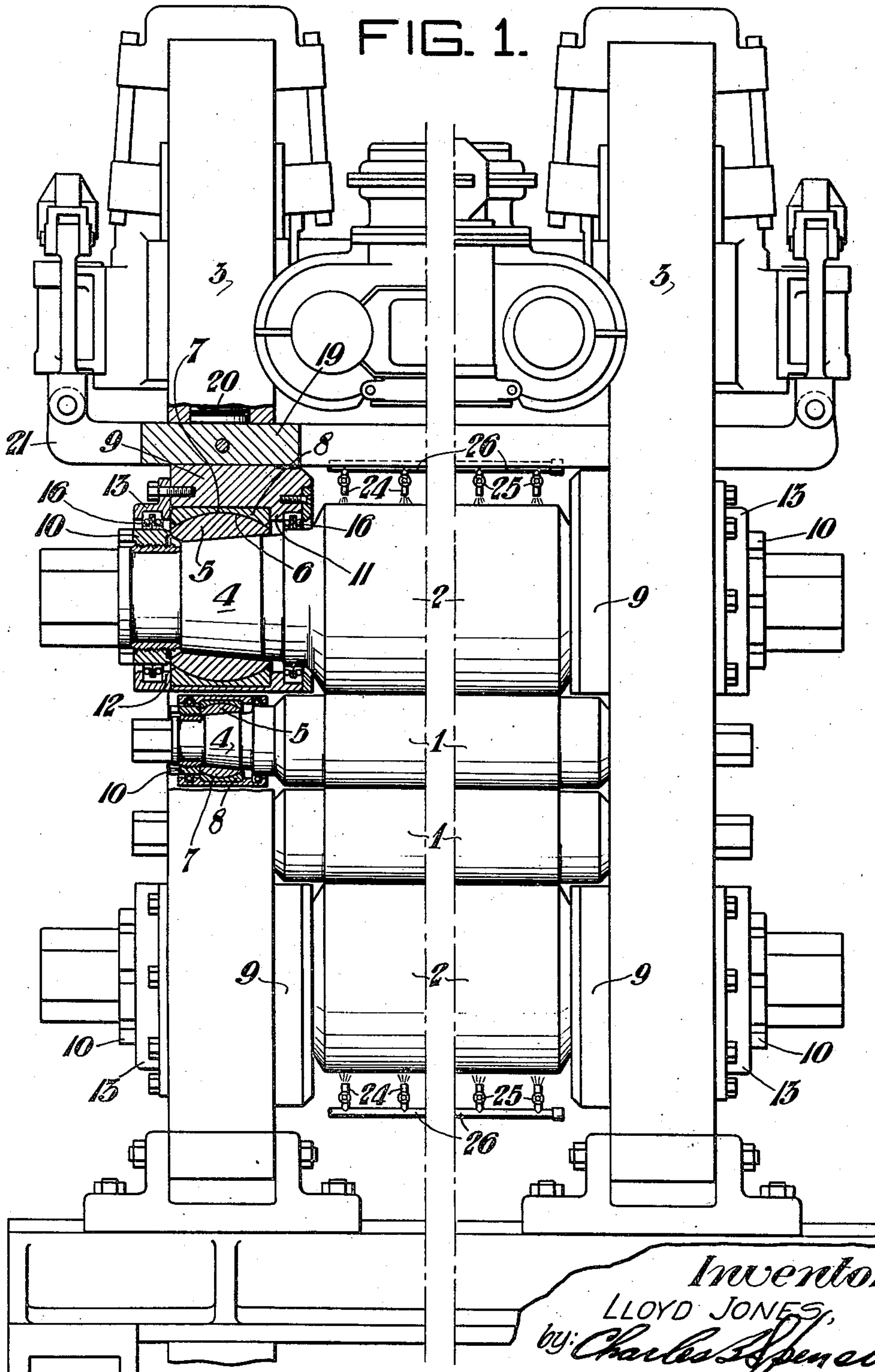
March 2, 1943. L. JONES 2,312,648

METAL ROLLING MILL

Filed March 15, 1941 3 Sheets-Sheet 1

FIG. 1.



Inventor:
LLOYD JONES,
by: Charles E. Spencer
his Attorney.

March 2, 1943. L. JONES 2,312,648

METAL ROLLING MILL

Filed March 15, 1941 3 Sheets-Sheet 2

FIG. 2.

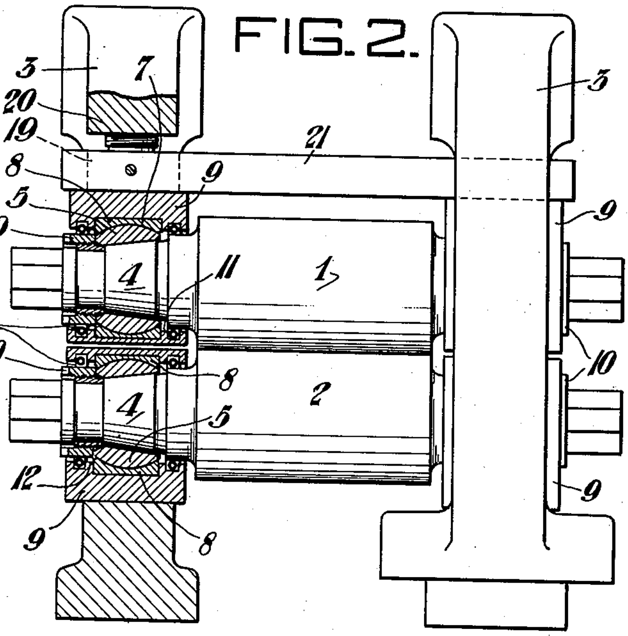
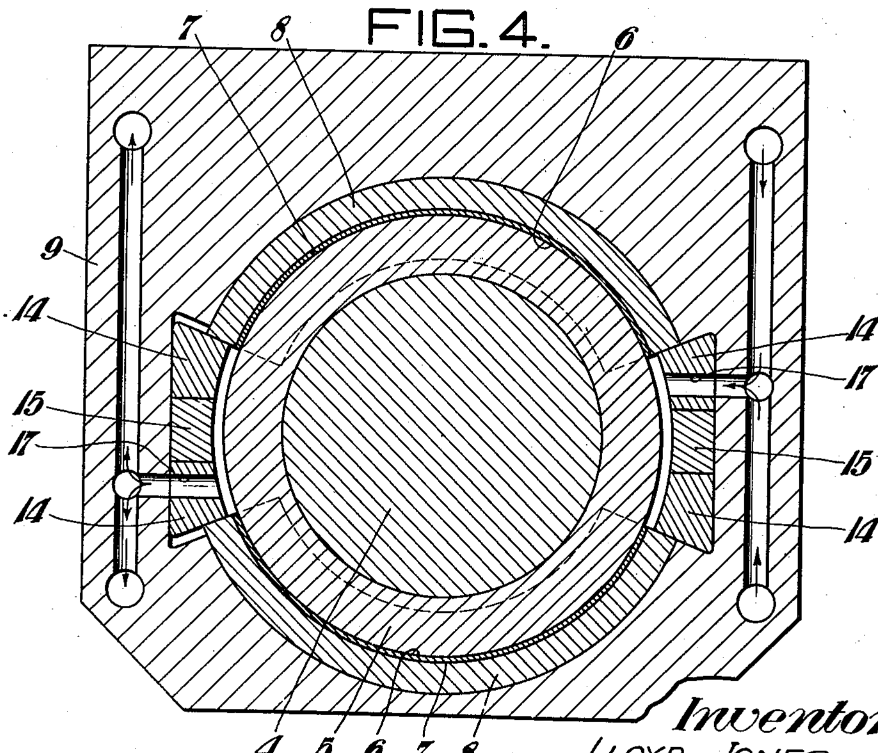


FIG. 4.



Inventor:
LLOYD JONES,
by Charles S. Spencer
his Attorney.

March 2, 1943. L. JONES 2,312,648

METAL ROLLING MILL

Filed March 15, 1941 3 Sheets-Sheet 3

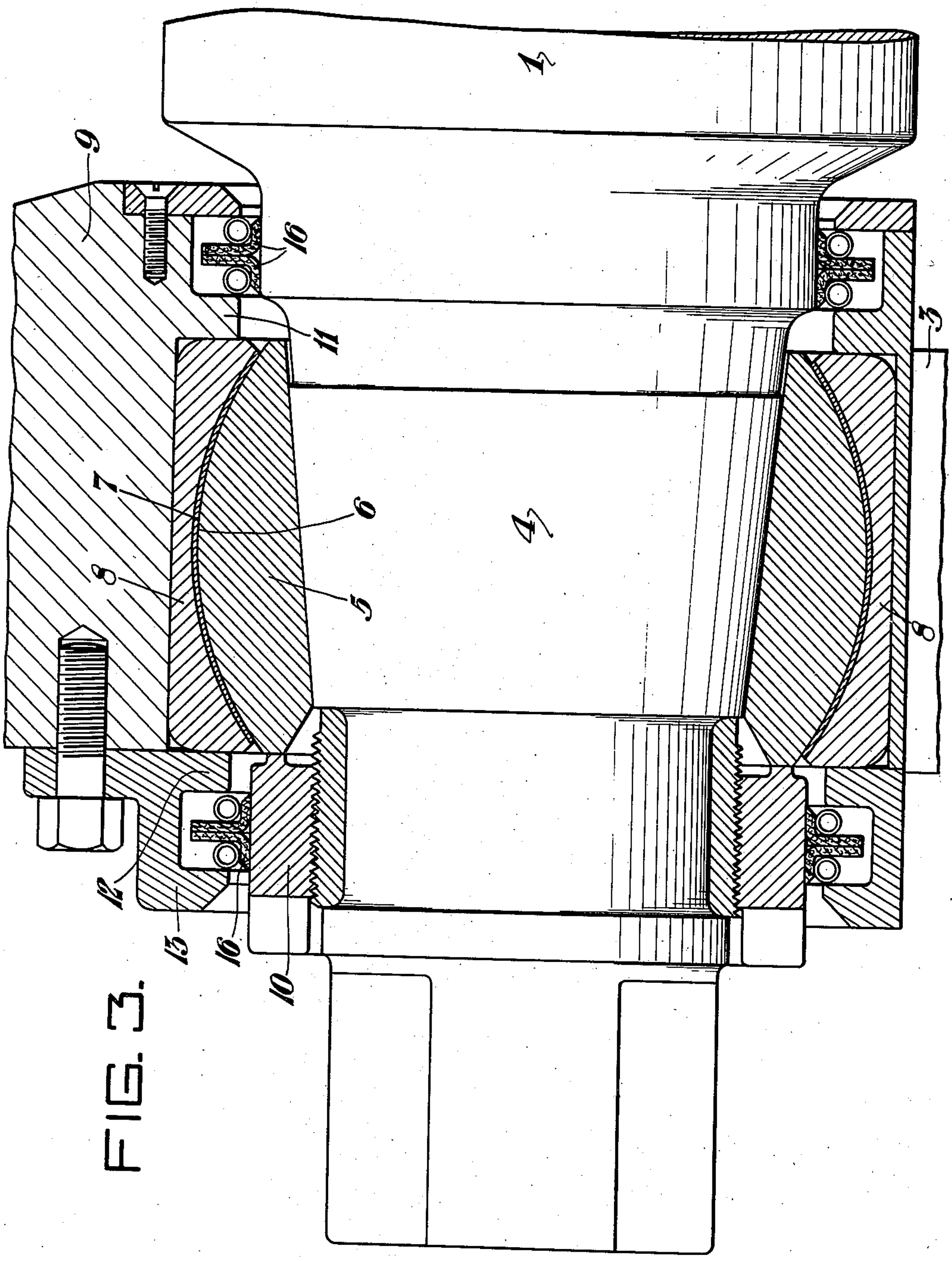


FIG. 3.

Inventor:
LLOYD JONES,
by: [signature]
his Attorney.

Patented Mar. 2, 1943 2,312,648

UNITED STATES PATENT OFFICE

2,312,648

METAL ROLLING MILL

Lloyd Jones, North East, Pa.

Application March 15, 1941, Serial No. 383,575

4 Claims. (Cl. 80—55)

This invention relates to rolling mills, one of the objects being to provide a mill that is better able to accommodate high rolling speeds and great pressures for the rolling of products having very accurately finished dimensions, such as sheet, strip, etc., than are mills of prior art design.

In order to perform precision rolling at high speeds and heavy pressures, it is essential that the rolls be maintained in accurate relationship. Furthermore, as the pressures between the rolls increase, the strength of the roll necks, as compared with the strength of the roll bodies, becomes increasingly important. With the increase in velocity of rolling, this neck condition becomes more vital as the sudden superimposed loads occasioned by the work entering and leaving the rolls increase as the square of the velocity. This condition is further aggravated when these loads acting on the roll bodies, in addition to causing deflection in the roll bodies and the roll necks, must also align the roll neck bearing chocks in the necessarily short interval of time available in the case of high velocity rolling.

These stress reactions are enormous, undeterminable and variable, and are very destructive on bearings, as obviously such alignment of the bearing chocks reflect all such neck reactions onto the bearing surfaces. As the inertia and other forces, such as friction, etc., resist instantaneous alignment of the bearing chocks, another disturbing element enters into the problem, namely, adverse deflection of the rolls themselves. When the rolls are free to deflect due to the rolling loads plus the superimposed work entering and leaving loads, the roll bodies and roll necks will assume comparatively simple deflection curves which can be compensated for with reasonable accuracy by proper roll contours. The resistance of the bearing chocks to quickly and totally align themselves, affects these otherwise simple deflective curves and causes them to assume compound or even reverse deflection curves which are as undeterminable and variable as the chock alignment loads themselves.

Another source of difficulty in existing mills for accurate rolling is the large number of pieces which must everlastingly move and adjust themselves to corresponding variations in loads. Every chock that must move and every portion within each bearing itself that changes its relative position are sources of trouble affecting the accurate relationship of the rolls. Wherever one part moves or rocks on another part with metal-to-metal contact, there is abrasion, distortion and inaccuracy. Hence, the elimination of all such disturbing factors is advisable and essential. These conditions apply to the rolling of all accurate products but are especially applicable to the production of flat thin strip and sheet material, etc.

Now, having reference to the accompanying drawings:

Figure 1 is a front elevation of a modern high-speed, heavy-pressure, four-high precision strip mill;

Figure 2 is a front elevation of a modern high-speed, heavy-pressure precision two-high mill;

Figure 3 is an enlarged longitudinal section of the chock and bearing exposing the roll neck; and

Figure 4 is an enlarged cross section of the chock, bearing and roll neck.

The mill illustrated by Figure 1 is a four-high mill and includes working rolls 1 supported by backing or pressure rolls 2 journaled in the windows of the mill housing 3 by means of self-aligning bearings permitting rapid deflection or flexing of the rolls in service.

The mill illustrated by Figure 2 includes rolls 1 which in a two-high mill combine the functions of work and pressure, this distinguishing it from a four-high mill, journaled in the mill housing 3 by means of self-aligning bearings. The same numerals are used for both Figures 1 and 2 because the parts are fundamentally the same.

Both the four-high type mill and the two-high type mill are shown to illustrate that the space limitations surrounding the roll necks are practically identical with all types of mills. Generally, the four-high type is best adapted for the rolling of wide accurate flat products, while the two-high type and three-high type, the latter type being unillustrated, are generally used for the rolling of shaped material such as structural beams, rounds, squares, etc. Due to the fact that when rolling flat products the material may extend across the entire faces of the roll bodies to within very short distances of each of their ends, the rolling pressures are usually greater than they are for the rolling of shaped products which usually contact relatively short portions of the faces of the roll bodies. This is one of the principal reasons for separating in a four-high mill the functions of work and pressure between separate rolls. There are special occasions in two-high and other types of mills when great pressures and high speeds combined with accuracy are demanded, and in such instances the type of bearing mounting as herein disclosed for a four-high mill will be advantageous in such other types.

Proceeding with the description, the rolls 1 and 2 have body diameters proportioned according to the rolling stresses involved, as contrasted to being of abnormal sizes for the purpose of rendering them relatively rigid or for the purpose of obtaining additional space for the accommodation of roller bearings, etc. Relatively small rolls are preferred for both working and pressure functions because small rolls do the work better in so far as the actual rolling of the metal is concerned, and from a pressure viewpoint the smaller the roll can be made commensurate with the pressures involved, the smaller and cheaper will be the entire mill structure and the rolls themselves which constantly wear out and will be less expensive to replace and much easier and cheaper to manufacture. While rolls of small or normal diameter will deflect more under a given load, this is not of concern as this invention takes specific care of this feature.

The rolls are provided with tapered necks 4 at each end on which are mounted bearings for positioning the rolls. These necks transfer the rolling loads through the bearings to the housing frame, and since the rolls are designed for the rolling stresses, the necks are designed to have relative strength. In other words, the necks are designed to have sufficient strength to carry any load that can be carried by the roll body providing the roll structure can assume a simple flexure curve. Experience and calculations indicate that this condition is met when the necks in their zones of maximum stress have a diameter adjacent to the roll body of about 70% of the nominal roll body diameter.

In each instance the middle portion of the neck is encircled by a narrow ring 5 which rotates with the neck, the outer periphery of the ring forming a continuous spherical sliding bearing surface 6 which cooperates with an interrupted spherical sliding bearing surface 7 formed by the inner portions of multiple segments 8 encircling the ring 5 and which are positioned in the chock 9. The ring 5 is removably fixed on the neck taper by a lock nut 10 and rotates with the neck, hence all radial loads and thrust loads combine as a single load coacting on the bearing surfaces 6 and 7 and holding the roll body in a predetermined position in all directions regardless of roll and neck deflections or misalignment of the rolls. The chocks on one side of the mill are held in all directions, while the chocks on the opposite ends of the rolls are held in all directions except endwise. This allows the roll to expand and contract without disturbing the roll relationship.

The bearing segments 8 are fixedly positioned in the chock 9 so that they have no side motion or rotary motion, as otherwise the accurate alignment of the roll both endwise and radially would be disturbed. The means of accomplishing this is by holding the segments between shoulders 11 and 12 formed by the chock 9 and cover plate 13, and by tapered wedges 14 and a tapered key 15. The chock 9 is fitted with the cover plate 13 so that the parts can be assembled around the ring 5. Means are provided in the form of seals 16 coacting with the roll neck, locking ring, etc., for excluding dirt and foreign substance from entering the bearing and for preventing lubricant losses when the assembly is mounted on the roll neck for operation. It is apparent that by removing the lock nut 10 the entire assembly consisting of the chock 9, cover plate 13, segments 8, ring 5 and seals 16 may be removed as a single unit.

Best results are obtained from the bearing surfaces 6 and 7 when they are lubricated by a continuous lubricating film formed by circulating lubricant from an outside source in the usual well known manner provided by commercial lubricating systems. By circulating the lubricant, which may be of any well known variety, the heat generated in the lubricant by pressure between the spherical sliding surfaces, plus any heat which may travel from the roll body into the roll neck, will be removed by the circulating lubricant and dissipated outside the chock assembly, this keeping the bearing parts and the roll neck at practically a constant temperature, thus preserving the bearing efficiency and preventing any distortion in the apparatus due to accumulated heat and consequent rise in temperature of any working parts. Passages 17 are shown for lubricant to enter one side of the bearing and be drawn between the sliding surfaces and escape via similar passages on the opposite side. The principle of lubricating bearings is well known and therefore merely indicated generally, it being understood that pipe connections and other well known accessories will be required.

To secure accuracy in the rolling of strip or other flat products, especially when gage tolerances of only a small fraction of a thousandth of an inch are permissible, requires extreme accuracy of machine work, and the design of the apparatus must be such that the accuracy of the setting or positioning of the roll and/or any part affecting the same shall stay in that relative position while the rolling is in progress. Any movement of the chocks or any movement within the chocks, except the smooth frictionless sliding of two surfaces separated by an extremely thin lubricant film, is apt to reflect on the gage and surface of the flat material. For these and other reasons the inventor designed the bearing as shown in the drawings.

Referring to Figures 3 and 4, the chocks 9 do not rock to accommodate roll deflection as the spherical bearing surfaces 6 and 7 separated by a thin film of lubricant which will permit the ring 5 encircling the neck 4 to assume angular displacement with practically no opposition from friction or inertia. As the ring 5 is fixedly positioned on neck 4, there is no clearance or wear in these parts, hence the relationship of ring 5 with its spherical surface 6 is therefore always the same to the neck 4 and to the rolling surface of the one or the other of the rolls 1 or 2, as the case may be. This is very important as the circumference of the roll body must always remain in exact relationship with the bearing surface 6 because the least eccentricity will produce gage variations in the strip.

The tapered portion of the neck and the roll body are finished machined at the same setting of the roll so that these parts are exactly concentric. This tapered portion of the neck must have a large diameter on account of strength so as to conform with roll body strength, this leaving a small radial space available for the ring 5, the segments 8 and the chock 9 where the opposing rolls contact the work or each other. It is impossible to manufacture the ring 5 with such a thin cross section and have it hold its shape and accuracy by itself. However, by forcing the ring 5 onto the accurately finished taper of neck 4, the ring will be supported throughout its inner circumference and maintain its shape and accuracy during operations, thus permitting the ring to be made quite thin as it is illustrated. Likewise, the segments 8 are not of sufficient cross section to maintain their shape and accuracy, but by means of the wedges 14 and the keys 15 they are forced into accurate position formed by the bore of chock **9**. I thus have a condition where the only moving joint and the only place where clearance exists is between the two accurately finished, high polished, spherical, bearing surfaces **6** and **7**, which are separated by a thin film of lubricant of predetermined dimensions.

In the production of accurately gaged strip with highly finished smooth surfaces, even the thickness of the oil film is important and must not be left to chance but must be governed and controlled. This is readily provided for in my bearing in that the diameters of the surfaces **6** and **7** are fixed and have a close definite relationship to each other so as to determine at all times the amount of lubricant film without unduly restricting the flow of lubricant through the bearing chock, because the spaces **18** formed between the wedges **14** and the ring **5** permit all lubricant not required for the film to by-pass the segments and flow out the opposite side of the bearing chock. This is very important as cool, fresh lubricant is always entering the bearing and air bubbles and air pockets are not permitted to form or heat to accumulate.

Other advantages of my construction are as follows:

All parts of all bearings are exact duplicates for the same size. The chock assemblies for either end of each roll and for both the top and bottom roll may be the same. The direction of rotation does not affect the design or parts. If the tapered portion of the neck **4** becomes damaged, it can be redressed without affecting the bearing assembly, because space is provided between the chock **9** and the end of the roll body for this purpose.

Due to the elimination of clearance in the parts, thus doing away with so called roll jumping when the piece enters between the rolls, and by eliminating the eccentric and highly objectionable and undeterminable loads occasioned by tilting of the chocks due to roll and neck deflections and by misalignment due to unequal spring in the housings, etc., and by the special arrangement of the parts wherein the highly polished, spherical bearing surfaces are rigidly maintained in true and accurate positions at all times, it has been found that the lubricant film is capable of sustaining effective loads per square inch of projected bearing area far beyond those used in present mill bearings. I am able, therefore, to reduce the length of the bearing surfaces to about 60% of the diameter of the bearing surface, and thus reduce the radial space required for the curved bearing surfaces to such dimensions as to permit the roll neck at all points to be commensurate in strength with the roll body. At the same time the effective load capacity of my bearings either closely approaches or exceeds the roll neck strength depending on the material of which the roll is composed. As regards comparative capacities of my bearing with equivalent commercial roller bearings used at the present time, indications show that this especially designed arrangement has four to seven times the load capacity of roller bearings. The only types of oil film bearings in use on four-high, high-speed, heavy-duty strip mills at the present time are of the straight cylindrical variety and are of the tilting chock type similar to the roller bearings so as to possess many of their defects.

In Figures 1 and 2 there is shown a liner block **19** interposed between the chocks **9** and the screwdowns **20** for vertically adjusting the rolls, the mill being provided with suitable equipment for controlling these screws. The general practice has been to operate each screw independently so as to horizontally align each end of the roll, and when moving the entire roll with a vertical movement, to couple the two screws together for simultaneous operation. Vertical adjustment of the rolls for changing the thickness of the rolling pass is rarely accomplished without the rolls getting out of parallel relationship and even if such vertical movement is accomplished without disturbing the parallel condition, this relationship is generally disturbed when the rolling load is first applied, because the elastic extension and compression in the housings, screwdowns etc. are never exactly the same on each end of the roll. Hence, the bearings which slide vertically in the housings must be arranged for a vertical tilting movement and also rotation of the rolls when said rolls are not parallel with each other as well as when they are parallel. This was heretofore accomplished by the chocks assuming an angular motion in the housings similar to the positions assumed by roll deflection. In fact, the two conditions generally exist simultaneously. It is obvious that any non-parallel eccentric load condition aggravates the bearing troubles and, clearly, a universal self-aligning lubricated bearing is the logical answer.

The equipment for operating the screwdowns is not disclosed for the reason that it may follow conventional practice. The blocks **19** may be connected by means of cross pieces **21** so that they will present a flat surface for supporting the top portion of chock **9** in a similar manner to that with which the lower chocks **9** seat on the flat surface of the housing.

In addition to the foregoing, it is to be understood that it is prior art to abstract heat from the roll neck bearings to keep them at uniform temperatures and to use various means for controlling the roll body temperatures all in attempts to maintain the roll body contours to the end of keeping an accurate rolling pass. However, due to the rolls being flexed in an unpredictable manner by the action of prior art neck bearing, as has been described, and due to the erratic loadings of the bearings due to their inability to accommodate rapid changes in the neck angularities, such attempts have not been successful. But in the case of the present invention, the bearings permit the rolls to assume true simple flexure curves which directly depend on the pressure applied which is a known quantity, and the bearings, also, are not subject to erratic loading, their loading, and, hence, their heating, being a true direct function of the pressure applied them. Therefore, I can, for instance, by means of sprays from nozzles **24** working individually through valves **25** from headers **26**, exactly control the roll contours by thermal control of the same and, also, can accurately control the bearing temperatures by controlling the temperature and flow rate of the bearing lubricant. It follows that the new bearing provides for maintenance of an exactly dimensioned rolling pass, the rolls being contoured to take care of the predictable flexure curves of the rolls, the roll contours which are then directly dependent of their temperatures being accurately adjustable by thermal control of the roll bodies and the bearings themselves being accurately maintained at predetermined temperatures by control of the cooling effect of their lubricant.

It is implied and understood by those familiar with the art that in all heavy-pressure, high-speed mills when rolling materials, there is a heat accumulating tendency in the rolls and adjacent parts which must be taken care of. The rolling art has compensated for said tendency for many decades by various well known devices, and they are therefore not disclosed for the reason that they may follow conventional practice.

The term "metal rolling mill" is general in character and covers a large number of special designs for rolling special products. A few of the best known kinds are called plate mills, structural mills, merchant bar mills, strip mills, etc., and, for example, a merchant bar mill would be totally unsuited for rolling plates, while, likewise, a structural mill could not roll wide thin strip, etc. The term "mill" is again indefinite as it may apply to a single roll stand or to a number of stands grouped in various arrangements, all cooperating together to produce a product. Also, the term "mill" may include a complete installation of rolling stands including drives, conveyers, reels, etc., for mechanically handling and rolling and storing the material from start to finish.

The kind of material produced generally determines the arrangement of the rolling mill stands in relation to each other, as well as the character of auxiliary equipment and its arrangement and, also, the character of the rolls which perform the work on the material and the arrangement of the rolls in relation to each other and their particular method of operation.

Hence, those familiar with the art of rolling prefer to designate rolling mills by the principal product rolled as, for example, wide thin strip mills, etc. In the above description, Figure 1 shows a four-high type of rolling mill stand which is especially adapted for the production of wide flat products such as tin plate, sheets, strips, plate, etc., and, as described, is characterized by new and novel means for producing such products with extreme accuracy and with greater ease, etc., and it is to be understood that in order to produce such products such improved rolling mill stands may be connected by any method to any source of power and may be used singly or in any kind of group arrangement, and they may be surrounded and supplemented by various and any appurtenances suitable for the production of such materials.

In the above description, Figure 2 represents a two-high rolling mill stand commonly employed in conjunction with three-high roll stands for the rolling of shaped material similar to rails, beams, angles, rounds, squares, etc. As described in the specification, the new and novel means are mainly applicable to such two-high mills producing such products where extreme accuracy combined with great pressure and high speed is required, as, for example, cold rolling thin strip, copper, brass, aluminum, etc., where the rolling problems are similar to the production of wide flat products made of less ductile material, or applicable to such two-high rolling mills where the top roll is frequently adjusted vertically and the pressures are great and the rolling in constant alternating directions as, for example, blooming mills, slabbing mills, etc.

I claim:

1. A bearing construction of the unit assembly type for a rolling mill comprising an inner ring member having a taper bore tightly fitted to a corresponding taper portion of a roll neck to rotate therewith and be supported and maintained in its true shape by said neck, the outer portion of said ring member having a spherical bearing surface which co-acts with spherical bearing surfaces formed on the inner portions of thin segments which are maintained in their true shape by being tightly fixed in the bore of a surrounding chock, the ring member and the bearing segments being radially thin so as to be of themselves unstable, for the purpose of increasing the spherical bearing arc so as to support the heavy imposed loads and also permit the use of a roll neck of sufficient size so that in its zone of maximum stress it will have a strength substantially equal to the roll body when occupying the limited available space between adjacent cooperating rolls.

2. A high-speed heavy-pressure precision rolling mill comprising the combination of pressure rolls having bodies that flex under their working load and tapered roll necks having sufficient dimensions to safely carry said load, thin solid one-piece bearing rings forced on and rigidly supported by said tapered roll necks and being sufficiently light in weight to be free from inertial restraint to angular roll neck movement due to rapid roll body flexing, said bearing rings having external spherical bearing surfaces, thin bearing liners encircling said rings and having internal spherical bearing surfaces cooperating with those of said rings, bearing chocks enclosing and rigidly supporting said liners with the latter immovably fixed therein, a mill housing having windows in which said bearing chocks are mounted for vertical movement and screw-downs for applying the working load to said chocks, said roll necks being free to assume instantaneously any angular position respecting said non-tilting chocks and said bearing rings and said bearing-liners being rigidly immovable respecting their associated parts so that the bearing pressure load per unit of area does not change with changes in roll neck angular positions respecting said non-tilting chocks.

3. A self-aligning roll neck bearing mounted in a mill frame window and comprising the combination of two bearing elements having co-operating sliding spherical bearing surfaces and both made so thin to conserve radial space as to be incapable of separately maintaining the shapes of said surfaces, the inner member having a tapered bore and being wedged onto a solid tapered roll neck various extents as required to rigidly maintain the form of its said surface, and the outer element being provided with a housing of adequate strength having a bore receiving said outer element, means being provided for rigidly wedging said outer element in said bore.

4. A metal rolling mill comprising the combination of a mill frame having windows, pressure rolls having roll necks projecting thru said windows, bearing chocks in said windows with said necks projecting therethrough, means for applying pressure to said necks through said chocks, solid peripherally continuous ring elements rigidly carried by each of said necks and externally provided with spherical bearing surfaces, and elements rigidly carried by each of said chocks and internally provided with spherical bearing surfaces slidingly mounting the first-named surfaces.

LLOYD JONES.