

June 1, 1965

O. ULRYCH

3,186,202

RING ROLLING MACHINE

Filed Dec. 18, 1962

6 Sheets-Sheet 1

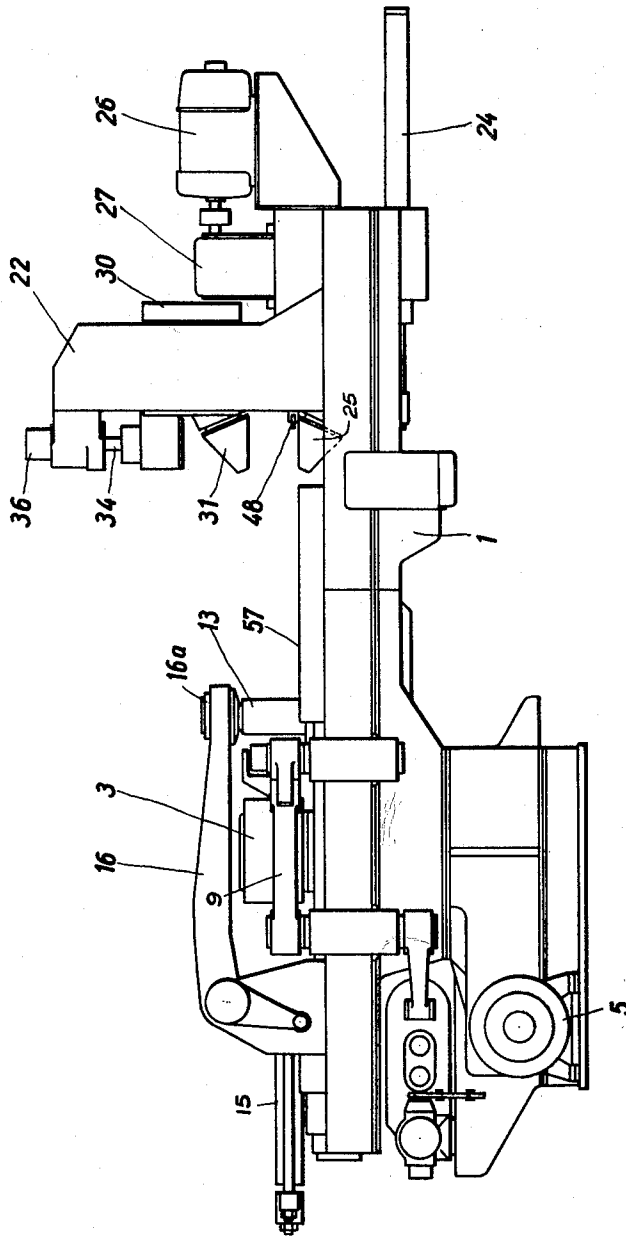


Fig. 1

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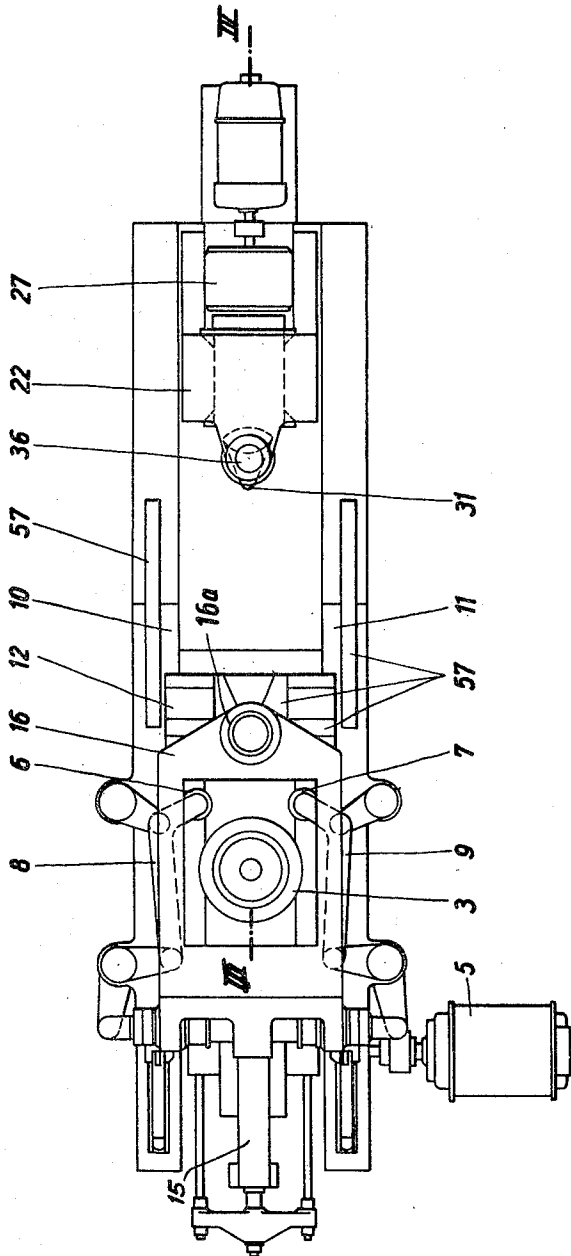
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6 Sheets-Sheet 2



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6 Sheets-Sheet 3

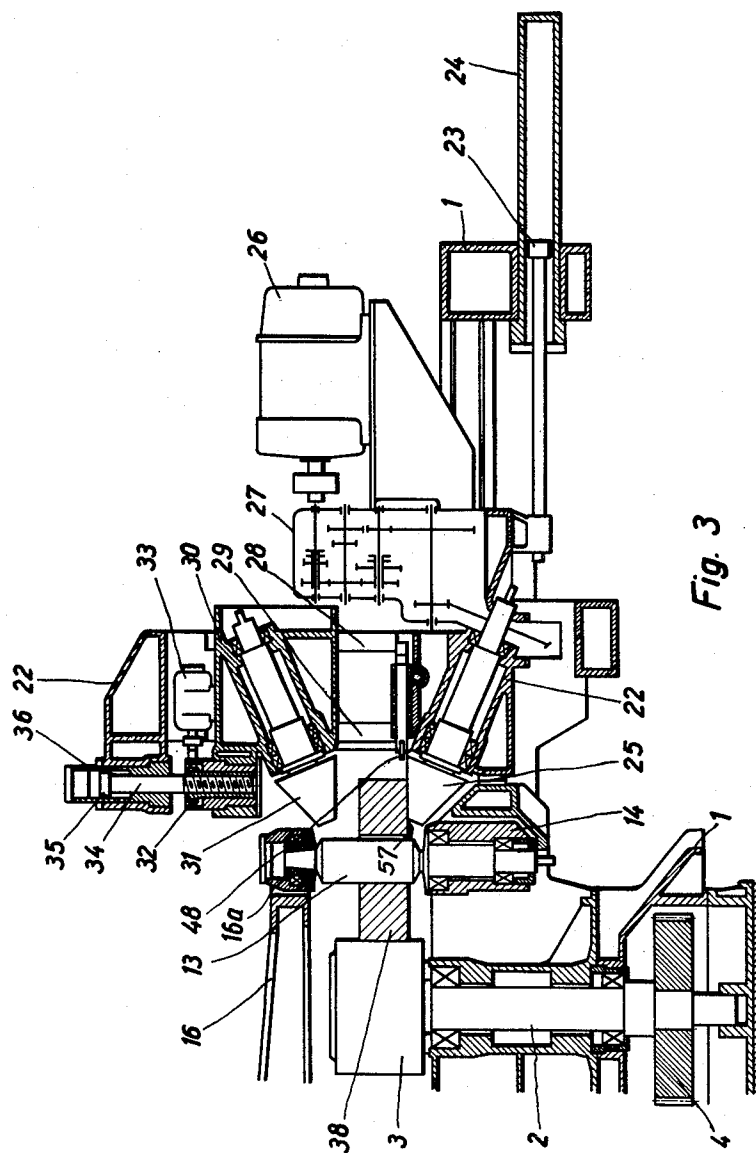


Fig. 3

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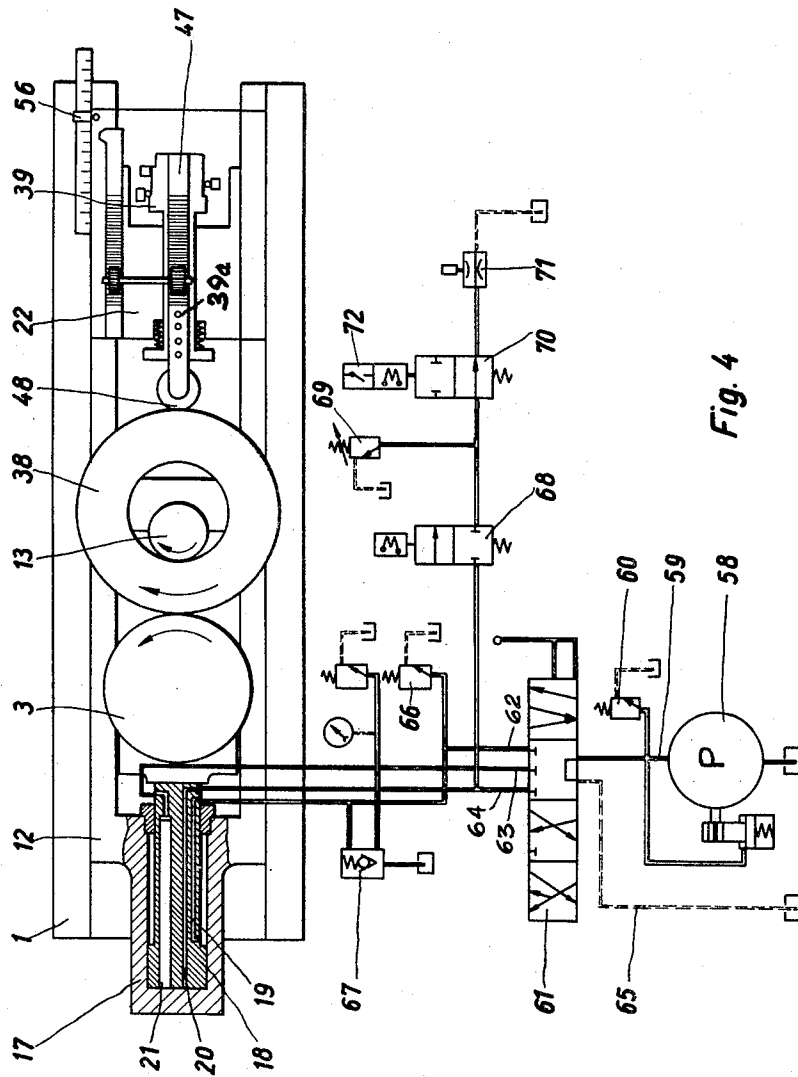
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6 Sheets-Sheet 4



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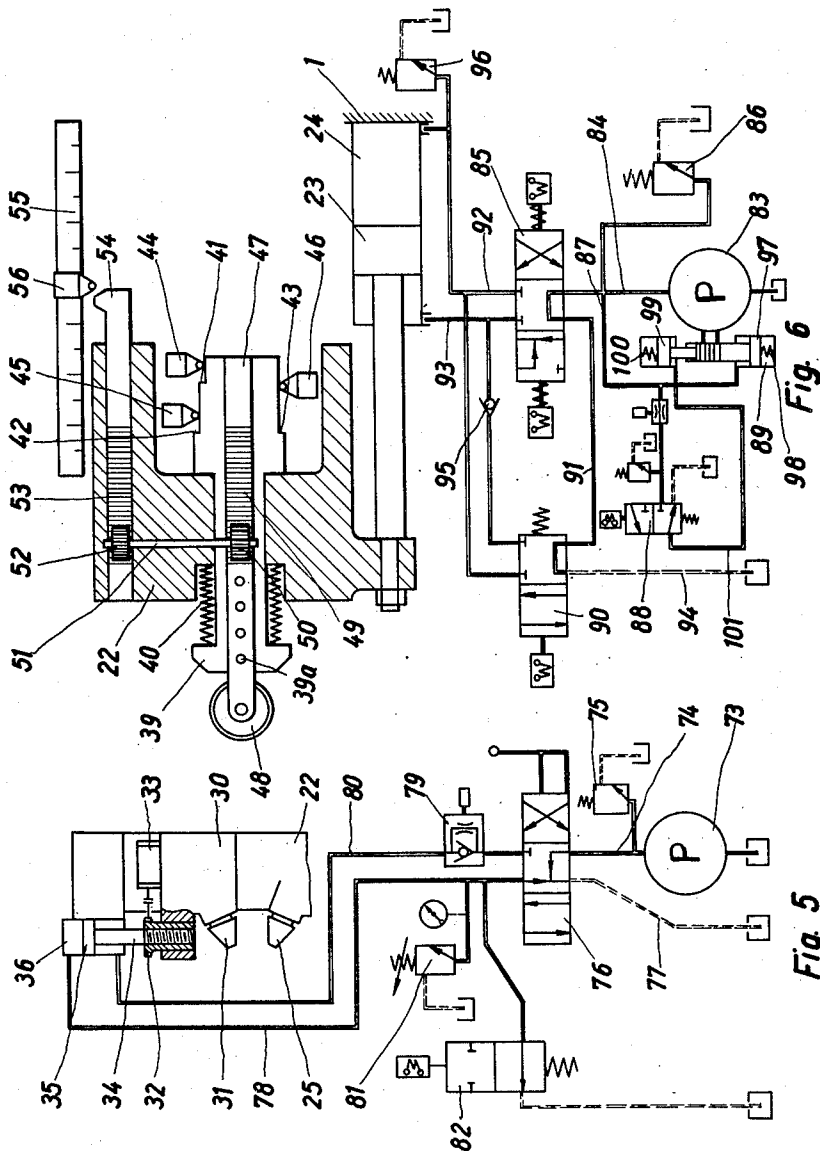
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RING ROLLING MACHINE

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6 Sheets-Sheet 5



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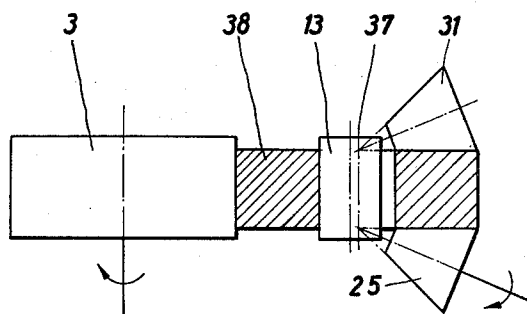


Fig. 7

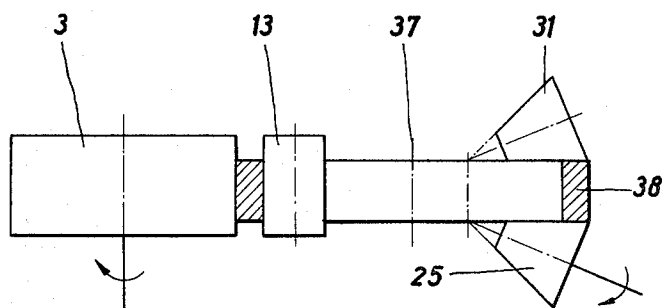


Fig. 8

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3,186,202

RING ROLLING MACHINE

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Claims priority, application Germany, Dec. 22, 1961, W 31,340

21 Claims. (Cl. 72—10)

The present invention relates to a ring rolling machine, and more particularly to a ring rolling machine including a first pair of rollers rolling the outer and inner peripheral surfaces of an annular blank and a second pair of rollers for rolling the annular end faces of the blank.

Ring rolling machines of this type serve the purpose of increasing the diameter of an annular blank. In accordance with the prior art, rollers acting on the axial end faces of the blank determine the coaxial height of the finished ring, but are incapable of rolling the blank to reduce the axial height of the same.

It is one object of the present invention to provide a ring rolling machine in which an annular blank is rolled to reduce the axial height thereof.

Another object of the invention is to provide a rapidly and economically operating ring rolling machine in which the rollers are not worn by movement relative to the blank and corresponding frictional engagement.

Another object of the invention is to provide a ring rolling machine requiring less power than conventional ring rolling machines.

With these objects in view one embodiment of the invention comprises first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second roller means for engaging and rolling a portion of the axial end faces of the annular blank; supporting means supporting the second roller means for movement in the direction in which the axial end faces move outwardly as the diameter of the blank increases; sensing means including feeler means for engaging one peripheral surface of the blank; and control means controlled by the sensing means and causing movement of the supporting means and of the second roller means at a speed related to the displacement of the sensing means so that the second roller means remain in rolling engagement with the blank as the diameter of the blank increases.

The sensing means are preferably mechanical feeler means, but optical or pneumatic sensing means may also be used. Limit switches are controlled by the sensing means and effect control operations of electromagnetic elements provided in hydraulic circuits.

Preferably the position of the sensing means on the supporting means can be adjusted in accordance with a type of blank rolled in the machine.

The limit switch can be set to a desired final diameter of the blank, and the rolling operation is automatically terminated when the blank has a desired diameter and exactly circular shape.

In the preferred embodiment of the invention, the second roller means are frusto-conical rollers mounted on a carriage, one of the frusto-conical rollers being mounted on a slide provided on the carriage.

One of the frusto-conical rollers is driven from a motor through a variable transmission so that its rotary speed, and peripheral speed can be adjusted to the circumferential speed of the rotating blank. Preferably, the peripheral speed of the frusto-conical rollers is slightly higher than the circumferential speed of the blank at the beginning of the operation.

The frusto-conical rollers are controlled from the sensing means so that the base circles roll on the outermost

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portions of the annular end faces, irrespective of the increase of the diameter of the blank.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is a side elevation of a ring rolling machine according to the present invention;

FIG. 2 is a plan view of the machine illustrated in FIG. 1;

FIG. 3 is a sectional view taken on line III—III in FIG. 2, but illustrating the machine in an operative position;

FIG. 4 is a diagrammatic view including a fragmentary plan view, partially in horizontal section, and a diagram of a hydraulic circuit, and illustrating apparatus required for actuating a first rolling device;

FIG. 5 is a diagrammatic view including a fragmentary side elevation, partially in section, and a diagram of a second hydraulic circuit, and illustrating apparatus required for actuating a second rolling device;

FIG. 6 is a diagrammatic view including a fragmentary horizontal sectional view, and a diagram of a third hydraulic circuit, and illustrating apparatus required for operating movable supporting means for the second rolling device;

FIG. 7 is a fragmentary schematic side elevation illustrating the position of the rolling devices at the beginning of an operation; and

FIG. 8 is a fragmentary schematic side elevation illustrating the position of the rolling devices at the end of an operation.

Referring now to the drawings, a main shaft 2 supports a main roller 3 and is rotatably mounted in the frame 1 of the machine. A pair of centering rolls 6, 7 are mounted on a pair of lever arms 8 and 9 which are mounted on the frame 1 of the machine and can be moved toward and away from the main roller 3 for centering an annular blank 38 in the position of FIG. 4, lever means 8, 9 being omitted in FIG. 4 for the sake of clarity.

A carriage 12 is mounted on frame 1 for movement along guideways 10, 11 and has a rectangular opening through which the main shaft 2 passes. A rectangular frame 16 is mounted on carriage 12, and can be operated by a hydraulic servomotor 15 to perform a pivotal movement between a raised position and a position in which a bearing 16a abuts the upper end of a roller 13 whose shaft is rotatably supported in a bearing 14 on carriage 12. When frame 16 is raised, the annular blank 38 can be placed in the position shown in FIG. 7, whereupon the frame 16 is lowered so that bearing 16a is pressed against the upper end of roller 13 to support the same during the following rolling operation in which the annular blank 38 will be rolled between rollers 3 and 13. During such rolling operation, the diameter of the annular blank increases, and at the end of the rolling operation the annular blank has far greater inner and outer diameters, as shown in FIG. 8.

Carriage 12 is moved in the plane defined by the axes of rollers 3 and 13 by means of the hydraulic servomotor which includes a cylinder 17 secured to carriage 12, and a piston means 18 secured to frame 1. Piston means 18 forms two chambers in cylinder 17, which can be supplied with pressure fluid through openings 19 and 20. Piston means 18 has a longitudinally extending cylinder bore in which an auxiliary piston 21 is mounted,

one end of the auxiliary piston 21 abutting one end wall of cylinder 17.

A carriage 22 is mounted on the other end of frame 1, and is slidable along guideways in the direction of the plane in which the axes of rollers 3 and 4 are located. Such movement is effected by a hydraulic servomotor including a double-acting cylinder 24 secured to frame 1, and a piston 23, best seen in FIG. 3 which is movable in cylinder 24.

A frusto-conical roller 25 is mounted for rotation on carriage 22, and is driven by motor 26 through a shiftable transmission 27 schematically indicated in FIG. 3.

When the annular blank is rolled between rollers 3 and 13, its diameter increases, and consequently the circumferential speed of the portion of the axial end face of blank 38 engaged by roller 25 will increase. The speed of motor 26, and the corresponding speed of roller 25, is selected in such a manner that the peripheral speed of roller 25 is slightly greater than the circumferential speed of the axial end face of the blank engaged thereby when a new blank is placed in the machine, and a rolling operation is started. As the diameter of the blank increases during the rolling operation, its circumferential speed will increase, and will become the same as the peripheral speed of the roller 25, which was too high at the beginning of the rolling operation. The transmission means 27 are shiftable to effect rotation of roller 25 at different rotary speeds, so that the peripheral speed of roller 25 can be adjusted.

In a preferred embodiment of the invention, the peripheral speed at the greatest diameter of roller 25 is 6% greater than the circumferential speed of the portion of the blank engaged thereby, and the several stages of the shiftable transmission 27 cause rotation of roller 25 at selected rotary speeds at which the peripheral speed at the smallest diameter of the frusto-conical roller 25 is the same as the peripheral speed at the greatest diameter of roller 25 when the same was driven by the preceding stage of the transmission.

Carriage 22 has vertical guideways 28, 29 on which a slide 30 is movable in vertical direction, and parallel to the axes of rollers 3 and 13. A frusto-conical roller 31 is mounted on slide 30 to cooperate with roller 25 in the positions illustrated in FIGS. 7 and 8. A worm gear 32 is mounted on slide 30 for rotation, but non-movable in axial direction, and is driven through a worm by an electric motor 33. Worm gear 32 has an inner female thread meshing with a thread on a piston rod 34 of a piston 35 located in a double-acting cylinder 36 which is secured to carriage 22. Cylinder 36 and piston 35 constitute a third servomotor by which slide 30 with frusto-conical roller 31 can be moved toward and away from frusto-conical roller 25. Roller 31 can be moved to a position in which rollers 25 and 31 cooperate to roll on the axial annular end faces of blank 36, as shown in FIG. 7. When rollers 31 and 25 are in the position of FIG. 7 and engage the annular blank 38 when the same has just been placed in the machine and has its smallest diameter, the apices of frusto-conical rollers 25 and 31 are located on the axis 37 of a new blank 38. As the diameter of blank 38 increases due to the rolling operation, axis 37 travels in the plane defined by the axes of the first rollers 3 and 13, so that the apices of the second rollers 25, 31 are no longer located on axis 37. The upper frusto-conical roller 31 is slightly offset in a known manner relative to the lower frusto-conical roller 25 in a direction of rotation of the blank 38 in order to compensate the turning moment produced by the rolling forces.

As best seen in FIGS. 4 and 6, sensing means are provided for sensing the increasing size of the rolled blank 38, and include a feeler means 39 having a feeler roll 48 engaging the outer peripheral surface of blank 38, and a switching member or portion 47 having a plurality of abutments 43, 42, 41 for respectively engaging limit

switches 46, 45, 44 when feeler means 39 is displaced due to the increasing diameter of blank 38. Feeler means 39 has a flange engaged by spring 40 which urges feeler means 39 to move relative to carriage 22 to a position in which a pair of shoulders on portion 47 abuts corresponding abutment faces of carriage 22. In this manner, one end position of roll 48 is determined. Portion 47 has a rack bar 49 meshing with a pinion 50 which is mounted on a shaft 51 rotatably supported on carriage 22 and carrying another pinion 52 meshing with a rack bar 53 of a control bar 54 guided for longitudinal movement on carriage 22. A projection on control bar 54 cooperates with a limit switch 56 which is adjustable along a graduated guide member 55, and can be fixed on the same in any selected position determined in accordance with the scale. During the rolling operation, blank 38 rests on a plurality of supporting surfaces 57, as indicated in FIG. 2.

The machine has a hydraulic control system. Hydraulic control and operating means for moving roller 13 toward roller 3 will now be described with reference to FIG. 4.

An automatically regulated oil pump 58 pumps fluid into the line 57 which has a safety valve 60. A manually operated control slide 46 is connected to the pressure line 59, and has four different positions controlling the flow through the pressure line 64, the preliminary supply line 63, the return line 62, and a discharge line 65. The return line 62 is connected to opening 19 in piston 18, the preliminary supply line 63 is connected with the bore of piston 18 in which the auxiliary piston 21 is located, and the return line 64 is connected with the opening 20 in piston 18. The return line 62 has a safety valve 66, and return line 62 and pressure line 64 are connected to a filling valve 67. Pressure line 64 is also connected to an electromagnetically operated slide valve 68 which is electrically connected to the limit switch 56. When limit switch 56 is operated, slide valve 68 connects the pressure line 64 with another electromagnetically operated slide valve 70, but interrupts this connection when in a normal position of rest. The electromagnetically operated slide valve 70 connects in its normal position of rest, the slide valve 68 with an adjustable throttle means 71 which discharges into an oil container. When the manually operated button 72 is actuated, slide valve 70 interrupts the connection between slide valve 68 and throttle 71.

Control valve 61 is shown in FIG. 4 in a position of rest in which the supply line 59 from the oil pump 58 is connected with a discharge line 65, while the other lines are closed. In a first control position, shifted to the left as viewed in FIG. 4, the connections schematically indicated by arrows at the right end of control valve 61 in FIG. 4, are established. Supply line 59 is connected with the return line 62, and lines 63 and 64 are connected with a discharge line 65, so that carriage 12 with roller 13 is retracted from the operative position shown in FIG. 4.

In a preliminary position of control valve 61, shifted one step to the right as viewed in FIG. 4, the connections are established which are indicated by the arrows in the second field from the left on valve 61 in FIG. 4. Supply line 59 is connected to the preliminary supply line 63, and connects the return line 62 with the discharge line 65, while line 64 is closed.

When control valve 61 is shifted all the way to the right as viewed in FIG. 4, connections are established as indicated by the arrows in the field at the left end of valve 61 in FIG. 4, and supply line 59 is connected with the preliminary supply line 63 and with the pressure line 64, while the return line 62 is connected with a discharge line 65.

The hydraulic control and operating means for operating slide 30 to move the upper frusto-conical roller 31 toward and away from the blank, will now be described with reference to FIG. 5.

An oil pump 73 pumps the operating liquid into the

supply line 74 which has a safety valve 75. The flow is controlled by a control valve 76 which is manually operated. A discharge line 77, a pressure line 78 leading to the upper chamber in cylinder 36, and a return line 80 connected through an adjustable throttle check valve 79 with the lower chamber in cylinder 36, are connected to the control valve 76.

The pressure line 78, which controls the axially exerted rolling pressure between rollers 25 and 31, is connected with a maximum pressure valve 81, and with an electromagnetically operated slide valve 82. In its normal position of rest, slide valve 82 connects pressure line 78 with an oil container, but when limit switch 45, see FIG. 6, is operated by the abutment 42 of the feeler means 39, this discharge is stopped.

Control valve 76 has three positions. In the illustrated normal position, the return line 80 is closed, and supply line 74 and pressure line 78 are connected with the discharge line 77. In the operative position in which valve 76 is during a rolling operation, valve 76 is shifted to the left as viewed in FIG. 5, and the connections indicated by the arrows at the right end of valve 76 are made. Supply line 74 is connected with the pressure line 78, and return line 80 is connected with the discharge line 77. To retract roller 31 from the blank, valve 76 is shifted to the right as viewed in FIG. 5, and the connections indicated at the left end of valve 76 in FIG. 5 are made. Supply line 74 is connected with the return line 80, while the pressure line 78 is connected with a discharge line 77.

The hydraulic control and operating means for moving carriage 22 with slide 30, and rollers 25, 31, are illustrated in FIG. 6.

An automatically regulated oil pump 83 pumps into a supply line 84 which is connected to an electromagnetically operated control valve 85. Pressure line 84 is connected to a safety valve 86, and to a regulating line 87 having a first branch line connected through an adjustable throttle and a maximum pressure valve to an electromagnetically controlled slide valve 88, and a second branch connected to the pressure chamber of a pump regulator 89 which controls pump 83.

Control valve 85 is connected to a line 91 leading to the electromagnetically operated slide valve 90, to a preliminary supply line 92 connected to the right hand chamber of cylinder 24, and to a return line 93 which is connected to the left hand chamber in cylinder 24. Piston 23 is connected to the carriage 22 to move the same with rollers 25 and 31. The electromagnetically operated slide valve 90 has a position of rest in which line 91 is directly connected to the discharge line 94, but when limit switch 44 is operated by abutment 41, or when limit switch 46 is operated by abutment 43, slide valve 90 connects line 91 through a check valve 95 with a return line 93, while the preliminary supply line 92 is connected with the discharge line 94. The preliminary supply line 92 has a safety valve 96.

The electromagnetically operated control valve 85 has three control positions. In the illustrated normal position of rest, supply line 84 is connected with line 91. When control valve 85 is shifted to the right, so that the connections illustrated at the left end of control valve 85 in FIG. 6 are operative, supply line 84 is connected with a preliminary supply line 92 and with the return line 93. When control valve 85 is shifted to the left so that the connections illustrated at the right end of control valve 85 in FIG. 6 are effective, supply line 84 is connected with a return line 93, while the preliminary supply line 92 is connected with line 91. In this position, carriage 22 is withdrawn.

The pump regulator 89 of pump 83 has a piston which is biased by spring 98 to move against the pump pressure prevailing in the regulating line 87. When the force of spring 98 prevails, the regulating piston is shifted to increase the output of pump 83, whereas when the pump pressure exceeds a desired pressure, the regulating piston is moved against the action of spring 98, the pump is

adjusted to pump a smaller amount of liquid so that the output of the pump is independent of the pressure encountered by the pump liquid.

A control piston 99 is biased by spring 100, and is located in a cylinder which is connected to a control line 101 supplied with liquid through the electromagnetically operated slide valve 88. Normally, a piston rod on piston 99 abuts regulating piston 97. The stroke of control piston 99, and the force of spring 100, are dimensioned so that control piston 99 holds regulating piston 97 against the action of spring 98 in a position in which the amount of oil pumped by pump 83 is comparatively small, for example 40% of the rated output of the pump.

The electromagnetically operated slide valve 88 connects in its position of rest, the control line 101 with a discharge line, while the connection with the regulating line 87 is interrupted. When the limit switch 46 is operated by the abutment 83 of the feeler means 39, the regulating line 87 is connected with the control line 101.

Operation

Carriage 12 with roller 13, and carriage 22 with rollers 25 and 31, are in the positions illustrated in FIG. 1. Slide 30 on carriage 22 is in a position corresponding to the lowest position of piston 35, and the upper end position of worm gear 32. Worm gear 32 is rotated by motor 33 in such a direction of rotation that piston 34 is downwardly moved due to the threaded engagement between piston rod 34 and the inner thread in worm gear 32. Slide 30 moves downward due to its own weight, and such downward movement is terminated when the distance between the frusto-conical rollers 25 and 31 corresponds to the desired axial thickness of the annular blank.

Control valve 76 is moved to the return position in which slide 30 is raised by piston 35. Main roller 3 is rotated by motor 5, and the lower frusto-conical roller 25 is rotated by motor 26.

An annular blank 35 is placed on the supporting faces 57 with roller 13 passing through the center hole in the blank. The lever means 16 with thrust bearing 16a are lowered by servomotor 15 so that bearing 16a abuts under pressure on roller 13, and prevent any bending of the shaft of roller 13 due to the rolling pressure during the rolling operation.

Control valves 81 and 85 are shifted to the preliminary control positions. Control valve 61 is shifted one step to the right as viewed in FIG. 4 to a preliminary control position in which the oil pumped by pump 58 is guided into the preliminary supply line 63 so that auxiliary piston 21 is operated to move cylinder 17, carriage 12, and roller 13 to the left as viewed in the drawing and toward main roller 3 until the annular blank is engaged on its outer peripheral surface by main roller 3, and at its inner peripheral surface by roller 13.

The liquid displaced through bore 19 of piston 18 flows through control valve 61 into the discharge line 65. The preliminary filling valve 67 permits the flow of liquid from a container in which an air cushion provides pressure, through pressure line 64 into the chamber on the left of piston 18 in cylinder 17.

Control valve 85 is shifted to the right as viewed in FIG. 6 to a preliminary control position in which pump 83 is connected with both chambers of cylinder 24. Since the pressure surface at the end face of piston 23 is greater than that of the annular pressure surface of piston 23 surrounding its piston rod, piston 23 moves to the left as viewed in the drawing, and carriage 22 with frusto-conical rollers 25 and 31 is moved toward roller 13 until rollers 25 and 31 are located on opposite sides of the annular blank 38.

When carriage 12 with roller 13 has moved so far that blank 38 is clamped between the cylindrical surfaces of rollers 13 and 3 so that the blank is located in a hori-

zontal plane perpendicular to the axes of rollers 3 and 13, control valves 61 and 76 are operated and shifted to control position effecting the rolling operations.

Control valve 61 is shifted all the way to the right as viewed in FIG. 4, so that the liquid pumped by pump 58 passes from the pressure line 59 into preliminary supply line 63 and pressure line 64 so that not only auxiliary piston 21, but also the large end free on the left side of piston 18 is subjected to pressure. The chamber on the other side of piston 18 is still connected with a discharge line 65. Slide 12 will roller 13 is slowly moved toward main roller 38, and exerts great rolling pressure against the clamped portion of annular blank 38. Blank 38 and roller 13 are rotated by main roller 3 due to the frictional coupling between the rollers and the blank, and the blank is rolled so that its radial thickness is reduced, while its diameter is increased so that the axis 37 of the blank travels to the right from the position of FIG. 7 toward the position shown in FIG. 8.

Control valve 76 is shifted to the left so that the lower chamber of cylinder 36 is connected with the discharge line 77 while supply line 74 is connected to pressure line 78 which communicates with the upper cylinder chamber. The liquid flows through electromagnetic slide valve 82 into a container. Since the liquid in the lower chamber of cylinder 36 can flow out through throttle check valve 79, slide 30 with frusto-conical roller 31 slowly moves downward until roller 31 rests on blank 38. However, no axial rolling pressure is yet exerted due to the fact that electromagnetically operated slide valve 82 is still open.

As the diameter of blank 38 increases due to the rolling action of the first rollers 3 and 13, the outer peripheral surface of ring 38 engages the feeler roll 48 so that feeler means 39 is moved relative to carriage 22 out of the position shown in FIG. 6 in which shoulders of portion 47 abut corresponding shoulders on carriage 22. The displaced position of the feeler means is shown in FIG. 4. When the diameter of the outer peripheral surface of blank 38 is so great that the outer peripheral surface of blank 38 is in contact with the base circles of frusto-conical second rollers 25 and 31, abutment 42 of feeler means 39, 47 engages and operates limit switch 45 which is electrically connected into the circuit of electromagnetically operated slide valve 82 and actuates the same to interrupt the connection between the pressure line 78 and the container for the liquid, so that the pressure liquid is confined in the upper chamber of cylinder 36 and provides sufficient pressure to move piston 35 with piston rod 34, worm gear 32 and slide 30 downward with frusto-conical roller 31 so that the rolling pressure is exerted by rollers 25 and 31 on blank 38 acting in axial direction to reduce the axial height or thickness of blank 38.

At the beginning of the operation, the apices of the frusto-conical peripheral surfaces of rollers 25, 31 are located on axis 37 of blank 38, as shown in FIG. 7, so that the peripheral speed at the smaller ends of frusto-conical rollers 25 and 31 correspond to the circumferential speed of the inner peripheral surface of blank 38, while the peripheral speeds at the larger ends of frusto-conical rollers 25 and 31 correspond to the circumferential speed of the outer peripheral surface of blank 38.

In accordance with the present invention, the respective speeds are not the same, but the peripheral speed of the driven roller 25 is slightly higher than the circumferential speeds of the inner and outer surfaces of blank 38, so that a small relative movement takes place which, however, is tolerable at the beginning of the rolling operation during which the blank is still very strong. On the other hand, when the diameter of the annular blank increases during the rolling operation, and the apices of the frusto-conical rollers 31 are no longer located on the axis 37 of blank 38, no relative movement takes place, which is desirable since the rigidity of the blank is reduced as its di-

ameter is increased. Due to this feature of the invention, the relative movement between the surfaces of the rollers 25, 31 and the end faces of blank 38 is reduced during the main part of the rolling operation which is an advantage as compared to the prior art construction where substantial sliding between the engaging surfaces, and corresponding frictional losses and heat development take place during the main part of the rolling operation.

When the feeler means is slightly pushed back during the following increase of the diameter of blank 38, abutment 41 of feeler means 39 operates limit switch 44 which is connected into the circuit of electro-magnetically operated slide valve 90 so that a small amount of liquid is pumped by pump 83 into the left chamber of cylinder 24, while the right chamber is connected to the discharge line 94. The pumped amount is limited to the equilibrium between springs 98 and 100 acting on regulating piston 97 together with control piston 99.

Carriage 22 slowly moves to the right, corresponding to the increase of the diameter of blank 38 so that rollers 25 and 31 remain in the position in which the base circles thereof are located in the region of the outer peripheral surface of blank 38, while the peripheral surfaces of rollers 25 and 31 abut the annular end faces of blank 38 whose radial thickness is simultaneously reduced so that the smaller ends of frusto-conical rollers 25 and 31 are not in engagement with the annular end faces of blank 38.

If the speed of movement of carriage 22 corresponds to the increase of the diameter of blank 38, the desired position is maintained continuously. However, if the speed of carriage 22 is greater than the increase of the diameter of blank 38, spring 40 urges feeler means 39 to the left as viewed in the drawing so that feeler roll 48 remains in engagement with the outer peripheral surface of blank 38. Due to the relative movement between carriage 22 with the limit switches, and feeler means 39, limit switch 44 is released by abutment 41 so that electromagnetically operated slide valve 90 returns to its initial position. Pump 83 is connected to the discharge, and carriage 22 stops until the diameter of blank 38 is sufficiently increased to displace feeler means 39 so far relative to carriage 22 that limit switch 44 is again operated.

If the speed of movement of carriage 22 is less than the increase of the diameter of blank 38, feeler means 39 is shifted to the right after limit switch 44 was operated, and limit switch 46 is operated by abutment 43. Limit switch 46 is connected into the circuit of the electro-magnetically operated slide valve 88 which is actuated so that the pressure liquid in regulating line 87 operates regulating piston 99 which is shifted against the action of spring 100 upwards as viewed in the drawing so that spring 98 can shift piston 97 of regulator 89 to the position in which the maximum amount of liquid cannot determine by the supply line 84, is pumped by pump 83. Electromagnetically operated slide valve 90 guides the pressure liquid into the left chamber of cylinder 24 so that carriage 22 is moved to the right at an increased speed while feeler means 39, 48 remains in engagement with blank 38, so that a relative movement between feeler means 39 and carriage 22 with the limit switches takes place until limit switch 46 is again released by abutment 43.

Due to the relative movement between the feeler means and the carriage 22 and the corresponding actuation of limit switches 44 and 46, the greatest peripheral surface portions of frusto-conical rollers 25 and 31 are automatically held in a position in which they engage the outermost portion of the annular end faces of blank 38, so that the relation between the circumferential speed of the blank and the peripheral speed of the frusto-conical rollers remains constant in the region of the outer peripheral surface of blank 38.

Due to the fact that the apices of frusto-conical rollers 25 and 31 move away from the axis 37 of the blank, the peripheral speed at the smaller ends of the frusto-conical rollers 25 and 31 is reduced as compared with the cir-

cumferential speed of the engaged portions of the annular end faces of blank 38. Assuming a selected slip of relative movement of 6% which is obtained by suitable design of the transmission means 27, such slip remains constant in the region of the outer peripheral surface of the blank due to the fact that the rotary speed of the driven frusto-conical roller 25 is 6% too high, while the slip or relative movement is reduced in the region of the inner peripheral surface of blank 38 as the diameter of blank 38 increases. Consequently, the rolling operation proceeds under the optimal technological conditions, without any additional load on the drive motors due to substantial slippage losses which require motors of greater power and constructions according to the prior art.

As the diameter of blank 38 increases, the axial rolling pressure between rollers 25 and 31 is reduced corresponding to the reduced radial height of the blank by manual or automatic adjustment of the maximum pressure valve 81. Finally, control valve 76 is shifted to its initial position either by manual operation, or under control of a limit switch, not shown, which is operated by the feeler means when the outer peripheral surface of blank 38 has a desired diameter. When blank 38 has the desired outer diameter, the projection on control bar 54 operates the limit switch 56 so that the electromagnetically operated slide valve 68 is actuated and opened whereby the liquid pumped by pump 58 flows from pressure line 64 through throttle 71 into a container. Throttle 71 is adjusted so that on the left side of piston 18, a pressure prevails which is sufficient to hold blank 38 in frictional engagement with main roller 3, but insufficient to cause a further rolling action reducing the radial thickness of blank 38. This smaller pressure is maintained during several revolutions of blank 38, and effects a rounding of the blank to exactly circular shape with the aid of the centering rolls 6 and 7. Limit switch 56 is actuated, and the radial rolling operation is terminated, as soon as blank 38 has the desired diameter selected and set by placing limit switch 56 in the corresponding position on the scale on member 55. If the blank has oval shape, limit switch 56 is actuated when the larger diameter of the blank operates feeler means 39, 48. As blank 38 is deformed into exactly circular shape, the previously greater diameter is reduced, so that the actual diameter of the finished blank would be smaller than the diameter set on the scale 55. This error is corrected by operation of push button 72 which causes the electromagnetically operated slide bar 70 to close so that the pressure liquid cannot flow through throttle 71, but passes through maximum pressure valve 69 which is adjusted to a pressure which causes a further controlled rolling operation and the corresponding increase of the diameter of the now exactly circular blank 38. When the desired diameter is attained, as can be determined by observation of limit switch 56 and scale 55, the supplementary rolling operation is terminated by releasing push button 72 so that the rounding operation is continued until control valve 61 is shifted to the return position. Control valves 76 and 85 are also placed in the return position, so that carriage 12 with roller 13, and carriage 22 with slide 30 and rollers 25 and 31 return to the initial positions. Holder frame 16 is open by operation of servomotor 15 so that the finished circular blank can be removed, and a new blank can be placed in the machine.

If a blank having a very small radial thickness is to be rolled, the axial rolling pressure would start only after a substantial increase of the diameter of the blank. Thus, only a short time would be available for the axial rolling operation of rollers 25 and 31, particularly since blanks of this type also have a comparatively small final outer diameter. In order to start the axial rolling operation on a blank of this type as soon as possible, a higher rotary speed is selected for the lower frusto-conical roller 25 by shifting transmission 27 to a suitable stage, and

the rack bar 47 with the feeler roll 48 is detached from feeler means 39 and then attached to the same in a displaced position in which feeler roll 48 is closer to roll 13 in the same position of carriage 22. This attachment is possible due to the provision of a number of equally spaced bolts 39a which pass through corresponding sets of equally spaced bores in feeler means 39 and rack bar 47. Due to the greater distance between feeler roll 48 and abutment 42, slide 30 is operated to move roller 31 toward the blank with the outer diameter of blank 38 engaging intermediate portions of the peripheral surfaces of rollers 25 and 31, and not the base circles of rollers 25 and 31. The peripheral portions of frusto-conical rollers 25 and 31 which cooperate with the outermost portions of the end faces of the blank move at a speed which is, for example, 6% higher than the peripheral speed of the main roller 3. Due to this adjustment, smaller blanks can be rolled under optimal conditions.

In accordance with the desired use of the ring rolling machine according to the invention, instead of the above explained adjustments of the transmission 27 and of the position of the feeler roll, a greater number of stages of a transmission may be provided, or an infinitely variable transmission may be used together with a feeler roll whose position can be gradually adjusted on feeler means 39. If the radial adjustment of the frusto-conical rollers is carried out in a continuous manner instead of stepwise, the several limit switches are replaced by a control element which is continuously adjusted. It is also contemplated to provide motors 5 and 26 with means for adjusting the rotary speed.

From the above description of the preferred embodiment of the invention, it will become apparent that the machine comprises first roller means 3 and 13, second roller means 25 and 31, supporting means 22, 30 for supporting the second rollers 25, 31, sensing means 39 to 48, and control means including the several hydraulic circuits controlled by the sensing means and causing the supporting means 22, 30 to move at such a speed that the second rollers 25, 31 move with the axial end faces of the blank as the diameter of the blank is increased by the rolling action of the first rollers 3, 13 and of the second rollers 25, 31.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of ring rolling machines differing from the types described above.

While the invention has been illustrated and described as embodied in a ring rolling machine for maintaining a pair of rollers in contact with a blank whose diameter increases due to the rolling operation, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A ring rolling machine comprising, in combination, first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second roller means for engaging and rolling portions of the axial end faces of the annular blank; supporting means supporting said second roller means for movement in the direction in which said portions of said axial end faces move as the diam-

eter of said annular blank increases due to the rolling action of said roller means; sensing means for engaging one of said peripheral surfaces of said annular blank and being movable so as to be displaced by the blank as the diameter of the same increases; and control means controlled by said sensing means and operatively connected with said supporting means for causing movement of the same in said direction at different speeds related to the displacement of said sensing means in such a manner that said second roller means move with said portions of axial end faces as the diameter of said annular blank increases.

2. A ring rolling machine comprising, in combination, first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second roller means including a pair of cooperating conical rollers for engaging and rolling portions of the axial end faces of the annular blank; supporting means supporting said second roller means for movement in the direction in which said portions of said axial end faces move as the diameter of said annular blank increases due to the rolling action of said roller means, and including carriage means movable in radial direction in relation to the annular blank and supporting one of said rollers, and a slide mounted on said carriage means for movement in axial direction in relation to the annular blank and supporting the other roller; drive means for rotating said one roller; means for operating said slide to move said other roller toward said one roller so that the annular blank is rolled between said rollers; sensing means for engaging one of said peripheral surfaces of said annular blank and being movable so as to be displaced by the blank as the diameter of the same increases; and control means controlled by said sensing means and operatively connected with said supporting means for causing movement of said carriage means at different speeds related to the displacement of said sensing means in such a manner that said second roller means move with said portions of axial end faces as the diameter of said annular blank increases.

3. A ring rolling machine comprising, in combination, first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second roller means including a pair of cooperating frusto-conical rollers for engaging and rolling portions of the axial end faces of the annular blank, said frusto-conical rollers having the surface portion thereof of greater diameter located at said outer peripheral surface; supporting means supporting said second roller means in an operative position in which said greater diameter surface portions of said frusto-conical roller are disposed at said outer peripheral surface of the blank, and also for movement in the direction in which said portions of said axial end faces move as the diameter of the annular blank increases due to the rolling action of said roller means; sensing means for engaging said outer peripheral surface of the annular blank and being movable so as to be displaced by the blank as the diameter of the same increases; and control means controlled by said sensing means and operatively connected with said supporting means for causing movement of the same at different speeds related to the displacement of said sensing means in such a manner that said second roller means move with said portions of said axial end faces as the diameter of the annular blank increases to maintain said greater diameter surface portion at said outer peripheral surface.

4. A ring rolling machine comprising, in combination, first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second roller means including a pair of cooperating frusto-conical rollers for engaging and rolling portions of the axial end faces of the annular blank; supporting means supporting said second roller means for movement in the direction in which said portions of said axial end faces move as the diameter

of said annular blank increases due to the rolling action of said roller means, and including carriage means movable in radial direction in relation to the annular blank and supporting one of said rollers, and a slide mounted on said carriage means for movement in axial direction in relation to the annular blank and supporting the other roller; drive means for rotating said one roller at a rotary speed causing a peripheral speed of said one roller slightly greater than the speed of movement of said portions of said axial end faces at the beginning of the rolling operation when the annular blank has a small diameter so that the peripheral speed of said one roller and the speed of said portions become equal as the diameter of the annular blank increases; means for operating said slide to move said other roller toward said one roller so that the annular blank is rolled between said rollers; sensing means for engaging one of said peripheral surfaces of said annular blank and being movable so as to be displaced by the blank as the diameter of the same increases; and control means controlled by said sensing means and operatively connected with said supporting means for causing movement of the same in said direction at different speeds related to the displacement of said sensing means in such a manner that said second roller means move with said portions of axial end faces as the diameter of said annular blank increases.

5. A ring rolling machine comprising, in combination, first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second roller means including a pair of cooperating frusto-conical rollers for engaging and rolling portions of the axial end faces of the annular blank; supporting means supporting said second roller means for movement in the direction in which said portions of said axial end faces move as the diameter of the annular blank increases due to the rolling action of said roller means; drive means for rotating one of said rollers at a rotary speed causing a peripheral speed of said one roller slightly greater than the speed of movement of the axial end faces of the annular blank at the beginning of the rolling operation when the annular blank has a small diameter so that the peripheral speed of said one roller and the speed of said axial end faces become equal as the diameter of the annular blank increases; sensing means for engaging one of said peripheral surfaces of the annular blank and being movable so as to be displaced by the blank as the diameter of the same increases; and control means controlled by said sensing means and operatively connected with said supporting means for causing movement of the same at a speed related to the displacement of said sensing means in such a manner that said second roller means move with said portions of axial end faces as the diameter of the annular blank increases.

6. A ring rolling machine comprising, in combination, a pair of first rollers for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same, said first rollers having axes located in a first plane which is radial with respect to the annular blank so that the annular blank rotates in a second plane perpendicular to said first plane about an axis of rotation located in said first plane and travelling away from said first rollers as the diameter of the blank increases; a pair of second rollers for engaging and rolling portions of the axial end faces of the annular blank, said second rollers having axes located in said first plane; supporting means supporting said second rollers for movement in said first plane in the direction in which said axis of the annular blank travels; sensing means for engaging one of said peripheral surfaces of the blank as the diameter of the same increases; and control means controlled by said sensing means and operatively connected with said supporting means for causing movement of the same

in said direction at different speeds related to the displacement of said sensing means in such a manner that said second rollers move with said portions of axial end faces as the diameter of the annular blank increases.

7. A ring rolling machine comprising, in combination, a pair of first rollers for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same, said first rollers having axes located in a first plane which is radial with respect to the annular blank so that the annular blank rotates in a second plane perpendicular to said first plane about an axis of rotation located in said first plane and travelling away from said first rollers as the diameter of the blank increases; a pair of frusto-conical second rollers for engaging and rolling portions of the axial end faces of the annular blank, said second rollers having axes located in said first plane and defining angles with each other and with said second plane; supporting means supporting said second rollers for movement in said first plane in the direction in which said axis of the annular blank travels; sensing means for engaging one of said peripheral surfaces of the blank as the diameter of the same increases; and control means controlled by said sensing means and operatively connected with said supporting means for causing movement of the same in said first plane at different speeds related to the displacement of said sensing means in such a manner that said second rollers move with said portions of axial end faces as the diameter of the annular blank increases.

8. A ring rolling machine comprising, in combination, first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second roller means for engaging and rolling portions of the axial end faces of the annular blank; supporting means supporting said second roller means for movement in the direction in which said portions of said axial end faces move as the diameter of the annular blank increases due to the rolling action of said roller means; sensing means including a feeler means mounted on said supporting means for movement in said direction relative to said supporting means and means biasing said feeler means inwardly toward the blank to engage the outer peripheral surface of the annular blank so as to be displaced by the same as the diameter of the same increases; and control means controlled by said sensing means in positions displaced relative to said supporting means and operatively connected with said supporting means for causing movement of the same at different speeds related to the relative displacement between said sensing means and said supporting means in such a manner that said second roller means move with said portions of said axial end faces as the diameter of the annular blank increases.

9. A ring rolling machine comprising, in combination, first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second roller means for engaging and rolling portions of the axial end faces of the annular blank; supporting means supporting said second roller means for movement in the direction in which said portions of said axial end faces move as the diameter of the annular blank increases due to the rolling action of said roller means; sensing means including a feeler means mounted on said supporting means for movement in said direction relative to said supporting means and means biasing said feeler inwardly toward the blank to engage the outer peripheral surface of the annular blank so as to be displaced by the same as the diameter of the same increases; and control means including a series of limit switches successively operated by said feeler means as the same is displaced relative to said supporting means, and operating means controlled by said limit switches and opera-

tively connected with said supporting means for causing movement of the same at different speeds related to the displacement of said sensing means in such a manner that said second roller means move with said portions of said axial end faces as the diameter of the annular blank increases.

10. A ring rolling machine comprising, in combination, first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second frusto-conical roller means for engaging and rolling portions of the axial end faces of the annular blank; supporting means supporting said second roller means for movement in the direction in which said portions of said axial end faces move as the diameter of the annular blank increases due to the rolling action of said roller means; sensing means including a feeler means mounted on said supporting means for movement in said direction relative to said supporting means and spring means acting on said feeler means to urge the same to engage the outer peripheral surface of the annular blank so as to be displaced by the same as the diameter of the same increases; and control means including a series of limit switches successively operated by said feeler means as the same is displaced relative to said supporting means, and operating means controlled by said limit switches and operatively connected with said supporting means for causing movement of the same at different speeds related to the displacement of said sensing means in such a manner that said second roller means move with said portions of axial end faces as the diameter of the annular blank increases, said spring means holding said feeler means in engagement with the outer peripheral surface of the annular blank when the movement of said supporting means causes movement of said second roller means at a speed greater than the speed of displacement of said portions of said axial end faces whereby said speed of said supporting means is adjusted.

11. A ring rolling machine comprising, in combination, a pair of first rollers for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same, said first rollers having axes located in a first plane which is radial with respect to the annular blank so that the annular blank rotates in a second plane perpendicular to said first plane about an axis of rotation located in said first plane and travelling away from said first rollers as the diameter of the blank increases; a pair of frusto-conical second rollers for engaging and rolling portions of the axial end faces of the annular blank, said second rollers having axes located in said first plane and defining angles with each other and with said second plane; supporting means supporting said second rollers for movement in said first plane in the direction in which said axis of the annular blank travels; sensing means including a feeler means mounted on said supporting means for movement in said direction relative to said supporting means and spring means acting on said feeler means to urge the same to engage the outer peripheral surface of the annular blank so as to be displaced by the same as the diameter of the same increases; and control means including a series of limit switches successively operated by said feeler means as the same is displaced relative to said supporting means, and operating means controlled by said limit switches and operatively connected with said supporting means for causing movement of the same at different speeds related to the displacement of said sensing means in such a manner that said second rollers move with said portions of axial end faces as the diameter of the annular blank increases, said spring means holding said feeler means in engagement with the outer peripheral surface of the annular blank when the movement of said supporting means causes movement of said second roller means at a speed

greater than the speed of displacement of said portions of said axial end faces whereby said speed of said supporting means is adjusted.

12. A ring rolling machine comprising, in combination, first roller means for engaging and rolling the inner and outer peripheral surfaces of an annular blank for increasing the diameter of the same; second roller means including a pair of cooperating rollers for engaging and rolling portions of the axial end faces of the annular blank; supporting means supporting said second roller means for movement in the direction in which said portions of said axial end faces move as the diameter of the annular blank increases due to the rolling action of said roller means, and including carriage means movable in radial direction in relation to the annular blank and supporting one of said rollers, and a slide mounted on said carriage means for movement in axial direction in relation to the annular blank and supporting the other roller; drive means for rotating said one roller; means for operating said slide to move said other roller toward said one roller so that the annular blank is rolled between said rollers; sensing means including a feeler means mounted on said supporting means for movement in said direction relative to said supporting means and adapted to engage the outer peripheral surface of the annular blank so as to be displaced by the same as the diameter of the same increases; and control means including a series of limit switches successively operated by said feeler means as the same is displaced, and operating means controlled by said limit switches and operatively connected with said supporting means for causing movement of said carriage means at different speeds related to the displacement of said sensing means in such a manner that said second roller means move with said portions of axial end faces as the diameter of the annular blank increases.

13. A ring rolling machine as set forth in claim 12 wherein said moving means include electromagnetic means controlled by said limit switches so that each successively operated limit switch causes movement of said carriage at a higher speed.

14. A ring rolling machine as set forth in claim 13 and including a servo motor for moving said other roller toward said one roller, and means for controlling said servo motor and being actuated by one of said limit switches.

15. A ring rolling machine as set forth in claim 14 wherein said servo motor means has a first position in which said rollers engage said blank and a second position in which said rollers roll said blank.

16. A ring rolling machine as set forth in claim 15 wherein said feeler means are mounted on said carriage for adjustment relative to the same, and wherein said drive means include variable transmission means.

17. A ring rolling machine as set forth in claim 12

and including a first motor for rotating said main roller, and wherein said drive means includes a second motor.

18. A ring rolling machine as set forth in claim 12 and including a scale member; a limit switch operated by said feeler means and mounted on said scale member for adjustment to a position corresponding to a desired outer diameter of said blank, said operating means including electromagnetic means electrically connected to said last mentioned limit switch so that said operating means is stopped when said blank has a desired and selected outer diameter.

19. A ring rolling machine as set forth in claim 18 and including spring means acting on said feeler means to urge the same into engagement with the outer peripheral surface with said blank, said feeler means being mounted on said carriage movable relative to the same in the direction of movement of said carriage.

20. In a ring rolling machine, in combination, roller means for engaging and rolling at least one surface portion of an annular blank which moves during rolling in a predetermined direction; supporting means supporting said roller means for movement in said predetermined direction; means for moving said supporting means in said predetermined direction at any one of a plurality of predetermined speeds; sensing means actuated by movement of said blank in said predetermined direction; and control means controlled by said sensing means and actuating said moving means to change the speed of movement of said supporting means from a slower speed to a faster speed when said blank moves in said predetermined direction faster than said roller means.

21. In a ring rolling machine, in combination, roller means for engaging and rolling at least one surface portion of an annular blank which moves during rolling in a predetermined direction; supporting means supporting said roller means for movement in said predetermined direction; means for moving said supporting means in said predetermined direction at any one of a plurality of predetermined speeds; sensing means actuated by movement of said blank in said predetermined direction; and control means controlled by said sensing means and actuating said moving means to change the speed of movement of said supporting means from a slower speed to a faster speed when said blank moves in said predetermined direction faster than said roller means and to stop movement of said supporting means when said blank moves in said direction slower than said roller means.

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