Feb. 14, 1939. G. J. BUCKNER 2,146,793

METHOD AND APPARATUS FOR ROLL TREATMENT

Filed Feb. 17, 1937 3 Sheets-Sheet 1

Fig. 1.

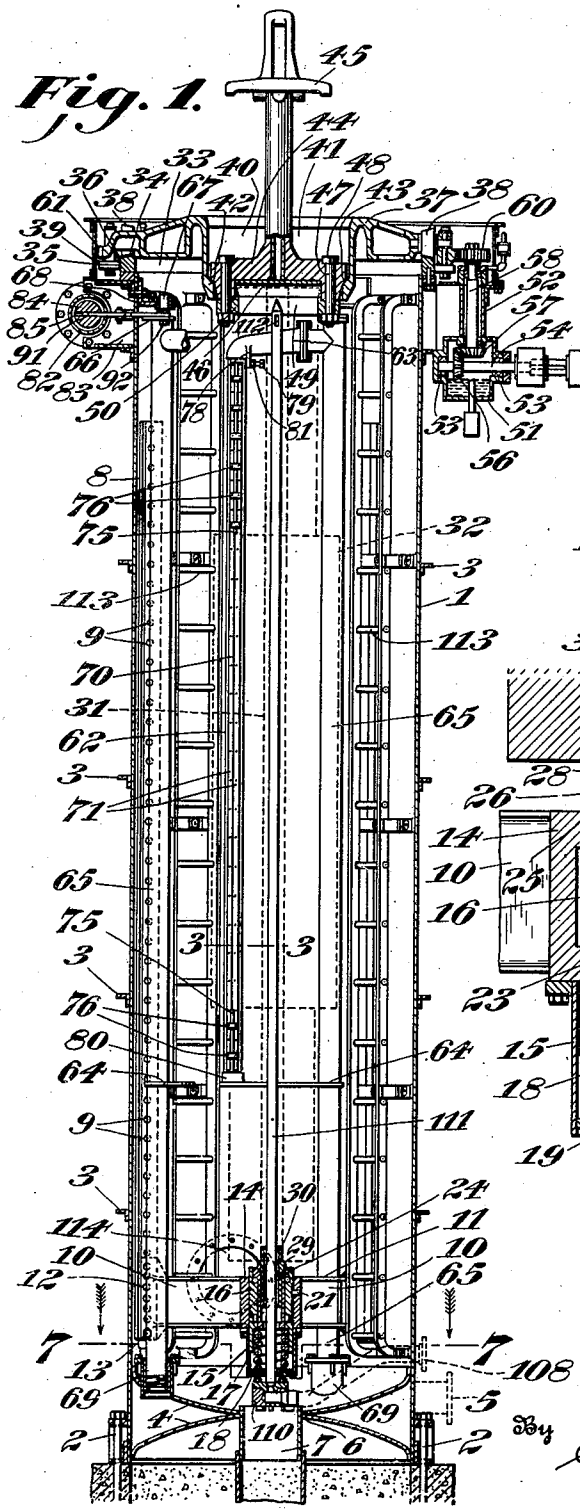


Fig. 2.

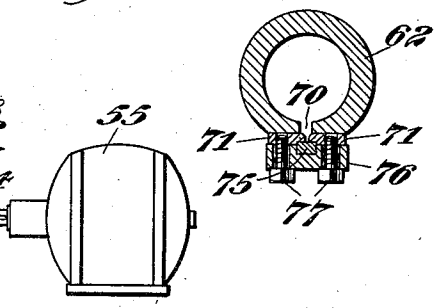


Fig. 3.

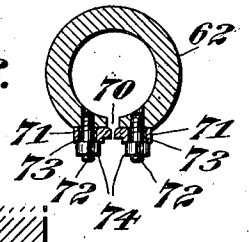
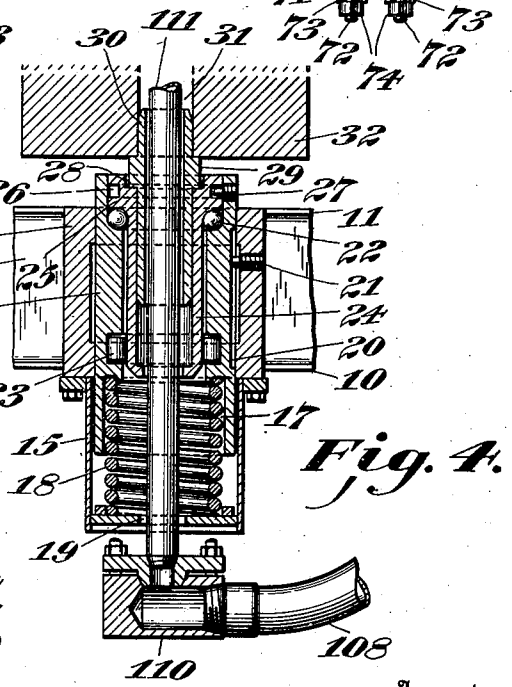


Fig. 4.



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METHOD AND APPARATUS FOR ROLL TREATMENT

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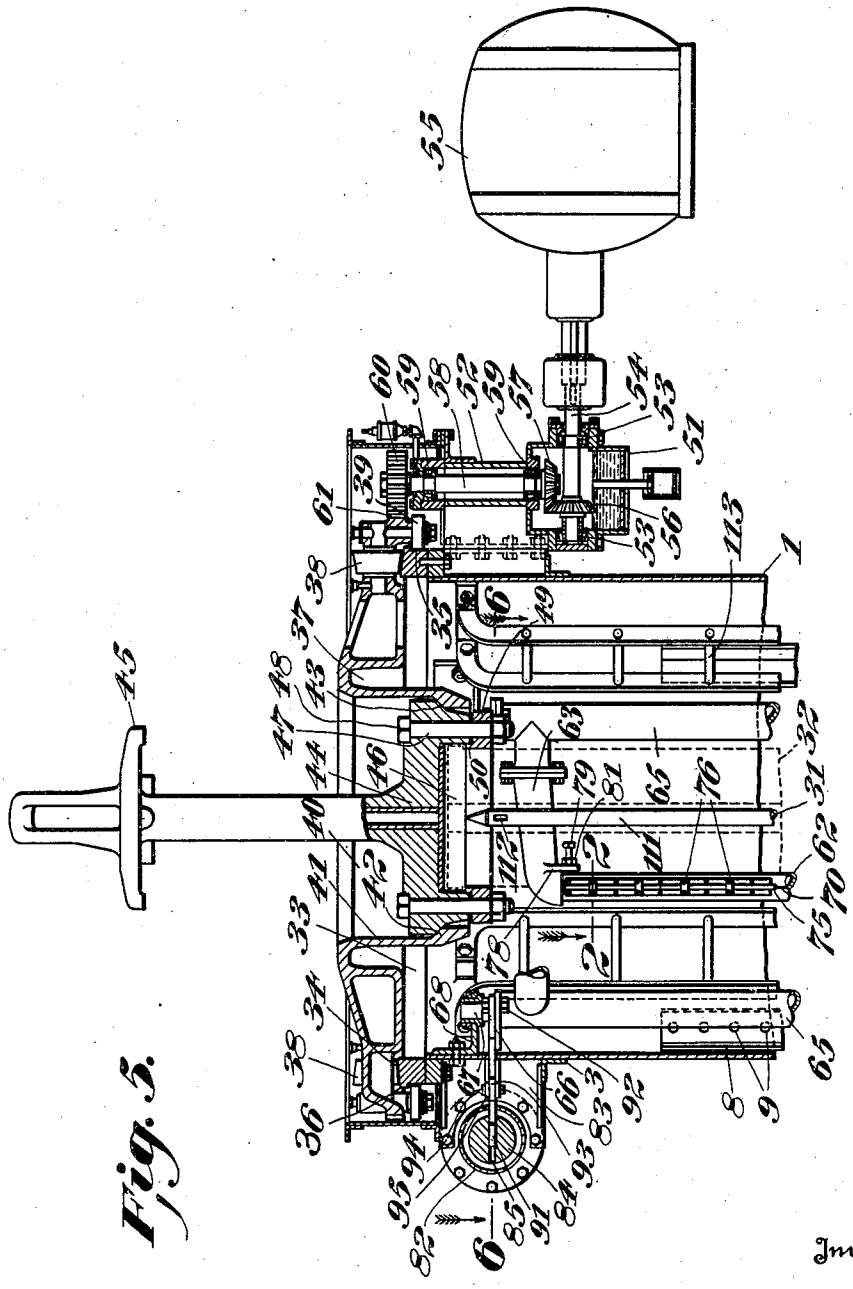


Fig. 5.

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METHOD AND APPARATUS FOR ROLL TREATMENT

Filed Feb. 17, 1937 3 Sheets-Sheet 3

Fig. 6.

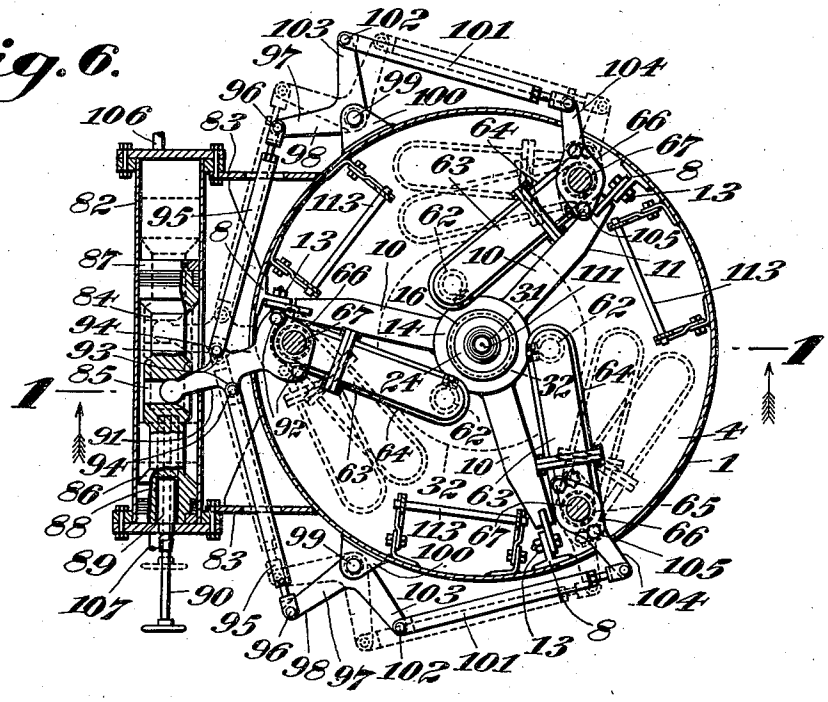
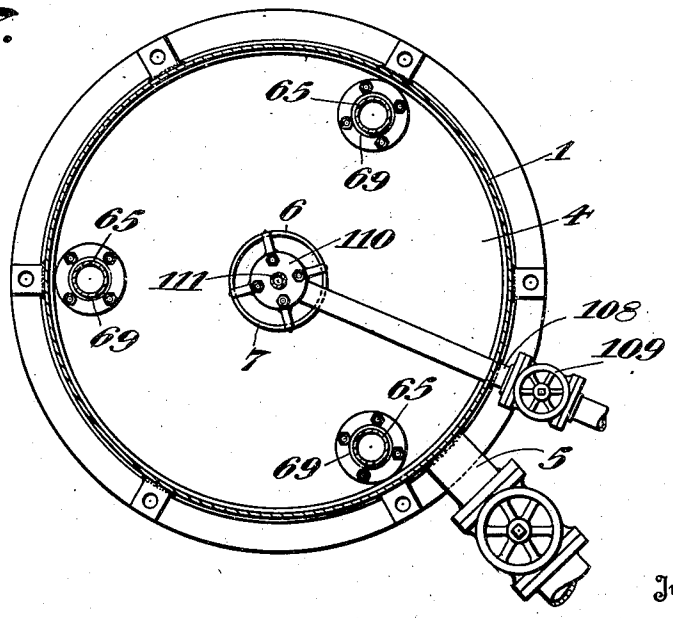


Fig. 7.



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UNITED STATES PATENT OFFICE

2,146,793

METHOD AND APPARATUS FOR ROLL TREATMENT

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Application February 17, 1937, Serial No. 126,156

42 Claims. (Cl. 266—6)

My invention relates to new and useful improvements in a method and apparatus for hardening and tempering tubular or cylindrical articles, and relates more especially to the treatment of steel rolls for rolling mills or the like.

It is well known that the rate and method of cooling has a definite effect on the degree of hardness, the resulting microstructure and the stresses set up in steel quenched from above the critical temperature. As a general rule, the hardness is greater and penetrates more deeply, the more drastic the quench. The microstructure of the hardened part will be martensitic, and as martensite has a larger volume than the rest of the section which has not been exposed to the quenching medium, compressional stresses will be set up in the hardened parts. Moreover, these stresses increase and reach a maximum as the object reaches ordinary temperatures. These stresses are not only caused by volume changes, but also occur during the quenching operation due to the temperature gradient existing between the parts directly exposed to the quenching medium and the interior of the object which is not exposed to the quenching medium.

In view of the above mentioned facts, another object of my invention is to provide means for simultaneously cooling the surface and inside of cylindrical articles so as to produce a more uniform structure and to minimize the temperature gradient between surface and center thereby minimizing the stresses usually set up when large objects are quenched on one surface only.

Another object of the invention is to decrease the length of time usually required for quenching large cylindrical objects. For example, I find that in quenching a roll twenty inches in diameter, the time required for its temperature to fall to 300° F. when quenched according to the present invention is approximately twenty-five minutes in contrast to previous methods which required approximately one hour.

Another object of the invention is to provide means for uniform and reproducible results by simultaneously quenching the surface and bore of cylindrical objects by means of continuous sheets of quenching mediums. Thus, by regulating the pressure and volume of the quenching medium, cylindrical objects may be quenched for a definite period of time, after which the object can be removed and placed in the tempering bath to remove residual stresses and prevent the high stresses occurring at ordinary temperatures. For example, I find that a cylindrical roll of 20 inch diameter and of certain analysis when quenched from 1550° F. according to the present invention, requires about 25 minutes to reach a uniform temperature of 300° F. It may then be placed in a tempering bath at 300° F. to remove harmful stresses and prevent the formation of stresses which would have been set up if the object had been cooled to lower temperatures.

Another object of the invention is a method of simultaneously quenching the surface and bore of cylindrical objects by two different types of quenching media, so as to produce different properties such as hardness and microstructure in the surface and the bore. For example, the surface and bore may be simultaneously quenched by water and oil respectively, or vice versa.

Another object of the invention is to provide means for simultaneously quenching the surface and bore of cylindrical objects and stopping the quenching action at either the surface or bore or both and utilizing the residual heat in the body of the object to temper the hardened surface.

Another object of my invention relates to a method of controlling the quenching operation in hardening and tempering a roll in such a way that the cross-sectional hardness produced will be proportional to the tangential stresses developed in service.

Another object of my invention relates to a method of hardening a roll having a bore by quenching it internally and externally, the heat transfer rate from both internal and external surfaces being controlled and varied during the quenching period so as to produce the desired hardness proportional to the tangential stresses developed in service.

Another object of my invention is to provide a machine having means for simultaneously quenching the external and internal surfaces of a roll having means which will permit variable rates of heat transfer during the operation.

Another object of my invention relates to arrangement and construction of the spray nozzles which are adapted to provide a plurality of continuous sheets of quenching fluid to strike the vertical sides of the roll at an angle to the roll surface. The length and width of each nozzle being adjustable for rolls of different sizes and length.

Another object of my invention relates to the mechanism for supporting the upper end of the roll and for rotating the said roll during the quenching operation.

Another object of my invention relates to the arrangement of the swinging spray pipes and the

manner of adjusting the same to suit various roll diameters.

Another object of my invention relates to the rotating centering device and the adjusting means therefor which is adapted for vertical movement to support the bottom end of rolls of different lengths.

Another object of my invention relates to the mechanism for swinging the spray pipes and the adjusting means therefor to allow the sprays to strike the roll being quenched at different angles.

Another object of my invention is to provide a machine having means for controlling the pressure of the quenching fluid and in which the roll speed can be varied and the direction of rotating of said roll may be either with or against the spray direction, as required.

A further object of my invention relates to the manner of quenching the bore or inside of the roll and for controlling it independently of the external quenching.

Other objects of my invention will hereafter appear.

There is a marked difference between the method of loading and consequent stresses encountered in two high and four high work rolls in mills during the rolling operation.

Two high rolls in a mill are mechanically, beams with fixed ends uniformly loaded across their central section. The resulting stresses during the rolling operation due to bending and driving torque are greatest at the outer surfaces, and decrease towards the center.

A four high roll in a mill during the rolling operation is compressed between the back up roll and the work or the outer work roll. Since an axial bore is necessary for metallurgical inspection and often for the circulation of a cooling medium, the roll is a heavy walled cylinder loaded at two diametrically opposite points.

Having thus given a general description of the objects of my invention, I will now in order to make the same more clear, refer to the annexed three sheets of drawings forming a part of this specification and in which like characters of reference indicate like parts.

Figure 1 is a vertical longitudinal section taken substantially on the line 1—1 of Fig. 6 with the spray pipes indicated in the position they will assume for quenching a roll of the largest diameter for which the machine is designed, the roll being indicated in dotted lines.

Fig. 2 is a transverse section through one of the spray pipes taken on the line 2—2 of Fig. 5, but drawn on an enlarged scale showing the manner of closing a portion of the nozzle openings.

Fig. 3 is a transverse section taken on the line 3—3 of Fig. 1 illustrating the manner of adjusting the width of the nozzle openings.

Fig. 4 is an enlarged detail view of the spring loaded dash pot and the adjustable tubular center support for the lower end of the roll during the roll quenching operation.

Fig. 5 is an enlarged detail view of the top portion of the quenching machine showing more clearly the manner of supporting the top end of the roll and the mechanism for rotating the roll.

Fig. 6 is a transverse section taken on the line 6—6 of Fig. 5, showing in full lines the parts of the machine in the position they will assume in quenching rolls of the smallest diameter for which the machine is designed.

Fig. 7 is a transverse section taken on the line 7—7 of Fig. 1.

Referring now to the various characters of reference on the drawings:

The numeral 1 indicates the outer cylindrical casing of the machine which is arranged vertically on a suitable base or foundation, and secured thereto as at 2. The cylindrical casing is provided with spaced annular reinforcing bands 3 of angular cross section which are secured to its outer surface preferably by welding. Within the lower end of the cylindrical casing is mounted a pair of annular concavo-convex dished plates 4 having flanged outer edges welded to the inner surface of the cylindrical casing 1, said dished plates 4 are disposed with their convex surfaces facing each other to provide a spaced double bottom wall adapted to form a chamber for receiving through the inlet pipe 5, the quenching fluid and distribute it to all the stand and spray pipes. The central portion of each of the concavo-convex dished plates 4 is perforated as at 6 to receive a short tube 7 which is welded thereto and forms the exhaust opening for the cooling medium after the quenching operation.

A plurality of equally spaced vertically extending flanged bars 8 preferably three in number and of T-section are attached to the inside of the cylindrical casing each having its leg extending inwardly and perforated as at 9 for engaging the outer ends of arms 10 of the spider 11 which are perforated as at 12 and adapted to register with the perforations 9 in the bars 8 for receiving pins or bolts 13 to allow the spider to be adjusted vertically to support rolls of different lengths. The central portion of the spider 11 is formed with a hub 14 having a cap extension 15 attached to its lower end. The said hub 14 and the cap 15 are adapted to form a dash pot cylinder for receiving a plunger 16 having a socket 17 formed in its lower end for receiving the upper end of a helical spring 18, while the lower end of said spring engages the inner face of the head of the cap 15 which is perforated centrally as at 19. The plunger 16 is formed tubular and provided with a vertical groove 20 for receiving the inner end of a set screw 21 threaded into the hub 14 to prevent the plunger from turning. The plunger is also provided with races for receiving ball and roller bearings 22 and 23 respectively, adapted to support a rotating sleeve 24 having a flanged upper end 25 provided with an annular groove 26 for receiving the inner end of a retaining screw 27. An annular groove 28 is formed in the upper end of the sleeve 24 in which is seated the lower surface of a collar 29 of a tubular center 30, the lower end of which extends into the rotatably mounted sleeve 24 while the upper end projects above the collar and is inserted in the lower end of the bore 31 of the neck of a roll 32 during the quenching operation. The lower end of the roll 32 engages the top of the collar and is centered and resiliently supported by the dash pot. As different sized rolls can be treated in this machine the center 30 may be made interchangeable for this purpose.

An annular track 33 is secured to the top end of the cylindrical casing 1 having a beveled top track tread surface 34, outer track side tread surface 35 and an outwardly extending top ledge 36.

A turntable 37 is supported upon the annular track 33 having beveled rollers 38 for engaging the top beveled track tread surface 34 and side rollers 39 for engaging the outer track side tread surface 35 to prevent lateral movement of the turntable, while the ledge 36 prevents the turntable 37 from being disengaged from the ma-

chine. The turntable has a central opening 40 formed therein which is surrounded by a downwardly extending annular flange 41 which is provided at its lower end with a thickened portion having a beveled inwardly extending seating surface 42 for engaging and supporting the beveled surface 43 of an annular head 44 of a hanger 45. The lower surface of the hanger head 44 is recessed as at 46 and the edges perforated as at 47 for receiving bolts 48 for attaching an annular split ring 49 thereto, which has a flanged inner upper edge 50 extending into the recess 46. The upper end of the neck of the roll 32 extends through the annular ring 49 and is provided with a collar for engaging the flange 50 of the split ring 49 and is centered and supported thereby as it is rotated by the turntable during the quenching operation.

In order to rotate the turntable, journal bearing housings 51 and 52 are secured to one side of the upper end of the cylindrical casing 1 adjacent to the turntable. The journal housing 51 is provided with roller bearings 53 for supporting a horizontally arranged drive shaft 54 driven by a motor 55 having a variable speed. Said drive shaft 54 has a bevel gear 56 mounted thereon meshing with a similar bevel gear 57, mounted on the lower end of a vertically disposed shaft 58 which is journaled in roller bearings 59 in the housing 52. The upper end of shaft 58 has a pinion 60 keyed thereto meshing with the toothed peripheral edge 61 of the turntable. The roll 32 is suspended vertically and supported at the top end by the turntable which rotates it about its longitudinal axis between a series of sprays, while the bottom end of said roll is centered and supported by means of the tubular center 30 and dash pot.

The spray pipes 62 preferably three in number are arranged vertically adjacent to the roll and are each supported by means of a pipe coupling 63 and a bracket arm 64 extending from the top and intermediate portions respectively of a stand pipe 65. The top end of each stand pipe 65 is flanged as at 66 and closed by means of a projecting stub shaft 67, which is journaled in a bracket 68 attached to the inside of the cylindrical casing 1, while the lower end of each of the said stand pipes extend into a gland 69 and communicate with the distribution chamber for the quenching fluid formed between the dished plates 4.

The spray pipes 62 are each provided with a vertical slot 70 adapted to form a spray nozzle to produce a continuous vertical sheet of spray for the surface of the roll during the quenching operation. As indicated more clearly in Fig. 3 the width of the openings can be adjusted by means of adjustable strips 71 which are attached to the flat surfaces of the spray pipes 62 by means of stud bolts 72 passing through slots 73 in the strips and clamped in position by means of nuts 74. These strips 71 may be adjusted the same distance apart, or one end may be spaced wider apart to give a greater quenching flow at one end of the spray pipe if desired.

As indicated in Figs. 1, 2 and 5 the length of the vertical slots or nozzles can be adjusted for rolls of different lengths by closing a portion of the slot by means of rectangular bars 75 which are held in position by means of clamps 76 and set bolts 77. In Fig. 1 these rectangular bars 75 are shown as attached to the top and bottom end portions of the spray pipe 62, but it will be readily understood that they may be placed at different positions as required.

I prefer to have the sprays strike the roll surface at substantially a tangential angle, but I have made provision by means of which this angle can be adjusted from the true tangent to a radial position. For this purpose the couplings 63 are each formed with a downwardly extending flange 78 each having a set bolt 79 threaded therein with the end engaging the spray pipe. The lower end of each spray pipe is seated in a socket 80 on the swinging end of the bracket arm 64. When the set bolt 79 is unscrewed slightly the spray pipe can be rotated to allow the spray to strike the roll surface at any desired angle from the radial to the tangential. After the desired angle of the nozzle is secured the set bolt is screwed tight against the spray pipe, and a lock nut 81 on the set bolt prevents the said set bolt 79 from loosening.

The spray pipes 62 are adapted to swing in an arcuate path inwardly or outwardly in unison from the central portion of the machine to suit various roll diameters by the following mechanism;

A horizontally disposed fluid pressure cylinder 82 is attached to the outside of the upper end of the cylindrical casing 1 by means of bracket plates 83. A plunger 84 having a transverse opening 85 formed centrally therein and provided with pistons 86 and 87 at opposite ends is mounted in the cylinder 82. The piston 86 is formed with a socket 88 adapted to receive a tubular support 89 for a graduated stop 90 for limiting the movement of the plunger. An arm 91 is attached as at 92 to the flange 66 of one of the stand pipes 65 and is provided with a disk shaped outer end which extends into the opening 85 in the plunger 84. Projecting ears 93 extend outwardly from the opposite sides of the intermediate portion of the arm 91 to each of which is pivoted as at 94 one end of an adjustable link 95, the opposite end of each of which is pivoted as at 96 to the arm 97 of a bell crank lever 98. The bell crank levers 98 have their central portions pivoted as at 99 to a bracket 100, which is secured to the outer side of the cylindrical casing 1. An adjustable link 101 having one end pivoted as at 102 to the other arm 103 of each bell crank lever and the opposite end to an arm 104 which is attached to the flange 66 of the other two stand pipes 65 as at 105.

When the spray pipes 62 are in the position indicated in full lines in Fig. 6 they will be in position to spray rolls of the smallest diameter to which this machine is designed and the graduated stop 90 will not be used, the tubular support 89 will then be received in the socket 88 in the piston 86.

When the spray pipes are in the intermediate position as indicated in dotted lines in the same figure the spray pipes will be in position for quenching rolls of the largest diameter and the graduated stop will then be adjusted as indicated in dotted lines. It will be understood that the graduated stop will be adjusted in quenching rolls in which the roll diameters are between the smallest and largest diameters for which this machine is designed. At the end of the quenching operation the spray pipes are swung to the outer position by exhausting the fluid pressure through the pipe 106 at one end of the cylinder 82 and admitting it through the pipe connection 107 at the opposite end of said cylinder.

The internal quenching of the roll is accomplished independent of that for the outer surface

of the roll, the fluid supply pipe is indicated by the numeral 108 and is controlled by a valve 109. This pipe extends through the cylindrical casing 1 near the bottom and has its inner end threaded into a coupling box 110 located just below the dash pot. A vertical pipe 111 has its lower end threaded into the coupling box 110 and extends up through the dash pot and the tubular center 30 to the top of the roll where it is perforated as at 112. As the bore of the roll is closed at the top by means of a plate disk, the quenching fluid is discharged through the perforation 112 and flows downwardly between the pipe 111 and the surface of the bore of the roll through the tubular center 30 and dash pot and is discharged at the lower end of the dash pot and then passes through the exhaust tube 7. The openings for the passage of the pipe 111 through the tubular center 30 and the dash pot are somewhat larger than said pipe to allow the quenching fluid to be discharged therethrough.

The internal diameter of the tubular center 30 is adjusted so that the bore of the roll will always be full of water moving with such a velocity that steam formation is prevented.

As this machine is designed for use in quenching rolls of large diameter and considerable length such as the work rolls for strip, plate mills or the like, the quenching tank is of considerable height it is therefore necessary to have vertically extending ladders 113 secured to the inside of the cylindrical casing 1 for the purpose of enabling a workman to climb up inside the quenching tank for inspection, adjustment of the parts, or making repairs, the workman entering the tank through a man hole 114 located near the lower end of the cylindrical casing 1 which is normally kept closed.

Having thus given the foregoing general and detailed description of my invention I will now describe the operation:

A roll to be quenched is first heated to the desired temperature in a furnace suspended by the hanger 45 and then transferred by means of the hanger to the quenching machine and suspended from the turntable 37 with its lower end supported by the tubular center 30 and the dash pot. Assuming that the smallest sized roll for which this machine is designed is being quenched as indicated in full lines in Fig. 6, and the quenching fluid is flowing through the supply pipes 5 and 108 for the external and internal quenching respectively for the roll 32, and simultaneously admitted into pipe 106 to the fluid pressure cylinder 82 thereby holding the piston 86 against the graduated stop end of the said cylinder and the swinging spray pipes in position so the sprays will strike the roll surface almost tangentially. The roll during the quenching operation will be rotated about its longitudinal axis preferably continuously either with or against the spray direction as required, by means of the turntable from which it is suspended which is driven by means of the motor 55 and the gearing connections. The motor 55 can be driven at variable speeds, which will permit heat transfer rate from both internal and external surfaces being controlled and varied during the quenching period in such a manner as to produce the desired hardness proportional to the tangential stresses developed in service. The spray nozzles for the external quenching of the roll surface produce vertical sheets of cooling fluid of adjustable height and thickness, while in the internal quenching the cooling fluid is admitted at the top of the bore of the roll and flows downwardly spirally as the roll is rotated and passes through the tubular center 30 and dash pot and is finally discharged together with the cooling fluid for the external quench through the tube 7 at the lower end of the machine.

After the quenching operation the flow of quenching fluid is turned off from the pipes 5, 106 and 108 and admitted in pipe 107 thereby sliding the plunger 84 to the opposite end of the cylinder 82, the spray pipe will then be swung to the outer position as indicated in dotted lines in Fig. 6.

If it is desired to quench rolls of the largest diameter for which this machine is designed, the graduated stop 90 is set to the position indicated in dotted lines in Fig. 6, the pressure is cut off from pipe 107 to the cylinder 82 and then admitted into pipes 5, 106 and 108, the spray pipes will then be swung to the intermediate position indicated in dotted lines and the operation will be repeated as above described. Rolls between the smallest and the largest diameters may be quenched in a similar manner by setting the graduated stop 90 at the required point to swing the spray pipes into the proper position and angle to quench the roll.

I preferably perform the internal and external quenching operations simultaneously and continuously but independently of each other to the completion of the operation, but my machine is so designed that the internal and external quenching operations may be performed separately and at different times if desired, and that either the internal or external quench may be interrupted at any time during the operation. By using a plurality of spray pipes having nozzles which produce a continuous sheet spray on the surface of the roll has the advantage over using a plurality of spaced nozzles for the same purpose as the quench is more uniform. When a roll is quenched by submersion the cooling action is imperfectly controlled. This can be accomplished to the best advantage with my machine which will permit of varying the pressure of the quenching fluid, varying the angle of incidence of the external sprays, varying the speed of rotation of the roll which changes the relative velocity of the sprays, changing the rotation of the roll which also changes the relative velocity of the sprays, and means for interrupting either the internal or external quench.

The quenching fluid preferably used in my machine will be water but I may use other quenching mediums for the internal or external quench such as oil, chemical solutions, air or gas which may be the same or different temperatures if I so desire.

I may also with this machine provide means for simultaneously quenching the surface and bore of the cylindrical objects and then temper such objects by forcing a preheated fluid through the spray pipes thereby hardening and tempering the object in the same machine.

Although I have shown and described my invention in considerable detail, I do not wish to be limited to the exact and specific details shown and described, but may use such substitutions, modifications or equivalents thereof, as are embraced within the scope of my invention, or as pointed out in the claims.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. In a machine for hardening a heated metal object, a turntable for suspending and supporting the upper end of a heated object, yielding means for supporting the lower end of the object, means

for rotating the turntable to rotate the object with the yielding means, and means for quenching the object by a continuous sheet spray.

2. In a machine for hardening a heated metal object disposed in a vertical position, a turntable for suspending and supporting the upper end of a heated object, a dash pot having a spring mounted therein for resiliently supporting the lower end of the object and adapted to rotate therewith, means for rotating the turntable, and means for quenching the object by a plurality of continuous sheet sprays.

3. In a machine for hardening a heated metal object, a turntable for suspending and supporting the upper end of a heated object, a dash pot having means for resiliently supporting the lower end of the object and adapted to rotate therewith, means for rotating the turntable, means for applying a quenching fluid to the surface of the object in a continuous sheet of spray, and means for laterally adjusting the position of the sheet spray.

4. In a machine for hardening rolls or the like, a turntable having means for suspending and supporting the upper end of the heated roll disposed in a vertical position, yielding means for supporting the lower end of the roll, means for rotating the turntable, and means for applying a quenching fluid to the surface of the roll in a continuous sheet of spray.

5. In a machine for hardening rolls or the like, a turntable for suspending and supporting the upper end of the heated roll disposed in a vertical position, a dash pot for yieldingly supporting the lower end of the roll, means for rotating the turntable with the roll, means for applying a quenching fluid to the surface of the rotating roll in a plurality of continuous sheets of spray, and means for laterally adjusting the position of the sprays.

6. In a machine for hardening rolls or the like, a turntable having means for suspending and supporting the upper end of the heated roll, a dash pot having means for yieldingly supporting the lower end of the roll, means for vertically adjusting the position of the dash pot, a center mounted on the dash pot for centering the lower end of the roll, means for rotating the turntable with the roll, means for applying a quenching fluid to the surface of the rotating roll in continuous sheet sprays, and means for simultaneously adjusting the positions of the sprays.

7. In a machine for hardening rolls or the like, comprising a turntable having means for engaging and supporting the upper end of the heated roll, a dash pot at the lower end of the roll, a sleeve rotatably mounted in the dash pot, a center mounted in the sleeve for engaging the lower end of the roll, means for rotating the turntable with the roll, and means for applying a quenching fluid to the surface of the roll in continuous sheet sprays.

8. In a machine for hardening rolls or the like, comprising a turntable having means for engaging and supporting the upper end of the heated roll in a vertical position, an adjustable spider at the lower end of the roll having a central hub with a cap extension, a vertically movable plunger mounted in the hub, a sleeve rotatably mounted in the plunger, a center mounted in the sleeve for engaging the lower end of the roll, means for rotating the turntable with the roll, and means for spraying the roll with continuous sheets of quenching fluid which extend the full length of the surface to be hardened.

9. In a machine for hardening rolls or the like, comprising a turntable having means for engaging and supporting the upper end of the heated roll in a vertical position, an adjustable spider at the lower end of the roll having a central hub with a cap extension, a vertically movable plunger mounted in the hub, a spring interposed between the plunger and the head of the cap, a sleeve journaled in anti-friction bearings in the plunger, a center mounted in the sleeve for engaging the lower end of the roll, means for rotating the turntable with the roll, and means for spraying the roll with continuous sheets of quenching fluid which extend the full length of the surface to be hardened.

10. In a machine for hardening rolls or the like having a central bore, comprising a turntable having means for engaging and supporting the upper end of the heated roll, a dash pot at the lower end of the roll, a sleeve rotatably journaled in the dash pot, a tubular center mounted in the sleeve adapted to extend above the sleeve and project into the bore of the roll, a collar on the center for engaging the lower end of the roll, means for rotating the turntable with the roll, and means for spraying the roll with continuous sheets of quenching fluid which extend the full length of the surface to be hardened.

11. In a machine for hardening rolls or the like having a central bore, comprising a turntable having means for engaging and supporting the upper end of the heated roll, a dash pot at the lower end of the roll, means for vertically adjusting the position of the dash pot, a tubular centering device mounted in the dash pot for supporting the lower end of the roll, a coupling box adjacent to the dash pot, a supply pipe connected to the coupling box, a tube connected to the coupling box and adapted to pass through the dash pot and centering device in spaced relation therewith and extend to the upper end of the bore of the roll, a perforation in the upper end of the pipe, means for rotating the turntable with the roll, and means for spraying the roll with continuous sheets of quenching fluid which extend the full length of the surface to be hardened.

12. In a machine for hardening rolls or the like, comprising a turntable having means for engaging and supporting the upper end of the heated roll, a dash pot having a centering device mounted therein for supporting the lower end of the roll, spray pipes mounted adjacent to the side surface of the roll, and means for swinging the spray pipes laterally.

13. In a machine for hardening rolls or the like, comprising a turntable having means for engaging and supporting the upper end of the heated roll in a vertical position, a dash pot having a centering device mounted therein for centering and supporting the lower end of the roll, vertically arranged spray pipes mounted adjacent to the side surface of the roll, stand pipes for supporting the spray pipes, and means for rotating the stand pipes to swing the spray pipes laterally of the roll.

14. In a machine for hardening rolls or the like, comprising a turntable having means for engaging and supporting the upper end of the heated roll in a vertical position, a dash pot having a centering device mounted therein for centering and supporting the lower end of the roll, vertically arranged spray pipes mounted adjacent to the side surface of the roll, a vertically extending slot formed in each spray pipe adapted to form a spray nozzle, means for adjusting the

width and height of each spray jet in relation to the roll surface, means for adjusting the angle of the spray nozzle, stand pipes for supporting the spray pipes, and means for rotating the stand pipes to swing the spray pipes laterally of the roll.

15. In a machine for hardening rolls or the like, comprising a cylindrical casing, spaced annular rings and vertically extending flanged bars for reinforcing the cylindrical casing, a distributing chamber formed at the lower end of the cylindrical casing, an exhaust tube extending through the central portion of the distributing chamber, an annular track secured to the top of the cylindrical casing, a turntable having means for engaging and suporting the upper end of the heated roll in a vertical position, a dash pot having a centering device mounted therein for centering and supporting the lower end of the roll, vertically arranged spray pipes mounted adjacent to the side surface of the roll, and means for swinging the spray pipes laterally of the side surface of the roll.

16. In a machine for hardening rolls or the like, comprising a cylindrical casing, a distributing chamber at the bottom of the cylindrical casing, means for supplying quenching fluid to the distributing chamber, a tubular exhaust pipe extending through the distributing chamber, an annular track mounted on the top of the cylindrical casing, a turntable mounted on the annular track having means for engaging and supporting the upper end of the heated roll in a vertical position, a dash pot having a centering device mounted therein for centering and supporting the lower end of the roll, stand pipes communicating with the distributing chamber, a spray pipe connected to each stand pipe and supported thereby adjacent to the side surface of the roll, and means for swinging the spray pipes laterally.

17. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, an annular track mounted on the top of the cylindrical casing, a turntable mounted on the track having means for engaging and supporting the upper end of the heated roll, a dash pot having a centering device mounted therein for supporting the lower end of the roll, a distributing chamber in the lower end of the cylindrical casing, a pipe for supplying quenching fluid to the distributing chamber, an exhaust tube extending through the distributing chamber, stand pipes communicating with the distributing chamber, a spray pipe connected to each stand pipe and supported thereby adjacent to the side surface of the roll, and means for rotating the stand pipes to swing the spray pipes laterally of the roll.

18. In a machine for hardening rolls or the like, comprising a turntable having means for engaging and supporting the upper end of the heated roll, a dash pot having a centering device mounted therein for supporting the lower end of the roll, means for vertically adjusting the position of the dash pot, spray pipes disposed adjacent to the side surface of the roll, a stand pipe for supporting each spray pipe, a coupling connecting each stand pipe with a spray pipe, and means for rotating the stand pipes to swing the spray pipes laterally of the roll.

19. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, an annular track mounted on top of the cylindrical casing, a turntable mounted on the annular track having means for engaging and supporting the upper end of the heated roll, a dash pot having a centering device mounted therein for supporting the lower end of the roll, spray pipes mounted adjacent to the side surface of the roll, a stand pipe for supporting each spray pipe, an arm attached to each stand pipe, means for connecting the arms together, and means for rotating the stand pipes simultaneously to swing the spray pipes laterally of the roll.

20. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, an annular track mounted on top of the cylindrical casing, a turntable mounted on the annular track having means for engaging and supporting the upper end of the heated roll, a dash pot having a centering device mounted therein for supporting the lower end of the roll, spray pipes mounted adjacent to the side surface of the roll, a stand pipe for supporting each spray pipe, an extending arm attached to each stand pipe, adjustable means for connecting the extending arms together, a fluid pressure cylinder attached to the cylindrical casing, a plunger mounted therein for engaging one of the extending arms attached to one of the stand pipes, fluid pressure means for reciprocating the plunger to swing the spray pipes laterally of the side surface of the roll, and a graduated stop for limiting the movement of the plunger.

21. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, vertical and transverse reinforcing means for the cylindrical casing, a distributing chamber formed in the lower end of the cylindrical casing, a pipe for supplying quenching fluid to the distributing chamber, an exhaust pipe extending through the distributing chamber, an annular track mounted on top of the cylindrical casing, a turntable mounted on the annular track having means for engaging and supporting the upper end of the heated roll, a dash pot at the lower end of the roll, a centering device rotatably mounted in the dash pot for supporting the lower end of the roll, a plurality of stand pipes connected to the distributing chamber, a spray pipe supported by each stand pipe adjacent to the side surface of the roll, and means for rotating the stand pipes to swing the spray pipes inwardly or outwardly from the side surface of the roll.

22. In a machine for hardening rolls or the like having a central bore, a turntable having means for engaging and supporting the upper end of a heated roll disposed in a vertical position, a rotatably mounted centering device adapted to support the lower end of the roll, means for rotating the turntable with the roll, means for admitting quenching fluid at the top end of the bore of the roll, spray pipes adjacent to the outer surface of the roll each having a vertical slot adapted to form a nozzle to play a sheet of quenching fluid on the roll.

23. In a machine for hardening rolls or the like having a central bore, a turntable having means for engaging and supporting the upper end of a heated roll disposed in a vertical position, a centering device adapted to rotate for supporting the lower end of the roll, means for rotating the turntable with the roll, means for admitting quenching fluid at the top end of the bore of the roll and advancing it to the opposite end of the roll, spray pipes adjacent to the outer surface of the roll each having a vertical slot adapted to form a nozzle to play a sheet of quenching fluid on the surface of the roll, and means for adjust-

ing the width and height of the slots in the spray pipes forming the nozzles.

24. In a machine for hardening rolls or the like having a central bore, a turntable having means for engaging and supporting the upper end of a heated roll disposed in a vertical position, a centering device adapted to rotate for supporting the lower end of the roll, means for vertically adjusting the centering device, means for rotating the turntable with the roll, means for admitting a quenching fluid at the top end of the bore of the roll and advancing it during the rotation of the roll to the opposite end of the roll, a plurality of vertically disposed spray pipes adjacent to the outer surface of the roll each having a vertical slot adapted to form a nozzle to play a sheet of quenching fluid on the surface of the roll, adjustable strips for increasing or decreasing the width of the slot forming the nozzle in each spray pipe, bars clamped to the strips for adjusting the length of the nozzles, and means for swinging the spray pipes laterally of the roll surface.

25. In a machine for hardening rolls or the like having a central bore, a turntable having means for engaging and supporting the upper end of a heated roll disposed in a vertical position, a centering device adapted to rotate for supporting the lower end of the roll, means for vertically adjusting the centering device, means for rotating the turntable with the roll, means for admitting a quenching fluid at the top end of the bore of the roll and advancing it during the rotation of the roll to the opposite end of the roll, a plurality of vertically disposed spray pipes adjacent to the outer surface of the roll each having a vertical slot adapted to form a nozzle to play a sheet of quenching fluid on the surface of the roll, means for adjusting the spray pipes to adjust the angle of the nozzle in relation to the roll surface, a stand pipe connected to each spray pipe, and means for rotating the stand pipes to swing the spray pipes laterally of the roll surface.

26. In a machine for hardening rolls or the like having a central bore, rotating means for supporting the upper end of the heated roll disposed in a vertical position, yielding means for supporting the lower end of the heated roll and adapted to rotate therewith, means for admitting a quenching fluid at one end of the bore of the roll and advancing it to the opposite end of the roll, and means for quenching the outer surface of the roll by a plurality of sprays in sheet formation which strike the roll at substantially a tangential angle and extends continuously the entire length of the surface to be quenched.

27. In a machine for hardening rolls or the like having a central bore, comprising a vertically disposed cylindrical casing, an annular track mounted on top of the cylindrical casing, a turntable mounted on the annular track adapted to engage and support the upper end of the heated roll, a dash pot at the lower end of the cylindrical casing, a centering device rotatably mounted in the dash pot for supporting the lower end of the roll, a coupling box adjacent to the lower end of the dash pot, a quenching fluid supply pipe connected to the coupling box, a vertically disposed pipe connected to the coupling box adapted to extend through the dash pot and centering device in spaced relation therewith to the top end of the bore of the roll, a perforation in the top end position of said pipe adapted to admit quenching fluid into the upper end of the bore of the roll for advancing it to the opposite end of the roll, and means for simultaneously quenching the outer surface of the roll by a plurality of sprays in sheet formation.

28. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, an annular track secured to the top end of the cylindrical casing, a turntable mounted on the annular track adapted to support the upper end of the heated roll, a dash pot at the lower end of the roll, a centering device mounted in the dash pot adapted to support the lower end of the roll, means for rotating the turntable with the roll, and a plurality of vertically arranged spray pipes each having a slot forming a nozzle adapted to play a quenching fluid on the surface to be treated.

29. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, a distributing chamber formed within the lower end of the cylindrical casing, a pipe for supplying quenching fluid to the distributing chamber, an annular track secured to the top end of the cylindrical casing, a turntable mounted on the annular track adapted to support the upper end of the heated roll, a dash pot supported from the cylindrical casing at the lower end of the roll, a centering device mounted in the dash pot adapted to support the lower end of the roll, means for rotating the turntable with the roll, a plurality of vertically arranged stand pipes having their lower ends connected to the distributing chamber, a spray pipe connected to and supported by each stand pipe adjacent to the surface of the roll, and means for rotating the stand pipes to swing the spray toward or away from the surface of the roll.

30. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, a distributing chamber formed within the lower end of the cylindrical casing, a pipe for supplying quenching fluid to the distributing chamber, means for supporting the opposite ends of the roll, means for rotating the roll about its longitudinal axis, a plurality of glands formed in the wall of the distributing chamber, a stand pipe having one end journaled in each gland, a journal bearing for the opposite end of each stand pipe secured to the cylindrical casing, a spray pipe disposed adjacent to the side surface of the roll connected to and supported by each stand pipe, and means for rotating the stand pipes to swing the spray pipes toward or away from the side surface of the roll.

31. In a machine for hardening rolls or the like, comprising means for supporting and rotating a heated roll, spray pipes disposed adjacent to the side surface of the roll, a stand pipe for supporting and supply quenching fluid to each spray pipe, and means for rotating the stand pipes to swing the spray pipes toward or away from the side of the roll surface.

32. In a machine for hardening rolls or the like, comprising means for supporting and rotating a heated roll, spray pipes disposed adjacent to the side surface of the roll, a distributing chamber for receiving quenching fluid, a stand pipe connected to the distributing chamber for supporting and supplying quenching fluid to each spray pipe, an arm extending from each stand pipe, and means connected to the arm adapted to rotate the stand pipes to swing the spray pipes toward or away from the side of the roll surface.

33. In a machine for hardening rolls or the like, comprising means for supporting and rotating the heated roll, spray pipes disposed adjacent to the side surface of the roll, a distributing

chamber for receiving quenching fluid, a stand pipe connected to the distributing chamber for supporting and supplying quenching fluid to each spray pipe, an arm extending from each stand pipe, adjustable connections between the arms, a fluid pressure cylinder having a plunger mounted therein for engaging one of the arms, and means for reciprocating the plunger to rotate the stand pipes and swing the spray pipes toward or away from the side surface of the roll.

34. In a machine for hardening rolls or the like, comprising means for supporting the opposite ends of the heated roll and for rotating the same, spray pipes each having a slot forming a nozzle disposed adjacent to the roll and adapted to spray its side surface, a distributing chamber for receiving quenching fluid, a stand pipe connected to the distributing chamber for supporting and supplying quenching fluid to each spray pipe, an arm secured to each stand pipe and extending therefrom, adjustable links and bell crank levers for connecting the arms, a fluid pressure cylinder having a plunger mounted therein for engaging one of the arms, fluid pressure means for reciprocating the plunger to rotate the stand pipes simultaneously and swing the spray pipes toward or away from the side surface of the roll, and a graduated stop adapted to limit the movement of the swinging spray pipes.

35. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, an annular track secured to the top of the cylindrical casing, a turntable mounted on the annular track, an opening formed centrally in the turntable, a downwardly extending flange surrounding the opening having an inclined seating surface, a hanger having a head formed with an inclined seating surface for engaging the seating surface of the flange, an annular ring attached to the head of the hanger for engaging and supporting the upper end of a heated roll, a centering device for supporting the lower end of the roll, spray pipes each having a slot forming a nozzle adapted to play a sheet of spray on the roll at an angle to the side surface, and a motor adapted to be driven at a variable speed for rotating the turntable to rotate the roll either with or against the direction of the spray on the surface of the roll.

36. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, an annular track secured to the top of the cylindrical casing, a turntable mounted on the annular track having means for supporting the top end of a heated roll, a plurality of vertically extending T-bars having their flanges secured to the inside of the cylindrical casing with their legs extending inwardly, perforations formed in the legs of the T-bars, an adjustable spider having arms at the lower end of the roll, perforations in the outer ends of the arms of the spider adapted to register with the perforations in the legs of the T-bars, bolts extending through the perforations in the ends of the arms of the spider and the legs of the T-bars for securing them together, a dash pot disposed centrally of the spider, a centering device mounted in the dash pot for supporting the lower end of the roll, means for rotating the turntable with the roll, and spray pipes disposed adjacent to the side surface of the roll.

37. In a machine for hardening rolls or the like, comprising a vertically disposed cylindrical casing, an annular track secured to the upper end of the cylindrical casing, a turntable mounted on the annular track having means for supporting the upper end of the heated roll, a centering device for supporting the lower end of the roll, a distributing chamber within the lower end of the cylindrical casing, glands formed in the upper wall of the distributing chamber, a plurality of vertically extending stand pipes each having its lower end journaled in one of the glands, a stub shaft projecting from the upper end of each stand pipe each journaled in a bracket attached to the side wall of the cylindrical casing, a spray pipe coupled to the upper end of each stand pipe, a bracket arm extending from each stand pipe having a socket formed at its outer end for supporting the lower end of each spray pipe, an arm extending from each stand pipe, adjustable means for connecting the arms together, and means operated by fluid pressure adapted to rotate the stand pipe and swing the spray pipes toward or away from the side surface of the roll.

38. The method of hardening a cylindrical metal body which consists in taking the cylindrical metal body which has been heated to the required temperature, suspending the cylindrical metal body from the top in a vertical position, resiliently supporting the lower end of the cylindrical metal body in such a manner as to allow for contraction, and then rotating the cylindrical metal body about its longitudinal axis between a plurality of continuous sheet sprays of quenching fluid which strike the cylindrical metal body at a substantially tangential angle to its surface.

39. The method of hardening a cylindrical metal body having a central bore, which consists in taking the cylindrical metal body heated to the required temperature, suspending the cylindrical metal body from the top in a vertical position, centering and resiliently supporting the lower end of the cylindrical metal body in such a manner as to allow for contraction, then rotating the cylindrical metal body between a plurality of sprays of quenching fluid which strike the cylindrical metal body in a continuous sheet, and then subjecting the central bore of the cylindrical metal body to the action of a quenching fluid as it passes through the central bore of the cylindrical metal body.

40. The method of hardening rolls having a central bore, which consists in taking a roll heated to the required temperature, suspending the roll from the top in a vertical position, centering and resiliently supporting the lower end of the roll to allow for contraction, rotating the roll about its longitudinal axis between a plurality of sheet sprays of quenching fluid which strike the outer surface of the roll at substantially a tangential angle in a continuous sheet from one end of the roll surface to be quenched to the other, and simultaneously admitting a quenching fluid at the top end of the central bore of the roll and advancing it to the opposite end of the roll.

41. The method of hardening rolls or the like having a central bore, consisting in heating the roll to be hardened to a predetermined temperature, suspending the roll from the top in a vertical position, centering and resiliently supporting the lower end of the roll in such a manner as to allow for contraction, rotating the roll on its longitudinal axis while holding it at opposite ends, applying a quenching fluid to the rotating heated roll by means of a plurality of continuous sheet sprays which extend the entire length of the surface to be quenched and strike the roll at an angle to said roll surface, and simultaneously treating the bore of the roll from end to end by

a quenching fluid moving with such velocity that vapor formation is prevented.

42. The method of hardening a roll having a central bore, which consists in first heating a roll to a predetermined temperature, suspending the roll from the top in a vertical position, centering and resiliently supporting the lower end of the roll in such a manner as to allow for contraction, then rotating the roll about its longitudinal axis, treating the bore of the roll with a rapidly moving quenching fluid, simultaneously quenching the surface of the roll independently of the internal quenching operation by means of sprays of sheet formation extending the full length of the surface of the roll being quenched, and controlling the internal and external treatment by varying the quenching period.

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