

Sept. 14, 1954

W. R. J. BALLARD

2,688,891

ROLLING MILL

Filed Oct. 25, 1949

8 Sheets-Sheet 2

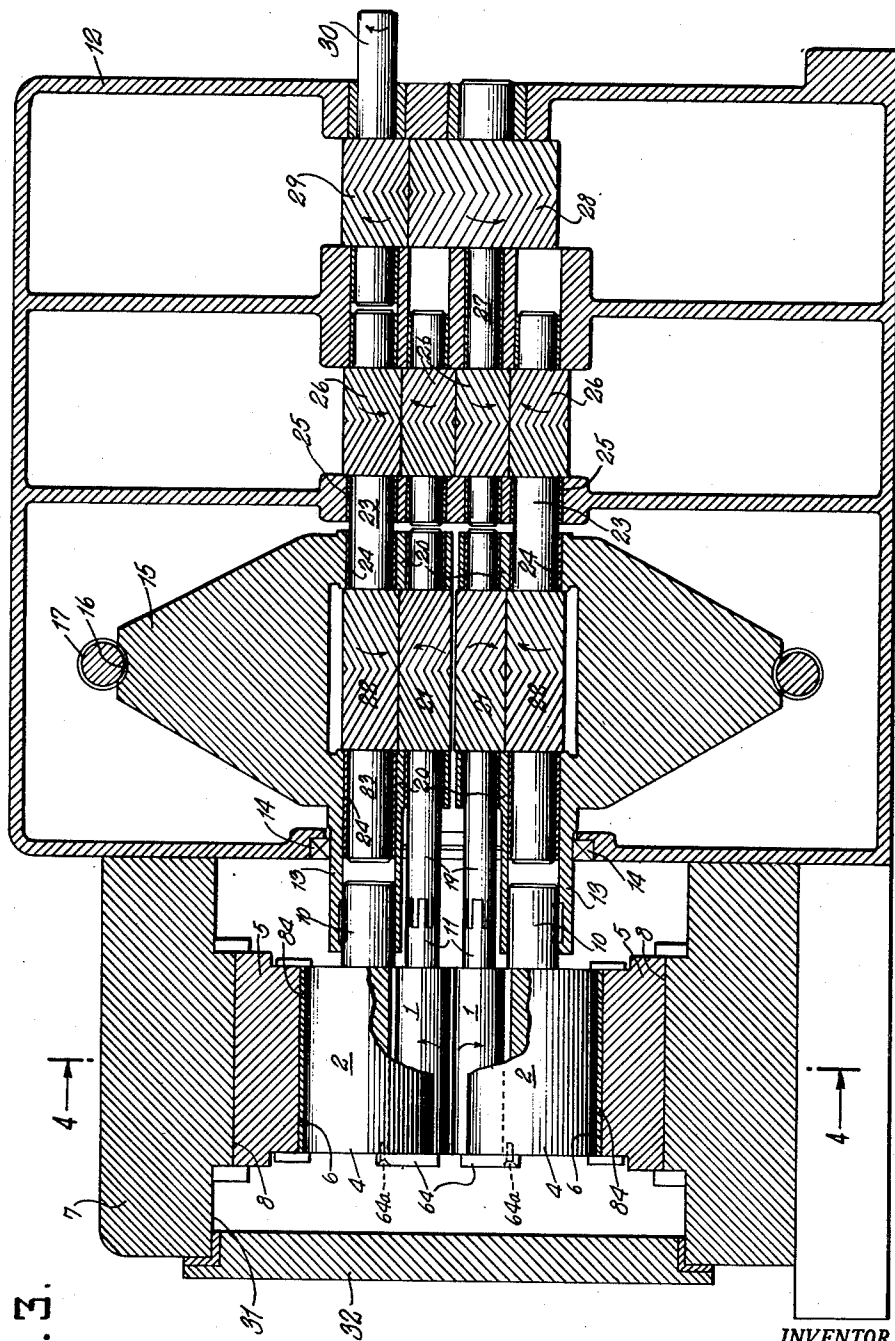


Fig. 3.

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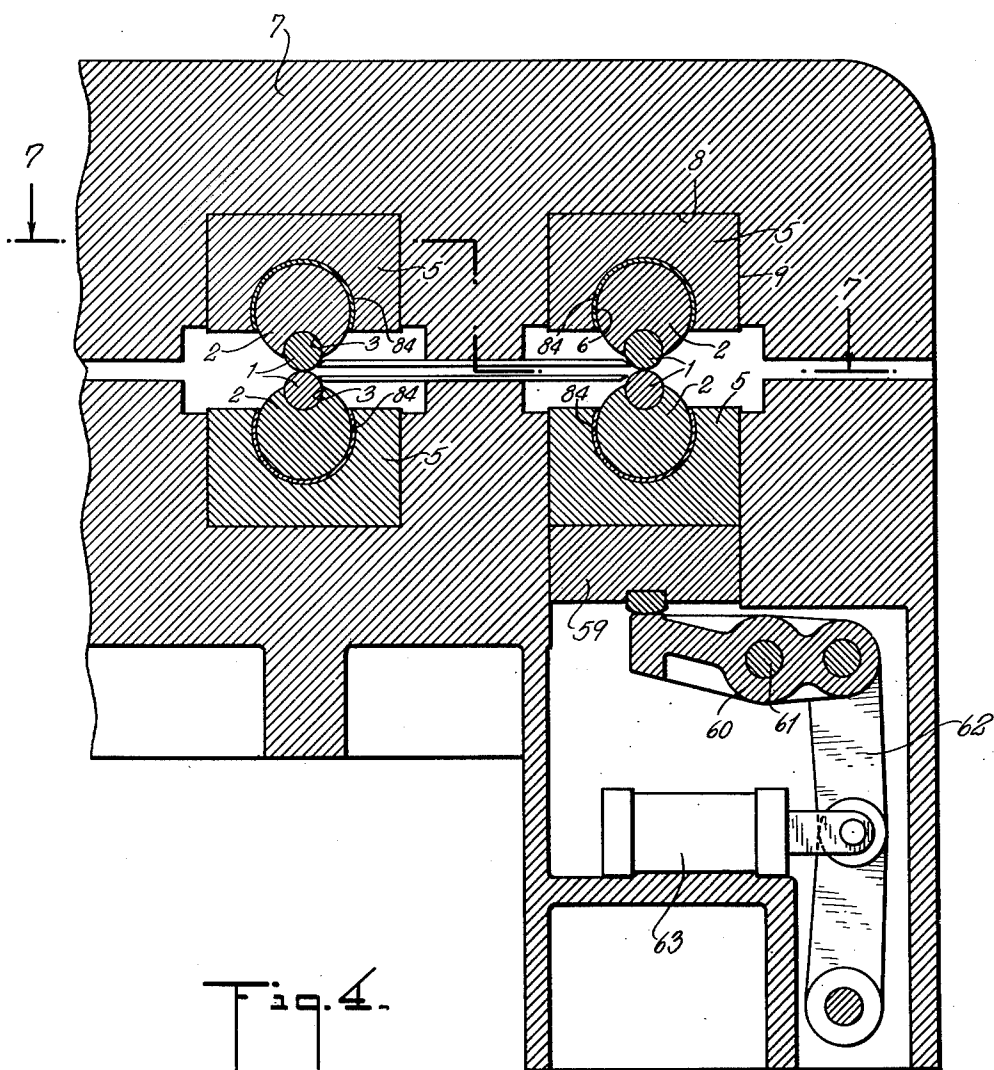
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8 Sheets-Sheet 3



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8 Sheets-Sheet 4

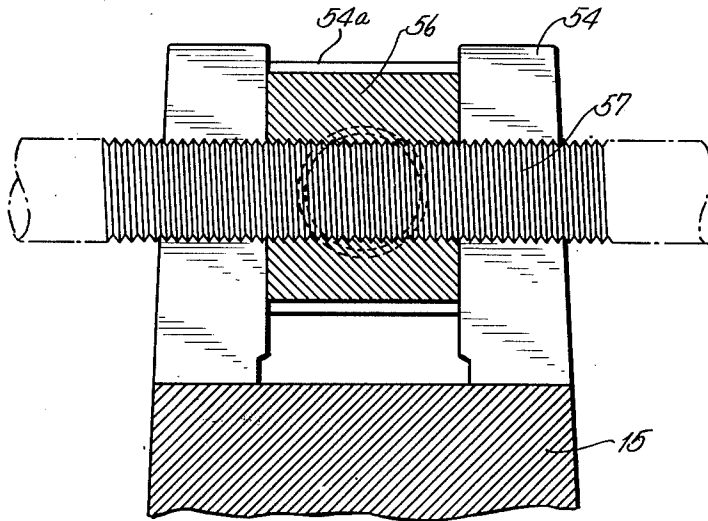
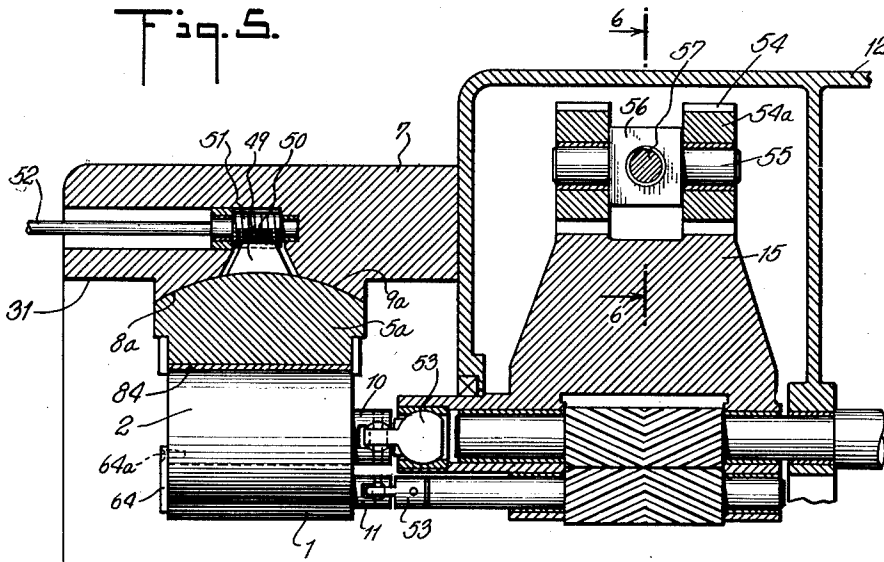


Fig. 6.

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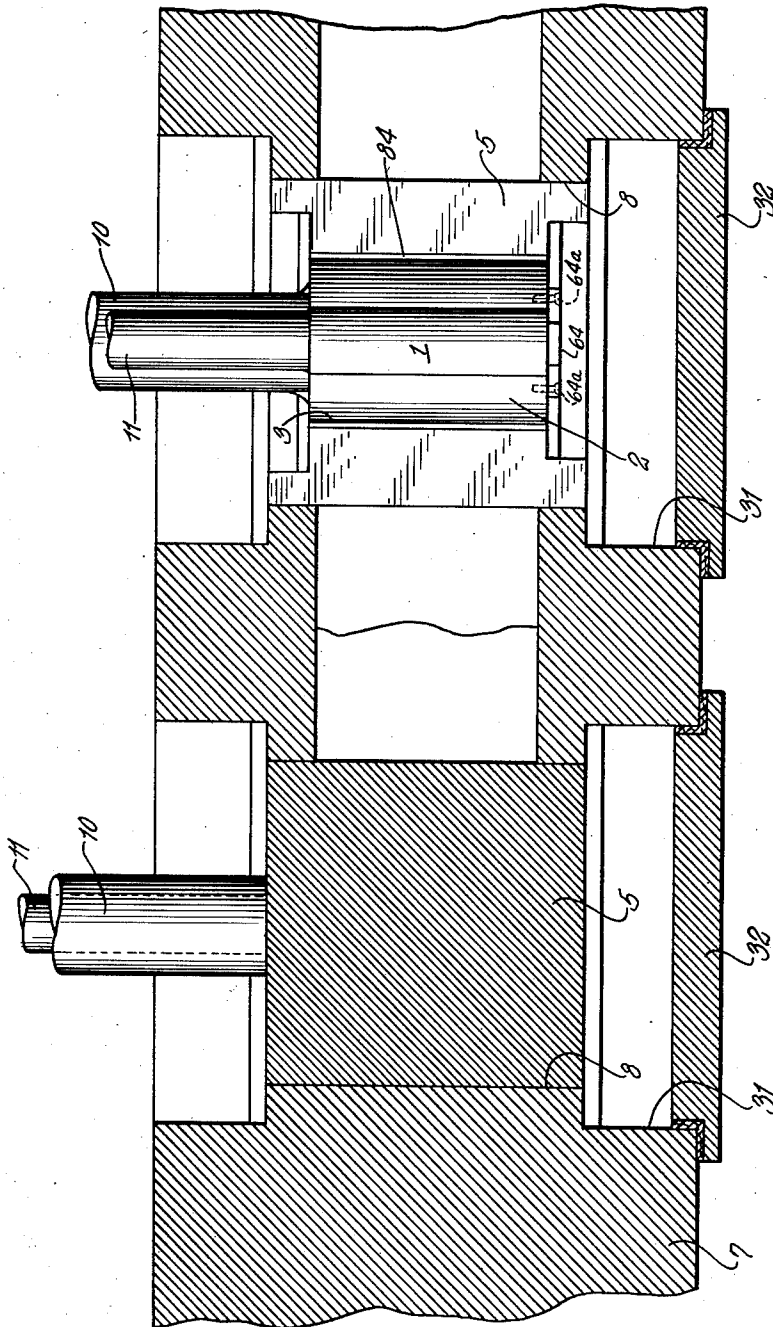
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8 Sheets-Sheet 5



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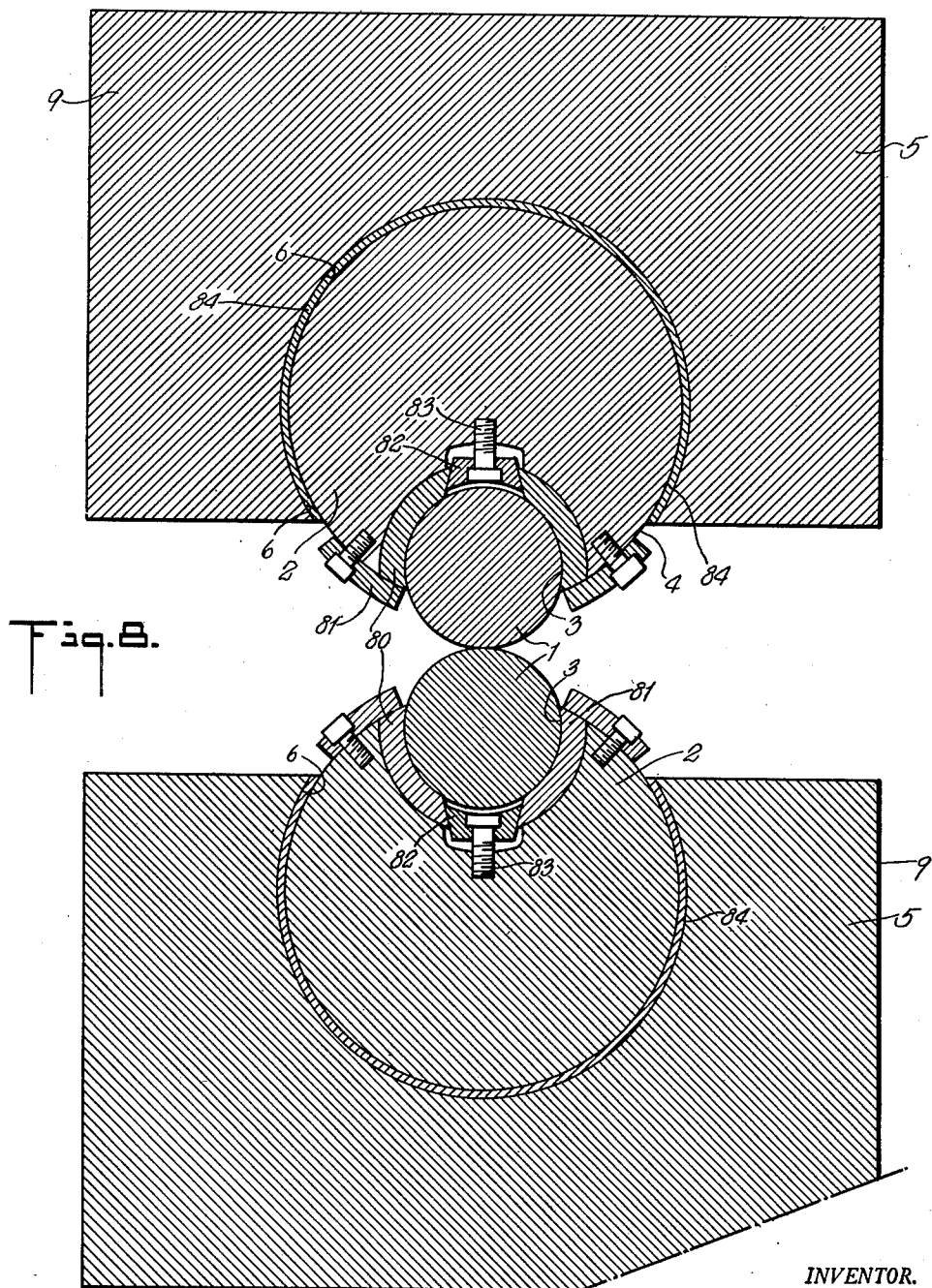
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8 Sheets-Sheet 6



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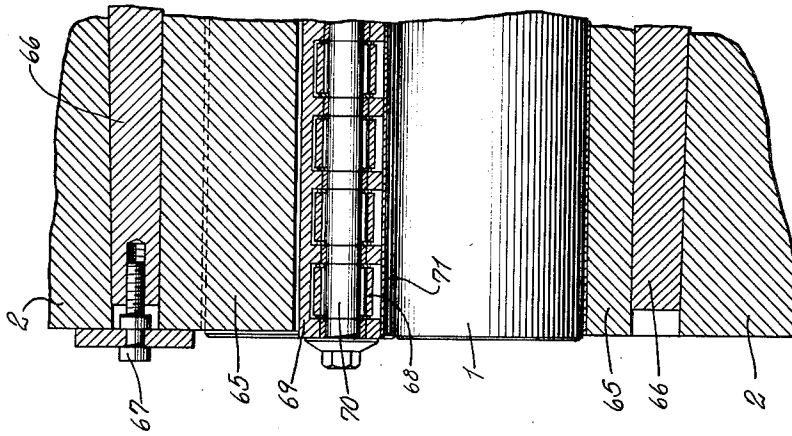


Fig. 10.

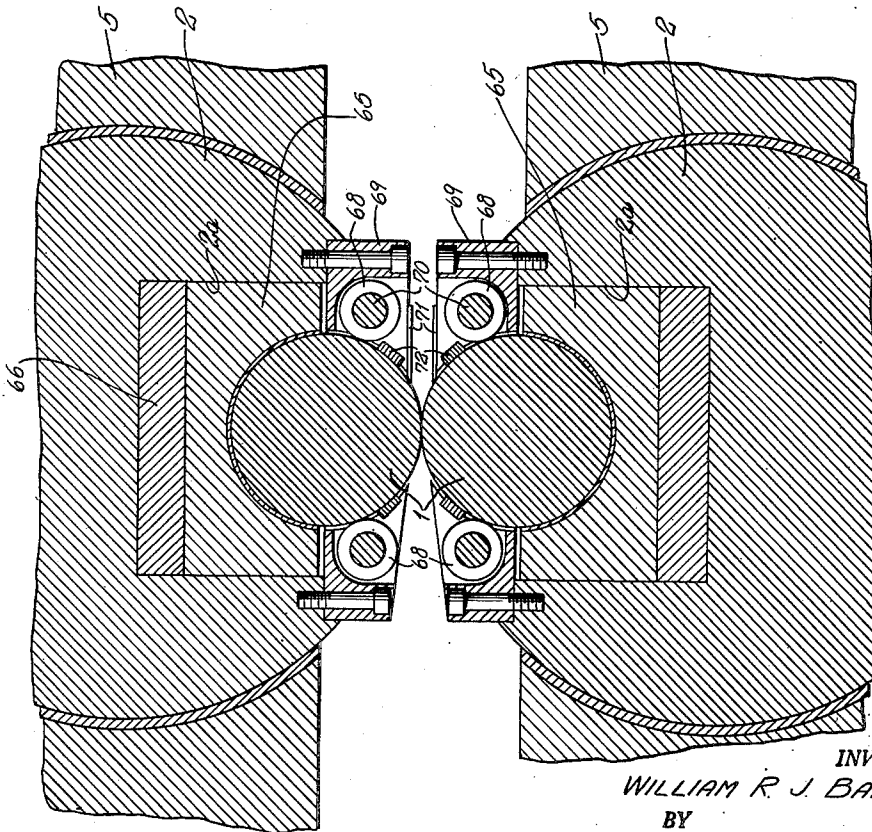


Fig. 9.

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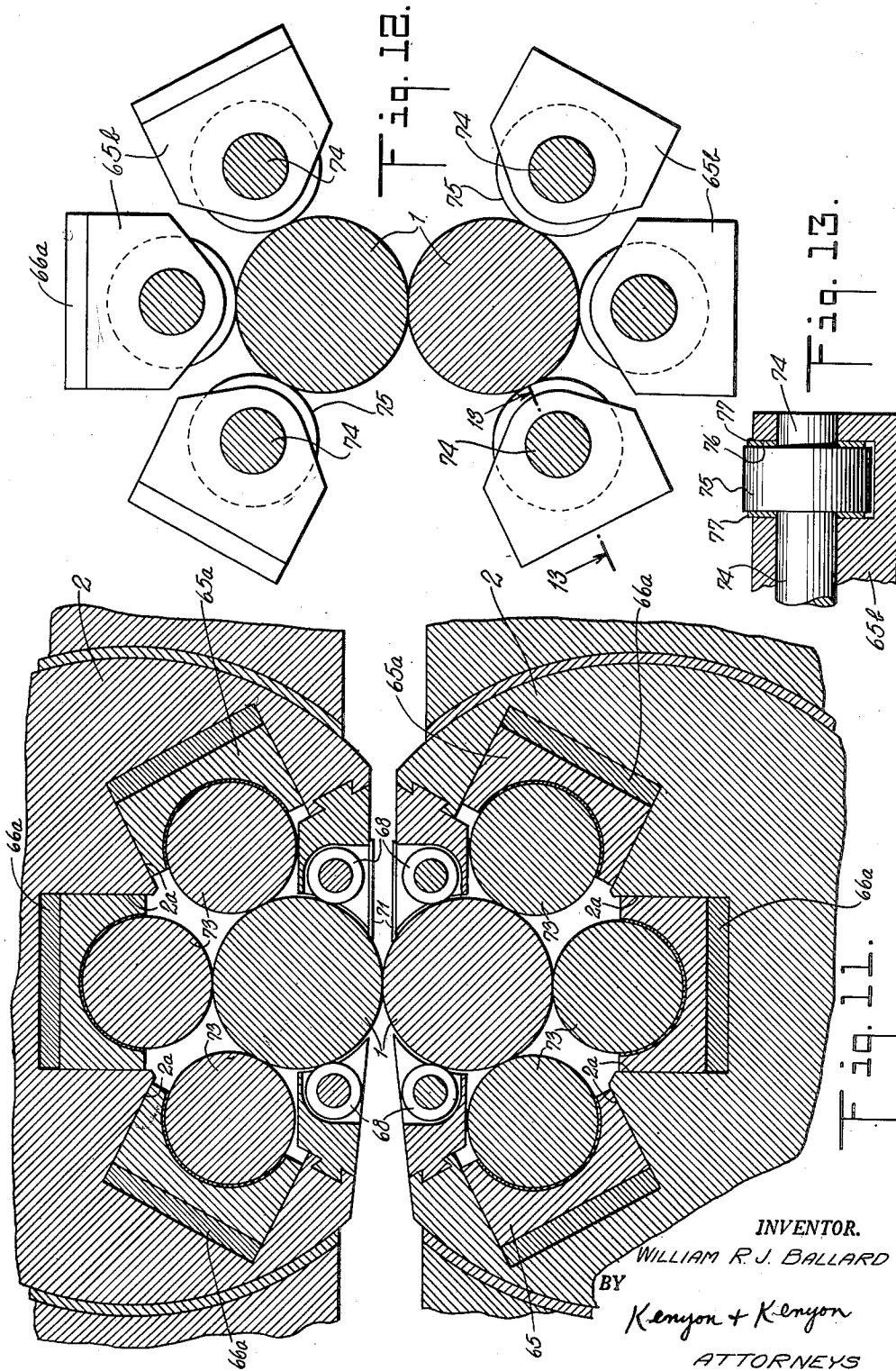
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8 Sheets-Sheet 8



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UNITED STATES PATENT OFFICE

2,688,891

ROLLING MILL

William R. J. Ballard, Stamford, Conn.

Application October 25, 1949, Serial No. 123,328

1 Claim. (Cl. 80—56)

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This invention relates to rolling mills having one or more sets of rolls adapted to roll on work under heavy pressure. The principles of the invention are particularly applicable to metal strip rolling mills used to reduce the thickness of the strip and to harden or temper the strip by cold rolling it.

In the case of cold rolling metal strip mills the roll pressures are extremes and usually the operating speeds are high. The rolls have smooth cylindrical bodies with necks journaled by chocks to which the roll pressure is applied. The rolls function like beams when the strip passes between the roll bodies. The high roll pressures cause the rolls to flex. Various expedients are used to prevent the roll flexure from causing the strip to be produced with convex sides and consequent lack of transverse gauge uniformity. Such expedients are not generally satisfactory.

One common expedient is to finish the rolls with convex bodies calculated to compensate for the roll flexure so that the working pass between the flexing rolls is defined by mutually parallel roll surfaces. This expedient can only give approximate accuracy because the roll pressure varies for many reasons. The convexity can be calculated so it is correct for only one roll pressure.

Another expedient is to use larger back-up rolls for supporting the work rolls which are actually doing the work on the strip. Space and cost limitations prevent these back-up rolls from being made big enough to approximate rigid beams, so the back-up rolls themselves work as flexing beams when the roll pressure is applied to their necks for transmission to the bodies of the work rolls. Currently the 4-high mill or its counterpart, the cluster mill, represents the most popular expedient even though its initial and maintenance cost is generally thought to be excessive. In the cluster mill the work rolls are each supported by two or more back-up rolls arranged in a cluster.

The performance of these 4-high and cluster mills is currently not very satisfactory. Transverse strip gauge uniformity is obtainable only when the mill is operated by highly skilled personnel. The training and labor cost involved by this personnel adds greatly to the production cost of the metal strip. This is additional to the high cost inherent to the purchase and use of a 4-high or cluster mill.

In such mills the roll necks are included with the bodies as part of the stressed beam structure, which is also true in any conventional mill.

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Therefore, the roll necks flex under the roll pressure applied to them. This introduces problems in connection with the design and maintenance of the roll neck bearings. The most common expedient of attempting to align the bearings with the rolls as they flex is to mount the bearings so that they can rock for alignment purposes. When rolling at high speeds, however, the beam stresses in the rolls shifts in value with a rate approaching or equaling audible vibration. Due to the high stresses, the bearings must be made massive and their mass prevents them from rocking in the same vibratory manner. Therefore, the bearings are battered and do not align with the roll necks at all unless the rolling speed is slow. These factors result in a high bearing maintenance cost being a characteristic connected with the production of metal strip. In the case of continuous strip steel cold rolling mills of the 4-high type, it is common to see a row of replacement bearings beside the mill in anticipation of bearing trouble. The introduction of the roller bearing and later of improved plain oil bearings has not adequately solved the bearing problem.

The deformation of the metal by the work rolls produces considerable heat in the roll bodies and this further complicates the operation of conventional strip mills. Faulty bearing operation heats the roll necks. In the case of cold rolling, liquid is sprayed on the rolls and on the work in an effort to control the heating. This is necessary because the heating is uneven and changes the contour of the work roll bodies. The bearing lubricant is cooled to try to offset bearing heating. These effects, combined with the roll body deformation resulting from the variable roll pressures, make the operation of a modern 4-high or cluster metal strip rolling mill terrifically complex.

With the foregoing in mind, one of the objects of the present invention is to provide a rolling mill, particularly a metal strip rolling mill, which may be manufactured at a much lower cost than conventional 4-high or cluster mills, and which will adequately support the work rolls so that they have the characteristics of substantial rigid non-flexing bodies. Note that successful attainment of this object practically eliminates the outlined problems excepting for the heating problem. In the latter connection, another object of the invention is to provide a metal strip rolling mill in particular which eliminates the conflicting flows of heat resulting from roll neck and roll body heating in the conventional mill.

Thus, this object is to provide a mill wherein the roll body receives heat substantially uniformly throughout, whereby the heating does not materially affect the roll body contour. Still another object is to dissipate the heat from the roll bodies more uniformly and rapidly than is possible in the case of the conventional practice of spraying a liquid coolant on the roll bodies and the work.

The bearing problems mentioned in connection with conventional 4-high mills is further aggravated by the fact that there is insufficient room available for the use of adequately large roll necks and, hence, adequately large bearings. The roll necks must be made sufficiently smaller than the roll bodies to provide clearance between the roll necks for the bearings. Recognizing this, the prior art has resorted in both 4-high mills and cluster mills to back-up rolls of excessive size primarily to provide room for bearings more closely approximating the size known to be required to carry the roll pressure load. These huge rolls add greatly to the naturally high cost of these mills.

The problem stated immediately above accounts for a further object of the present invention. This object is the provision of a metal strip rolling mill permitting the use of bearings for applying the necessary pressure to the roll bodies and which bearings have bearing surfaces adequately large to carry in a proper manner the loads imposed on them. Successful attainment of this object further contributes to lowering the cost of metal strip production since it means that the roll bearings will have service lives comparable to those enjoyed by bearings generally in applications other than the 4-high or cluster mills.

A specific example of a metal strip rolling mill of a continuous multiple stand type is illustrated by the accompanying drawings and described hereinbelow for the purpose of explaining the principles and operation of the invention. Once skilled rolling mill designers are familiar with these principles and operation they may alter the illustrated and described constructional details and they may find various modifications suggesting to themselves equal or perhaps greater enjoyment of this invention's principles and operation. The present drawings and description suggest a few possible modifications.

These accompanying drawings are more or less schematic in character because this facilitates simplification of the disclosure. The various figures are as follows:

Fig. 1 is a side elevation of the mill;

Fig. 2 schematically shows two of the roll stands with a convenient arrangement for guiding the advancing ends of the strip from the exit of one stand to the entrance of the other;

Fig. 3 is a transverse cross section taken on the line 3—3 in Fig. 1 and showing the roll pressure adjusting and roll driving equipment;

Fig. 4 is a longitudinal cross section taken on the line 4—4 in Fig. 3 and showing the last two roll stands with the last of these arranged in a modified form respecting the arrangement shown by Fig. 1;

Fig. 5 is a view similar to Fig. 3 excepting that it shows only the upper work roll assembly and suggests a modification providing a control for leveling the work roll of this assembly;

Fig. 6 is a cross section taken on the line 6—6 in Fig. 5;

Fig. 7 is a horizontal longitudinal section taken on the line 7—7 in Fig. 4;

Fig. 8 is a vertical section similar to Fig. 4 showing only one stand of the work rolls and with a suggestive modification thereof;

Fig. 9 is a view similar to Fig. 8, but shows a further possible modification.

Fig. 10 is a partly sectioned side view of Fig. 9;

Fig. 11 is similar to Figs. 8 and 9, but shows a further modification;

Fig. 12 is also similar to Figs. 8 and 9 but shows still another modification, and

Fig. 13 is a section taken on the line 13—13 in Fig. 12.

This mill uses neckless work rolling rolls 1. They are small-diameter work rolls similar to the work rolls of a 4-high strip mill excepting for the absence of the necks. They are in the form of solid cylinders of sufficient length for the strip which the mill will be called upon to roll. They are made as truly cylindrical as is possible. They may be made smaller in diameter than is indicated by the drawings because the roll pressure is applied to them in such a manner that they carry the resulting stress entirely in compression. These work rolls are not called upon to function as beams. They may be rotatively powered and when they are, they must be large enough to carry the torque safely.

These neckless work rolls 1 are journaled by their bodies in chocks 2. These chocks are as long as the rolls they journal and each chock has a cylindrical bearing recess 3 in which the roll 1 is mounted. Thus the rolls 1 function as journals and are journaled by the bearing recess 3 of the chocks 2. The rolls are supported by the chocks throughout their entire lengths and cannot act as beams under the rolling pressure they must carry. There is one chock for each roll and each chock is at least as long as the roll it journals.

The chocks 2 have cylindrical exteriors 4. In each instance the bearing recess 3 is eccentric to the axis of the cylindrical exterior 4 of the chock. The chocks 2 are in turn journaled by blocks 5 having cylindrical recesses 6 in which the chocks are fitted by their external cylindrical surfaces.

A frame 7 houses all of the stands of rolls shown by the drawings. This frame has windows 8 in which the blocks 5 fit. The blocks 5 have rectangular outsides 9 and the windows 8 are correspondingly shaped to hold the blocks against rotation. The blocks 5 fit precisely in the windows 8 with their outsides supported by the frame 7 surrounding the windows. The frame is adequately strong to carry the reaction of the pressure applied to the rolls by each stand to roll the strip.

As shown best by Fig. 3, the cylindrical chocks 2 have concentric extensions 10 and the work rolls 1 have corresponding extensions 11. These extensions are in the nature of necks, but do not function at any time to carry any stress other than torque.

A pinion stand is provided for each roll stand and these pinion stands are housed by a box 12 mounted at one side of the frame 7. In each instance, the extension 10 connects with a control shaft 13 journaled by the box 12 by a partial or three-quarter bearing 14 and turned by a radially projecting lever arm 15 having its swinging end provided with an arcuate series of worm gear rack teeth 16 engaged by a worm 17 and with the latter turned by worm and worm wheel gearing 18 indicated in Fig. 1. This latter gearing may be controlled in the fashion conventional mill screw downs are controlled to vary the roll pressure of the mill. The present arrangement

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eliminates the complications involved by the two usual screw downs, however, since only one control is involved in each instance.

Each work roll is driven by its extension 11 connecting with a drive shaft 19 journaled by an extension of the lever arm 15 as at 20. Thus, rocking of the lever arm 15 causes the associated chock to turn and the roll mounted by this chock to swing with the roll's extension 11 and its drive shaft 19 swinging while remaining concentric. This shaft 19 is keyed to a pinion 21 which meshes with a pinion 22 journaled by a shaft 23 in the lever arm 15 by bearings indicated at 24. One of these shafts 23 is journaled by the pinion stand box 12 at 25 and this bearing 25 with the bearing 14 together journal the swinging lever arm 15 and provide it with a fulcrum concentric with the axis of the associated cylindrical chock.

In the foregoing description reference has been made to the arm and pinion stand assembly associated with each individual chock and work roll assembly. At each stand there are two of these assemblies and they are substantially identical excepting that the lever arms 15 point upwardly and downwardly in the case of the upper and lower chock assemblies respectively.

In the case of each stand the respective shafts 23 of the pinions 22 are keyed to a common multiple pinion train comprising the pinions 26. This pinion train interconnects the two shafts 23 in their necessarily opposite rotative arrangement. The pinions 21 and 22 then carry the rotation to the drive shafts 19 and provide the work rolls of the stand with the necessarily opposite rotation. One of the pinions 26 is keyed to a drive shaft 27 keyed to a gear 28 meshed with a pinion 29 with the latter being keyed to the main drive shaft 30 of the stand and which projects to the outside of the pinion stand box 12.

Window access openings 31 are provided along one side of the frame 7 at each of the roll stands. On the side of the frame towards the pinion box 12 the frame joins with this box in an oil-tight manner. On the opposite side of the room each of the openings 31 is provided with a removable or opening oil-tight door 32. The pinion box 12 is oil-tight. The frame 7 has a strip entrance 33 provided with an oil seal 34 and a strip exit 35 which has an oil seal 36. The oil seals 34 and 36 are designed to permit entrance and exit of the strip without material loss of oil-tightness of the mill's interior.

In Fig. 1, various strip handling accessories are indicated. At the entrance of the mill an uncoiling strip coil spindle 37 is shown and this spindle projects from a box 38 which may contain equipment for braking the rotation of the spindle 37 to put back tension on the strip. At the entrance 33 a small stand of power pinch rolls 39 is indicated since this may provide greater convenience in feeding the strip through the mill when threading it up at the start of rolling operations.

Likewise at the exit end of the mill various equipment of convenience is indicated. In particular a coil spindle 40 is shown extending from a box 41 which may contain equipment for powering the spindle 40 to pull the strip from the mill. If desired, sufficient power may be applied to the spindle 40 to produce effective tension rolling in the last stand of work rolls in the mill. Tension between the stands may be applied by control of the drive shafts 30. A powered endless belt 42 is also shown carried by a frame 43 having a swinging bottom gate 44. When the

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end of the strip comes from the mill, the belt 42 serves to wrap the strip around the spindle 40 and get the coiling started. Thereafter, the gate section 44 may be dropped and the frame 43 lifted clear from the coil of strip. The frame 43 is mounted by a rod 45 depending from a linear acting motor 46 which effects the lifting of the frame 43.

Other arrangements for facilitating the operation of the mill may be provided. For example, in Fig. 2, endless belts 47 are shown positioned between two adjacent roll stands by drums 48. By rotatively powering these belts 47 so their adjacent bands travel in the direction of the strip, the strip may be evenly guided from one stand to another during its passage through the mill. Such belts may be used between each pair of stands.

In some instances, it may be desirable to provide an arrangement for leveling the work rolls 1. An arrangement for doing this is suggested by Fig. 5. In this instance a block 5a having a cylindrical outside surface is substituted for the pillar 5, which has the rectangular outside surface. This cylindrical surface is indicated in Fig. 5 at 9a and extends longitudinally respecting the roll. The window 8a has a corresponding cylindrical surface. These cylindrical surfaces are concentric about the center of the bottom of the work roll 1. Therefore, by providing the chock block 5a with a lever arm 49 having arcuately arranged worm gear rack teeth 50 in its top engaged by a worm gear 51 rotated by a shaft 52, which is adapted to be turned when leveling is desired, the roll 1 may be transversely rocked.

This arrangement requires universal joints 53 between the chock and roll extensions 10 and 11, respectively.

In Figs. 5 and 6 a modified arrangement is also shown for rocking the lever arms 15 of the respective roll stands. In each instance the lever arm in this modification has its ends provided with radially extending guides 54 in which crossheads 54a radially ride. These crossheads 54a function as bearings which mount journals 55 projecting from a nut 56. This nut is in threaded engagement with a screw shaft 57 which may run the length of the pinion box 12 and engage each of the nuts 56 of each of the pinion stand assemblies associated with each of the roll and chock assemblies of each of the roll stands. It is possible to provide this arrangement for either the upper or lower work roll and chock assemblies exclusively. In either instance when the screw shaft 57 is rotated, it moves the various nuts 56 back and forth, which rock the various lever arms 15 simultaneously. During this action, the crossheads 54a can slide to compensate for the arcuate motion of the guides 54.

One roll stand assembly is shown on a larger scale and in greater detail by Fig. 8. This shows the recesses 3 for the rolls as being provided by removable bearing liners 80 positioned tightly by removable outer retainers 81 and a wedge bar 82 wedged between the adjacent side edges of the liners 80 and positioned by a plurality of screws 83. By pulling up on the screws 83 the wedge bar 82 jams the bearing liners 80 more tightly against the retainers 81. This anchors the bearing liners 80 solidly in place so that they are adequately supported and backed up by the recesses in the chocks 2. This Fig. 8 also shows that a bearing liner 84 may be used between the cylindrical outside of the chock 2 and the cylindrical recess provided in the block 5. The

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rolls 1, the liners 80, the chocks 2, the blocks 9 and the liners 84 are all the same length.

In Fig. 4 the lower work roll, the chock and the block are shown supported by a platform 59 with the latter held up by a two-armed lever 60 pivoted at 61 to the frame 7, and with this lever rocked by a toggle 62, work up a hydraulic motor 63 of the cylinder and piston type. This arrangement may be used when it is desired to roll the work through the last stand under a constant roll pressure. In such an instance, the hydraulic motor 63 may be connected with a hydraulic accumulator supplying the motor 63 with hydraulic liquid under a constant pressure translated to the block through the action of the toggle 62 and the lever 60. The last stand of the mill is thus provided with a constant roll pressure regardless of slight variations in the hardness of the strip such as are sometimes encountered due to compositional variations throughout the length of the strip. The block 59 is vertically sliding in this modification.

The illustrated mill operates as follows.

It is to be assumed that the strip to be rolled is made of brass and that it has already been produced in the form of a coil of strip. It is to be assumed that the object is to reduce the gauge and provide the strip with an appropriate temper. This, of course, assumes cold rolling operations.

The coil of strip is placed on the un-coiling spindle 37 and its outer end is fed to the pinch rolls 39. These feed the strip to the first roll stand and the strip then threads itself through the mill to the coiling spindle 40. The belts 47 may be used wherever convenient guiding is needed or desirable.

The enclosure of the roll stands provided by the frame 7 and the oil-tight doors 32 together with the pinion box 12 permit the entire mill, including the pinion stand, to be flooded with lubricating oil. This oil also functions as a lubricant and coolant for the work rolls, the latter being completely submerged in the oil as is the strip length going through the mill. The oil seals 34 and 36 prevent material loss of oil at the entrance and exit of the mill. If it is desired to use different liquids in the mill and in the pinion stand box, these two units are then sealed from each other to effect separation of the two liquids.

With the work rolls 1, the chocks 2 and the blocks 5 made by good precision manufacturing methods, the work rolls are solidly positioned and should be permanently leveled respecting each other. There is no way for them to get out of alignment.

The roll pressures of the various stands are adjusted by operating the worm gearings 18 to rotate the various chocks. Since the rolls 1 are journaled by these chocks eccentric to the latter's axis of rotation, rotation of the chocks swings the rolls to and from each other. It is in this fashion that the roll pressures are established as required to progressively roll the strip to the desired gauge or temper.

In the event it is thought necessary to provide for angular control of one or more of the work rolls, the arrangement shown by Fig. 5 is incorporated where desired. Thus, by rotation of the shaft 52, the work roll 1 in such an instance may have its angularity varied relative to the other roll. This is usually referred to as leveling, although it is sometimes done deliberately to roll heavy on one side of the strip for various reasons.

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Since the mill is capable of such fixed and constantly maintained adjustments, the chock turning arrangement shown by Figs. 5 and 6 may be used so that the entire mill, when once set up, may have all of the stands opened and closed at once. The rolls may be open during the threading operation of the roll stands and then closed so that the rolling may immediately start. Alternately, with a fixed reduction progression from stand to stand, this arrangement may be used simply to produce different ultimate gauges or tempers.

With the mill threaded and operating, there is practically no attention required by the mill operator. Once set up, one coil of strip after another may be fed through the mill with the operator required only to load the unreduced coils successively on the spindle 37 and remove the coils of reduced strip from the spindle 40. If tension rolling is involved it is done by conventional controls applied to the motors driving the various drive shafts 30 to put power into the respective roll stands. Due to the solid nature of the mill, it may be adjusted by skilled personnel and then left in the care of unskilled personnel during its operation.

By referring to sectional views such as are shown by Figs. 4 and 8, it is easier to understand the precision operation of which this mill is capable. Between the working parts of the roll 1, the roll contacts the work with almost a line contact. This is particularly true in the case of rolling brass strip because the roll pressures are not so heavy as to tend to flatten the rolls so much where they engage the work. The stress resulting from the roll pressure is transmitted to this line contact through wedge shaped areas extending the length of the rolls. These stress zones are distributed upwardly to the chocks 2, from them to the blocks 5, and from them to the solid backing provided by the frame windows 8. Nowhere is there any looseness, nor are any of the parts functioning as beams excepting for the massive frame. Everything other than the heavy frame is in compression excepting for the torque the rolls must carry when they are powered. With the parts made by precision methods, it is substantially impossible for the rolls 1 to lose their proper shapes. There are large areas for conducting heat from the rolls and the rolls are, as previously explained, working in solid liquid coolant which is bathing everything inside the mill. Practically all of the previously described operational troubles inherent to 4-high and cluster mills are eliminated.

In connection with the above it should be noted that the block 5 provides a chock bearing constructed and arranged to back-up a substantially arcuate segment of the chock 2. In turn the various illustrated bearing means of the chock provide for backing-up an arcuate segment of the roll body 1 corresponding to the chock segment backed-up by the block. All the parts are equally long so there can be no uneven stress distribution lengthwise of the assemblies. The stress fans out uniformly from the line of contact with the work with the solid massive frame providing the reaction.

If exact control of temper is desired, the last stand is arranged as shown by Fig. 4. This provides a relatively constant roll pressure whereby the rolls tend to work soft strip portions a little more than they do hard strip portions whereby to produce a substantially uniform temper throughout the length of the strip.

In the case of the upper roll and chock assemblies, the rolls are held in the recesses in the chocks and the latter are held in the recesses in the blocks by making these recesses slightly more than semi-cylinders. The blocks 9 may be solidly anchored in the windows 8 by screws and the like. Thus, all the working parts of the mill are solidly united as contrasted to the looseness characterizing conventional mills due to the many parts they incorporate.

Since the rolls are journaled by their own bodies, large bearing surfaces are possible. It is possible to provide larger bearing surfaces than the calculated stresses indicate are required to provide good bearing practices. Thus, the bearing difficulties of 4-high and cluster mills are overcome.

Referring to Fig. 3 the pinion stand operation is substantially as follows.

With the main drive shaft 30 powered, the pinion 29 drives the gear 28. The inner end of the shaft 30 is not connected with the shaft of any of the pinions 26, but the inner end of the shaft 27 is keyed to the next to the bottom one of the pinions 26. The end of the shaft 27 projecting from the pinion 26 toward the mill is not connected to anything. The two intermediate pinions 26 drive the upper and lower pinions 26 in opposite directions and these latter pinions power the shafts 23 to power the pinions 22. The ends of the shafts 23 projecting towards the mill from the pinions 22 are not connected to turn anything. With the two pinions 21 driven by the pinions 22, the shafts 19 are turned so that the roll extensions 11 are powered to drive the roll stand. Rocking action of the lever arms 15 turns the associated chock extension 10 and effects roll pressure control. The pinion 21 and shafts 19 swing concentrically with the chocks 2 during such control motion.

In the event one of the work rolls becomes damaged, as by allowing a wrench or the like to go through the mill on the strip, it may be easily and quickly replaced. This is done by draining the oil or other coolant from the mill, removing the door 32 opposite the damaged roll and slipping the roll out endwise.

Collars 64 are fastened by screws 64a to the face of the chocks 2 to bear against the ends of the rolls 1. These thrust collars may not be required when the mill is produced by good precision manufacturing methods. If they are used, it is simple to remove the one at the damaged roll so that this roll may be replaced by a good roll.

The rolls may be also easily changed when they wear. If the rolls are ground and polished to return their finish, their diameter is, of course, reduced slightly. When this occurs, it is possible to replace the bearing liners 60 with a new set finished to conform to the new roll diameters. All of this work may be done through the windows of the mill when the doors are open.

In the modification shown by Figs. 9 and 10 the rotative chocks 2 are provided with windows 2a in which half bearings 65 are positioned. These half bearings are suitably lined and journal the necklace rolls 1. Wedges 66 are positioned between the ends of the windows 2a and the half bearings 65, and these wedges are provided with take-up screw adjustments 67. The described roll stand construction permits such precision operation as to permit the use of accurately calibrated roll position indicators. As the work rolls wear and are reduced in diameter by re-

finishing the use of these wedges permits maintenance of the indicator calibrations.

In this instance the rolls 1 are retained in the half bearing 65 by roller retainers 68 journaled by removable bracket bars 69. These roller retainers 68 are journaled by a shaft 70 in slightly eccentric relation throughout so that by rotating the shaft 70 the seating pressure of the rolls 1 in their bearings may be adjusted when necessary.

In this modification doctor blades 71 are arranged to clean the roll bodies. Felt wipers 72 are position between the doctor blades and the bearing surfaces. These are practical expedients which may or may not be required depending upon the cleanliness prevailing during the rolling operations and other factors.

In Fig. 11 a further modification is suggested. This is much along the lines of the modification of Figs. 9 and 10 except that in this instance the chocks 2 each have three of the windows 2a and these each journal a bearing roller 73 which in turn journals the necklace roll 1. In this instance the half bearings 65a are provided with wedge take-ups 66a so that roll body position may be maintained as the roll size reduces due to refinishing work. In this modification the previous described retainer rollers 68 are used to retain the rolls relative the chocks 2. Slight differences are involved in the details, but they are generally comparable.

The above modification shown by Fig. 11 permits considerable multiplication of the bearing surface area made available by the preceding forms. This increase in bearing area may be desirable where extreme service conditions are encountered such as those existing in the case of steel strip temper mills.

Still another modification is suggested by Figs. 12 and 13. The type of chocks shown by Fig. 11 may be used in this instance and are therefore not illustrated. The main difference is that instead of the half bearings 65a shown in Fig. 11 bearing blocks 65b are mounted in the windows 2a of the chocks. These blocks each mount a shaft 74 extending the length of the work rolls 1 and on which a plurality of anti-friction bearings 75 such as roller or ball bearings are mounted. A suitable number of these bearings are used on each shaft to structurally brace the work roll. The bearing may be laterally positioned by working in pockets 76 provided with thrust washers 77. This provides the shaft 74 with a plurality of supports lengthwise. The peripheries of the bearings 75 directly engage the peripheries of the work rolls. Otherwise the retainer rollers and other features of the preceding example may be used.

When the rolls and chocks are mounted as shown by Fig. 3, for example, the thrust plate member 64 may be replaced by thrust members carried by the doors 32. These doors may be strongly made and provided with strong locks, in such instances. Such an arrangement speeds roll changes, because opening of the door frees the rolls for removal.

I claim:

A rolling mill subcombination including a rolling mill roll, a frame, a chock rotatively mounted by said frame and journaling said roll eccentrically to said chock's rotative axis so that rotative adjustment of said chock adjusts said roll's position, and means rotatively adjusting said chock and holding it at any of a plurality of rotatively different positions, said roll having a

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substantially cylindrical body and said chock being substantially as long as said body and journaling the latter substantially throughout its entire length, said chock having a cylindrical exterior substantially throughout its length, and said frame having a bearing substantially as long as said chock and in which said chock is journaled by its said exterior, said chock's bearing being constructed and arranged to back-up a substantial arcuate segment of said chock substantially throughout the latter's length, and said chock having a bearing means journaling said roll body and which is constructed and arranged to back-up an arcuate segment of said roll body substantially throughout the latter's length and corresponding to said segment backed up by said chock's bearing, said chock having guideways radiating from said roll body and containing reciprocative chocks substantially as long as said roll body with substantially equally long cluster rolls journaled by said reciprocative chocks and bearing on said roll body and with means adjust-

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ing and positioning said reciprocative chocks, whereby to provide said roll body bearing means.

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