United States Patent

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[54] **HIGH-PRESSURE ROLLING OF WORKPIECES**

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Related U.S. Application Data

[63] Continuation of Ser. No. 634,947, May 1, 1967, abandoned.

[30] **Foreign Application Priority Data**

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Aug. 17, 1966 Republic of South Africa.....66/4911

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[51] **Int. Cl.**.....................................**B21b 19/08**, B21b 3/06

[58] **Field of Search**...................72/113, 112, 110, 107, 102, 72/98, 126, 96, 100, 87, 194, 191

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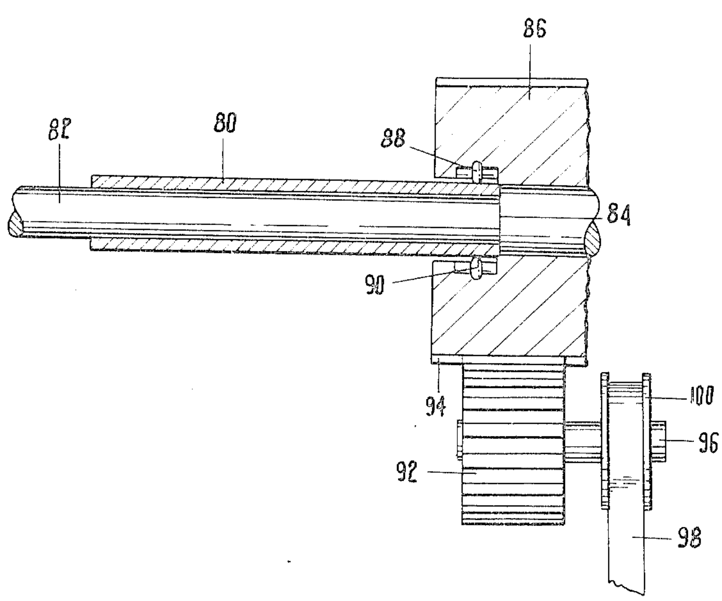
[57] **ABSTRACT**

A die for drawing tubular workpieces has its orifice defined by a ring of small rollers which are rotatable to work the workpieces around their circumference. Means may be present to straighten the tube and the die may include means to make the wall thickness of the workpiece uniform.

27 Claims, 15 Drawing Figures



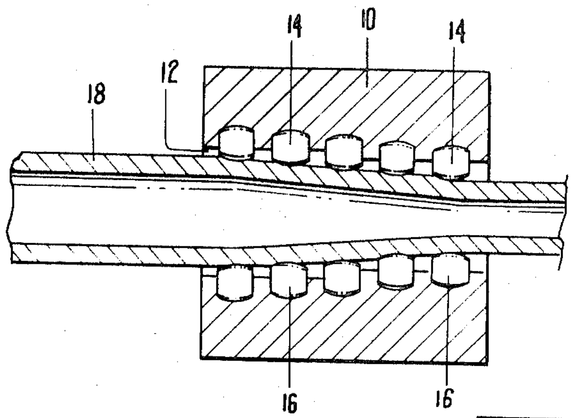


Fig 1

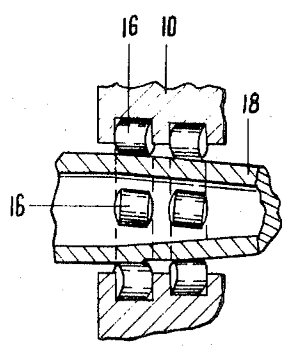


Fig 2

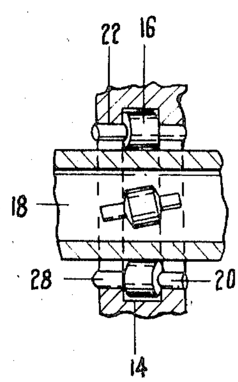


Fig 3

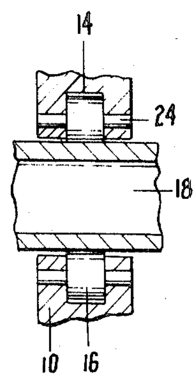


Fig 4

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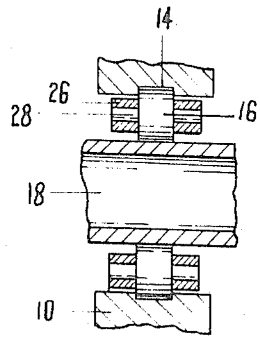

Fig 5

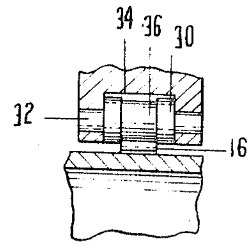

Fig 7

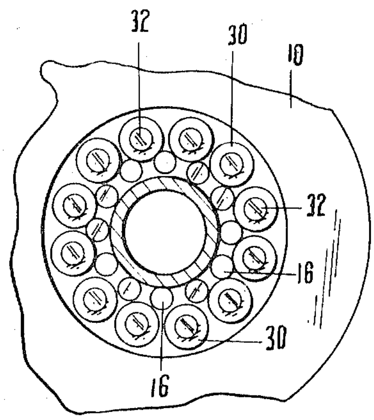

Fig 6

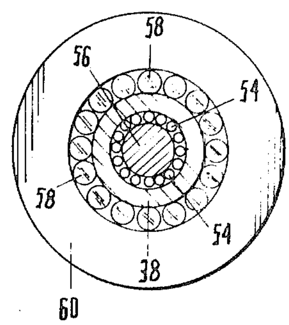

Fig 15

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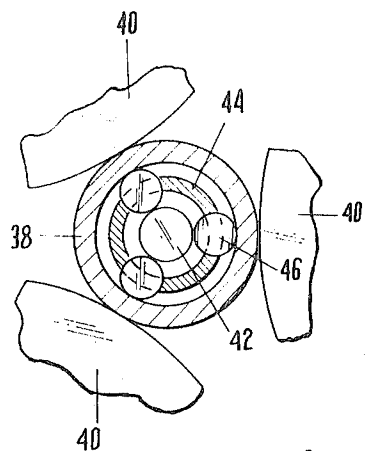

Fig. 8

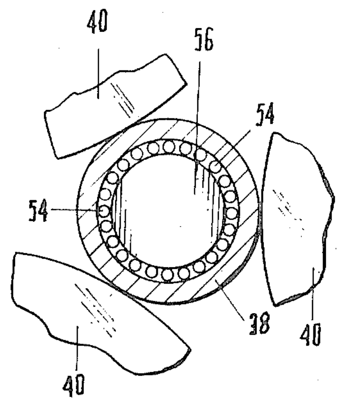

Fig. 10

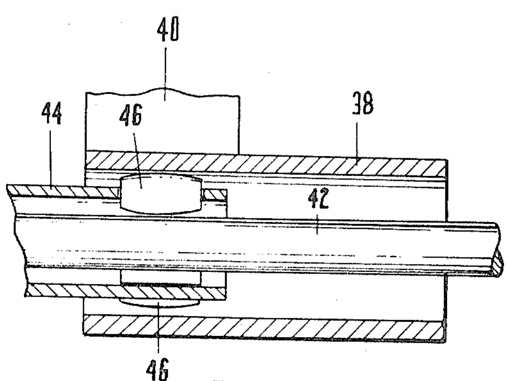

Fig. 9

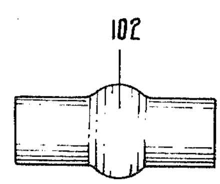

Fig. 11

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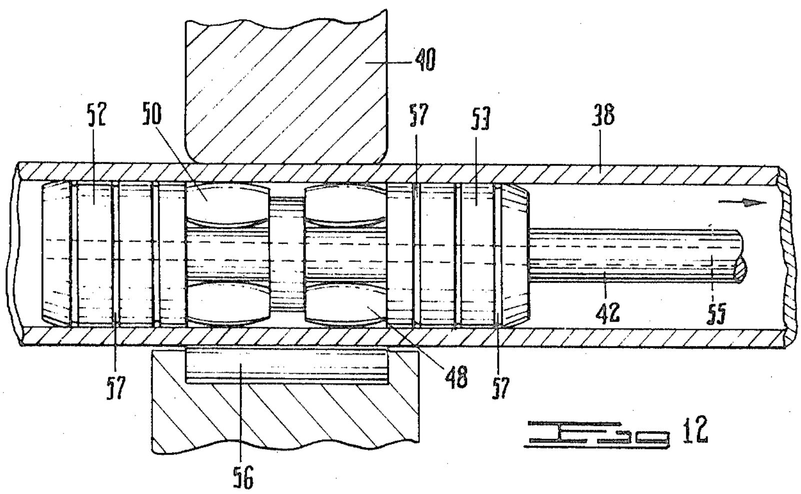

FIG. 12

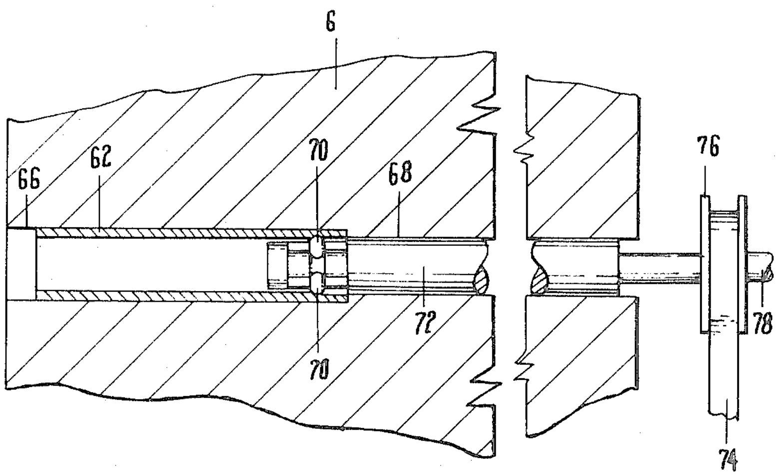

FIG. 13

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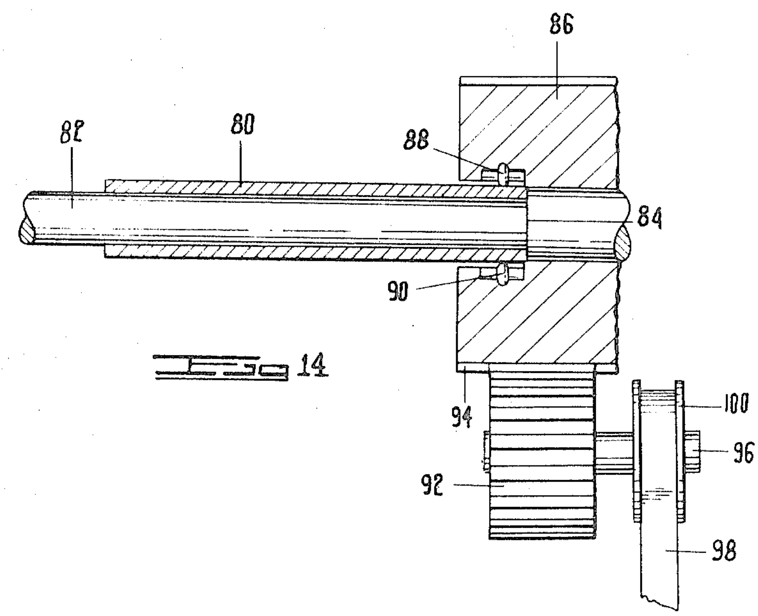

Fig. 14

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HIGH-PRESSURE ROLLING OF WORKPIECES

This application is a continuation of application Ser. No. 634,947, filed May 1, 1967 and now abandoned.

This invention relates to the treatment of tubular workpieces, by which is meant operating on them to produce a tube of uniform outer or inner diameter, or both, or of uniform wall thickness.

The object of the invention is to provide apparatus which permits tube to be produced to a high standard of precision which is not attainable by conventional techniques, and at a cost which compares favorably with the cost of such techniques.

Conventional methods employ dies through which the material is drawn or extruded. Apart from inaccuracy due to die wear, there is always the problem of maintaining the core of the die in correct alignment with the shell. Without such alignment, wall thickness cannot be controlled, and it is common experience that wall thickness can vary by as much as 20 percent in commercial tubing.

To avoid these difficulties and defects, the present invention makes use of the concept of subjecting the tube to a rolling operation, internally or externally, carried out by a series of small rollers arranged to rotate and to profile the tube as they roll in line contact with it, by applying progressively around the circumference of the tube pressure over a very small area, so that the intensity of pressure is very high.

According to the invention, apparatus to put this concept into practical effect consists, broadly, of a die through which the tubular workpiece is adapted to be drawn, the die orifice being, at least partly, defined by a ring of small rollers; means to cause rotation of the rollers around the circumference of a workpiece in the orifice, and means to pass the workpiece through the orifice. The circumference may be the external or the internal circumference.

Further according to the invention, the rollers are individually "skewed" to the axis of the orifice, so that, as they turn, they tend to draw the workpiece through the throat. The transport of the workpiece may be achieved solely by this means, or axial force may be applied externally to the workpiece.

Also according to the invention, the die includes a series of rings of rollers, spaced apart along the length of the orifice, to reduce the effective diameter of the orifice, so that the workpiece is progressively treated as it advances through the orifice.

Several embodiments of the invention are illustrated in the accompanying drawings, in which:

FIG. 1 is a vertical section through one from of die,

FIG. 2 is a fragmentary view, in section, of a form of die in which the rollers are arranged to "skew."

FIG. 3 is a similar view of another embodiment in which the rollers are mounted on stub axles,

FIG. 4 is a similar view, showing rollers that are pinned in a holder,

FIG. 5 is a similar view of rollers mounted in a cage,

FIG. 6 is an end view showing the rollers backed by other rollers,

FIG. 7 is a fragmentary view showing the arrangement of FIG. 6 in detail,

FIG. 8 is a fragmentary end view partly in section showing a tubular workpiece being internally worked,

FIG. 9 is a section on the line 9—9 of FIG. 8,

FIG. 10 is an end view of another embodiment for internal working of a tube,

FIG. 11 is a side view of the preferred form of roller,

FIG. 12 is a fragmentary vertical section showing a means to straighten as well as work a tube internally,

FIG. 13 is a vertical section through a machine for internally treating a tube to obtain a uniform wall thickness,

FIG. 14 is a similar view, but showing a tube being externally treated for the same purpose, and

FIG. 15 is an end view showing a tube being treated simultaneously, internally and externally.

In FIG. 1, the die consists of a body 10 having an orifice 12 that is stepped. Inside the orifice is a series of spaced grooves 14, each of which constitutes a race for a series of small rollers 16 which line the orifice to provide the throat through which a tubular workpiece 18 is drawn. For the required relative rotation between the tube 18 and rollers 16, the body 10 may be rotated, or the tube 18 may be rotated as it is passed through the throat.

Each roller 16 is convex in profile. If the rollers are "square on" to the tube, external means must be provided to draw the tube through the throat. Any means suitable for this purpose may be used, for instance a chuck which grips the leading end of the tube, or a capstan around which the tube is coiled. However, it is preferable to arrange the rollers so that they act to draw the tube through the die, or at least assist in doing so. To this end, the rollers are arranged obliquely to the axis of the throat, so that they form a sort of Archimedean screw to drive the tube. This arrangement is described later.

It will, of course, be appreciated that, for a small reduction of diameter, or for soft material, it may not be necessary to provide several rings of rollers: one ring may be sufficient.

In FIGS. 1 and 2, the rollers are arranged to roll on the floor of the channels 14. In FIG. 3, each roller is provided with stub axles 20 that roll on the lands 22 of the grooves.

The rollers may be free within the grooves in the sense that they are held in the grooves only by the presence of the tube 18. In some cases, this may be disadvantageous since, when the throat is empty, the rollers will fall out of it. Accordingly, in FIGS. 4 and 5, the rollers are held positively within the grooves, in FIG. 4 by being mounted on pins 24 that are journaled within holes in the sidewalls of the grooves, and in FIG. 5 by being mounted within cages 26 with which stub axles 28 on the rollers are engaged.

In FIGS. 6 and 7, the rollers 16 are backed by rollers 30 which have stub axles 32 that are journaled in the sidewalls of the groove 34. The rollers 30 are circumferentially grooved at 36, and the groove serves as a guide for the roller 16. As will be seen in FIG. 6, the series of rollers 16 is intercalated with the series of rollers 30, so that each roller 16 is backed by two rollers 30.

In FIGS. 4, 5, 6 and 7, the rollers may be permanently kept in a skewed position by skewing their mountings.

Thus far, the embodiments described concern the profiling of the outer surface of tubular workpieces, to provide a uniform outer diameter and a good finish. If the wall thickness of the tube is not uniform, it remains so. In the embodiments that are illustrated in FIGS. 8, 9, 10 and 12, it is the inner surface of the tubular workpiece that is treated.

In FIGS. 8 and 9, the tubular workpiece 38 is caused to travel axially through a throat defined between juxtaposed rollers 40 that rotate about fixed axes. Inside the throat, and within the cavity of the tube is a rod 42 coaxial with the tube, surrounded by a tubular holder 44 slotted to accommodate rotatably a series of rollers 46 which rotate about their axes, which are kept in a fixed position relative to the rollers 40, as shown in FIG. 8, by the holder 44.

In operation, the tube 38 is offered to the throat and is drawn or propelled through it. The rollers 40, or one or two of them, is or are rotated, which imposes rotation on the tube 38. The rod 42 is simultaneously rotated in the opposite direction. This causes the rollers 46 to rotate. As the tube advances between the rollers 46 and the rollers 40, a uniform internal diameter is imposed on it by the rollers 46, the tube being buttressed by the rollers 40. This operation sizes the internal and external diameters simultaneously. Preferably, the tube is initially slightly undersize in these diameters.

Tubes in their raw state are almost invariably bent, especially when they come in long lengths. The arrangement of FIG. 12 is intended to be of use in straightening them and slightly elongating them. The raw tube 38 is traversed past a multiroller system, which may be large rollers as shown at 40 in the top part of the figure, or a series of needle rollers 56 as seen in the lower part. Within the traversing tube 18 is an assembly of rollers 48, 50 which may be skew mounted, in advance of which is a plunger 52 and to the rear of which is a second plunger 53 of somewhat greater diameter. The assembly is rotated by a stem 42 fast with the rear plunger 53, the rotation being transmitted to the inner rollers 48, 50 and the front plunger through the stem 42 around which the inner rollers 48, 50 revolve.

The tube 38 is drawn through the throat between the inner rollers and the outer rollers. The front plunger 52 is a sliding fit within the tube cavity. The inner rollers reduce the wall thickness while straightening the tube, and the rear plunger 53 is a sliding fit within the increased internal diameter of the tube. For the sake of clarity, this increase has not been illustrated in FIG. 12.

Pressure oil may be fed to the outer surfaces of the plungers 52, 53, through a bore 55 in the stem 42 and through grooves 57 in the plungers in communication with the bore 55.

In FIG. 10, an arrangement such as in FIGS. 8 and 9 is shown, but in place of a few inner rollers there is a large number of needle rollers 54 between the inner surface of the tube 38 and the outer surface of a core 56. The rollers 54 are constrained against endwise movement by engagement in grooves in the core 56 but need not otherwise be constrained, as they are held in position by the tube. There are sufficient rollers 54 to line completely the throat defined between the tube and the core.

In FIG. 15, the same system of needle rollers 54 is seen, but the outer rollers 40 give place to a large number of needle rollers 58 which surround the tube and which are contained within the bore of a hollow, cylindrical holder 60. The rollers, 58, like the rollers 54, are confined against axial movement by being located within annular grooves in the holder 60, but need not otherwise be constrained. As the throat is defined between two sets of rollers that are buttressed against radial displacement, so that the throat is and remains uniform, passage of the tube 38 through the throat imposes on the tube prescribed inner and outer diameters.

In FIGS. 13 and 14, embodiments are shown which produce concentric, straight tubes from commercial tubing which, as is usual, is both eccentrically apertured and bent. In FIG. 13, a tube 62, which has been sized as to outer diameter by the apparatus or otherwise, is placed within a housing 64 having a bore 66 in which the tube is a close fit. The bore 66 is, at 68, reduced to the exact diameter to which it is desired to bring the inner diameter of the tube. A number of rollers 70, arranged for orbiting in a circle, which is exactly the diameter of the reduced bore of the housing, is mounted on a mandrel 72 which is a sliding fit in the reduced bore 68 and which projects into the bore 66 to define therewith an annular passage. The rollers 70 are passed through the reduced bore by advancing the mandrel 72, which is simultaneously rotated, by means such as a belt 74 which engages a pulley 76 slidably mounted on a splined stem 78 projecting rearwardly from the mandrel 72. As the rollers 70 advance into and through the tube, they orbit and roll out any eccentricity in the bore of the tube, which is removed from the machine straight, with uniform wall thickness, and well-finished internally. The strength of the tube will be enhanced by the rolling operation.

In FIG. 14, the tube 80 is first finished as to its inner diameter, either by the means of the invention or otherwise. Thereafter, it is impaled upon a mandrel 82 and inserted into an annular passage defined by the mandrel 82 and an enlarged bore or counterbore 88 of a cylindrical housing 86. The mandrel 82 has a shoulder 84 against which the end of the tube abuts, and which marks the division between the length of mandrel that enters the tube and a part of diameter exactly equal to that to which the outer diameter of the tube is to be brought. This larger diameter is used as a guide over which slidably passes a cylindrical housing 86 that carries, with a counterbore 88, a series of small rollers 90 which orbit the tube, and define a circle of exactly the diameter to which the tube is to be brought. The housing is caused to traverse the tube and at the same time is rotated by means such as a gear wheel 92 that engages teeth 94 on the periphery of the casing. The gear wheel 92 is rotated through a shaft 96 driven by a belt 98 passing around a pulley 100 on the shaft. Rotation of the housing causes the rollers 90 to orbit around the tube and to profile the tube between themselves and the mandrel 82 to the prescribed outer diameter, at the same time rolling out eccentricities in the bore to produce a uniform wall thickness.

The mandrel in FIG. 14, or the bore 66 in FIG. 13 might, of course, be profiled such as by splines or other formations to produce a complementally profiled surface in the finished tube.

The shape of the rollers that impose the profile upon the workpiece is, in all embodiments of the invention, of importance. A convex or barrel shape is essential for internal profiling. The best form of roller is illustrated in FIG. 11, in which it will be seen that the convexity consists of an annular swage 102 at the middle of the roller. For external rolling, the rollers may be convex, cylindrical or even concave if the rollers are obliquely mounted.

The rollers may be obliquely mounted to promote travel of the tube relatively past them, or it may be desirable that the rollers be so mounted that they take up their own orientation as the operation proceeds. To this end, the rollers may be floatably mounted as in FIG. 2, in the sense that they are permitted a measure of play which permits them to swivel to balance the forces acting on them.

It will be observed that in all embodiments the rollers are backed either longitudinally or at both their ends against thrust from the workpiece. This allows high-pressure intensity to be exerted over a small area of the workpiece while the rollers are fully supported, and a large force may be applied to urge them towards the workpiece.

I claim:

1. Apparatus for rolling a tubular workpiece comprising structure defining an annular throat and within the throat an annular series of nonspherical rollers, each of which has its center portion of greater diameter than the diameter of its axially outer portions, said throat comprising at least one backing member having a surface which is a surface of revolution on which surface at least said outer portions of the rollers roll in line contact, whereby in use a tubular workpiece passing through the throat with relative rotation between the workpiece and the rollers about the axis of the workpiece undergoes deformation of a surface thereof.

2. The apparatus of claim 1 further comprising means for causing relative rotation between the rollers and a workpiece.

3. The apparatus of claim 1 further comprising means for advancing the workpiece through the throat.

4. The apparatus of claim 1 wherein the rollers are arranged so as in use to act on the outside of the workpiece.

5. Apparatus as claimed in claim 4, and a mandrel located within the throat to support the inside surface of the workpiece.

6. Apparatus as claimed in claim 5, in which the surface of said mandrel is contoured.

7. The apparatus of claim 1 wherein the rollers are arranged so as in use to act on the inside of the workpiece.

8. Apparatus as claimed in claim 7, in which the throat-defining structure is contoured.

9. The apparatus of claim 1 wherein the rollers are arranged with their axes substantially parallel with the axis of the throat.

10. The apparatus of claim 1 in which the rollers are arranged with their axes oblique relative to the axis of the throat.

11. The apparatus of claim 1 including a number of annular series of rollers spaced apart along the length of the throat.

12. The apparatus of claim 11 in which the diameters of the circles encompassed respectively by the series of rollers decrease along the length of the throat.

13. The apparatus of claim 1 in which the backing member is formed with an annular groove for said series of rollers.

14. The apparatus of claim 13 in which the backing member is bored to provide the throat and said groove is provided within the wall of the bore.

15. The apparatus of claim 7 in which the backing member is a stem adapted to enter the workpiece.

16. The apparatus of claim 15 in which the structure is a housing with a cylindrical aperture which encloses the workpiece.

17. The apparatus of claim 15 in which the structure is a series of rollers parallel with and mounted around the workpiece.

18. The apparatus of claim 14 in which the backing member is bored to the outer diameter to which the workpiece is to be brought and is counterbored to receive the rollers.

19. Apparatus for treating a hollow workpiece, comprising first and second means defining between them an annular aperture and an annular series of rollers in the aperture, said first means including at least one backing member having a surface which is a surface of revolution on which surface at least the axially outer portions of the rollers are supported in line contact, the workpiece and said first means being axially and rotatively movable relative to each other to cause the rollers to traverse a periphery of the workpiece, said rollers being freely supported on said backing member for orbital movement about said backing member whereby upon rotative movement of said first means and workpiece relative to each other, the line of contact between each roller and the backing member rotates about the periphery of the backing member and a surface of the workpiece undergoes deformation.

20. Apparatus as claimed in claim 19, said rollers being elongated in their axial direction and having a center portion which contacts the workpiece and is of greater diameter than the endwise outer portions of the rollers which do not contact the workpiece, the total length of said line of contact between said backing member and the rollers being greater than the length of said center portion which contacts the workpiece.

21. Apparatus as claimed in claim 19, in which said backing member comprises a mandrel that extends into the workpiece to cause the rollers to act on the inner surface of the workpiece, said second means comprising an elongated circumferentially continuous wall that acts on the outer surface of the workpiece.

22. Apparatus as claimed in claim 21, in which the mandrel is of a diameter equal to that required of the workpiece, the mandrel having a sliding fit in an elongated bore coaxial with the circumferentially continuous wall and formed in a rigid housing.

23. Apparatus as claimed in claim 20, in which each of the rollers has stub axles on opposite axial ends of said center portion, the stub axles of each roller having a combined axial length greater than that of said center portion, at least the stub axles of the rollers being supported in line contact on said backing member.

24. A method of rolling a workpiece having at least one surface which is a surface of revolution, the method comprising:

a. rolling the said surface at high pressure by the median portion of each of a plurality of rollers, each roller being arranged with a major component of the direction of its axis parallel to the axis of the said surface of the workpiece,
b. supporting and rolling the portions of each of the said rollers on either axial side of the said median portion in rolling line contact with massive backup means, the axial length of said line contact being greater than the axial length of contact between the workpiece and the said median portions,
c. causing relative movement between the workpiece and the rollers about the axis of the said surface of the workpiece, and
d. causing relative movement between the said workpiece and rollers in the direction of the said axis of the said surface of the workpiece, the arrangement being such that rolling causes considerable metal flow in the workpiece.

25. A method as claimed in claim 24 in which there is no substantial deviation from true rolling between the backup means and the said portions on either side of the median portion of each roller.

26. Apparatus for rolling a workpiece having at least one surface which is a surface of revolution, the apparatus comprising:

a. structure defining a throat and being comprised at least partially by a series of rollers, each said roller having a median portion to engage the workpiece and additional portions on either axial side of said median portion, and
b. massive backup means on which the said additional portions are supported and roll in line contact, the axial length of the said line contact being greater than the axial length of said median portion.

27. Apparatus as claimed in claim 26 in which the diameter of the said median portion is greater than the maximum diameter of the said additional portions.

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