are normal to the axis of the work. Additionally, because Roeckner employs a series of roll sets with each following set of larger cross-section than the one preceding it, Roeckner could only work in one longitudinal direction of the workpiece and could not have rolling action on all passes of his rolls across the workpiece in either direction. Thus one-half of the longitudinal movement Roeckner employs is waste movement.

It is a general object of the present invention to provide an improved method of roll-reducing the thickness of the walls of rings wherein forming pressure is applied uniformly and simultaneously to both the O.D. and I.D. whereby both sides may be under uniform compression with advantageous results, the method making it possible to keep a mean diameter.

A further object of the invention is to provide apparatus for effecting commercial exploitation of the improved method.

A more specific object of the invention is to provide an improved apparatus wherein the cylindrical work is clamped at one end and driven, and wherein tool holders with tools which engage and exert reducing pressure on both the O.D. and I.D. are fed axially to reduce the wall thickness while simultaneously elongating the work cylinder.

A further object of the invention is to provide apparatus which permits the use of multiple sets of tool holders to thereby speed up the work.

A further object of the invention is to provide improved apparatus which may be so constructed as to permit radial movement of the inside and outside tool holders simultaneously during the reducing operation whereby contoured tubular shapes may be produced.

With the above and other objects in view, the invention consists of the improvements in the art of roll-reducing ring wall thickness and all of the steps of the method, and all parts and combinations of the apparatus as set forth in the claims and all equivalents thereof.

In the accompanying drawings, illustrating one preferred type of apparatus for carrying out the invention, in which the same reference numerals designate the same parts in all of the views:

FIG. 1 is a plan view of the improved apparatus, the work being shown in horizontal section;

FIG. 2 is a sectional view taken on a line 2—2 of FIG. 1;

FIG. 3 is a fragmentary view showing the rolls in the process of reducing the wall thickness of the work;

FIG. 4 is a longitudinal section through a part of a cylindrical starting blank having a corrugated longitudinal section;

FIG. 5 is a similar view showing the cylinder of FIG. 4 after it has been reduced;

FIG. 6 is a fragmentary longitudinal sectional view of another starting blank; and

FIG. 7 is a similar fragmentary view showing the cylinder of FIG. 6 after it has been reduced by a method resulting in a ribbed formation.

Referring more particularly to the drawings, it is to be understood that the apparatus shown in FIGS. 1 and 2 is merely one exemplification of apparatus for carrying out the improved invention. Referring to such apparatus, the numeral **10** designates a headstock having a suitable base, said headstock forming a bearing for a rotatable mandrel having a face plate **11** for rotation therewith, the mandrel being driven by an electric motor **12**. The face plate carries suitable fixtures **13** for removably supporting the work **14**, which work is a ring or cylinder of metal.

While the present invention may be carried out with one set of reducing rolls, it is preferred to use a plurality of sets, as illustrated, in order to speed up the work. Accordingly, on each side of the headstock **10** is a bed

frame **16**. Inasmuch as the structure on each side is the same, only one side will be described, the same numerals being used on corresponding parts on the opposite side. Slidably mounted for horizontal movement axially of the work is a slide **17**. The sliding movement may be accomplished in any desired manner. However, in the illustrated embodiment there is a screw **18** extending through the slide and having threaded connection therewith as shown in FIG. 2, the ends of the screw being journaled for rotation in the bed frame **16**, with one end being driven by an electric motor **19**, there being a reduction gear box **20** interposed between the motor and screw **18** so that the latter is driven at a reduced speed.

Each slide **17** has slidably mounted thereon a main carriage **21** which carriage is suitably guided for movement in a radial direction with respect to the work. The slide carries a double-acting hydraulic cylinder **22** having a ram **23** which acts between the cylinder and the slide **17**. Thus, when hydraulic fluid is caused to flow in one direction in the cylinder **22** it will act on a piston therein to cause extension of the ram **23**, and when the hydraulic fluid is caused to act in a reverse direction it will cause retraction of the ram **23**, as is well known in the hydraulic art. Thus radial movement of the carriage **21** in a selected direction can be effected hydraulically.

In addition to the above, there is mounted on each main carriage **21** a supplemental carriage **24** which is mounted for sliding movement in a radial direction with respect to the work. The supplemental carriage **24** carries a double-acting hydraulic cylinder **25** having a ram **26** which acts between the cylinder and the main carriage **21**. When hydraulic fluid is caused to flow in one direction in the cylinder **25** it will act on a piston therein to extend the ram **26**, and when it is caused to flow in a reverse direction it will act to retract the ram. Thus, radial movement of the supplemental carriage **24** on the carriage **21** may be hydraulically controlled in a predetermined manner.

The supplemental carriage **24** has a right-angular extension **27** which extends axially of the work and externally thereof. On the end of said extension a reducing roll **28** is rotatably carried for engagement with the O.D. of the work. The main carriage **21** has a right-angular extension **29** which extends axially of and within the work. Rotatably mounted on the end of the extension **29** is a reducing roll **30** positioned for engagement with the I.D. of the work **14**.

OPERATION

In operation, a ring or cylinder **14** which is to have its wall thickness reduced is suitably clamped in the fixtures **13** of the face plate **11**. The slides **17** are then adjusted through the rotation of the screws **18** to a position to start acting on the free end of the work. In effecting a suitable starting adjustment the carriages **21** are adjusted radially so that the general position of the reducing rolls **28** and **30** fits the diameter of the workpiece. Thereafter a fine adjustment may be effected by additionally adjusting the carriages **21** and **24** toward and away from each other. Where a plurality of sets of reducing rolls are employed, as is illustrated, the motions of the main slides **17** are synchronized in any suitable manner to obtain a uniform feed in an axial direction of the work. In FIG. 1, the method of reducing the wall thickness on a plain cylinder **14** is illustrated. With the variable speed motor **12** in operation, the work is rotated at a selected variable speed and this causes the reducing rolls **28** and **30**, which are idlers, to be driven. As the slides **17** feed along the work the wall thickness is reduced in the manner shown in FIG. 1, and simultaneously the cylinder is elongated. Several passes are usually required and the carriages **21** and supplemental carriages **24** are adjusted closer together for each pass. This apparatus and method may be used for either hot or cold forming. In a test

operation, a test ring having a diameter of 32 inches, a length of 12⅞ inches, and a wall thickness of .748 inch was employed. Reduction was made in three passes to a wall thickness of .203 inch and a length of 32 11/16 inches. With this method, the fibers on the I.D. are subjected to the same compressive penetration as the fibers on the O.D., and less forming pressure is required than with conventional processes. This method also results in uniform grain refinement with no stretching or other abuse of the metal on the I.D. While the shapes of the tools **30** may be different from the shapes of the tools **28** to produce desired effects, it is usually advantageous to have identical rolls **28** and **30**, as shown in FIG. 3, so as to obtain uniform properties on both sides of the material. The movement of the rolls **28** and **30** may be governed by hydraulic tracer units (not shown) acting through the hydraulic cylinders **22** and **25** in order to obtain accurate wall thicknesses and diameter. In the process shown on the work in FIG. 1, the movement of the carriages **21** and **24** may be synchronized so as to obtain the same penetration from the I.D. as from the O.D.

With the apparatus illustrated it is also possible, by effecting major adjustments of the carriages **21** and **24**, to produce contoured tubular shapes, which shapes can also be under the control of tracer units. As shown in FIG. 4, a starting blank **31** of uniform thickness having an annular corrugation **32** may be reduced to the form of FIG. 5 wherein all of the axially extending wall portions **31'** and **32'** are of reduced thickness and of increased length. During such reduction the carriages **21** and **24** will move radially to adjust to the contour of the corrugation.

As another example, FIG. 6 illustrates a starting blank **33**. This may be reduced in a predetermined manner with the rolls **28** and **30** separating at predetermined intervals to provide ribs **34**, and with the main portion of the length being uniformly reduced and elongated as at **33'**. The apparatus permits the production of a wide variety of tracer-controlled contoured shapes in the final tubular article.

It is apparent that with the present method, as illustrated in FIG. 1, the reducing rolls **28** and **30** may be adjusted toward each other equal amounts for each pass so as to maintain a mean diameter. With conventional methods, where reduction is from the O.D. only, it is not possible to maintain a mean diameter.

Various changes and modifications may be made without departing from the spirit of the invention, and all of such changes are contemplated as may come within the scope of the claims.

What I claim is:

1. Apparatus for roll reducing ring wall thickness while maintaining substantially the same mean diameter of a cylindrical workpiece which is being elongated, comprising: a head stock having a rotatably supported face plate, means on said face plate for removably supporting one end of a cylindrical workpiece for rotation while the workpiece is being elongated and while maintaining the interior of the workpiece open, a bed frame positioned adjacent said head stock, a first tool holder mounted on said bed frame for adjustable movement radially of the workpiece and having a rotatably supported reducing roll positioned for engagement with the O.D. of the workpiece, a second tool holder mounted on said bed frame for movement radially of the workpiece and having a rotatably supported reducing roll positioned for engagement with the I.D. of the workpiece, the axes of said reducing rolls being parallel to the axis of the workpiece, and said rolls having a width dimension which is minor compared to the length of the cylindrical workpiece, said rolls having like cross-sectional shapes and being supported in the same transverse plane substantially equal distances from a midpoint in the thickness of the workpiece wall to form an extrusion orifice which is of less height than the thickness of the workpiece wall and which extends transversely of the reducing rolls, and means for causing relative feed motion between the tool holders and face plate in a direction axially of the workpiece while the latter is being rotated to cause continuous extrusion of cylindrical wall portions of the workpiece through the extrusion orifice between the reducing rolls, and thereby simultaneously reduce the wall thickness and elongate the cylindrical workpiece while working equally on both sides and while maintaining substantially the same mean diameter of the workpiece.

2. Apparatus as claimed in claim **1** in which the reducing rolls are idlers and are adapted to be rotated by the rotating workpiece.

3. Apparatus as claimed in claim **1** in which there is a plurality of circumferentially spaced sets of reducing rolls all in the same transverse plane.

4. In a method wherein the wall thickness of a cylindrical workpiece may be reduced and its length extended with the use of a single set of inner and outer reducing rolls while maintaining substantially the same mean diameter, which method involves the use of a set of said rolls having a width dimension which is minor compared to the length of the cylindrical workpiece and whose peripheries have like cross-sectional shape so that the coacting portions of the rolls of said set form a relatively short transverse extrusion orifice in relation to the length of the workpiece, the steps of supporting a cylindrical workpiece on a fixed longitudinal axis for rotation around said axis, rotatably supporting the set of reducing rolls with the rolls on axes that are parallel to the axis of the workpiece and so that one roll engages the outside and the other roll the inside of the cylindrical wall of the workpiece in cooperating relationship with one another, pressurably adjusting said rolls equal amounts toward each other so as to maintain substantially the same mean diameter on the workpiece and so that the space between the bite of the rolls, which space forms the extrusion orifice, is less than the original wall thickness of the workpiece so as to obtain substantially uniform working of and therefore substantially identical properties on the inner and outer sides of the workpiece wall, rotating the workpiece on its longitudinal axis, and forcibly causing relative feed motion between the reducing rolls and the workpiece in a direction axially of the workpiece while the work and reducing rolls are rotating on their respective axes to cause continuous extrusion of cylindrical wall portions of the workpiece through the extrusion orifice between the reducing rolls, and thereby simultaneously reduce the wall thickness and elongate the cylindrical workpiece while maintaining substantially the same mean diameter of the workpiece.

5. A method as claimed in claim **4** which includes the steps of repeating the feed motion back and forth in multiple passes, and adjusting the rolls toward one another equal amounts between passes.

6. In a method of reducing the wall thickness of a cylindrical workpiece by the use of a plurality of sets of reducing rolls whose peripheries have like cross-sectional shape so that the coacting portions of the rolls of each set form a transverse extrusion orifice, the steps of supporting a cylindrical workpiece on a fixed longitudinal axis for rotation around said axis, rotatably supporting the sets of reducing rolls with the rolls circumferentially spaced and all in the same transverse plane and with one roll of each set engaging the outside and the other roll engaging the inside of the cylindrical wall of the workpiece in cooperating relationship with one another, pressurably adjusting said rolls so that the space between the bite of each set which forms the extrusion orifice is less than the original wall thickness of the workpiece, rotating the workpiece on its longitudinal axis, and forcibly causing relative feed motion between the reducing rolls and the workpiece in a direction axially of the workpiece while the work and reducing rolls are rotating on their respec-

tive axes to cause continuous extrusion of cylindrical wall portions of the workpiece through the extrusion orifices between the reducing rolls of the sets and thereby simultaneously reduce the wall thickness and elongate the cylindrical workpiece.

7. A method as claimed in claim 4 which includes the step of separating the reducing rolls at predetermined intervals to provide a circumferential rib on each side of the workpiece which is substantially normal to the axis of the workpiece.

8. A method as claimed in claim 6 which includes the step of separating the reducing rolls at predetermined intervals to provide a circumferential rib on each side of the workpiece which is substantially normal to the axis of the workpiece.

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