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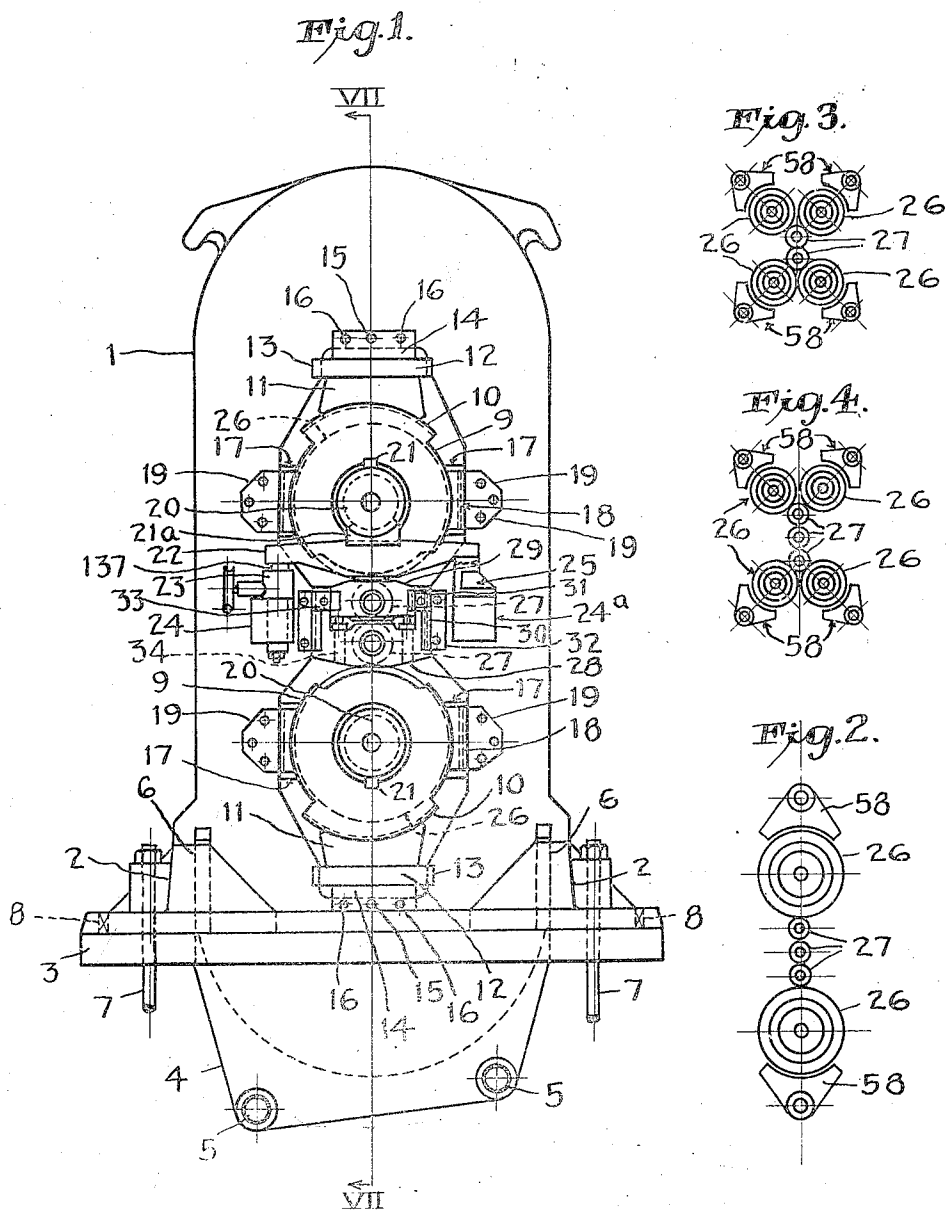
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2,056,433

ROLLING MILL

Filed April 26, 1933

6 Sheets-Sheet 1



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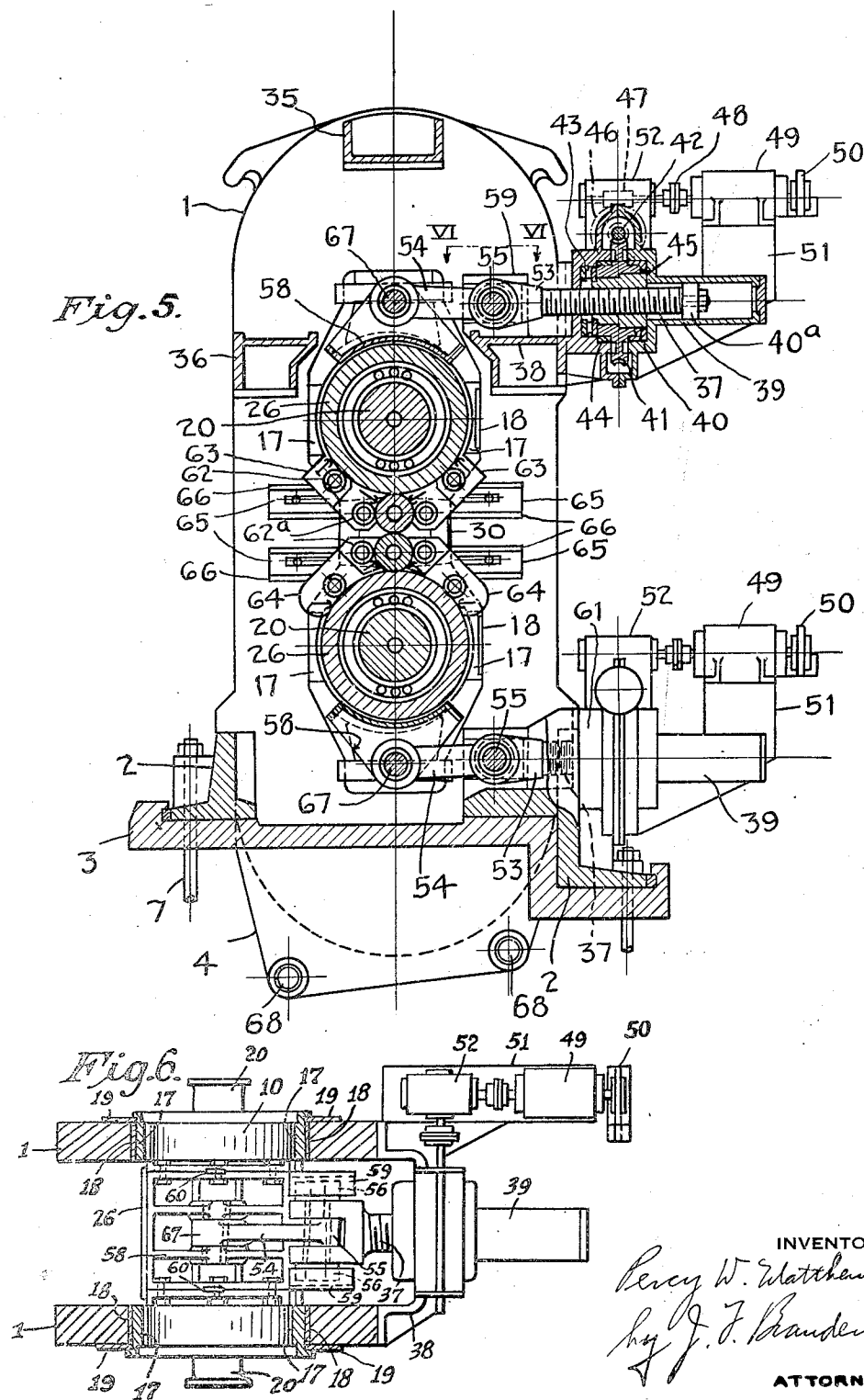
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ROLLING MILL

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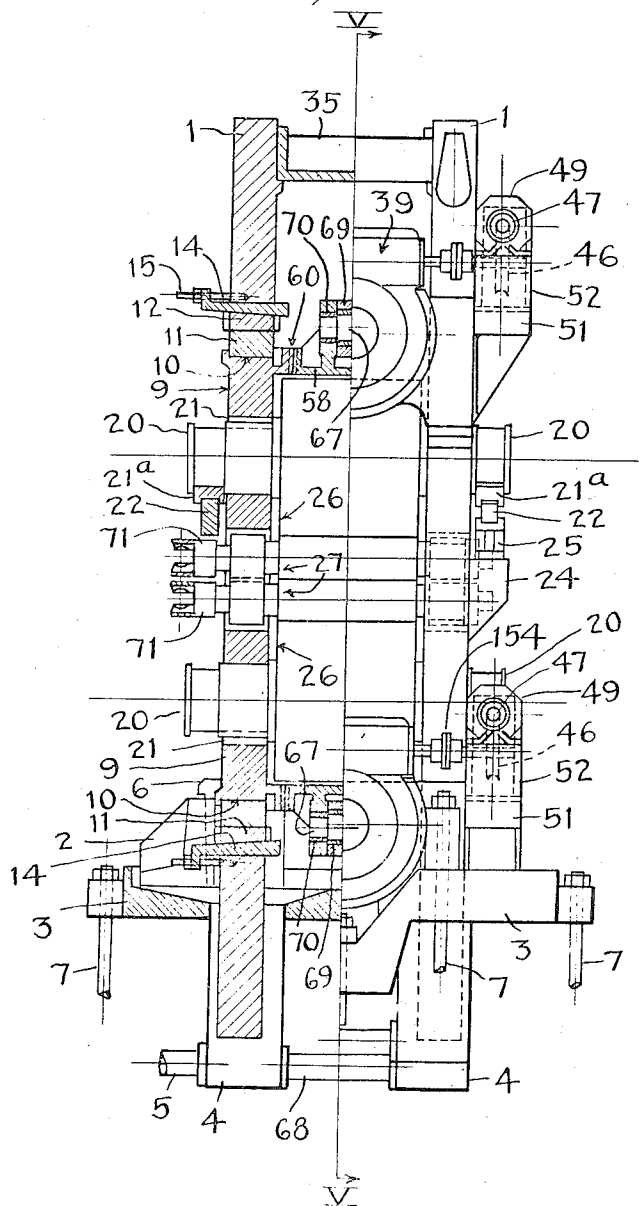
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Fig. 7.



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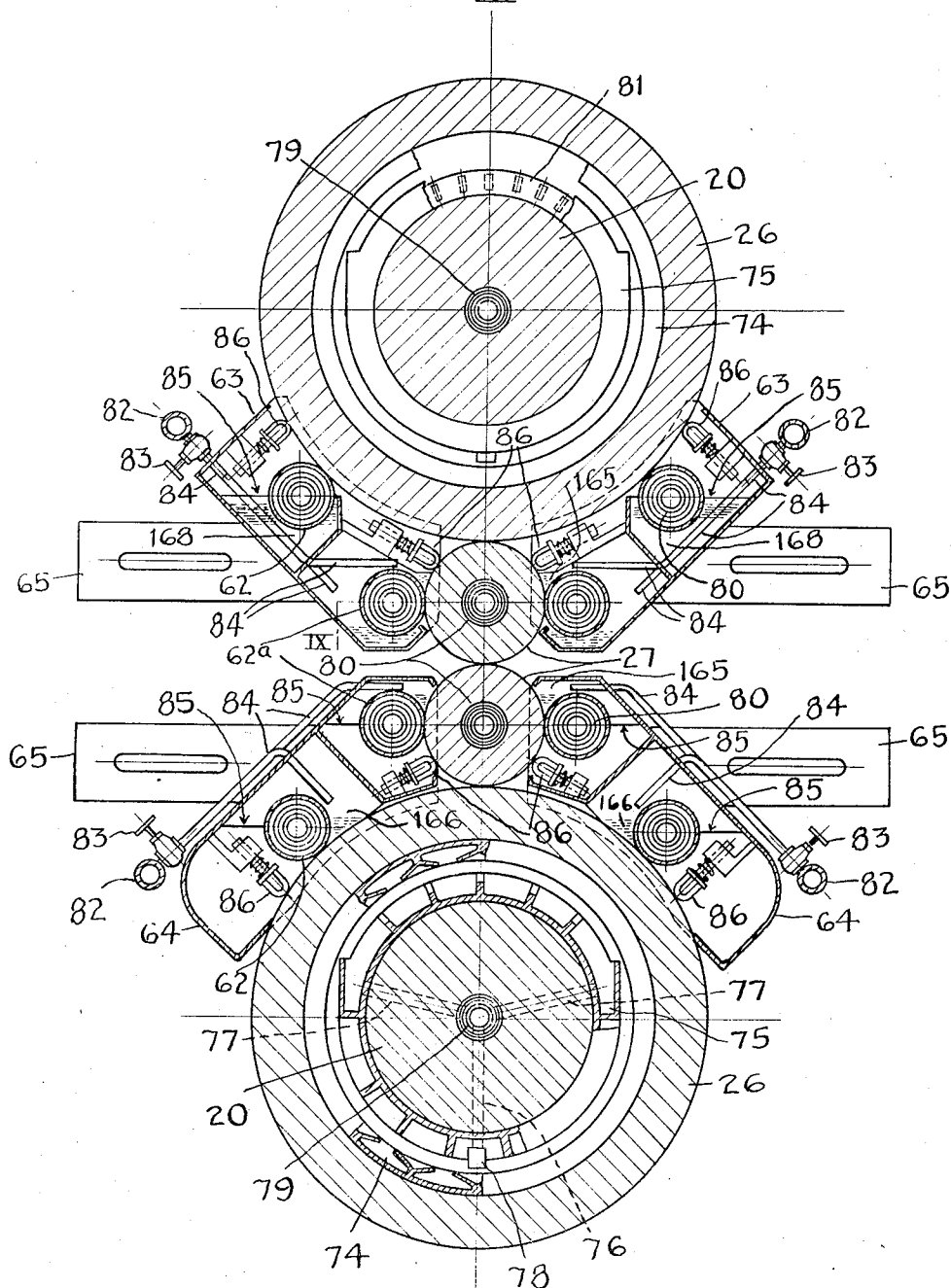
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Fig. 8.
IX



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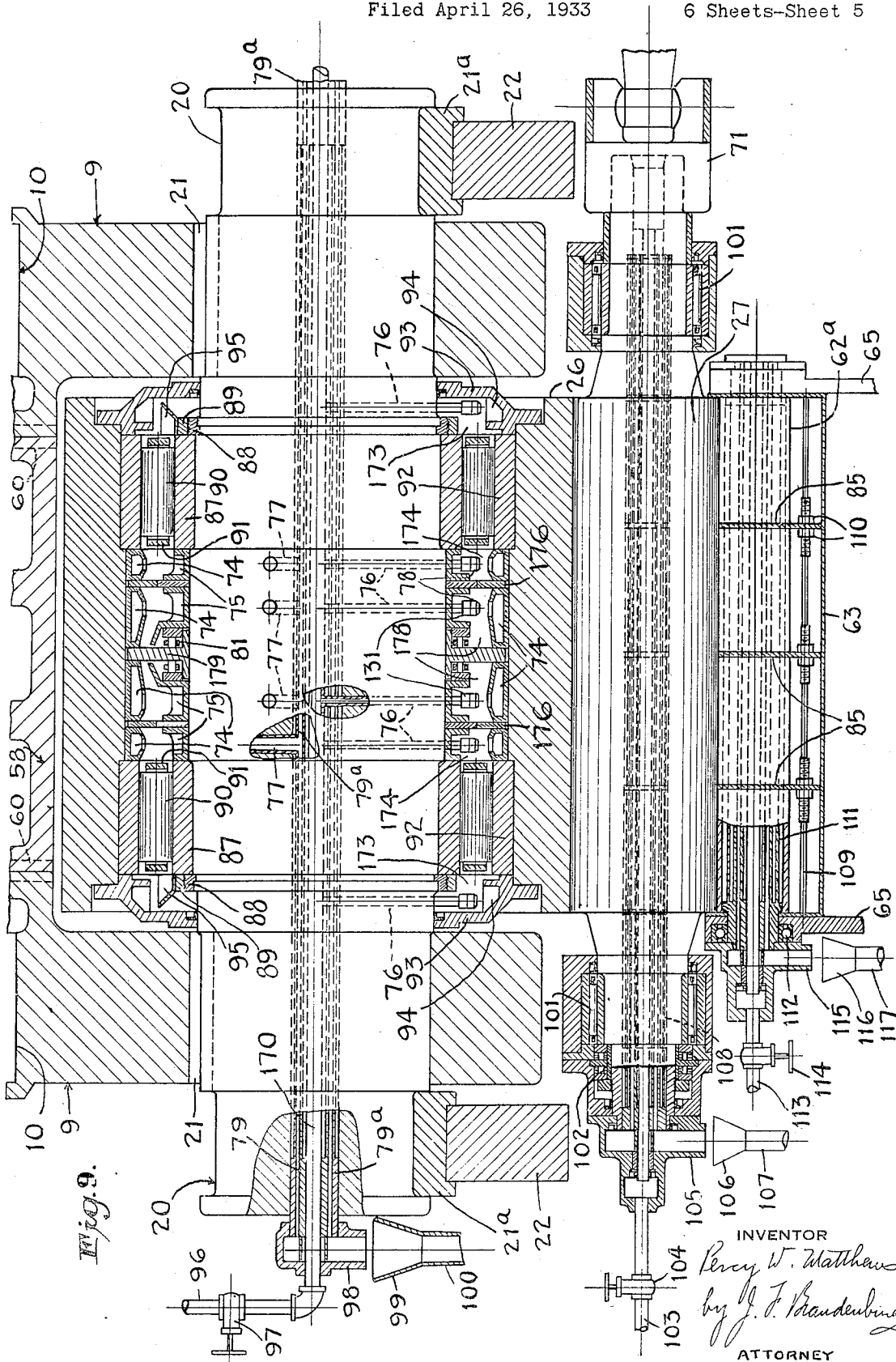
P. W. MATTHEWS

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ROLLING MILL

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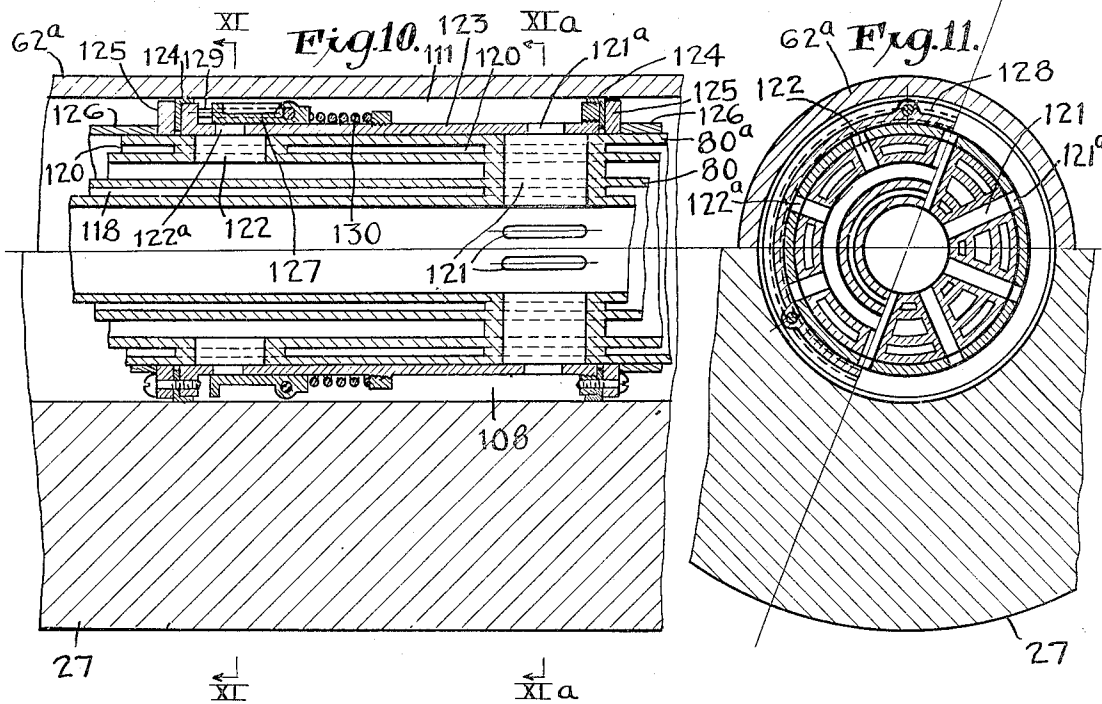
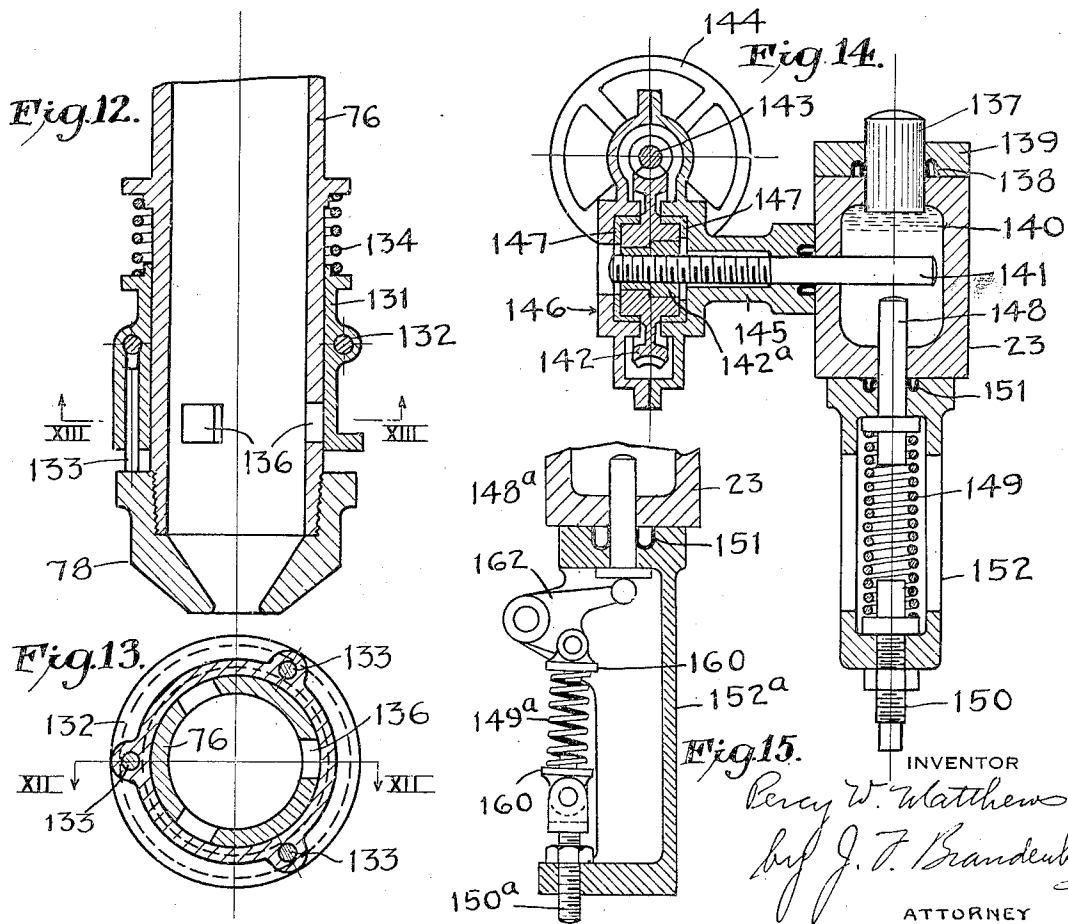
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2,056,433

ROLLING MILL

Percy W. Matthews, Pittsburgh, Pa., assignor, by direct and mesne assignments, of thirty-eight one-hundredths to Edgar J. Griffiths, Pittsburgh, Pa., nineteen one-hundredths to Joseph F. Brandenburg, Larchmont, N. Y., and five one-hundredths to Charles W. Neill, West Englewood, N. J.

Application April 26, 1933, Serial No. 667,997

42 Claims. (Cl. 30—38)

This invention relates to rolling mills, and more particularly to that class of rolling mills known to the industries as four-high mills, or mills having relatively small diameter working rolls backed up or supported by backing-up or supporting rolls of relatively large diameter.

Such mills are used to exert a tremendous pressure upon the material which is being elongated between the working rolls, exerting such pressure equally across the full width of the material being elongated between the working rolls and delivering a product which is flat and of practically equal thickness across its full width and for its full length.

Such mills require that the adjustment of the rolls, causing them to advance towards, or retreat from, each other, be made by very small increments.

Such mills require that the working and backing-up rolls be of practically constant diameter throughout their entire length, except that the backing-up rolls may have their diameter varying by extremely small amounts, being slightly larger in their middle than at their ends to compensate for any deflection that may take place in these rolls, due to the tremendous pressure that is exerted by them, on the working rolls.

Such mills also require that the temperature of the rolls be controlled within a very close range and that this temperature be maintained for the full length of the working rolls, in order that the diameter of the working rolls can be maintained constant and also that the temperature of the material, while in contact with the working rolls, can be maintained practically constant for its entire width and thus avoid a warped and buckled product coming from the mill.

Such mills also require that the faces of the rolls be lubricated with a suitable lubricant to prevent the material being rolled from adhering to the rolls and to produce a better finish on the rolled product.

Such mills also require that the upper backing-up roll and upper working roll be balanced and that such balancing means shall so support the rolls that there is no blow on the bearings, supporting the rolls, when the material enters or leaves the mill; also that the working roll balance shall provide the means for affording traction between the working rolls and the backing-up rolls for the purpose of driving the backing-up rolls.

Such mills also require that the means used for balancing the upper backing-up and working rolls provide for quickly and simply affording

working clearance for removing the backing-up and working roll units, bodily, from the mill when it becomes necessary to change the rolls.

In the known types of rolling mills, the tremendous pressure required for elongating material between the working rolls has been furnished by means of screws located on the top of each housing. Such screws are quite long and have the power required to rotate them applied at one end, while the resistance to their turning is offered at practically their other end, resulting in considerable torsional deflection taking place in the screws, which very greatly increases the friction between the threads on the screw and the threads in the screw-box or nut, and in many cases squeezes out the lubricant between the faces of the screw-threads and causes the screws to heat up and seize in the screw-boxes or nuts. This torsional deflection of the screws causes an unequal pressure to be exerted on the rolls and likewise on the material being elongated between the working rolls, resulting in the material being thicker at one side than at the other, for no matter how substantial the connecting shafting and gearing may be made, connecting the two screws together, this will not in any way reduce the torsional deflection in the screws. This torsional deflection reduces the useful work done by the screws on the rolls, and no matter how well the screws are made, or how close the physical properties of the material agree, from which the two screws were made, it is not practical to assume that each screw will torsionally deflect the same amount. Unless pressure-indicating devices are used between the ends of the screws and the roll supports and means are provided for operating one screw independently of the other, this pressure can not be equalized.

In the known type of rolling mills, the backing-up rolls have been supported in anti-friction bearings carried in bearing casings in the housings, which has resulted in these backing-up rolls becoming beams of considerable span, which in order to reduce deflection in the body of the rolls to a minimum have had to be made of extremely large diameter, making them extremely heavy, difficult and expensive to manufacture, as well as requiring expensive equipment to handle them.

In the known type of rolling mills, the controlling of the temperature and lubricating of the rolls has been accomplished by having streams of temperature-controlling fluid flowing over the faces of the rolls, with attempts made to control the internal temperature of the working rolls by

passing temperature-controlling liquid in at one end of the rolls and out at the other end.

An object of this invention is to provide a rolling mill in which the tremendous pressure required to elongate material between the working rolls of the mill can be applied, substantially equally, at each end of the backing-up rolls, both top and bottom, by means of bearing blocks of large area, so that the force is substantially uniformly distributed over the whole length of the backing-up rolls, and transmitted through the working rolls to the material being elongated between the working rolls, to produce a material that has had an equal pressure exerted on it over its entire width and length and is therefore of the same thickness over its entire width and length.

Another object is to provide working and backing-up rolls in which it is possible to efficiently control the temperature of these rolls by internal and external temperature-controlled zones, installing in each of these zones means whereby the supply of temperature-controlling fluid is thermostatically controlled at each zone, thus providing means whereby the diameter of the rolls is controlled within very close limits, and as desired, and also providing means for maintaining a practically constant temperature across the whole width of the material being elongated between the working rolls, while in contact with said working rolls, thus removing the danger of the material being warped and buckled upon its leaving the mill.

Other objects are to provide means for placing the anti-friction bearings for supporting the backing-up rolls inside the temperature-controlled zones of the rolls; to provide means for continuously supplying temperature-controlling lubricating fluid to these anti-friction bearings through thermostatically-controlled supply pipes at the zones; to provide means whereby it will not be possible to squeeze the lubricating fluid out of these bearings when operating the screw-down with the rolls stationary; to reduce the unsupported length of the backing-up rolls as much as possible, thus reducing the deflection in the rolls and likewise the necessity for having rolls of large diameter, resulting in a great saving in weight, cost of manufacture and of handling the rolls; and to provide means whereby it will be possible to have the backing-up and working rolls made of material which may be heat-treated and hardened to any extent desired.

Still other objects are to provide means whereby the top backing-up and top working rolls are balanced so that there is no blow on the anti-friction bearings, when the material enters or leaves the mill; to provide means for affording ample working clearance for the purpose of removing a top backing-up roll unit or the working roll units bodily from the mill when desired; to provide means for keeping the working rolls in tight contact with the backing-up rolls so as to furnish traction for driving the backing-up rolls by the working rolls; to provide zone-divided means whereby the faces of the backing-up and working rolls may be lubricated in an efficient and economical manner to prevent the material being rolled from adhering to them and to help produce a better finish on the material being rolled in the mill.

Other objects, features and advantages of the invention will appear or be pointed out as the specification proceeds.

In the accompanying drawings, forming part hereof:

Fig. 1 is a side elevation of a four-high mill made in accordance with the invention, having two working rolls and two backing-up rolls.

Fig. 2 is a diagrammatic view showing the relative positions of the rolls when applying the invention to a five-high mill having three working rolls and two backing-up rolls.

Figs. 3 and 4 are diagrammatic illustrations showing the use of four backing-up rolls in a four-high and five-high mill, respectively.

Fig. 5 is a sectional view on the line V—V of Fig. 7.

Fig. 6 is a fragmentary top plan view from the line VI—VI of Fig. 5.

Fig. 7 is an end view, looking to the right in Fig. 5, the cooling rolls and casing being removed, and a portion of the mill being shown in section taken on the line VII—VII of Fig. 1.

Fig. 8 is an enlarged sectional view through the working and backing-up rolls and the cooling rolls and casings.

Fig. 9 is an enlarged right-sectional view on the line IX—IX of Fig. 8.

Fig. 10 is an enlarged fragmentary sectional view, on radial planes, of a working roll and a cooling roll.

Fig. 11 is a sectional view, one-half on the line XI—XI and one-half on the line XII—XII of Fig. 10.

Fig. 12 is an enlarged detail sectional view of the thermostatically-controlled fluid supply nozzle, on the line XII—XII of Fig. 13.

Fig. 13 is a sectional view on the line XIII—XIII of Fig. 12.

Fig. 14 is an enlarged vertical sectional view of the fluid-filled accumulator and displacement balance cylinder for the working and backing-up rolls.

Fig. 15 is a sectional view, showing a modified form of a part of the structure illustrated in Fig. 14.

A mill housing 1 has housing supporting girders 2 on a bed plate 3. A drain tank 4 extends below the bed plate, and fluid flows from the tank through drain pipes 5. The housing 1 is securely keyed to the supporting girders 2 by keys 6, and the girders 2 and bed plate 3 can be fastened to a foundation by bolts 7. The girders are keyed to the bed plate by keys 8.

A rotatable screw-down equalizing shaft housing 9 has a cam face 10 in contact with a bearing block 11. There is a similar cam face at the other end of the equalizing shaft housing. The portions of the housing on which these cam faces are formed comprise "plate cams", the term being used in this specification to indicate a cam of the type in which the relative movement of the follower is at right angles to the axis of rotation of the cam, as compared with "cylindrical" cams in which the follower has all or at least a component of its movement in a direction parallel to the axis of rotation of the cam. The face of a plate cam may be as wide as desired.

A tapered wedge block 12 extends through the side wall of the mill housing, and has flanges 13 on each end to hold it in position. A tapered wedge 14 also extends through the side wall of the mill housing, and this wedge can be moved by a "pull" bolt 15 or "push" bolts 16 for lining up the rolls in case of any misalignment of the housings.

The housing 9 is movable vertically in side bearings 17. Each of these side bearings is horizontally adjustable by means of a tapered wedge 18.

The housing 9 is held in the mill housing by clamps 19.

A rotatable screw-down equalizer shaft 20 is keyed to the housing 9 by a key 21. The shaft 20 turns on a bearing block 21a, which is supported by a balance beam 22. An accumulator or displacement balance cylinder 23 is filled with mercury or other suitable fluid, and is supported under one end of the balance beam 22 by a lug 24 on the side of mill housing 1. A similar lug 24a supports a pivot bracket 25 under the other end of the balance beam 22. The function of the cylinder 23 and pivot bracket 25, and the operation of the balance beam 22 will be explained hereinafter. The construction thus far described is the same on both sides of the mill.

Backing-up rolls 26 of large diameter contact with working rolls 27, which are of relatively small diameter. The lower and upper working rolls have housings 28 and 29, respectively, and tapered wedges 30 and 31, respectively, are used for lining up the housings. Clamps 32 and 33 hold the housings 28 and 29, respectively, in the mill housing. An accumulator and displacement balance cylinder 34 is filled with mercury or other suitable fluid. This cylinder 34 is for balancing the upper backing-up roll, as will be more fully explained in the description of Fig. 14.

Figs. 2 and 4 are diagrammatic views showing five-high mills with one and two backing-up rolls for the top and bottom working rolls. Fig. 3 shows the location of the backing-up rolls when using two for each working roll of a four-high mill. These views illustrate three of the modifications which can be made in the preferred embodiment of the invention.

Fig. 5 shows top and side separators 35 and 36, respectively, for the mill housing. A screw 37 is partially enclosed by an upper screw-down housing 38 and screw-down housing cover 39. The screw 37 threads through a screw-box or nut 40, and has a guide block 40a which slides in the housing cover 39.

A worm-wheel 41 is driven by a worm and shaft 42. An anti-friction thrust bearing 43 is located between the mill end of the screw-box or nut 40 and the worm-wheel 41, and a bushing 44 is located between the screw-down housing 38 and the hub of the worm-wheel 41. At the other side of the worm-wheel there is a bushing and thrust washer 45 between the screw-down housing cover 39 and the hub of the worm-wheel 41.

The worm and shaft 42 are driven by a worm-wheel 46, which is rotated by a worm and shaft 47. A flexible coupling 48 connects the worm and shaft 47 with an electric motor 49. The electric motor has a magnetic brake 50, which is released by power supplied to the motor but strong enough to prevent rotation of the motor when the power is not turned on. A bracket 51 supports the motor. The worm reduction gearing described is contained in a case 52. Similar screw-down mechanism is provided for the bottom backing-up roll.

A clevis 53, on the end of the screw 37, is connected to a link 54 by a pin 55. Rollers 56 (Fig. 6) on opposite ends of the pin 55 run in guides 59 which are attached to the housing 38.

The rotatable housings 9 are securely tied together by a connecting frame 58. Keys 60 (Figs. 7 and 9) insure permanent alinement of the housings 9 and connecting frame 58.

The lower screw-down housing 61 forms a part of the supporting girder 2. The other parts of the lower screw-down mechanism are similar to

that already described for the upper backing-up roll and are designated by the same reference characters.

Temperature-controlling rollers 62 and 62a contact with the backing-up rolls 26 and working rolls 27, respectively. These rollers can be used to either heat or cool the rolls with which they contact. For some rolling processes it is desirable to add heat to the working rolls, and for other rolling processes it is necessary to cool the working rolls. There are two temperature-controlling rollers 62 for the upper backing-up roll and two temperature-controlling rollers 62a for the upper working roll. All of these upper temperature-controlling rollers are contained in an upper roller casing 63. The lower temperature-controlling rollers are contained in a lower roller casing 64. Each of the roller casings is supported by an arm 65 slidable in a guide 66.

Both the upper and lower links 54 are connected to their respective frames 52 by pins 67.

Referring to Fig. 7, a pipe 68 connects the tanks 4. Bushings 69 and 70 are shown surrounding the pins 67. Bushings can also be used as bearings for the pin 55 (Figs. 5 and 6). Anti-friction bearings can be substituted for these bushings. Universal jaw ends 71 cooperate with driving spindles for driving the working rolls 27.

Inside of each backing-up roll 26 is a fluid discharge trough 75 (Fig. 8), a fluid supply pipe 76, and fluid return pipe 77. Fluid from the pipe 76 is supplied through a nozzle 78 on the end of the pipe 76. Heat-insulated fluid supply and return pipes 79 and 79a, respectively, extend along the axis of the backing-up roll 26. Other heat-insulated fluid supply and return pipes 80 and 80a, respectively, extend along the axis of the working roll 27.

An anti-friction thrust bearing 81 is located midway between the ends of the backing-up roll.

Fluid for the outside of the temperature-controlling rolls 62 and 62a is supplied through headers 82. Shut-off valves 83 control the supply of fluid from the header 82, through individual supply lines 84, to the separate compartments of the roller cases 63 and 64.

Each of the compartments of the roller cases 63 and 64 has laterally adjustable division baffles 85. Spring-controlled wipers 86 have tips of felt or other suitable material in contact with the faces of the rolls for wiping off any excess liquid or foreign matter.

Referring to Fig. 9, anti-friction bearings have their inner races 87 securely clamped against lateral movement on the shaft 20 by means of split collars 88 and locking nuts 89. These anti-friction bearings have rollers 90, and cages or separators 91 for separating and alining the rollers 90. Their outer races 92 are securely clamped to the backing-up roll 26 by means of end covers 93.

Conveyer buckets 94 on the inside faces of the end covers carry up liquid and discharge it into hoppers 95, from which it flows into the anti-friction bearings.

A fluid supply pipe 96, having a shut-off valve 97, connects with one end of the pipe 79. A discharge head 98 at the end of the pipe 79a is located above a funnel 99 at the entrance to a drain line 100.

A neck at each end of the working roll 27 runs in an anti-friction bearing 101. The end of the working roll remote from the universal jaw end 71 is provided with an anti-friction thrust bearing 102. Fluid is supplied to the working roll through a supply line 103 and valve 104. The fluid from

the pipe 80a flows from a discharge head 105 into a funnel 106 at the entrance to a drain line 107. An annular space 108 between the inside wall of the working roll and the outside of the pipe 80a is used for thermostatic zone-temperature-control units which will be explained in describing Fig. 10.

A threaded rod 109 extends through the division baffles 85, and the baffles are held in position by nuts 110 threaded on the rod.

The temperature-controlling roller 62a has an annular space 111 for thermostatic zone-temperature-control units. The ends of the roller run in anti-friction bearings 112, one of which is shown in Fig. 9. Fluid is supplied to the temperature-controlling roller through a supply pipe 113 and valve 114. A discharge head 115 directs fluid flowing from the temperature-controlling roller 62a into a funnel 116 at the top of a drain pipe 117.

Figs. 10 and 11 show the pipes which extend along the axes of one of the working rolls 27 and one of the temperature-controlling rollers 62a. The pipes within the other working roll and other temperature-controlling rollers are similar to those shown in these views. The fluid supply pipe 80 has a double wall and an insulating space 118 between the walls. The fluid return pipe 80a has a double wall enclosing an insulating space 120. The pipes 80 and 80a communicate with the annular space 111 through ports 121 and 122, respectively.

A sleeve 123 surrounds the pipe 80a and has openings 121a and 122a in register with the ports 121 and 122. A packing ring 124 and a packing backing-up ring 125 at each end of the sleeve 123 close the space between the pipe 80a and the inside wall of the roll 62a. The rings 125 contact with spacing sleeves 126.

A sleeve 127 has an annular mercury chamber 128 from which extend cylindrical portions in which plungers slide as the mercury expands and contracts with changes of temperature. One such plunger 129 is shown in Fig. 10. The construction will be more fully explained in the description of Figs. 12 and 13. A spring 130 urges the sleeve 127 into a position over the ports 122a to cut off the flow of fluid through these ports. The plungers 129 bear against a shoulder at the end of the sleeve 123, and when the mercury in the sleeve 127 expands, it thrusts against the plungers 129 and forces the sleeve 127 toward the right in Fig. 10 so that the ports 122a are opened. The degree of opening depends on the expansion of the mercury which is heated by the fluid in the annular space 111. The piping and thermostat control in the working roll 27 are the same as that described for the temperature-controlling roll 62a.

Figs. 12 and 13 show a thermostatically controlled sleeve 131 on the lower end of one of the fluid supply pipes 76 similar to the thermostatic control means of the sleeve 127. A mercury chamber 132 has cylindrical portions in which plungers 133 are slidable. A spring 134 is compressed between the sleeve 131 and a collar on the pipe 76. This spring 134 urges the sleeve 131 toward the nozzle 78 at the end of the pipe so that the plungers 133 contact with the nozzle 78. When the mercury in the chamber 132 expands with heat, it causes relative movement between the sleeve 131 and plungers 133. Since the plungers are prevented from moving by the nozzle 78, the sleeve is moved away from the nozzle. When the mercury contracts, the spring 134 moves the sleeve toward the nozzle 78.

The nozzle 78 has a small discharge orifice, and

there is a plurality of ports 136 around the periphery of the pipe 76 above the nozzle 78. These ports 136 are covered by the sleeve 131 except when the fluid in the zone gets hot enough to cause the mercury to expand and move the sleeve 131 upward until it uncovers the ports 136. When the invention is used to supply heat to the rolls and rollers, the openings uncovered by the thermostatically operated sleeves are located so that movement of the sleeves by expansion of the mercury closes the openings through which the heating fluid circulates.

Fig. 14 is a sectional view through the cylinder 23 and adjacent parts. A plunger 137 extends through the top of the cylinder 23. A packing ring 138 around the plunger is held in place by a cover 139. The cylinder is filled with mercury 140, or other suitable fluid, and a displacement plunger 141 extends through the side of the cylinder.

A worm-wheel 142 is secured to a nut 142a, which fits a threaded end portion of the displacement plunger 141. The worm-wheel is operated by a worm and shaft 143, and the shaft is turned by a hand-wheel 144, or an electric motor may be substituted for the hand-wheel.

The worm-wheel 142 and part of the displacement plunger 141 are enclosed in a housing 145 having a cover plate 146. Bearings 147 on both sides of the worm-wheel 142 contact with an outside bearing surface on the hub of the worm-wheel and also extend over the ends of the hub to serve as thrust bearings.

A balancing-adjusting plunger 148 is urged upward by a spring 149, and the compression of this spring is adjustable by an adjusting screw 150, which threads through a bracket 152. One end of the balance beam 22 (Fig. 1) is supported by the plunger 137. The mercury or other fluid in the cylinder 23 is under pressure from the spring 149 and the plunger 137 is therefore urged upward by the spring acting through the liquid and the plunger 137 can move downward by displacing the adjusting plunger 148 against the pressure of the spring. The cylinder 23 and its associated elements thus provide means whereby the faces of all supporting members for the top backing-up roll are held in close contact with one another and remove any danger of the anti-friction bearings receiving a blow when the material enters or leaves the mill.

Fig. 15 shows a modified construction for exerting spring pressure on a balance-adjusting plunger 148a. The spring 149 shown in Fig. 14 causes a varying pressure to exist in cylinder 23, dependent on the amount of compression of the spring. This variation in pressure is in some cases undesirable. Fig. 15 shows levers used in combination with spring 149a to produce a constant pressure on cylinder 23, which arrangement of levers compensates for the varying force exerted by the spring for the various working deflections of the spring. Instead of bearing directly against a screw 150a and plunger 148a, the spring 149a has fittings 160 at its ends, and these fittings are pivotally connected to the adjusting screw 150a and a second class lever 162 which is fulcrumed on a bracket 152a and contacts with the bottom of the plunger 148a.

The operation of the invention is as follows:

Referring to Fig. 9, a temperature-controlling fluid of high specific heat and of a predetermined pressure and temperature is supplied to the roll 27 by supply pipe 103, the flow of which fluid may be shut off or regulated by valve 104. The supply pipe 103 is connected by suitable means to central

insulated supply pipe 80, which extends for practically the full length of the interior of the working roll 27. The circulation of the fluid within the working roll is the same as in the cooling roller 62a, which will be described. The fluid returns from the working roll 27 through the annular space 108 and discharge head 105, to the funnel 106 at the top of the drain line 107.

The interior of the working roll 27 may be divided into any number of temperature-controlling zones, with means for thermostatically controlling the supply of temperature-controlling fluid inside each zone. For the purpose of illustration, six such zones have been provided, but I do not limit myself to such a number.

The drawings and specification disclose temperature-controlling means for absorbing heat from the working and backing-up rolls. I do not, however, limit myself to this feature as the means shown may be used for supplying heat to the temperature-controlling backing-up and working rolls without in any way departing from the essential features.

The temperature-controlling and lubricating of the exterior of the working rolls 27 and backing-up rolls 26 will now be described.

Referring to Fig. 8, temperature-controlling rollers 62a and 62 are held in contact with the faces of the working rolls 27 and backing-up rolls 26, and are revolved by frictional contact with the rolls. V-shaped spaces 165 are formed between the rollers 62a and working rolls 27, and V-shaped spaces 166 are formed between lower backing-up rolls 26 and rollers 62. Reservoirs 168 are provided in the upper roll casing 63, in which the rollers 62 in contact with the face of the upper backing-up roll 26 are immersed in lubricant. The V-shaped spaces 165 and 166 and the reservoirs 168 are divided up into zones by means of baffles 85, which are adjustably mounted on rods 109 (Figs. 8 and 9) and secured in predetermined positions on them by means of nuts 110. The baffles 85 are constructed of suitable material, which will not mark or scratch the rolls or rollers.

A suitable lubricant is furnished to each zone of the zone-divided spaces 165, 166 and reservoirs 168 from the supply headers 82 by means of the individual supply pipes 84, which are each equipped with regulating and shut-off valves 83.

Referring to Fig. 9, the temperature-controlling roller 62a is in the form of a thin hollow cylinder containing heat-insulated supply and return pipes 80 and 80a, to which pipes the ends of roller 62a are suitably attached. The ends of pipes 80 and 80a are suitably arranged for the mounting of the inner races of the anti-friction bearings 112, while the outer races of the anti-friction bearings 112 are mounted in the supporting arms 65 of the upper and lower roller casings 63 and 64.

The roller casings 63 and 64 to which are attached the arms 65 (Fig. 5) are slidably mounted in guides 66 provided on housing 1.

Referring to Figs. 10 and 11, the annular space 111 is provided between the interior of the roller 62a and the exterior of the heat-insulated return pipe 80a. The thermostatically-controlled temperature-control units, already described, are located in this annular space 111.

Referring back to Fig. 9, a temperature-controlling fluid of high specific heat and of a predetermined pressure and temperature is furnished to the temperature-controlling roller 62a by means of the supply pipe 113, the supply being regulated or shut off by valve 114. Pipe 113 is

suitably connected to the central heat-insulated supply pipe 80.

The pipe 80 has a series of supply ports 121 arranged throughout its length, and the pipe 80a has return ports 122 which connect the interior of the pipes 80 and 80a with the annular space 111 formed between the outside of the pipe 80a and the interior of the roller 62a. In the annular space 111 are installed the sleeves 123 upon each end of which are arranged the packing rings 124 backed up by backing rings 125, thus sealing off portions of the annular space 111 into zones. In each sleeve 123 are a series of ports 121a for the supply, and 122a for the return, of the temperature-controlling fluid. Mounted on the sleeve 123 is a thermostatically controlled sleeve 127, which is provided with a circular mercury chamber 128 and plungers 129, one end of the plungers 129 being in contact with the mercury in the chamber 128, the other end in contact with a flange on the end of the sleeve 123. Between the back of the sleeve 127 and the collar on sleeve 123, there is a spring 130, which forces the sleeve 127 toward the left in Fig. 10 to close the ports 122a.

Central supply pipe 80, return pipe 80a, and annular space 111 are insulated from one another by means of the sealed spaces 118 and 120, thus preventing as far as possible the transfer of heat between the supply and return temperature-controlling fluid. The sleeves 123 will be prevented from turning on the pipe 80a by suitable means. The sleeves 123 may be separated in the annular space 111, if desired, and spacing sleeves 126 or other suitable means may be used for the purpose of separating them. It will thus be seen that the temperature-controlling fluid entering the zone formed by the sleeve 123 absorbs heat from the roller 62a, expands the mercury in the chamber 128, which acts on plungers 129 and moves the sleeve 127, uncovering the return ports 122a in sleeve 123, and allowing the temperature-controlling fluid to pass into ports 122a connecting annular space 111 to return pipe 80a through which the fluid flows to the discharge head 115 and into open funnel 116 connected to drain line 117.

Thus it will be seen that the interior of the working roll may be divided up into any number of temperature-controlling zones with means for thermostatically controlling the supply of temperature-controlling fluid inside each zone.

Fluid from the drain lines 107 and 117 flows to a central treating plant, where the temperature-controlling fluid is brought back to a predetermined temperature and returned under a predetermined pressure to the supply pipes 103 and 113.

The control of the temperature of the backing-up rolls will now be described. Referring to Figs. 8, 9, 12, and 13, temperature-controlling fluid is supplied by pipe 96, the fluid supply being controlled or shut off by valve 97. Pipe 96 is connected in a suitable manner to central supply pipe 170 within the insulated supply pipe 79. Connecting to central supply pipe 170 is a series of pipes 76, which discharge into a series of zones as follows: Zone 173 formed by the end covers 93 and anti-friction bearings comprising inner race 87, outer race 92 and aligned and separated rollers 90; zone 174 formed by the aforesaid anti-friction bearings and diaphragms 176; and zones 178 formed by the diaphragms 176 and the central thrust plate 179 of the double-acting anti-friction thrust bearing 81.

Each of the fluid supply pipes 76 is equipped at its end with a nozzle 78 having a small discharge orifice. A series of ports 136 (Figs. 12 and 13) are provided in the periphery of the pipe 76, these ports being covered by the sleeve 131 having the circular mercury chamber 132 and the plungers 133, one end of the plungers 133 being in contact with the nozzle 78 and the other end in contact with the mercury in the mercury chamber 132.

A temperature-controlling fluid supply pipe 76 with thermostatically controlled discharge ports 136 is shown discharging fluid into each zone 173, part of the fluid flowing directly into the anti-friction bearing and into zone 174, and the balance of the fluid being conveyed up the side of the zone 173 by means of the buckets 94 provided around the periphery of the end covers 93. The buckets when approaching the top of zone 173 become inverted and discharge their contents into the hopper 95, which directs the fluid into the anti-friction bearing, keeping all parts of the anti-friction bearing thoroughly flooded with temperature-controlling fluid. Another of the fluid supply pipes 76 discharges into zone 174, because the temperature of the temperature-controlling fluid leaving the anti-friction bearing may be beyond the range of the temperature desired to be maintained in this zone, and therefore additional temperature-controlling fluid must be supplied to this zone.

Another of the temperature-controlling fluid supply pipes 76 discharges fluid into each of the zones 178. The temperature-controlling fluid is conveyed up the sides of zones 174 and 178 by means of the buckets 74, which, when approaching the top of the zones 174 and 178, become inverted and discharge their contents into discharge troughs 75, which are connected by pipes 77 to the insulated return pipe 79a which discharges the fluid through the discharge head 98 into the open funnel 99 attached to drain pipe 100, from where it flows to a central temperature-controlling fluid-treating plant, where it may be filtered, pumped, temperature-regulated and returned at a predetermined temperature and a predetermined pressure to the supply pipe 96.

At zones 178 a portion of the discharge troughs 75 are carried up over the top of the double-acting anti-friction thrust bearings to prevent buckets 74 from discharging their contents back down into zones 178 through the thrust bearings.

Thus the backing-up roll is divided into a number of temperature-control zones, and the temperature-controlling fluid is admitted to each zone by thermostatically controlled means located in each zone and operated as follows: The supply pipes 76 upon which are mounted the sleeves 131 are submerged in temperature-controlling fluid in each zone, to such a depth that the mercury chamber in sleeve 131 is adequately covered so that any change in the temperature of the fluid will cause the mercury to expand in the chamber and force sleeves 131 up, uncovering ports 136 and admitting an increased volume of fluid to the zone. It will also be seen that this interior zone dividing of the backing-up rolls, together with the interior zone-divided temperature-controlling rollers 62, provides means for controlling the diameter of the backing-up rolls within reasonable limits, for the purpose of compensating for any deflection that may take place in these rolls. The interior zone-dividing of the working rolls 27, together with the interior zone-divided temperature-controlling rollers 62a, provides

means for controlling and maintaining a practically constant temperature and likewise a practically constant diameter of the working rolls for their entire length, so that the material elongated between the working rolls is of substantially the same thickness for its entire width and length. The temperature of the material elongated between the working rolls, when worked cold or comparatively cold, is practically constant over its entire width since any transfer of heat from the working rolls to the material or from the material to the working rolls is practically even over the full width of the material, so that the material after rolling is flat and not warped or buckled. When rolling material having a higher temperature than the temperature of the working rolls, any difference in the temperature of the material, in any part of its width, over the temperature of any other part of its width, causes a greater rate of heat transfer from the material to the working rolls at such part, so that the material will leave the rolls at a more nearly even temperature, thereby reducing to a minimum the warping and buckling caused by uneven temperature.

The invention is not limited to the number of rolls or rollers shown, or to any particular number or length of temperature-controlling zones, or number and location in each zone of supply pipes 76. The number and type of anti-friction bearings can be changed. Separate supply pipes can be carried to each zone in place of the central supply pipe 170, and other changes and modifications may be made, and various features of the invention may be used alone or in combination with other features, without departing from the invention as defined in the claims.

I claim:

1. A sheet rolling mill comprising a set of working rolls through which the material passes, a set of backing-up rolls for holding the working rolls against the material during a rolling operation, one set of rolls being hollow with a plurality of partitions spaced axially on the inside of each roll and dividing the roll into several temperature-controlling zones along the length of the roll behind its peripheral face, and means for supplying separate streams of fluid to the respective zones to control the temperature of the roll throughout its length.

2. In a rolling mill for rolling sheet material of any practical width up to a width substantially equal to the length of the body of the rolls, the combination of two sets of rolls consisting of upper and lower hollow working rolls having working faces of uniform diameter throughout their width, and upper and lower backing-up rolls, a bearing at each end of each working roll, a plurality of partitions in each working roll spaced axially and dividing the roll into temperature-controlling zones, several of which are within the length of the working face of the roll and at least one of which is located in the bearing at each end of the roll, and means for supplying fluid to the respective temperature-controlling zones to maintain the temperature and diameter of the roll substantially constant.

3. In a rolling mill, a hollow roll having a body portion, partitions in said roll spaced axially and dividing the roll into several temperature-controlling zones, conduits through which fluid flows to and from the respective zones, said zones being sufficiently numerous and sufficiently short, in relation to the size of the roll, to maintain the temperature and diameter of the roll substantial-

ly constant when the rolling mill is in operation.

4. In a rolling mill, a hollow roll, partitions dividing the interior of the roll into several cylindrical axially extending temperature-controlling zones, conduits for the flow of liquid to and from the respective zones, and means for independently controlling the flow of liquid through said zones, including a thermostat for each zone.

5. In a rolling mill, a hollow roll with its interior divided by partitions into several axially extending, cylindrical chambers, conduits through which separate streams of liquid flow to and from the respective chambers, and means for controlling the rate of flow through the respective chambers including a thermostat for each chamber exposed to the heat of the liquid in that chamber.

6. A rolling mill including a hollow roll containing two axially spaced partitions, a chamber for temperature-controlling liquid between said axially spaced partitions, another temperature-controlling liquid chamber in the roll adjacent the chamber between said partitions, a conduit for liquid extending through the adjacent chamber and opening into the chamber between said partitions, and heat insulating means over said conduit to minimize heat transfer through the walls of the conduit where it passes through said adjacent chamber.

7. A rolling mill including a hollow roll containing two axially spaced partitions, a chamber for temperature-controlling liquid between said axially spaced partitions, another temperature-controlling liquid chamber in the roll adjacent the chamber between said partitions, a conduit for supplying liquid to the chamber between said partitions, another conduit for the flow of liquid from the chamber between said partitions, both of said conduits extending through said adjacent chamber, and heat insulating means over each of said conduits to minimize heat transfer through the walls of said conduits.

8. In a rolling mill, a hollow roll divided by axially spaced partitions into several temperature-controlling zones, a pipe extending through the partitions and opening into each of said zones, and heat insulating means surrounding the pipe to prevent any substantial transfer of heat between the liquid in the pipe and the temperature-controlling zones through which it passes.

9. In a rolling mill, a hollow roll divided by axially spaced partitions into several temperature-controlling zones, a common supply conduit passing through the roll and opening into each of said zones for supplying temperature-controlling liquid to said zones, a common discharge conduit passing through the roll and opening into each of said zones, and heat insulating means over both of said conduits.

10. In a rolling mill for rolling sheet material of various widths, the combination of two sets of rolls consisting of an upper and a lower hollow working roll and upper and lower backing-up rolls, together with means inside of the working rolls dividing the interior of said working rolls into several zones and controlling the temperature and likewise the diameter of the working rolls in said zones, including thermostatically controlled means located in said zones, and bearings for supporting and locating said hollow temperature-controlled zone-divided working rolls.

11. In a rolling mill for rolling sheet material of various widths, the combination of two sets of rolls consisting of an upper and a lower

working roll and an upper and a lower hollow backing-up roll, together with means inside of the backing-up rolls dividing the interior of said backing-up rolls into several zones, thermostatically controlled means located in said zones for controlling the temperature and likewise the diameter of the backing-up rolls, within the limits of said zones, by means of temperature-controlling fluid supplied through said thermostatically controlled means, and means for removing said temperature-controlling fluid from said zones.

12. In a rolling mill for rolling sheet material of various widths, the combination of two sets of rolls consisting of an upper and a lower hollow temperature-controlled zone-divided working roll, and upper and lower hollow temperature-controlled zone-divided backing-up rolls, together with hollow temperature-controlled zone-divided temperature-controlling rollers in contact with the exterior of said working rolls and cooperating with the working roll internal temperature control to control the temperature and diameter of said working roll within the limits of said zones, together with zone-divided means for continuously lubricating the faces of said working rolls.

13. In a rolling mill for rolling sheet material of various widths, the combination of two sets of rolls consisting of an upper and a lower hollow temperature-controlled zone-divided working roll, and upper and lower hollow temperature-controlled zone-divided backing-up rolls, together with hollow temperature-controlled zone-divided temperature-controlling rollers in contact with the exterior of said backing-up rolls and cooperating with the internal temperature-control of the backing-up rolls to control the temperature and diameter of said backing-up rolls within the limits of said zones, together with means for continuously lubricating the faces of said backing-up rolls.

14. In a rolling mill for rolling sheet material of any practical width up to a width substantially equal to the length of the body of the rolls, the combination of two sets of rolls consisting of an upper and a lower hollow temperature-controlled zone-divided working roll, and upper and lower hollow temperature-controlled zone-divided backing-up rolls, together with hollow temperature-controlled zone-divided temperature-controlling rollers in contact with said working and backing-up rolls for controlling the temperature of the exterior of said working and backing-up rolls, together with means for continuously supplying suitable temperature-controlling fluid to the temperature-control zones of said working rolls, backing-up rolls and temperature-controlling rollers at any predetermined desired pressure and temperature, and zone-divided means for lubricating the faces of said working and backing-up rolls.

15. In a sheet rolling mill, hollow working rolls between which the sheets pass, means for supplying temperature-controlling fluid to a multiplicity of zones within each working roll to maintain the temperature and diameters of the working rolls uniform throughout their width, hollow backing-up rolls in contact with the working rolls for holding them against the work with great pressure, bearings located in each backing-up roll and spaced from the ends of the roll to reduce the unsupported span of said roll so that it is subject to substantially no deflection when under load, and means for supplying temperature-controlling fluid to a multiplicity of zones in each of

the backing-up rolls to maintain the temperature and diameter of the backing-up roll uniform throughout its width.

16. In a rolling mill having working rolls, and hollow backing-up rolls, anti-friction bearings for each hollow backing-up roll, said bearings being located within the backing-up roll behind the face of the roll for reducing the unsupported span of said backing-up roll, and means for controlling the temperature of each backing-up roll including axially spaced partitions dividing the hollow interior of the backing-up roll into zones, and conduits for supplying temperature-controlling liquid to said zones.

17. In a sheet rolling mill, hollow rolls, means for circulating fluid through said rolls to control their temperature, and other means for controlling the temperature of said rolls including temperature-controlling rollers in contact with the peripheral surfaces of said hollow rolls.

18. A sheet rolling mill comprising working rolls between which the sheet passes, backing-up rolls in contact with the working rolls for holding them against the sheet with great pressure, means for circulating fluid through the working rolls to control their temperature, and other means for controlling the temperature of said working rolls including temperature-controlling rollers in contact with the peripheral surfaces of the working rolls.

19. A sheet rolling mill comprising hollow working rolls between which the sheet passes, means for circulating fluid through the working rolls for controlling their temperature, hollow backing-up rolls in contact with the working rolls for holding them against the sheet with great pressure, means for circulating fluid through the backing-up rolls for controlling their temperature, and auxiliary temperature controlling means for the working rolls and backing-up rolls, said auxiliary temperature-controlling means including rollers in contact with the peripheral surfaces of the working rolls and backing-up rolls.

20. In a rolling mill, working rolls, hollow backing-up rolls with axially spaced partitions dividing the hollow interior of each backing-up roll into temperature-controlling zones, means for circulating liquid through said zones, and bearings for the backing-up rolls including anti-friction members located in certain of the temperature-controlling zones.

21. A temperature-controlling roller comprising a hollow body portion, axially spaced partitions dividing the interior of the roller into several chambers for the circulation of temperature-controlling liquid behind the face of said roller, and conduit means within said roller for the supply and discharge of the temperature-controlling liquid to and from the respective chambers in proportion to the amount of heat transferred through the portion of the roll face overlying said chamber.

22. A temperature-controlled roll having a hollow body portion, partitions in the roll spaced axially and dividing the roll into several temperature-controlling zones, conduits through which fluid flows to and from the respective zones, said zones being sufficiently numerous and sufficiently short, in relation to the size of the roll, to maintain the temperature of the roll substantially constant across its width when the face of the roll is rolling on a surface which exposes the roll to different temperatures across its width.

23. In a rolling mill having a working roll and

a hollow backing-up roll, bearings located within the backing-up roll and behind the face of the roll to reduce the unsupported span of said backing-up roll, and means for controlling the temperature of the backing-up roll including axially spaced partitions dividing the hollow interior of the backing-up roll into temperature-control zones with the bearings in separate zones, and conduits for supplying temperature-controlling liquid to the respective zones.

24. In a rolling mill having a working roll and a hollow backing-up roll, axially spaced partitions dividing the hollow interior of the backing-up roll into temperature-controlling zones, means for circulating liquid through said zones, and bearings for the backing-up roll located in certain of the temperature-controlling zones.

25. The combination with a rolling mill having working rolls for rolling sheets, and backing-up rolls for holding the working rolls against the work with great pressure, of mechanism for controlling the pressure of the rolls including rotary plate cams located near opposite ends of a backing-up roll, supporting means on which each cam turns in a fixed plane of rotation, mechanism for rotating both of the cams in unison so that both ends of the backing-up roll move an equal distance, and means within the rolls for maintaining a substantially uniform temperature across the width of the rolls, so that the diameter of the rolls and the pressure on the working rolls on the work is maintained equal across the entire width of the work.

26. In a rolling mill for rolling sheet material of any practical width up to a width substantially equal to the length of the body of the rolls, the combination of two sets of rolls including an upper and a lower working roll and an upper and a lower hollow backing-up roll, each of which is divided internally into several zones across its width for temperature-controlling fluid, means for bringing the rolls together by an equal amount from end to end to regulate the pressure against the work, said means comprising an equalizing shaft extending through and projecting beyond the end of each backing-up roll, a cam rigidly connected to each end of the equalizing shaft, a connecting frame joining both cams, and mechanism connecting with said frame for moving it and the cams and equalizing shaft in unison.

27. In a rolling mill for rolling sheet material of various widths, the combination of two sets of rolls consisting of an upper and a lower working roll and an upper and a lower temperature-controlled zone-divided hollow backing-up roll, together with means including rotatable equalizing shafts for bringing the rolls together by an equal amount from end to end so that said rolls offer substantially the same resistance for their whole length to the material being rolled, inner races on said rotatable equalizing shafts, outer races in said temperature-controlled zone-divided hollow backing-up rolls, separated and aligned continuously-lubricated rollers between said inner and outer races, means for continuously supplying temperature-controlled lubricant to said rollers and said inner and outer races, and means for removing said lubricant.

28. In a rolling mill of the class having working rolls held against the work by backing-up rolls, the combination with at least one of the backing-up rolls of an equalizer shaft extending through said backing-up roll, cam means secured to the equalizer shaft, means for moving the shaft and cam means in unison, several temperature-

controlling zones in the backing-up roll, and conduits for the flow of fluid to and from said zones.

29. In a rolling mill for rolling sheet material extending practically the full width of the mill, the combination of an upper and a lower working roll and an upper and a lower backing-up roll, together with operating mechanism for bringing the rolls together, said operating mechanism including rigid plate cams constructed and arranged so that the rolls are brought together at both ends by exactly the same amount, and means within the rolls for maintaining the temperature uniform across the faces of the rolls and the diameter of the rolls uniform so that they offer the same resistance throughout their width to the material being rolled in the mill.

30. A sheet rolling mill comprising relatively small-diameter working rolls between which the material passes, relatively large-diameter backing-up rolls in contact with the working rolls, and means for holding the backing-up rolls against the working rolls including members adjacent opposite ends of the backing-up rolls for regulating the pressure of the backing-up rolls against the working rolls, and mechanism for moving the members at the opposite end of each backing-up roll in unison and in such a manner that every point of said members moves in a plane, said members comprising plate cams so constructed and arranged that their movement causes an increase or decrease in the pressure of the backing-up rolls against the working rolls depending on the direction of movement of said plate cams.

31. The combination with a rolling mill having working rolls for rolling sheets, and backing-up rolls for holding the working rolls against the work with great pressure, of cam means for moving the backing-up rolls to bring the working rolls closer together, said cam means including a rotary cam at each end of each backing-up roll, means supporting the cams for each backing-up roll for rotation in parallel planes, said cams being so shaped and in such relation to the backing-up roll that their rotation causes movement of the backing-up roll in a direction parallel to the planes of rotation of the cams, and mechanism for operating said cams in unison.

32. The combination with a rolling mill having working rolls for rolling sheets, and backing-up rolls for holding the working rolls against the work with great pressure, of screw-down mechanism including plate cams located at the opposite ends of a backing-up roll, means supporting each cam for rotation in a fixed plane, and common mechanism for rotating both of the cams in unison so that both ends of the backing-up roll move an equal distance and the pressure on the working rolls and work is maintained equal across the entire width of the work.

33. In a sheet rolling mill, working rolls through which the sheets pass, backing-up rolls in contact with the working rolls for holding them against the work with great pressure, a shaft extending through one of the backing-up rolls, anti-friction bearings between the shaft and the backing-up roll, said bearings being located within the roll and spaced from the ends of the roll to reduce the unsupported span of said roll, plate cams rigidly connected with opposite ends of the equalizing shaft, and means for rotating the shaft and both of the plate cams as a unit to change the position of the backing-up roll.

34. In a rolling mill for rolling sheet material of any practical width up to a width substantially

equal to the length of the body of the rolls, the combination of two sets of rolls including an upper and a lower working roll and an upper and a lower hollow backing-up roll, means for bringing the rolls together by an equal amount from end to end to regulate the pressure against the work, said means comprising an equalizing shaft extending through and projecting beyond the end of each backing-up roll, a cam rigidly connected to each end of the equalizing shaft, a connecting frame joining both cams, and mechanism connecting with said frame for moving it and the cams and equalizing shaft in unison.

35. In a rolling mill for rolling sheet material of any practical width up to a width substantially equal to the length of the body of the rolls, the combination of two sets of rolls comprising an upper and a lower working roll and upper and lower backing-up rolls, together with means including rotatable equalizer shafts mounted in and securely keyed to rotatable housings, together with bearings for said rotatable housings, cam faces on said rotatable housings and cam bearing blocks cooperating therewith, means securely tying together the rotatable housings, and electric motor-operated means cooperating with a screw connected to the rotatable housing for causing said housings to rotate in either direction so that said working rolls and backing-up rolls advance towards each other or retreat from each other by an equal amount from end to end and cause said rolls to offer substantially the same resistance for their whole length to the material being rolled, together with fluid-filled accumulator means, displacement balance cylinders and means cooperating therewith for balancing said upper backing-up roll, rotatable equalizing shaft, rotatable housings and cam bearing blocks and keeping them in tight contact with seats in the mill housings, together with fluid-filled accumulator, displacement balance cylinders and means cooperating therewith for balancing said upper working roll, and working roll housings and for keeping both the upper and lower working rolls in firm contact with the upper and lower backing-up rolls to provide traction for driving the backing-up rolls, together with wedge means between mill housings and the cam bearing blocks for aligning said working and backing-up rolls in the housings.

36. In a four-high rolling mill for rolling sheet material extending practically the full width of the mill, the combination of an upper and a lower working roll and an upper and a lower backing-up roll, together with operating mechanism for bringing the rolls together, said operating mechanism being constructed and arranged so that each end of each pair of rolls is brought together by exactly the same amount and offer the same resistance to material being rolled in the mill, said operating mechanism being rotatably mounted in housings and including an equalizing shaft rotatably mounted in anti-friction bearings in the backing-up rolls, the rollers in said anti-friction bearings moving between inner and outer races of said anti-friction bearings upon any movement of said operating mechanism.

37. The combination with a rolling mill having working rolls for rolling sheets, and backing-up rolls for holding the working rolls against the work with great pressure, of means for holding each backing-up roll against a working roll and for regulating the pressure of the backing-

up roll against the working roll, including cam means comprising a screw threading through a screw box or nut, supporting means extending from each end of the backing-up roll, plate
 5 cam means at each end of the backing-up roll and into which said supporting means extend, and motion-transmitting connections through which the cam means at each end of the backing-up roll are operated as a unit by relative
 10 movement of said screw and screw box.

38. In a rolling mill, working rolls, backing-up rolls for holding the working rolls against the work with great pressure, mechanism for changing the position of at least one of the backing-
 15 up rolls to regulate the pressure of the working rolls against the work, said mechanism comprising a shaft on which the backing-up roll rotates, cams into which the opposite ends of said shaft extend, a rigid connection between the
 20 cams making them parts of a common rigid structural unit, and an operating device for moving said unit to change the position of the backing-up roll.

39. In a rolling mill having a plurality of rolls, mechanism for changing the position of at least
 25 one of the rolls to regulate the pressure of the mill against the work, said mechanism comprising a shaft on which the pressure-regulating roll rotates, cams into which the opposite ends
 30 of said shaft extend, a rigid connection between the cams making them parts of a common rigid structural unit, and an operating device for moving said unit to change the position of the pressure-regulating roll.

35 40. In a rolling mill of the class having working rolls held against the work by backing-up

rolls, the combination with at least one of the backing-up rolls of an equalizer shaft extending through said backing-up roll, cam means
 5 secured to the equalizer shaft to form a unitary structure with said shaft, said means having a cam surface through which is transmitted the thrust that holds the backing-up roll against the
 10 working roll, and apparatus for moving the shaft and cam means as a unit to adjust the roll pressure.

41. A rolling mill including working rolls, backing-up rolls, and means for shifting the position of at least one of the backing-up rolls to regulate the pressure of the working rolls against
 15 the work, said means comprising rigid plate cams adjacent each end of the backing-up roll, roll supporting means extending from opposite ends of the backing-up roll and into said cams
 20 in such relation that rotation of the cams shifts the backing-up roll toward or from the working rolls, and a connection securely fastened to the plate cams at both ends of said backing-up
 25 roll for moving both plate cams as a unit to shift both ends of the backing-up roll by precisely the same amount.

42. In or for a rolling mill, a hollow roll and temperature-controlling apparatus within the roll including means for cooling several different longitudinal portions of the roll to substantially the same temperature in order to maintain
 30 the diameter and the pressure of the roll against one or more cooperating rolls substantially constant across the entire width of the face of said roll when the roll is operated in a rolling mill.

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