

Aug. 22, 1939.

T. SENDZIMIR

2,170,732

ROLLING MILL

Filed Aug. 30, 1934

3 Sheets-Sheet 1

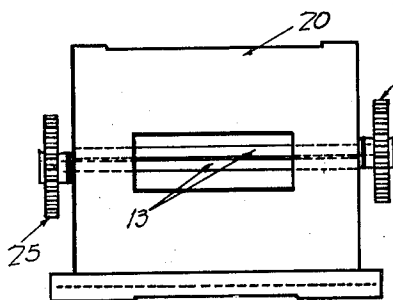


FIG. 1.

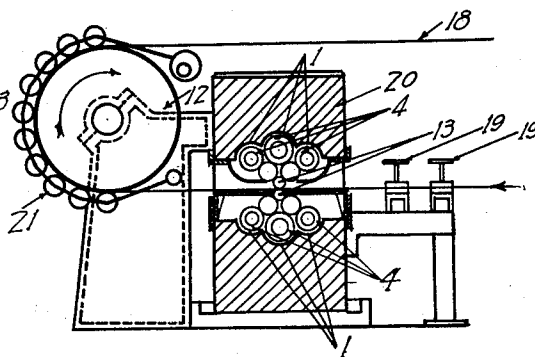


FIG. 2.

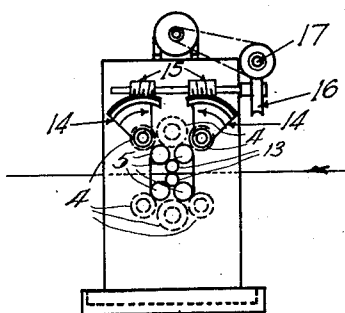


FIG. 3.

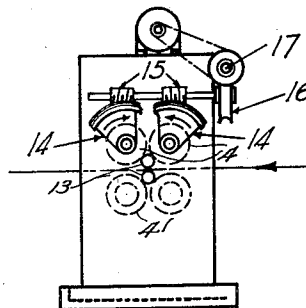


FIG. 4.

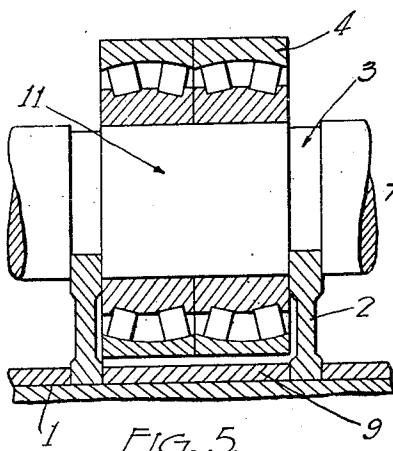


FIG. 5.

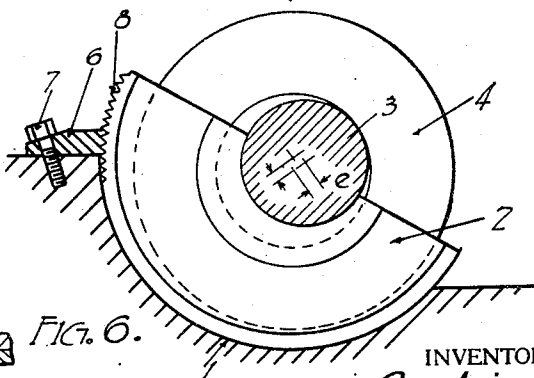


FIG. 6.

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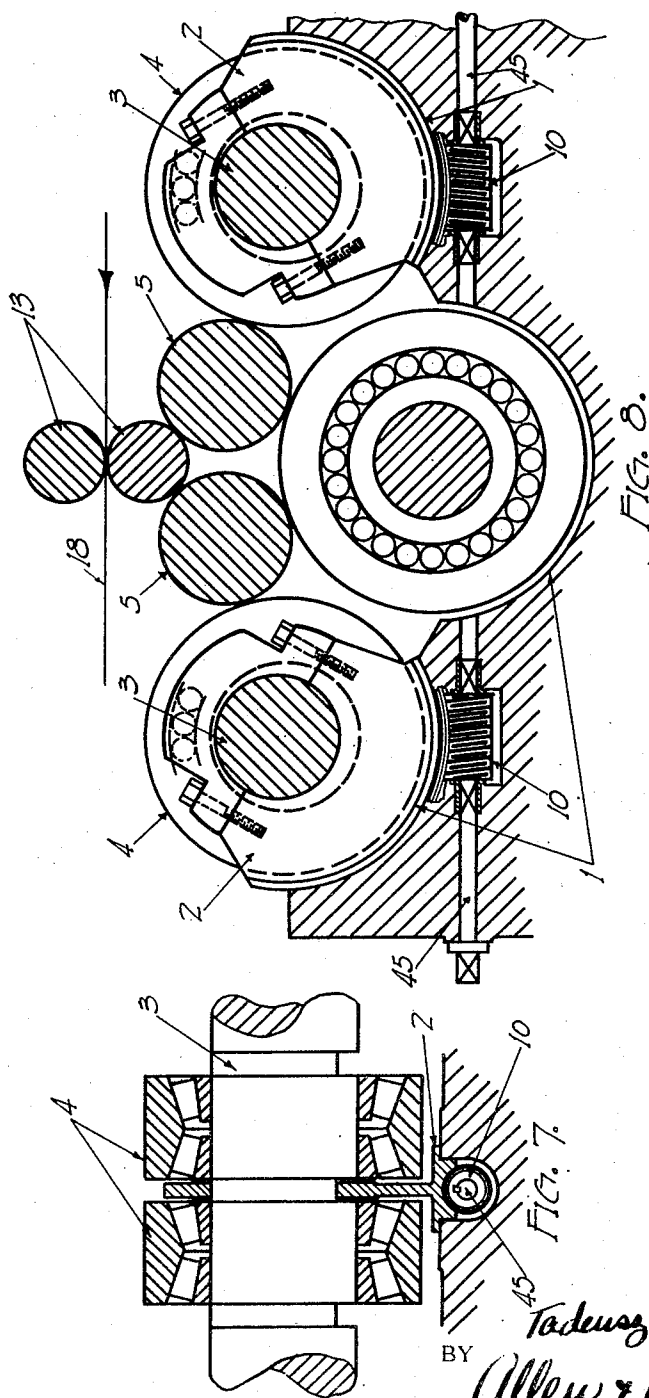
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3 Sheets-Sheet 2



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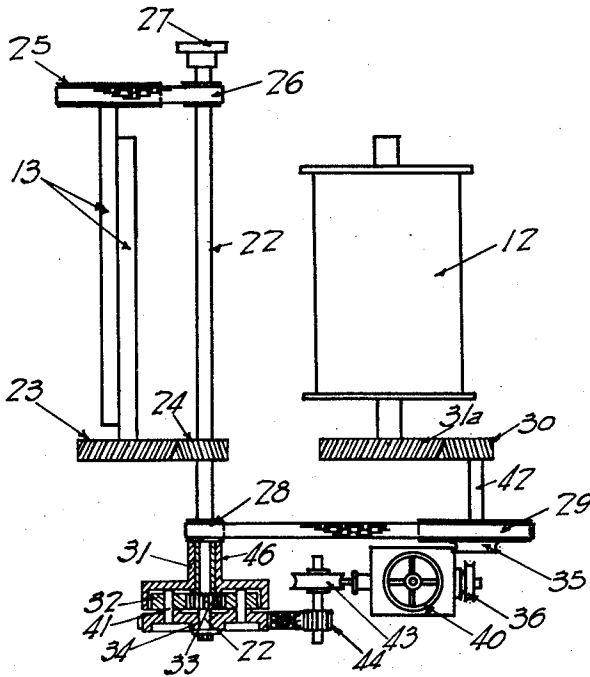
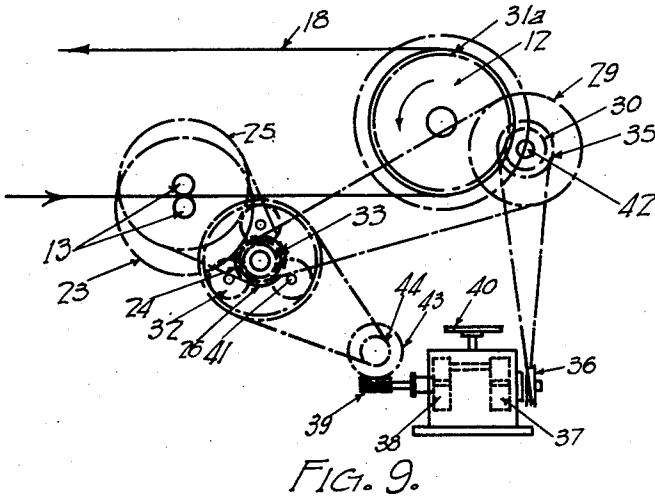
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ROLLING MILL

Filed Aug. 30, 1934

3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

2,170,732

## ROLLING MILL

Tadeusz Sendzimir, Katowice, Poland, assignor  
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Application August 30, 1934, Serial No. 742,075

20 Claims. (Cl. 80—38)

This invention relates to mills for rolling strips and similar flat material of great widths and comparatively thin gauges, in long lengths, using backed-up working rolls of small diameter.

I found that inaccuracies in the gauge of pre-rolled raw material, especially for wide strips, such as from three to eight feet wide, where products of continuous hot mills as raw material are not always available, invariably cause inaccuracies in the finished product and also cause that product to be warped, wavy and not quite straight in its longitudinal direction.

The above difficulties are particularly accentuated if the raw material consists of several pieces of strip welded together, owing to differences not only in gauge but also in temper of the individual pieces of metal.

I entirely overcome those difficulties by using a new design frame and roll support and also by incorporating a stretching apparatus for continuously straightening and positively elongating the material each time after it leaves the rolls.

This invention relates to mills in which the backing-up elements are mounted upon shafts which are supported, at frequent intervals, by bearing members resting upon rigid frame beams.

Figures 1 and 2 show the general arrangement of the mill in front elevation and in a vertical transverse section, respectively.

Figs. 3 and 4 show the side view of the frame with details of the roll-adjusting apparatus.

Figs. 5 and 6 show a longitudinal and cross section of the shaft bearing the roll-supporting elements, together with excentrically adjustable supporting bearing members.

Figs. 7 and 8 show another way of adjusting such excentric bearing member, in longitudinal and cross section, respectively.

Figs. 9 and 10 show schematically, in cross section and in top view, the gearing arrangement of the mill, including one way in which the predetermined stretch adjustment may be put into effect.

In the general type of rolling mill frame which consists of two beams and two or four columns and is either made out of one piece of metal, or the parts are securely bolted or joined together, in such way that the columns, owing to their rigid juncture with the beams, help to reduce the bending stresses in the latter, I introduce the novel feature of circular-shaped channels, at least two to each working roll, provided in the rigid frame beams, parallel with the working rolls and at least as long as the maximum width of the strip.

Into those channels 1 are fitted bearing members 2 the bore of which fits the shafts 3 which bear the supporting rings 4. The bore of the bearing member, or of at least one row of them, is excentric with their outside diameter, so that by adjusting the angular position of the individual bearing members, a similar effect may be produced, as by adjusting the crown of the working rolls, by grinding them.

The construction of the backing elements for the working rolls can best be understood by reference to Figs. 5 to 8, inclusive. In the construction shown in Figs. 5 and 6, the working rolls 13 may contact directly with the backing elements 4 which are mounted on four shafts 3, the shafts 3 being themselves supported in the spaces between the backing elements 4 by the bearing members 2, schematically shown in Fig. 4. Fig. 3 schematically shows an arrangement where the working rolls 13 are each supported by two intermediate rolls 5, which in turn are supported by a total of six backing members similar to those of Fig. 4.

In Figs. 5 and 6, 1 represents a channel which in cross-section is an arc of a circle, bored in the mill frame beam 20. Bearing members 2 fit snugly in these channels 1, and are spaced apart by half bushings 9. The shafts 3 rest on their respective bearing members 2 and carry the excentric barrels 11 between the members 2. Each of the excentric barrels 11 carries the backing rings 4 which are of a construction similar to a roller bearing with a thicker outer rail. It is of course understood that if Fig. 5 were carried out toward the right and left it would show alternately placed bearing members 2 and backing rings 4, all the way across between the vertical columns of the mill housing. The rings 4 contact the working rolls 13 or the intermediate rolls 5, respectively, as described above.

Figs. 7 and 8 represent a modification of the roll support, in which the bearing members 2 are not only fitted into the bores of the channels 1, but are also guided axially therein, thus eliminating the half bushings 9. In this modification the bearing members 2 are fitted with caps bolted on as shown for the purpose of better holding the shaft 3. The backing rings 4 are of a slightly different construction than those shown in Fig. 5, and are mounted individually between the bearing members 2 instead of in pairs as shown in Fig. 5. It is of course understood that Fig. 7 similarly to Fig. 5, is only a partial view. Fig. 8 shows the three shafts 3 supported in the frame, each by a number of bearing members 2, and

carrying between the members 2 a number of backing rings 4. The rings 4 contact with the intermediate rolls 5, which in turn support the working rolls 13. In the central one of the three shafts 3 the bearing member 2 was omitted to clearly show the construction of the backing ring 4.

This feature not only makes it easy to adjust the mill quickly, to roll a raw material of different widths, hardness and metallurgical characteristics, for which otherwise working rolls of a different crown would be required, but also removes the objectionable fact that crowned rolls have a bigger diameter at the middle than at the sides, which causes the metal at the sides to drag behind and, in view of the fact that this error cumulates as the rolling process goes on, is frequently a cause of strip rupture.

Semi-circular channels 1 with separate bearing members 2 represent big advantages over either projections machined in the frame beam, to support directly the necks of shaft 3, or planed channels of other sections, than round. The high specific pressures on the bore of bearing member 2 can only be supported when both surfaces are hardened and ground, as is possible with semi-circular bearing members 2. Secondly, semicircular channels 1 can be machined to much closer tolerances, than other sections, and such very small tolerances are essential for the correct operation of this type of mill.

The rigid and "short" frame construction where all roll reaction forces are taken up by comparatively small supporting rolls and bearing members and finally land in solid frame beams, so that the total length of mechanical parts under stress is hardly more than one-third of what it is in a modern mill of the four high type, make the total elastic deflection under working conditions only a small fraction of the usual figures.

This feature facilitates rolling much more true to gauge than on other types of machines. To this is added another important possibility and that is the ease with which the supporting rings 4, the eccentric shafts 3 and eventually also the intermediate shafts 5 can be flooded with a cooling lubricant, so that with the relatively small size of those elements, there is no possibility of a local heating up interfering with the accuracy of the product or the smoothness of the operation of the mill.

The angular adjustment of the bearing members 2 offers, however, another improvement: it permits of such an adjustment of the outer bearing members that, when rolling strips of a width narrower than the maximum width the machine will take, such supporting rings as are beyond the edge of the strip do not participate in taking up the reaction due to rolling stresses. It is evident that, with the comparatively small diameter rolls employed, any support at or beyond the edge of the strip is detrimental, as it causes a deflection of the end of the roll towards the strip and so causes the vicinity of that edge to become wavy and thinner in gauge.

The adjustment of the bearing members 2 is obtained either as in Fig. 6 by removing clamp 6, turning the bearing member 2 by hand to the desired position and then replacing clamp 6 and securing it by screw 7, so that it engages small teeth 8 on a part of the outside diameter of bearing member 2. A difference of one tooth would give an adjustment of a few ten-thousandths of an inch. A fraction thereof may be

obtained by inserting shims underneath the clamp 6.

The parallelism of bearing members 2 is, in this instance, secured by distance pieces 9, there being setscrews on the last lateral bearing member 2 pressing the whole row of bearing members 2 and distance pieces 9 in the axial direction and thereby firmly securing them in position.

Another method of adjusting the angular position of bearing members 2 is shown in Figs. 7 and 8. The bearing member 2 is wider at its periphery and a part of it is toothed to engage with worm 10 so that adjustment can be obtained by turning worm 10 the shaft of which can be reached from outside.

These are only two examples of adjusting and locking in position bearing members 2. Such adjustment can be effected in many other ways and this description is not meant to limit the object of this invention in any way.

The apparatus for positive predetermined stretching of that part of the strip which is situated between the working rolls and the stretching block 12, in combination with the frame and roll support described, gives another important improvement which is obtained through the use of a very compact and rigid parallel roll-adjusting device.

At least one, and preferably two symmetrically disposed roll-supporting ring carrying shafts 3 have excentric barrels interposed between each two necks, so that by turning the shaft 3 a vertical displacement of the working rolls 13 is obtained.

For extreme rigidity there is a worm gear segment 14 at each end of the roll-carrying shafts 3, securely coupled with it. An accurate adjustment of the angular position of the shafts 3 may be obtained by any known and approved means. I prefer to obtain it by the use of one shaft carrying two worms, one right and one left, engaging the two sectors 14, said shaft 15 having one worm gear 16 keyed onto its end and actuated by one shaft 17 which engages by means of two identical worms both worm gears 16, one at each side of the machine and is driven from an outside source, as by an electric motor, by means of a gearing or chain drive.

Fig. 2 shows the general arrangement of the mill. The strip 18 passes successively through brakes or the like 19, a pair of working rolls 13 supported as described in the frame 20, then round the stretching block 12 and under driven rolls 21 which increase the friction of the strip on block 12. The free ends of the strip may either be reeled up, for each pass, or may preferably be joined together and led over a sheave, not shown on the drawings. The distance between the latter and the mill must of course be variable, to provide for the increasing length of the strip; and I prefer to apply a tension on that portion of the strip which lies outside of the machine.

In conjunction with rigidly supported working rolls of cylindrical shape, without any crown, my apparatus for stretching the strip at the spot where it leaves the working rolls and over the distance between this spot and the stretching block 12, makes it possible to obtain very heavy reductions at each pass, such as 50% or more, and obtain a perfectly flat material, although the raw material employed may have inaccuracies in thickness such as 10% and also differences in temper due to unequal annealing. It also readily permits rolling, down to the finest

gauges, starting with a raw material of thicker gauge than usually employed in the present practice, such as  $\frac{1}{4}$ " thick for rolling strips down to .010" or .005", for mild steel.

I obtain this by applying the drive to the working rolls, on one side, and to the stretching block, on the other, from one source of power supply, as from an electric motor, not shown, through flange 27 and main shaft 22, Fig. 10, through positive gearing such as a pair of gears 23 and 24 to the lower roll and a chain drive 25 and 26 to the upper, while the drive of the stretching block, although it is quite positive, allows a certain fine adjustment of ratio.

This object is obtained by interposing, in the chain of driving gears, as 28, 29, 30 and 31, preferably at the high speed side, a compensating gearing like a variable speed taper belt drive of sufficient size to make the slippage negligible, or a positive hydraulic gearing as such with the motor part taking a constant quantity of oil per revolution and the pump part supplying variable quantities per revolution e. g. by varying the stroke.

Figs. 9 and 10 show a modification of this latter system wherein, through the use of a planetary gearing and other arrangements, it is possible to transmit through the variable speed gearing only a small percentage of the total power, such as one or two percent.

Pinion 33 is keyed onto the shaft 22 and drives gear 31, which is rotatable on shaft 22 and carries the driving sprocket 28, linked by chain to the sprocket 29, the shaft of which drives the gear 30 for the drum 12. The gear 31 has its internally directed teeth in mesh with and driven through one or more planetary pinions 32. The latter turn round pins 41 which are secured in the web of the sprocket 34 which is free to rotate on the shaft 22. The sprocket 34 is coupled with the worm 39 which is driven, through suitable gearing, from the motor 38 of a variable speed positive hydraulic gear or any other mechanical or electrical gearing of the kind with adjustable ratio and little or no slipping. As shown, the coupling between worm 39 and sprocket 34 is provided by worm wheel 43 and sprocket 44, the latter driving a chain that engages sprocket 34.

The other end of such gear, as the hydraulic pump 37, is driven preferably from some part of the mill gearing, such as the intermediate shaft 42, through belt sheaves 35 and 36.

If the adjusting wheel 40 of the variable speed gear is set at naught, worm 39 does not rotate while the mill is in motion and the gearing from the main shaft 22 both to the working rolls 13 and the stretching block 12 is a fixed ratio positive gearing and should be such as to make the tangential speed of the stretching block slightly higher, for mild steel about two percent higher than the tangential speed of the working rolls.

As the rolling operation progresses and the strip, from an original thickness of say .15" has been rolled down to .09", it may be desirable to reduce that advance from 2% down to 1% and later to even less than that, in order to obtain a perfectly flat and accurate strip and yet run no risk of the strip breaking. This is obtained by so adjusting the variable speed transmission gear, as by turning the wheel 40, that the worm gear 34 turns, in an inverse direction in this instance, making one-half or one or two revolutions to each one hundred revolutions of the gear 31, or any intermediate ratio of course.

When an optimum proportion of stretching, for each successive draft or pass is once established, for a given rolling program, I prefer to so link the adjusting wheel 40 with the working roll adjusting sectors 14, as by a combination of levers, chains or the like, as to obtain an automatic repetition of the same rolling conditions with every coil of strip, independently of the operator.

Successive regrinding makes the diameter of the working rolls 13 less and this condition would upset the predetermined ratio of stretching. The compensating gearing above described could be so proportioned as to take care also of this factor, but I prefer to use it solely to obtain the very fine adjustment and use other means, such as replace the chain pinion 28, with a smaller one, when the comparatively small range of adjustment of the compensating gearing is passed.

It is only with this system of rolling, with absolutely stiff gearing, with the stretching block quite close to the mill frame and of such small diameter, as the thickness of the raw material will permit, with suitable means to make the grip of the block upon the strip positive, by increasing the friction, as by a chain of driven rolls encircling about one half of it, the last link being tightened, as by an excentric shaft and an air cylinder, to compensate for the diminishing thickness of the strip and with the frame and roll support absolutely rigid and the rolls of uniform diameter throughout, that those important results can be obtained.

It is evident that with known constructions where for instance the reel is driven by a motor, a certain tension is applied on the strip, such tension having a beneficial result on the rolling operation, by decreasing the roll pressure necessary and for other reasons.

But when a portion of the strip that may for instance be slightly thicker than other portions passes between the working rolls, the pressure on the rolls will increase and the frame will give way elastically and the product will be thicker at this spot. With such thicker strip leaving the rolls, the pull remaining virtually constant, the tension per square inch of the section will become less. This again increases the roll pressure and thus the error is accentuated and made worse.

In comparison with this my constant predetermined stretch system will stretch the strip irrespective of its thickness and section and with it, it is surprisingly easy to remove inaccuracies in the raw material of such high order, as would make that material entirely unsuitable for rolling in other mills.

In connection with the above said I want to revert again to the roll-adjusting device. With the adjusting shafts 3 having excentric barrels 11 interposed between each two bearing members 2, a very rigid and absolutely parallel adjustment in the vertical position of the working roll is obtained.

Such parallel adjustment would not be suitable for ordinary types of rolling mills, as they do not possess a predetermined adjustable ratio stretching device right after the working rolls and of necessity must rely upon an uneven setting of the distance between the rolls, on their right and left-hand sides, in order to correct small inaccuracies, although such correction causes such side as is pressed more to elongate more with the result that the whole strip has a tendency to run

on the taking-up reel to the right or the left, as the case may be.

Systems of roll adjustment are known where such adjustment is obtained by eccentrically adjusting the bearings of supporting rolls, especially on the "cluster" type but, beyond an outside similarity, they have nothing to do with my invention.

Having now briefly described the essential features of my invention and its mode of operation, I declare that what I invented is:

1. In a rolling mill, a frame having at least two vertical columns and horizontal cross members forming rigidly connected beams therebetween, said entire frame being formed of one piece of metal whereby the bending resistance of the columns and the increased rigidity of the beams helps to decrease the deflection of the working rolls produced by roll pressure, small thickness working rolls in said frame, shafts mounted in said frame backing up elements for said working rolls carried on said shafts, and members directly supported on said beams engaging said shafts at a plurality of points across said beams, said beams being formed with channels across them, said channels having a section of an arc of a circle, and said members having curved surfaces engaging said channels but eccentrically to the shaft supports therein, and means for adjusting their position in said channels for the purpose described.

2. In combination with a cross beam of a rolling mill housing, having a channel therein forming an arc of a circle, a support having a journal therein for supporting the backing up roll shaft, and an outer periphery of constant curvature eccentric to said journal and engaging said channel, and means for adjusting the position of said support in said channel.

3. In a rolling mill the combination of a pair of working rolls and a pulling device for applying tension to a piece as it comes from the rolls, means for driving the pulling device so that the speed of movement of the piece under the influence of the pulling device bears a definite maintained relation to the speed of operation of the said rolls, and means whereby said relation is maintained during acceleration and deceleration of the rolls.

4. In a rolling mill the combination of a pair of working rolls and a pulling device for applying tension to a piece as it comes from the rolls, means for driving the pulling device so that the speed of movement of the piece under the influence of the pulling device bears a definite maintained relation to the speed of operation of the said rolls, and means whereby said relation is maintained during acceleration and deceleration of the rolls and means for adjusting the relative speed relationship of said driving means.

5. In a rolling mill the combination of a pair of working rolls and a pulling device for applying tension to a piece as it comes from the rolls, means for driving the pulling device so that the speed of movement of the piece under the influence of the pulling device bears a definite maintained relation to the speed of operation of the said rolls, and means whereby said relation is maintained during acceleration and deceleration of the rolls and means for adjustably holding back the piece at the entering side of the rolls.

6. In a rolling mill the combination of a pair of working rolls and a pulling device at the exit side of the same, common means for driving the working rolls and the pulling device by direct

mechanical connections, and means for adjusting the speed ratio in said connections, whereby the peripheral speed of the rolls will bear a positive relationship to the speed with which the piece is pulled at the exit of the same at any adjustment.

7. In a rolling mill the combination of a pair of working rolls and a pulling device at the exit side of the same, common means for driving the working rolls and the pulling device by direct mechanical connections, and means for adjusting the speed ratio in said connections, whereby the peripheral speed of the rolls will bear a positive relationship to the speed with which the piece is pulled at the exit of the same at any adjustment, and adjustable hold-back means applied to the piece at the entering side of the said rolls.

8. That method of rolling under tension which consists in passing a piece between working rolls and applying a pull to the piece as it leaves the rolls which bears a positive definite speed relation to the peripheral speed of the rolls.

9. A method of reducing metal which comprises rolling said metal and during said step, advancing said metal under force beyond said mill with a linear speed which bears a positive constant relationship to the peripheral speed of the rolls of said mill.

10. In a device for rolling metal, two instrumentalities, one of which is substantially only a reducing instrumentality and the other of which is substantially only an advancing instrumentality and means for maintaining the speed of said two instrumentalities at a fixed, predetermined proportional interrelationship.

11. In a device for rolling metal, two instrumentalities, one of which is substantially only a reducing instrumentality and the other of which is substantially only an advancing instrumentality, means for maintaining the speeds of said two instrumentalities at a fixed predetermined proportional interrelationship, and means for adjusting the speeds of said instrumentalities to different proportional interrelationships.

12. A method of rolling under tension, which consists in passing a piece between working rolls and advancing said piece beyond said working rolls at a speed sufficient to produce a tension in said piece, but at a linear speed which continuously bears a constant predetermined positive relationship to the speed of said rolls.

13. A method of rolling under tension which consists in passing a piece through working rolls, simultaneously feeding said piece beyond said rolls by means having substantially no reducing function so as to produce a tension therein, and positively proportioning the effect of said feeding means to the reduction produced by said rolls so as to maintain the elongation constant in spite of variations in the piece, by causing said feeding means to operate at a speed definitely related to the speed of the rolls.

14. A process of rolling under tension which comprises passing a piece through a mill and advancing said piece at least beyond said mill by means having substantially no reducing function and continuously and positively maintaining, during the rolling process, a constant predetermined elongation in the piece, by advancing said pieces at a speed bearing a fixed relationship to the speed of the rolls of said mill.

15. That method of producing band or strip of great width as compared to its thickness by rolling under tension, which consists in passing a

piece between working rolls and applying a pull to the piece as it leaves these rolls so as to control the linear speed of the piece, and positively causing the said linear speed to bear a constant and definite relationship to the peripheral speed of the rolls.

16. A process of rolling under tension which comprises passing a piece through working rolls, and continuously advancing said piece beyond said rolls at a predetermined, positively fixed speed which is faster than the peripheral speed of said working rolls.

17. In a rolling mill, a frame having at least two vertical columns and horizontal cross members adapted to take up the deflection of the working rolls throughout their entire length, said frame constituting statically, as regards roll pressure reactions, one entire block whereby the bending resistance of the columns and the increased rigidity of the beams help to decrease the deflection of the working rolls, and means for controlling the pass clearance of the mill while maintaining the respective relation of the various mill housing members.

18. In a rolling mill, a frame having at least two vertical columns and horizontal cross members adapted to take up the deflection of the working rolls throughout their entire length, said

frame constituting statically, as regards roll pressure reactions, one entire block whereby the bending resistance of the columns and the increased rigidity of the beams help to decrease the deflection of the working rolls, small thickness working rolls in said frame, shafts mounted in said frame, and backing up elements for said working rolls carried on said shafts, and members directly supported on said beams engaging said shafts at a plurality of points across said beams and means for controlling the pass clearance of the mill while maintaining the respective relation of the various mill housing members.

19. In a rolling mill the combination of a pair of working rolls and a non-reducing pulling device at the exit side of the same, common means for driving the working rolls and the pulling device by non-slip mechanical connections so as to insure a fixed ratio of angular velocities of said working rolls and said pulling device.

20. In a rolling instrumentality, the combination of a mill adapted to produce a certain predetermined elongation, a non-reducing strip advancing means, and means for driving said strip advancing means at a speed relation to the mill rolls required to produce said predetermined elongation.

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