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BAENSCH et al.(10) **Pub. No.: US 2013/0042660 A1**(43) **Pub. Date: Feb. 21, 2013**(54) **METHOD AND APPARATUS FOR MAKING
COLD-PILGER-ROLLED PIPE****Publication Classification**(76) Inventors: **Michael BAENSCH**, Rheinberg (DE);
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Moenchengladbach (DE)(51) **Int. Cl.**
B21B 37/78 (2006.01)
(52) **U.S. Cl.** **72/12.8**(57) **ABSTRACT**

An apparatus for making a cold-pilger-rolled tube has two grooved pilger work rolls rotatable in a roll frame about respective axes to compress a tubular workpiece moving in a travel direction around a mandrel extending in the direction between a nip formed between the grooved rolls and anchored upstream of the nip in a thrust block. An outside diameter of the workpiece is measured downstream in the direction from the rolls as the workpiece passes through the nip, and an actuator engaging one of the rolls relative the other of the rolls shifts it transversely to the travel direction as the workpiece passes through the nip in accordance with the measured outside diameter for maintaining a uniform outside diameter of the workpiece.

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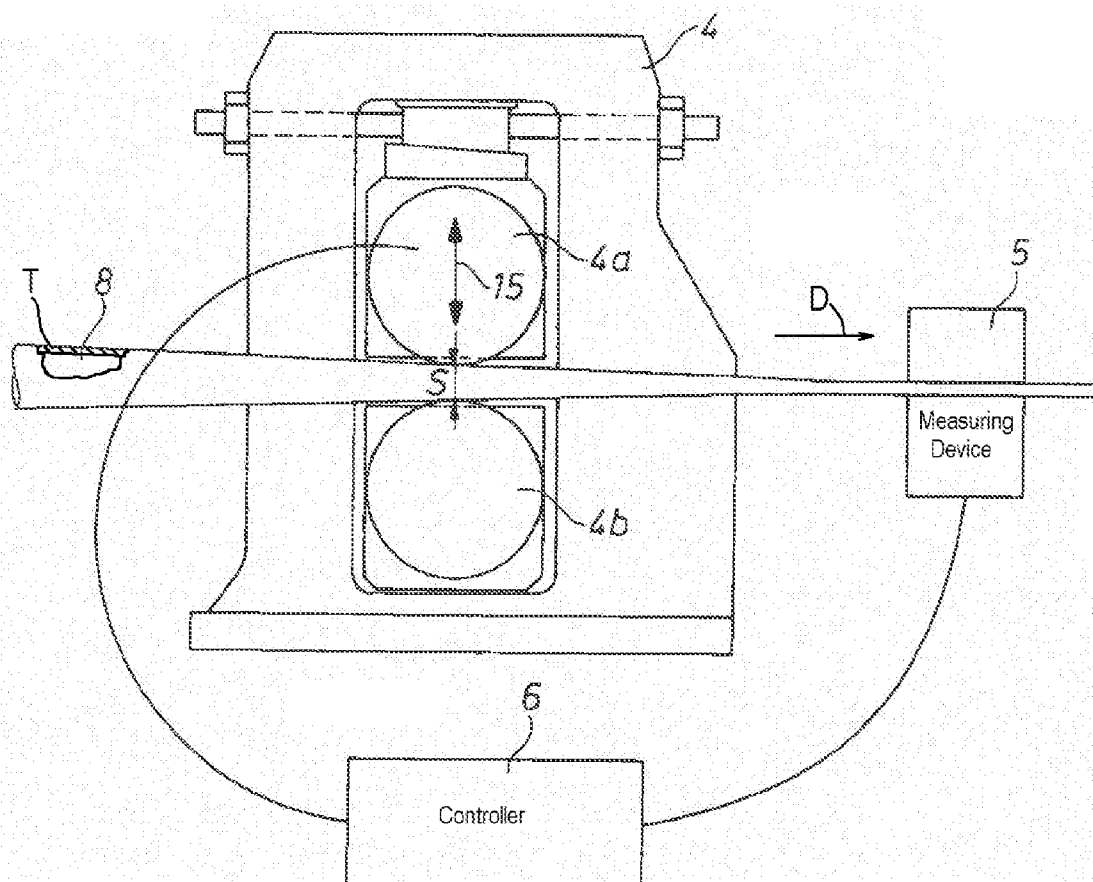


Fig. 1

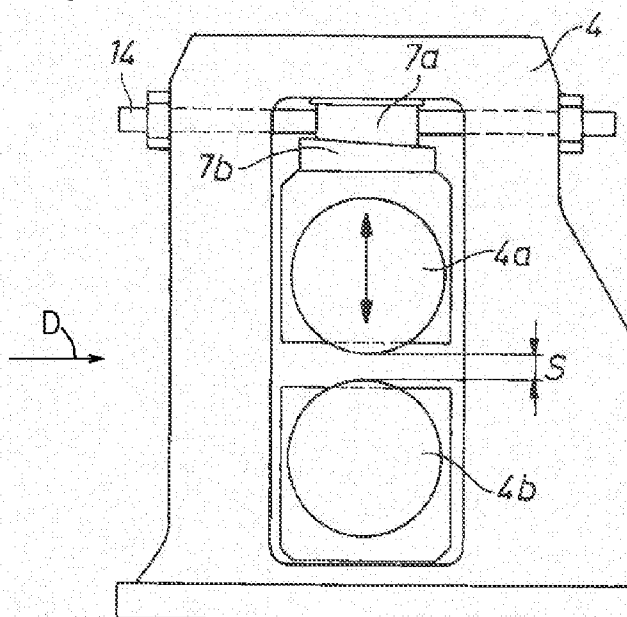


Fig. 2

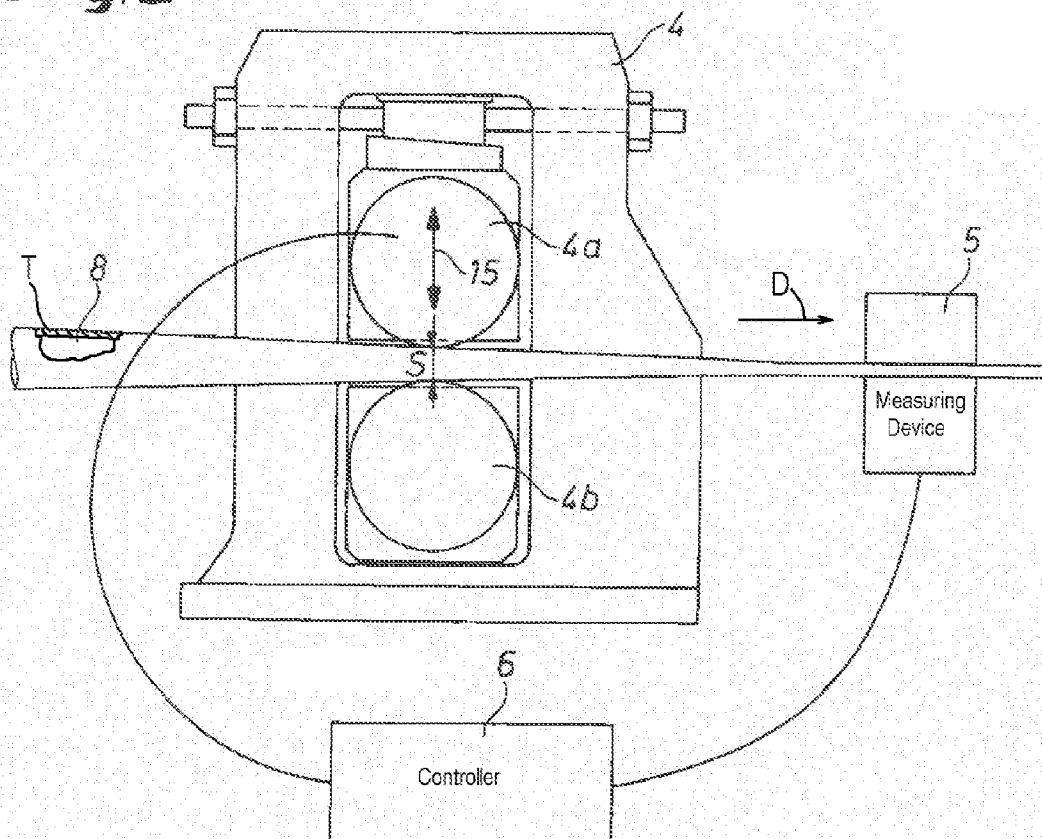


Fig. 3

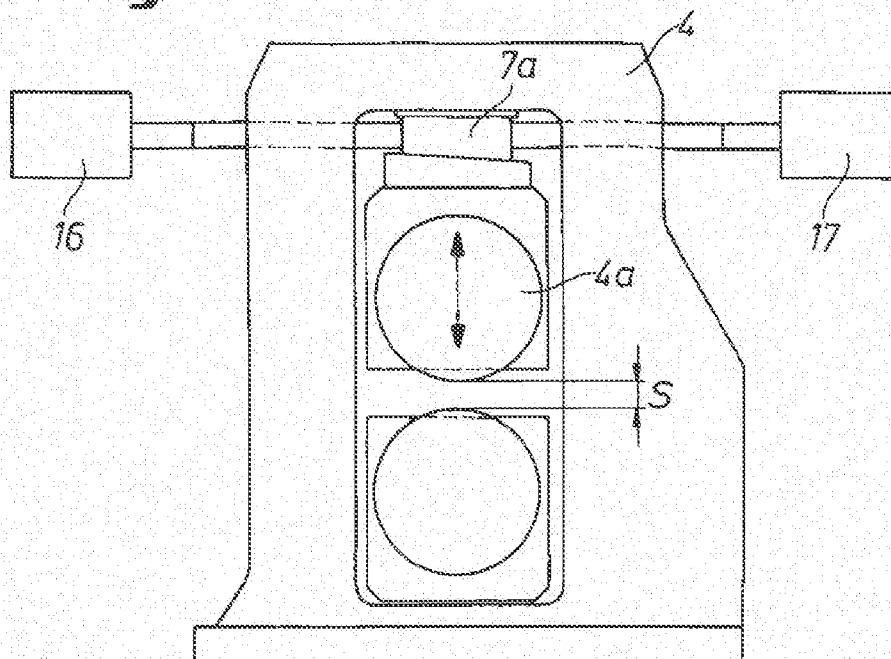


Fig. 4

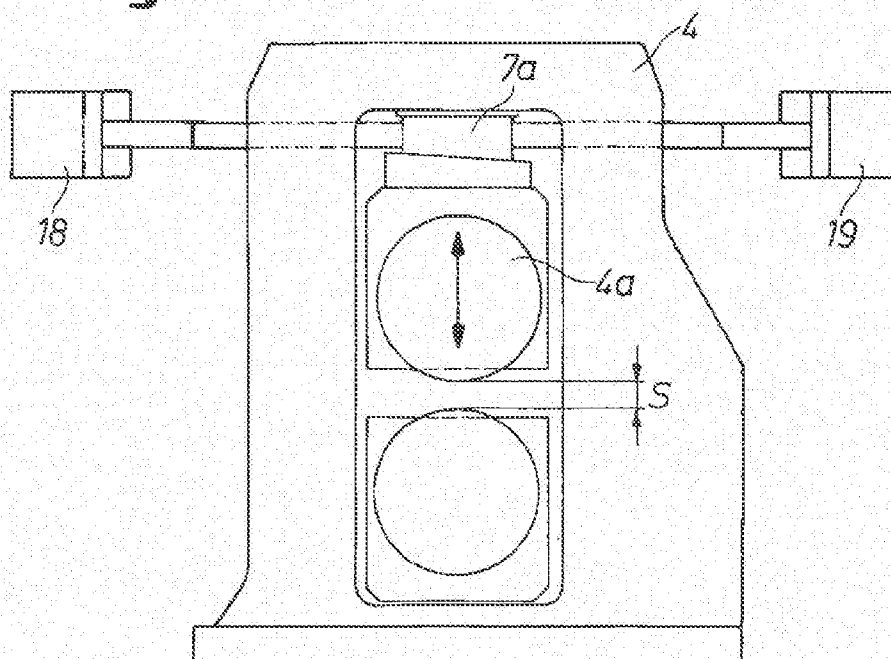


Fig. 5

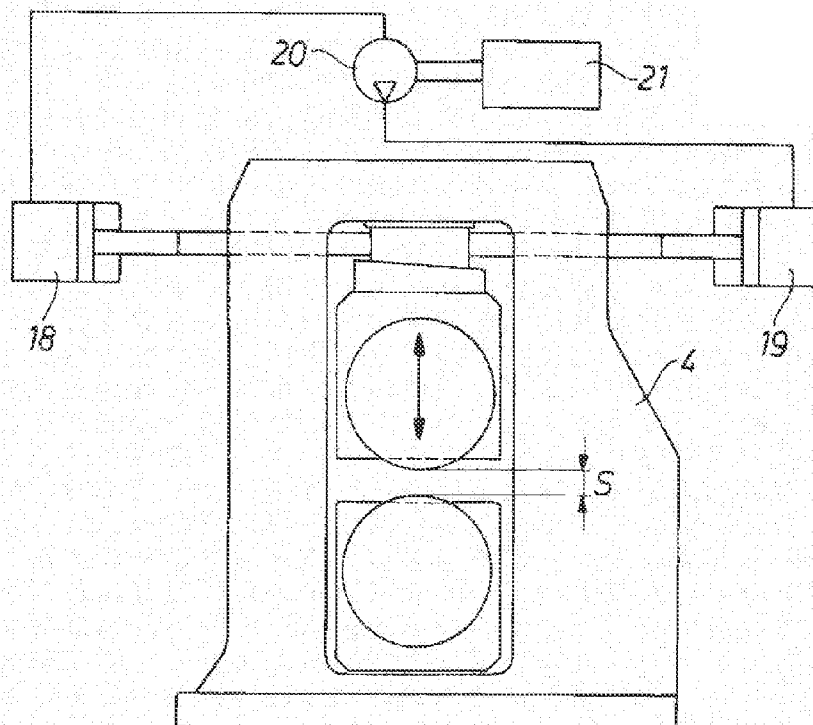


Fig. 6

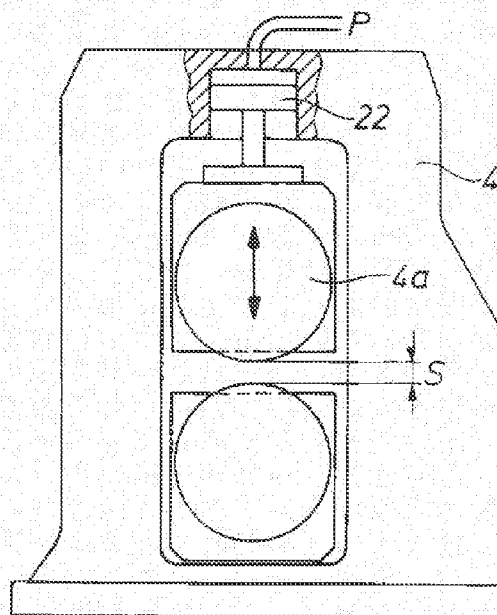


Fig. 7

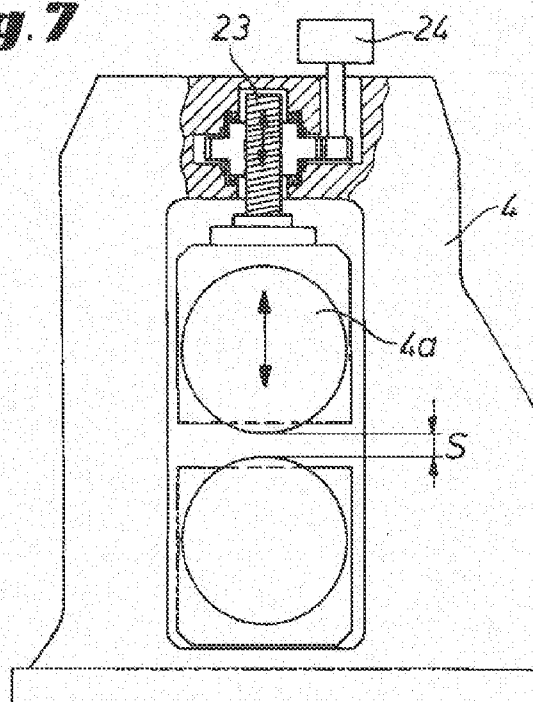


Fig. 8

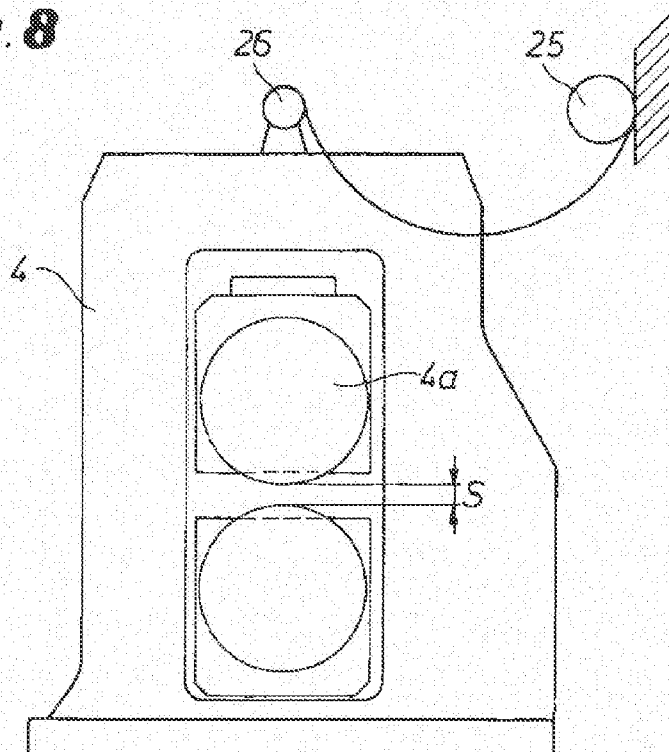


Fig. 9

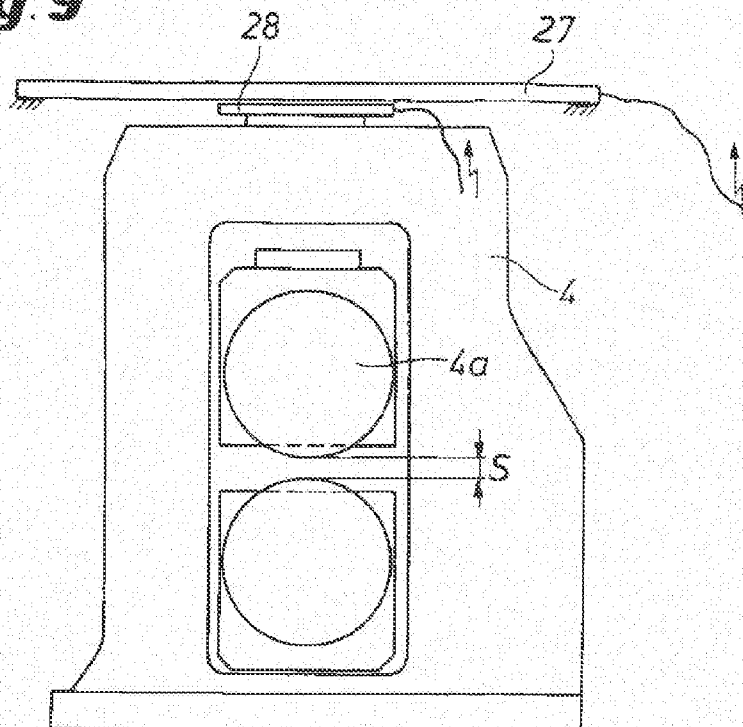


Fig. 10

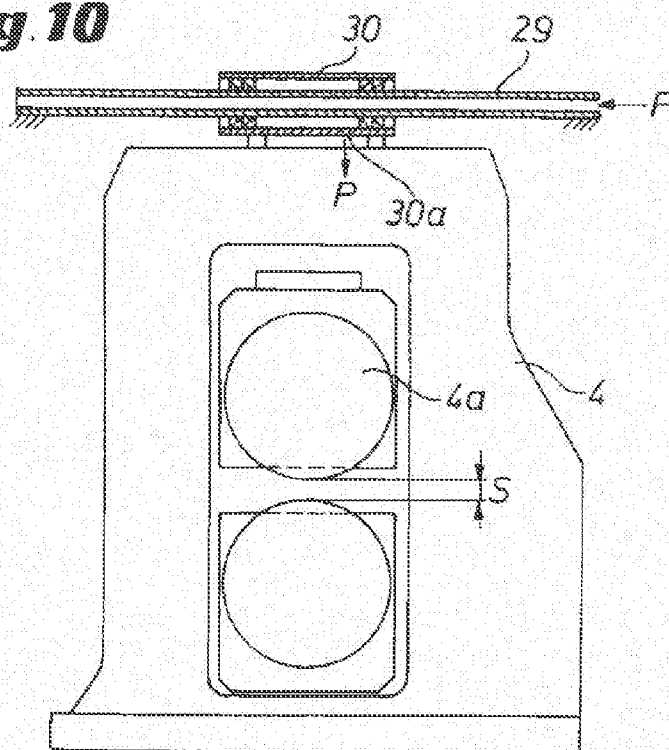


Fig. 11

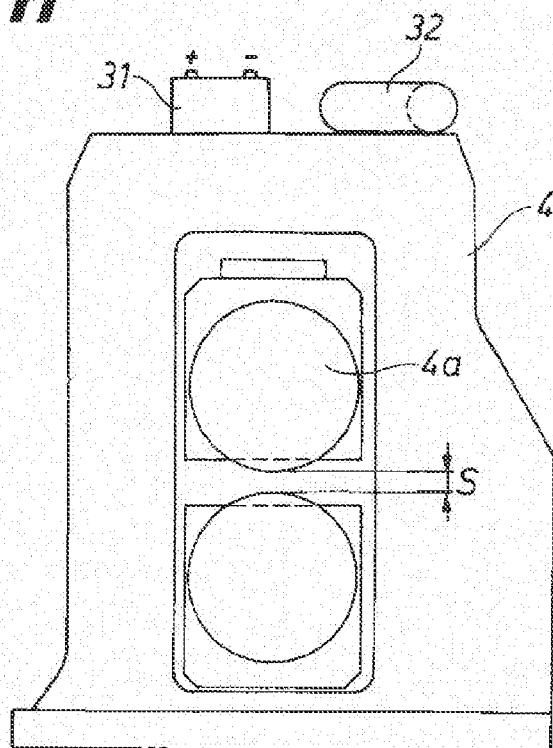


Fig. 12

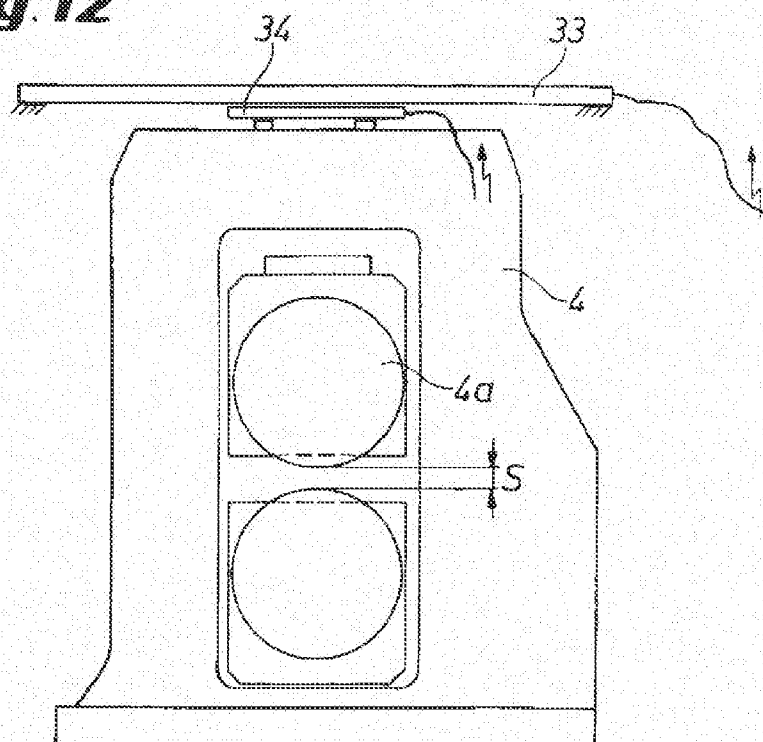


Fig. 13

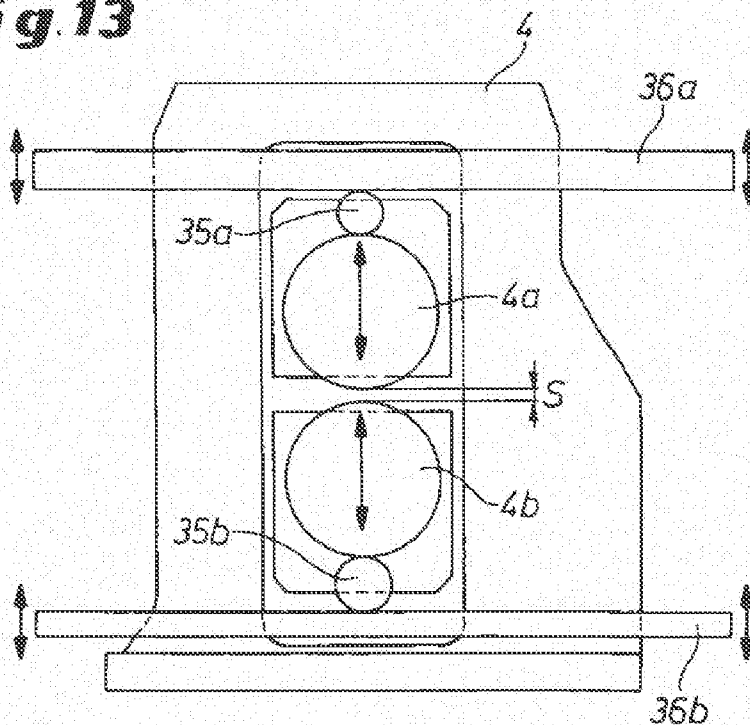
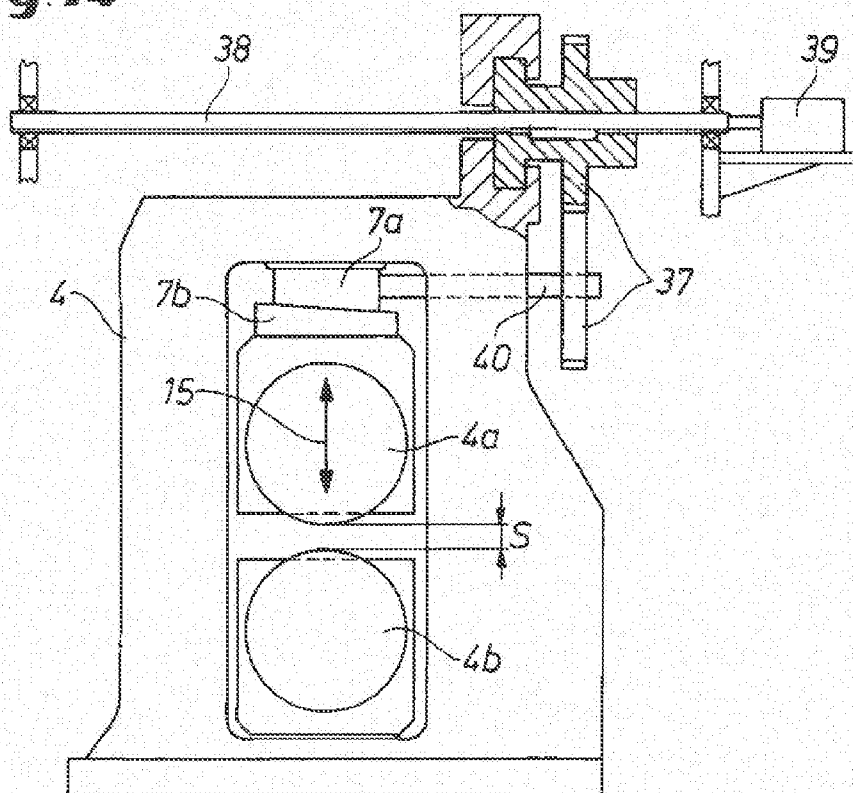


Fig. 14



METHOD AND APPARATUS FOR MAKING COLD-PILGER-ROLLED PIPE

FIELD OF THE INVENTION

[0001] The present invention relates to the manufacture of tubing. More particularly this invention concerns making cold-pilger-rolled tubes.

BACKGROUND OF THE INVENTION

[0002] A standard apparatus for making a tube has two grooved pilger rolls rotatable about respective axes to press a tubular metal workpiece moving in a travel direction against a mandrel extending in the direction between a nip formed between the grooved rolls. The mandrel is supported upstream of the nip in a thrust block and has a frustoconically tapered downstream portion extending through the nip so that as the tubular workpiece is compressed against around the mandrel its diameter and wall thickness are conformed to the final desired dimensions. The rolls themselves are each formed with a substantially semicircular groove to impart the desired cylindrical outer surface to the workpiece.

[0003] With this system, tubes are typically manufactured to especially stringent size tolerances. Dimensional changes can however occur in the product during manufacture. Whenever the tube diameter threatens to depart from the tolerance range, or had already departed from this range, the rolling mill is shut down and the size of the roll gap is corrected. Any rapidly occurring dimensional changes may remain undetected with such periodic sampling-type inspections. Confirming that a dimensional adjustment had been successfully performed was also possible only after at least one entire additional tube had been made or unless the rolling mill was again halted to inspect dimensions. Ultimately, production time was lost during each dimensional inspection since the rolling mill had to be stopped.

[0004] Optical methods such as those using laser light grids are suitable for measuring the diameter of finished tubes.

[0005] The application of nondestructive testing methods for the cold-pilger-rolling process is, however, not known in the prior art. Instead, the testing methods used heretofore have continued to pursue the principle where measurement is performed after forming and sampling have been completed, and subsequently individual or multiple forming parameters are then modified based on the test values, and finally the result of this parameter modification is then checked once again after a further completed forming process.

OBJECTS OF THE INVENTION

[0006] It is therefore an object of the present invention to provide an improved method and apparatus for making cold-pilger-rolled tubes.

[0007] Another object is the provision of such an improved method and apparatus for making cold-pilger-rolled tubes that overcomes the above-given disadvantages, in particular that enable the position of at least one forming die to be adjusted effected during cold pilger rolling based on measurement data obtained during the forming process.

SUMMARY OF THE INVENTION

[0008] An apparatus for making a cold-pilger-rolled tube has two grooved pilger work rolls rotatable in a roll frame about respective axes to compress a workpiece moving in a travel direction against a mandrel extending in the direction

between a nip formed between the rolls and anchored upstream of the nip in a thrust block. According to the invention an outside diameter of the workpiece is measured downstream in the direction from the rolls as the workpiece passes through the nip, and means for displacing one of the rolls relative the other of the rolls transversely to the travel direction as the workpiece passes through the nip in accordance with the measured outside diameter for maintaining a uniform outside diameter of the workpiece.

[0009] According to the invention, the means for displacing is operatively linked to at least one work roll engaging the tube from the outside, and the means for displacing is in turn connected to the measuring device. This is preferably effected by interconnecting a controller between the means for displacing and the measuring device, this measuring device being especially preferably connected to a data memory for the adjustment and/or operational parameters.

[0010] This way, an online apparatus is provided for producing cold-pilger-rolled tubes that is able to monitor the rolled product and detect defects that may occur preferably almost immediately, and preferably to perform appropriate corrective countermeasures preferably still during the ongoing forming process.

[0011] This not only allows the ongoing forming process to be monitored continuously; it furthermore also enables any is corrective and adjustment actions to be tracked and evaluated almost immediately in order to immediately initiate and effect any required corrections.

[0012] To this end, the means for displacing is connected to at least one tool or die engaging the tube from outside, preferably at least one roll, and can thereby effect and adjust the roll gap setting in the desired manner and preferably online with the measuring device.

[0013] In an advantageous embodiment of the invention, deviation in the outside diameter of the tube from a specified set-point value or from a tolerance range is determined during the forming process. This is especially advantageously effected by comparing measurement data with specifications and reference data stored in a controller, and, in particular, in the controller's memory. An apparatus is thus created that automatically monitors adherence to the required tolerances during the entire manufacturing process, and preferably also ensures that appropriate actions are taken.

[0014] The measuring device is preferably optical, such as a laser sensor that provides nondestructive and reliable online measurement of the outside diameter of the cold-pilger-rolled tube using equipment that is especially easy to handle while achieving especially precise measurement results.

[0015] The outside diameter is typically measured not only when the tube is at one fixed position. Instead, the cold-pilger-rolling process produces a regular rotation of the tube about its longitudinal axis. It is therefore possible to provide measurement coverage over the entire circumference of the formed tube simply by the preferred fixed positioning of the measuring device relative to the rotation of the tube relative to the measuring device produced during the normal manufacturing operation. The approach is also preferred whereby not only one measurement at one specific site on the tube is performed, but a plurality of measurements is performed while, for example, maintaining a specified frequency extending over the entire forming process. As a result, determining the recorded measurement data also enables the effect of any measurement errors to be minimized by simple means.

[0016] In a preferred embodiment of the invention, the work roll engaging the tube from the outside is supported in at least one adjustment position at which the roll gap can be set, and preferably also secured in this position. This reliably ensures the ability to readjust the apparatus and readjust the roll gap, preferably automatically and during the forming process.

[0017] In a first alternative embodiment of the invention, the adjustment device can include an electrically adjustable adjustment wedge that can alter the roll gap preferably steplessly to any appropriate shape and thickness by utilizing readily controllable and available means.

[0018] In a second alternative and similarly preferred embodiment of the invention, the adjustment device has a hydraulically adjustable adjustment wedge and in order to supply the hydraulic fluid a pump for the fluid is preferably disposed on the roll stand itself. This also provides a stepless adjustment of roll gap by simple and easy-to-control means. The preferred positioning of the pump on the roll stand itself additionally contributes to the compactness of the constructive design while reducing the length of the hydraulic lines to the minimum extent necessary.

[0019] In a third alternative and similarly preferred embodiment of the invention, the adjustment and fixation of the roll gap is effected by one or more hydraulic cylinders. This preferred embodiment too enables stepless adjustment of the roll gap to be ensured by simple and easy-to-control means.

[0020] In a fourth alternative and similarly preferred embodiment of the invention, the adjustment of the roll gap is, however, implemented by vertically adjusting at least one back-up roll for the work roll engaging the tube from outside. This avoids having to adjust the work roll itself that engages the tube from outside, preferably the one roll, and being connected thereby to the adjustment device. Instead, the adjustment device can be connected to the back-up roll, thereby ensuring indirectly that the roll gap can be adjusted by similarly simple and reliably controllable means.

[0021] The preferred approach in this regard is furthermore one whereby the transmission of measurement data, and optionally control data, to the adjustment device(s) is effected through cables. In an alternative and similarly preferred approach, however, transmission is possible wireless or by telemetry in order to thereby minimize the amount of cabling and the installation space required for this purpose. Using wireless transmission of measurement and optionally control data, also obviates the need to encapsulate cables and protect the cables from the effects of the forming process.

[0022] A preferred approach according to the invention is one where not only the one work roll engaging the tube from outside is adjustable but also where in addition the rolling mandrel is also mounted in the rolling mill so as to be adjustable. To this end, the rolling mandrel is preferably also connected to the measuring device and optionally to the controller. This ensures that all of the tools involved in the forming process can be set appropriately in their position relative to each other in order to achieve the best possible forming product. The flexibility of the apparatus is advantageously enhanced in terms of its ability to react to deviations from the specified size in wall thickness and/or the outside diameter of the tube.

[0023] In a second aspect of the invention, a method is provided to produce cold-pilger-rolled tubes by means of a rolling mill, which method includes a rolling mandrel sup-

ported on at least one mandrel thrust block, and at least two tools engaging the tube from outside, preferably rolls, as well as a measuring device to measure the wall thickness of the tube during the forming process. According to the invention, the means for displacing the work roll engaging the tube from outside always adjusts the position when the measuring device connected to it detects a deviation in the outside diameter of the formed tube from a specified value or tolerance range.

[0024] The means for displacing is preferably connected not only to the measuring device but also a controller in order to implement the method according to the invention.

[0025] The advantages achieved by the method according to the invention and realizable effects correspond to those that have already been described with reference to the first aspect of the invention.

[0026] The method according to the invention provides preferably fully automatic measurement of the outside diameter of the formed tube and appropriately corrects any detected deviations by re-adjusting the roll gap between the rolls.

[0027] The preferred approach in this regard is one where the outside diameter is measured over the entire circumference of the tube and over its entire length. To this end at least one measuring device, preferably exactly one fixed measuring device, is provided inside the apparatus. The fact that a partial revolution of the tube about its longitudinal axis is effected in the rolling mill for each feed motion during the forming process enables the fixed measuring device to cover the entire circumference of the formed tube. This is furthermore implemented by using especially simple means, yet still yields a reliable measuring result for the outside diameter of the entire tube.

[0028] A preferred approach is finally one where to implement the method according to the invention not only the rolls but also an adjustably disposed rolling mandrel are adjusted so as to counteract deviations in the outside diameter or wall thickness from a specified value and tolerance range. This enables the flexibility of the equipment and of the method according to the invention to be especially advantageously enhanced in terms of being able to deal with conformity variations of any kind and to remedy these at any site by the most effective means.

BRIEF DESCRIPTION OF THE DRAWING

[0029] The above and other objects, features, and advantages will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

[0030] FIG. 1 is a side schematic view of a first roll stand according to the invention;

[0031] FIG. 2 is a partly sectional schematic side view of the first roll stand according to the invention with its control system;

[0032] FIGS. 3 and 4 are schematic side view of second and third roll stands according to the invention;

[0033] FIG. 5 is a schematic side view of the third roll stand according to the invention with its control system;

[0034] FIGS. 6 through 14 are schematic side views of fourth through twelfth roll stands according to the invention.

DETAILED DESCRIPTION

[0035] As seen in FIG. 1 a roll 4 for the cold-pilger-rolling of tubes comprises an upper die or work roll 4a and a lower die or work roll 4b carried in a horizontally reciprocal frame or stand 4 and defining a roll gap S through which extends a mandrel 8 (FIG. 2) for the stretch reduction of a tube T into a predetermined cross-section and predetermined wall thickness. The upper roll 4a can be moved up and down by an adjustment wedge 7a, thereby enabling the size of roll gap S to be set appropriately. Adjustment of adjustment wedge 7a is in turn effected by rotating a spindle 14 that axially fixed at both ends in the frame 4 and threaded to the adjustment wedge 7a. Rotating the spindle 14 makes the adjustment wedge 7a move left or right in a workpiece travel direction D, with the angled surface of adjustment wedge 7a to slide relative to the complementary angled surface of adjustment wedge 7b that is connected directly to the chock for roll 4a that is mounted in the frame 4 so as to only be movable vertically, perpendicular to the direction D.

[0036] FIG. 2 shows roll stand with the tube T passing between upper work roll 4a and lower work roll 4b. For the sake of simplicity, the rolling mandrel 8 used with the also employed the cold-pilger-rolling method is not shown. The tube T in the drawing runs in the direction D from left to right passing through roll gap S between the upper roll 4a and the lower roll 4b, and after forming is complete enters a measuring device 5 in which the outside diameter of the tube T is measured. The measurement data from measuring device 5 is fed to a controller 6 that after accessing appropriate operating data issues as required a control command to adjust the roll gap S by moving the upper work roll 4a up or down in the direction of an arrow 15.

[0037] FIG. 3 is a schematic side view of second embodiment of the invention where an adjustment wedge 7a can be moved horizontally in the direction D for shifting the upper roll 4a by electric or hydraulic motors 16 and 17, in order to adjust roll gap S in the desired manner.

[0038] FIG. 4 is a schematic side view of a third embodiment of the invention in which, unlike the first and second embodiments of FIGS. 1 through 3, the lateral movement of adjustment wedge 7a is effected by hydraulic cylinders 18 and 19. In this case as well, the horizontal movement of the adjustment wedge 7a produces vertical movement of the upper work roll 4a and an adjustment of roll gap S in the desired manner.

[0039] FIG. 5 shows a fourth embodiment that is variant of the system of FIG. 4 in which a pump 20 driven by a motor 21 controls the flow of oil to the hydraulic cylinders 18 and 19. In a preferred approach, both the pump 20 and the motor 21 are attached in a fixed manner to the roll-stand frame 4 so as to limit to the necessary minimum the installation space of roll stand together with all of its ancillary modules.

[0040] FIG. 6 is a side schematic view of a fourth roll stand according to the invention. A vertically effective hydraulic cylinder 22 functions directly and without the use of adjustment wedges or the like to shift the upper work roll 4a and thereby adjust the roll gap S in the desired manner. The vertical adjustment of the piston inside the hydraulic cylinder 22 is effected by supplying the hydraulic fluid under pressure P from an external source.

[0041] FIG. 7 is a schematic side view of a fifth embodiment of the invention. Adjustment of the roll gap S by adjusting the vertical position of the upper work roll 4a is effected here by a spindle 23 that functions as an element supporting

the upper work roll 4a. The spindle 23 is vertically fixed in the stand 4 and threaded into a large nut rotatable by a motor 24, and thus effects not only the stepless adjustment of roll gap S by means of the vertical position of work roll 4a but also the fixation of upper work roll 4a in the desired position.

[0042] FIG. 8 is a schematic side view of a sixth embodiment of the invention, showing the supply of power to the actuator itself. It is thus obvious that this embodiment can also be appropriately combined with the embodiments of FIGS. 1 through 7. The supply of power to the roll stand is implemented through an external source 25 to a terminal 26 that is attached in fixed fashion to roll 4. The power to the unillustrated actuator for upper roll 4a is supplied from this terminal via a flexible cable.

[0043] FIG. 9 is a schematic side view of a seventh embodiment of the invention, showing as in FIG. 8 the type of electrical power supply to roll 4 and its unillustrated actuator for the upper roll 4a. This seventh embodiment of the invention can thus also be appropriately combined with the embodiments shown in FIGS. 1 through 7. The supply of power in this case is done inductively between a stationary electrical conductor 27 and a pick-up 28 is connected to the frame 4 and operatively connected to each other in such a way that a voltage is induced in the pick-up 28 without contacting the conductor 27, the voltage being sufficient to supply the unillustrated actuator for the upper roll 4a in order to appropriately adjust the roll gap.

[0044] FIG. 10 is a schematic side view of an eighth embodiment of the invention. This embodiment too involves the supply of power to the system and, in particular, its unillustrated actuator for the upper roll 4a. This eighth embodiment can thus also be appropriately combined with the embodiments shown in FIGS. 1 through 7. The supply of power to this eighth embodiment is effected hydraulically through a feed tube that is supplied from outside with hydraulic fluid under pressure P. The feed tube 29 has at least one, preferably two holes on one side, preferably its upper side, through which the hydraulic fluid can enter a fluid reservoir 30 that is slidably supported on the feed tube 29. This fluid reservoir is fixed to the roll frame 4, and has on its lower side an opening 30a through which the hydraulic fluid can be transported under pressure P to the unillustrated actuator for upper roll 4a.

[0045] FIG. 11 is a schematic side view of a ninth embodiment of the invention. This ninth embodiment can also be combined as required with the embodiments shown in FIGS. 1 through 7. Power is supplied here electrically and/or hydraulically. An electric power source 31 and/or a pressure accumulator 32 is attached in fixed fashion to the roll frame so as to effect the electrical and hydraulic supply of power.

[0046] FIG. 12 is a schematic side view of a tenth embodiment of the invention. This tenth embodiment involves the transmission of control and measurement data from the unillustrated measuring device and/or unillustrated controller to the unillustrated actuator of the system, in particular, to the actuator of the upper roll 4a. It is thus obvious that this tenth embodiment can also be appropriately combined with the embodiments of the invention shown in FIGS. 1 through 11. The transmission of control and measurement data is implemented by means of cables or telemetry, a telemetric non-contact transmission of data being effected from the unillustrated measuring device and/or the unillustrated controller through a transmitter 33 to a receiver 34 carried on the frame 4 of this tenth embodiment of the invention.

[0047] FIG. 13 is a schematic side view of a roll stand in an eleventh embodiment of the invention. In contrast to the previously described embodiments, it has a pair of respectively displace rolls **4a** and **4b** that are supported by respective back-up rolls **35a** and **35b** in the roll frame **4**. These back-up rolls **35a** and **35b** in turn are supported on respective beams **36a** and **36b** that are vertically shiftable in the frame **4** such that an appropriate vertical and/or angular adjustment of the support beams **36a** and **36b** also enables roll gap **S** to be adjusted between the upper and lower rolls **4a** and **4b**. Particularly in the case of a roll stand that is displaceably disposed laterally along the longitudinal orientation of support beams **36a** and **36b**, this approach when given an appropriate orientation of support beams **36a** and **36b**, allows rolling of the back-up rolls **35a**, **35b** along the support beams **36a** **36b** for adjustment, either a constant setting for roll gap **S** or, on the other hand, a movable setting of roll gap **S** to be adjusted depending on the positioning of the roll frame **4** along the support beams **36a**, **36b**. It is of course obvious for the person skilled in the art that the eleventh embodiment illustrated here can be combined with the features described with reference to FIGS. 1 through 12.

[0048] FIG. 14 is a schematic side view of a twelfth embodiment of the invention. In this solution, a pair of gears **37** that are in mesh can slide axially along a fixed drive shaft **38** to which the upper gear **37** is splined. Changes in roll gap **S** can be transferred thereby from a fixed motor **39** that rotates the shaft **38** to an adjustment wedge **7a** that is threaded onto a spindle **40** rotated by the lower gear **37**. Thus, no matter what the position of the frame **4** and gears **37** along the shaft **38**, rotation of this shaft **38** by the motor will rotate the spindle **40** and move the upper roll **4a** up or down as needed.

We claim:

1. In an apparatus for making a cold-pilger-rolled tube having two grooved pilger work rolls rotatable in a reciprocating roll frame about respective axes to compress a tubular workpiece moving in a travel direction against a mandrel extending in the direction between a nip formed between the rolls and anchored upstream of the nip in a thrust block, the improvement comprising:

means for measuring an outside diameter of the workpiece downstream in the direction from the rolls as the workpiece passes through the nip; and

means for displacing one of the rolls relative the other of the rolls transversely to the travel direction as the workpiece passes through the nip in accordance with the measured outside diameter for maintaining a uniform outside diameter of the workpiece.

2. The apparatus defined in claim 1, further comprising control means between the means for measuring and the means for displacing for operating the means for displacing to maintain a uniform outside diameter of the workpiece.

3. The apparatus defined in claim 1, wherein the control means has a memory in which is stored data including a desired outside diameter of the workpiece.

4. The apparatus defined in claim 2, wherein the control means compares the measured outside diameter of the workpiece from the means for measuring with the desired outside diameter and operates the means for displacing to change transverse position of the one roll when a differential between the measured outside diameter and the desired outside diameter exceeds a predetermined limit.

5. The apparatus defined in claim 1, wherein the means for measuring is a laser sensor.

6. The apparatus defined in claim 1, wherein the means for displacing includes an actuator braced between the frame and the one roll.

7. The apparatus defined in claim 6, wherein the actuator is a movable wedge braced between the frame and the one roll.

8. The apparatus defined in claim 7, wherein the actuator further includes a hydraulic cylinder braced between the wedge and the frame.

9. The apparatus defined in claim 6, wherein the actuator is a hydraulic cylinder transversely braced between the one roll and the frame.

10. The apparatus defined in claim 6, further comprising: respective backing rolls flanking and engaging the work rolls, at least one of the backing rolls being transversely shiftable by the actuator.

11. The apparatus defined in claim 6, wherein the means for measuring or the means for controlling is mounted away from the frame and is connected to the actuator by a wired or wireless link.

12. The apparatus defined in claim 1, wherein the thrust block is also shiftable relative to the work rolls.

13. The apparatus defined in claim 12, wherein the means for displacing is also connected to the thrust block.

14. A method of making a cold-pilger-rolled tube, the method comprising the steps of:

simultaneously moving a workpiece in a travel direction through a nip between two grooved pilger work rolls rotatable in a roll frame about respective axes while pressing the workpiece against around a mandrel extending in the direction through the nip; measuring an outside diameter of the workpiece downstream in the direction from the rolls; and displacing one of the rolls relative the other of the rolls transversely to the travel direction in accordance with the measured outside diameter for maintaining a uniform outside diameter of the workpiece.

15. The method defined in claim 14, further comprising the step of:

processing the measured outside workpiece diameter in a controller and operating at least one actuator connected to the one roll in accordance with the measured outside workpiece diameter.

16. The method defined in claim 15, wherein the outside diameter is measured and the one roll is displaced as the workpiece passes through the nip.

17. The method defined in claim 14, wherein the outside diameter is read with a laser sensor.

18. The method defined in claim 14, wherein the outside diameter is measured all around the workpiece.

19. The method defined in claim 14, wherein for each tube that made or each revolution of the workpiece as it passes through the nip the outside of the workpiece is measured at least 5 times.

20. The method defined in claim 14, further comprising the step of:

displacing the thrust block and mandrel in or transverse to the travel direction as the workpiece passes through the nip in accordance with the measured outside diameter when same lies outside a predetermined range.