Aug. 28, 1923. 1,466,459

J. M. PERRY

ROLLING MILL

Filed April 3, 1922

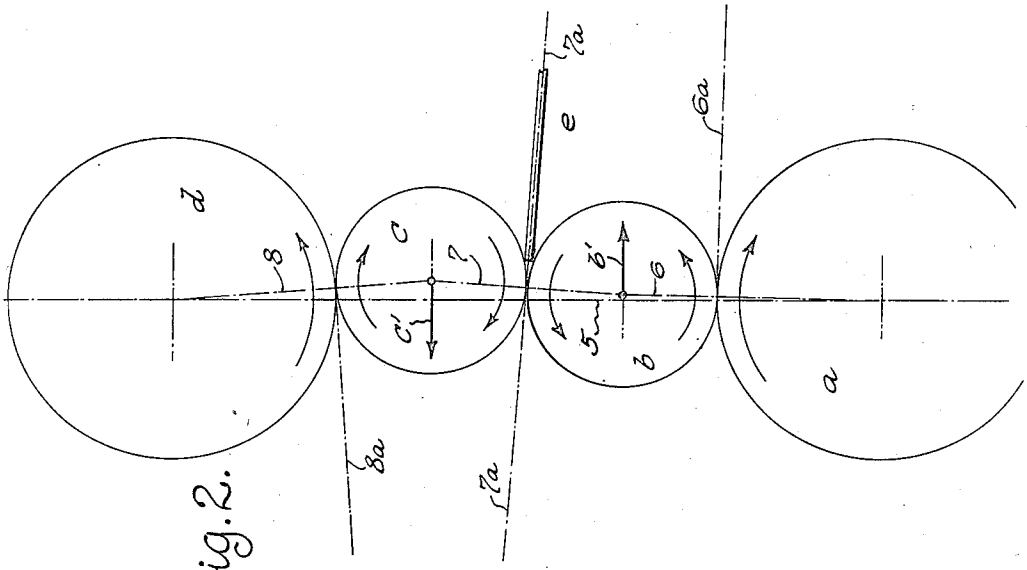


Fig. 2.

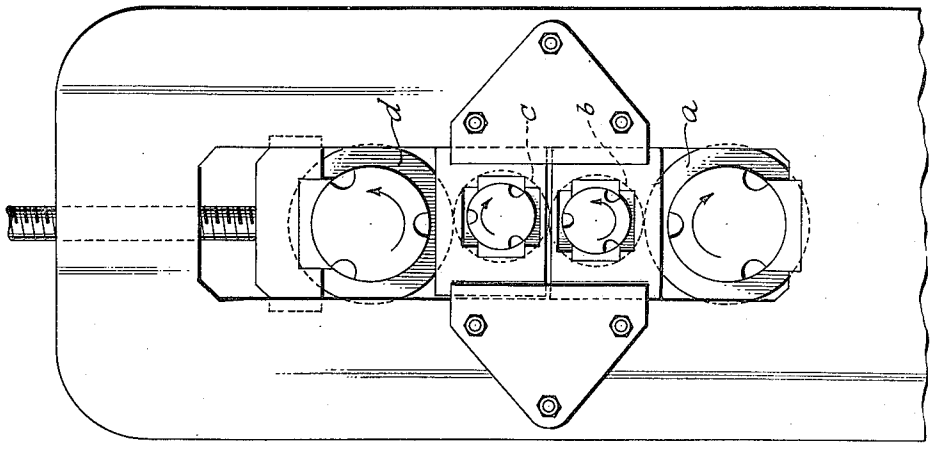


Fig. 1.

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ROLLING MILL.

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To all whom it may concern:

Be it known that I, JAMES M. PERRY, a citizen of the United States of America, residing at Detroit, in the county of Wayne and State of Michigan, have invented certain new and useful Improvements in Rolling Mills, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to improvements in Rolling Mills, pertaining more particularly to mills utilizing a single pass, the rolls which form the pass being of substantially equal diameter, these rolls being of the contact-driven type and each supported by a roll of large diameter as compared to the diameter of these active rolls, the arrangement producing what may be termed a "four-high" mill, the rolls of large diameter forming the lower and upper rolls of the set of the rolls, the two active or reducing rolls being the intermediate rolls of the set.

Mills of this type are especially adapted for use in rolling thin plates and especially where the plates are in "pack" arrangement. Where the rolls of the pass are of equal and large diameter, the reduction made in the pass is more or less limited by reason of the comparatively large radius of the arc of the rolls which is in contact with the material, thus placing a limit to the amount of reduction possible during a single pass of the material and increasing the number of passes required to produce the desired gauge of sheet. Where the arrangement employs rolls of different diameter as the rolls of the pass, the difference in radius of the two arcs provides for an unequal "bite" on the metal, so that a greater reduction is had on one side than on the other, a condition which makes such arrangement useless where the material is being rolled as a "pack"; such an arrangement can and is used—the three high type—for rolling single plates but these mills do not attempt to produce the thin gauge sheets in pack form because of this difficulty of unequal reduction.

A number of problems are presented in connection with mills of the single-pass type where the attempt is made to employ "four-high" principles. The "two-high" type is generally employed, but the rolls are of comparatively large diameter with reduction small. In the four-high type the intermediate rolls are of comparatively small diameter—presenting an arc which will permit of reductions as high as 40% to 50% in a single pass, these rolls taking on the characteristics of a tool in a general combination in which the lower roll functions as the anvil, the upper roll as the hammer, and the intermediate rolls as the tool.

One of these problems is the fact that under reductions of such high value the pressures applied to the bearings of the rolls are extremely large, and the small diameters of the rolls practically prevent the use of large diameter journals at the ends of these rolls, so that there is constant liability that the shearing strains placed on the journals will quickly damage the rolls and render them unserviceable. And if this is avoided, these pressures on the journals quickly wear the bearings in such manner that the rolls become loose and "wobbly" and therefore unserviceable.

Another problem arises because of the single-pass condition and the necessity for repeatedly passing the material through the pass because of the small reduction action required to prevent rendering the rolls unserviceable. Since the material rapidly cools, it must be brought back into the pass quickly for the succeeding pass operation, with the result that the rolls become heated to such an extent as to set up conditions of undue expansion. This problem has led to the development of the practice of roll-turning and heat expansion, one of the rolls being turned with a concave surface, the opposing roll then being brought to a complemental relation by making a number of dummy passes of material, the two rolls becoming heated by this action and brought to an approximate uniformity; the difficulty comes from maintaining uniformity in the heat expansion, as well as the time and labor required in the roll-turning and the heat-expanding activities, a difficulty that is especially onerous where the mill is of the two-high type.

There is no material difficulty in mounting a set of rolls of the four-high type with the intermediate rolls of smaller diameter, and with the axes of the rolls in vertical alinement—such mounting simply involves the addition of a second intermediate roll in the three-high mill of commercial prac-

tice. But such arrangement is of no material advantage in service, for reasons above indicated, the pressure produced during rolling—which reach very large values—being opposed only by the bearings and journals of the intermediate rolls, and thus quickly deteriorating and becoming unserviceable; in this can be found a controlling reason for the failure to employ the four-high type of mill for operations of this kind.

The solution of the problems involved, is to be found in a change in the mounting or rather in the location of the axes of the several rolls forming the set. I have found that there is a constant tendency of the contact-driven rolls to move in the direction of movement of the driver for the roll, and by producing the characteristics of a wedge space of decreasing dimensions corresponding to the diameter of the roll active in this direction of tendency, I am able to cause the rolls themselves to set up the conditions of support such as to prevent these high pressures becoming effective on the roll journals, of the active reduction rolls; in other words, the set of rolls then become stable through the fact that increase in pressures such as would tend to increase this tendency to move with the driver, acts to attempt to force the roll into a space of less dimensions and thus sets up a resistance value opposing the pressures being exerted, such resistance value not affecting the rotation of the rolls but having a direct effect on the tendency of the roll axes to be shifted in the direction of driver movement in presence of such pressures.

It is this solution that forms the basis of the present invention and which is embodied in an arrangement by which the axes of the several rolls are so located with respect to a definite line—which may be the line connecting the axes of the upper and lower rolls—as to set up this wedge space characteristic with respect to the two intermediate rolls, these wedge spaces extending in opposite directions in the two rolls, due to the fact that the driver for one intermediate roll moves in a direction opposite the direction of movement of the driver for the other intermediate roll, the two drivers referred to being the lower roll and the plate or "pack"—and which I am including under the general term of "work" —respectively.

To these and other ends, therefore, the nature of which will be readily understood as the invention is hereinafter disclosed, my invention consists in the improved constructions and combinations of parts hereinafter more particularly described, illustrated in the accompanying drawings, and more particularly pointed out in the appended claims.

In the accompanying drawings, in which similar reference characters indicate similar parts in each of the views,—

Figure 1 is an end view of a portion of a roll support having the rolls arranged in accordance with a preferred embodiment of the present invention.

Fig. 2 is a diagrammatic view illustrating the relative locations of the rolls of the set.

Referring more particularly to the disclosure of Fig. 2, the lower roll is indicated at *a*, the lower intermediate roll at *b*, the upper intermediate roll at *c* and the upper roll at *d*. Of these, roll *a* is the driver, rolls *b*, *c* and *d* being contact driven. The view shows the rolls *b* and *c* in contact, this being the position when no work is being reduced.

In this view the axes of rolls *a* and *d* are shown as in vertical alinement, but this is more or less illustrative. Such alinement is preferred, but, if desired, the axis or roll *d* may be shifted to either side of the vertical line 5 which represents such alinement of the axes of the two rolls, it being understood, of course, that the axes of rolls *b* and *c* will be properly arranged to carry out the fundamental features of the invention, when such change is made.

e indicates the "work" and which may be a single plate or a "pack" of plates, the work being shown as about to enter the pass between rolls *b* and *c*, the direction of rotation of these rolls being such as to advance the work through the pass. As will be understood, the "bite" of rolls *b* and *c* is capable of effecting a large reduction, due to the fact that the diameter of rolls *b* and *c* is small as compared with the diameter of rolls *a* and *d*, thus setting up the conditions of an active arc of comparatively small radius. It will be understood of course that the entrance of the work will space roll *c* from roll *b*, thus placing work *e* as the driver for rolls *c* and *d*, the motive power for the set of rolls being applied only to roll *a*, the remaining rolls being contact driven.

For the purpose of indicating the general fundamentals of the invention a brief explanation will be made of the general action if the two rolls *b* and *c* were arranged with their axes on line 5, thus placing the axes of the four rolls in vertical alinement. With such arrangement, the tangent of the line of contact between each pair of rolls would extend at direct right angles or perpendicular to line 5. If the work were entered in the pass of such arrangement, the pressures set up would be exerted in directions such as to tend to cause the intermediate rolls to shift the axes away from such line, and any shifting tendency would tend to carry the rolls into a space of increasing width and thus render the rolls less active. The only resistance to this action is that provided by

the journals and bearings of the active rolls, thus setting up conditions of shearing strains on the journals—if the bearings be capable of resisting the intense effects of wear—or rapid deterioration of the bearings, or both. And this effect will rapidly increase as the amount of reduction per pass increases; so that a mill of such arrangement would be practically effective only under conditions where the pressures set up by the reducing action are not sufficient to produce these effects on the journals and bearings in other words, the percentage of reduction must be retained at a low amount.

One variation from such arrangement—and which indicates one embodiment of the present invention—is shown in the location of the axes of rolls *b* and *c* in Fig. 2. As will be seen, the axis of roll *b* is shifted to the right of line 5, line 6 indicating the line connecting the axes of rolls *a* and *b*, producing an angle value between lines 5 and 6. It will be readily understood that with this change, the tangent of the line of contact of rolls *a* and *b* will extend at right angles or perpendicular to line 6 as indicated by line 6^a.

The axis of roll *c* is also shifted to the right of line 5; the length of shift of this axis is not limited, however, to that which would preserve the angle value between lines 5 and 6, but is increased sufficiently to produce a greater angle value between a line 7—which connects the axes of rolls *b* and *c*—and line 5, the result being that the line 7^a—which represents the tangent to the line of contact between rolls *b* and *c* and extends perpendicular to line 7—is not parallel to line 6^a, but that lines 6^a and 7^a converge away from roll *b* toward the right—as indicated by arrow *b'*—thus setting up the characteristic of a wedge space located on that side of line 5 corresponding to the direction of rotation of driver *a*.

As will be seen, line 8, which connects the axes of rolls *c* and *d*, also extends at an angle to line 5, but the lines of divergence of the angle 5—8 extend in a general reverse direction from the lines of divergence of the lines of angle 5—6, the result being that line 8^a—which represents the tangent to the line of contact of rolls *c* and *d* and extends perpendicular to line 8—also varies from a perpendicular to line 5 and in converging relation to line 7^a in the direction of the arrow *c'*, lines 7^a and 8^a thus setting up the characteristics of a second wedge space, these wedge spaces being located on opposite sides of a composite line represented by the lines 6—7—8.

It will be understood, of course, that the particular angles shown are more or less illustrative, and that the angle 5—7 would slightly change in value when the work is introduced, but the disclosure of Fig. 2 will illustrate a fundamental characteristic of the invention and which is found in the presence of the two wedge spaces—one for roll *b* and the other for roll *c*—converging from a generally predetermined line with the convergence of the two spaces being in opposing directions from such line, the convergence of one space being opposite to that of the other space.

The results obtained by the mounting will be readily understood. Due to the fact that roll *a* is the driver for roll *b*, the latter will tend to move in the direction of movement of its driver roll *a*—in the direction of arrow *b'*—but since such movement would attempt to crowd roll *b* into a space of less dimension, there is set up a resistance value to offset any effective action on the journals and bearings of roll *b* in this direction. And while line 7^a on the opposite side of line 5, would seemingly indicate the presence of an increasing space to the left of line 5 into which roll *b* might tend to move, such tendency is overcome by reason of the fact that roll *b* to move in this direction, must move upward on roll *a* in order to reach the high point of the latter—represented by the intersection of the roll circle and line 5—or mount roll *a* before roll *b* could effectively tend in the direction opposite that indicated by arrow *b'*.

The rotation of roll *b* acts to advance the work *e* whenever the latter is introduced into the pass, the presence of the work in the pass attempting to separate rolls *b* and *c*, the movement of roll *c* being resisted by roll *d* held positively by the adjusting mechanism, the latter permitting such vertical movement of rolls *c* and *d* to provide for a pass of the desired dimension. The movement of roll *c* in the vertical direction instead of in the direction of line 7, slightly affects the value of the angle 5—7 as heretofore pointed out.

Separation of rolls *b* and *c* transfers the drive of roll *c* from roll *b* to the work *e*, the advance of the work causing roll *c* to rotate in the direction shown. As will be understood, the metal of the work tends to bank up at the entrance to the pass, and it is the effect of this that imparts to roll *c* the tendency to move with its driver (work *e*) in the direction of arrow *c'*. But this movement of roll *c* is resisted by the wedge space characteristic provided by 7^a and 8^a, it being necessary not only that roll *c* advance in a direction to carry it into a space of less dimension, but in addition, the roll would be required to "mount" roll *d*—indicated by the difference in the perpendiculars of lines 5 and 8—as well as tend to mount roll *b*, it being understood that the strain line of rolls *b* and *c* would extend through the pass to the right of the high point of roll *b*.

As a result the tendency of the work to provide pressure conditions within the set of rolls

such as a place shearing strains on the journals of rolls *b* and *c* or produce excessive wear on the bearings of these rolls, is resisted automatically by the presence of these wedge space characteristics, increase in value of pressure application automatically increasing the value of the resistance afforded by the necessity of the rolls *b* and *c* moving into spaces of dimension less than those of the rolls themselves.

The invention therefore rests primarily on the discovery by me that the active roll tends to move in the direction of movement of its driver, and that it is possible to build up a wedge space characteristic for such roll through the location of the several roll axes, the wedge space being active in the direction in which the roll would move under such tendency. Because of this the opposing pressures of the active rolls tend to neutralization in the transverse direction, thus relieving the journals and bearings from the strains and wear which would otherwise be set up. Neutralization of pressures in the longitudinal direction—the vertical direction—flows from the stability characteristic set up by the arrangement of the rolls; the active rolls are supported by the barrels of rolls *a* and *d* of comparatively large diameter and hence capable of having large journals and bearings.

In the present application of these general principles, I have located the wedge spaces so as to extend in opposite directions, due to the fact that the drivers for the two rolls *b* and *c*—roll *a* and work *e*, respectively—have their respective movements in opposite directions, the wedge spaces thus being positioned to resist the roll tendency to move in a direction which would tend to set up these straining conditions in presence of pressure application. And since the resistance value builds up concurrently with the building up of the pressure value, the journal and bearing conditions of the active rolls produce no material limiting factor in determining the maximum reduction possible on the work during movement through the pass at any time.

Preferably roll *b* has its bearings arranged to prevent lateral movement of the roll, so that the angle 5—6 remains practically constant. And I prefer that the bearings for roll *c* be similarly arranged; however, this is not absolutely essential, and I contemplate an arrangement in which lateral movement is permitted to a limited extent, but such movement is limited so as to prevent the roll axis reaching a point where the angle 5—7 would be of the same value as the angle 5—6 or of less value than such angle. And while roll *d* also might have a lateral movement, I prefer that the bearing for this roll be arranged to be maintained stable against such lateral movement.

As before pointed out the axis of roll *d* need not be vertically alined with that of roll *a* as long as the general arrangement of the roll axes is preserved. I prefer, however, the vertical alinement since such arrangement permits of maximum efficiency.

While I have herein shown and described a preferred arrangement and embodiment of my invention, it will be readily understood that changes or modifications therein may be found desirable or essential in meeting the various exigencies of use; and I desire to be understood as reserving the right to make any and all such changes and modifications as may be found desirable or necessary in so far as the same may fall within the spirit and scope of the invention as expressed in the accompanying claims, when broadly construed.

The support, housings, bearings, etc., shown are of any usual and well known character and are not specifically described, the drawings illustrating one well-known arrangement.

It will be understood, of course, that a succession of mills of this kind may be employed to set up the condititons of a continuous mill; and such arrangement is not only possible but especially advantageous owing to the fact that with the mill of the present invention the rolls can be kept at approximately uniform working temperatures by the application of a cooling agent to the rolls during the period between the reduction activities of the mill on a succession of plates or packs.

Having thus described my invention, what I claim as new is:

1. In rolling mill formations of the single pass type, a set of four rolls equal in number on opposite sides of the pass with one of the rolls active as a reducing roll. the reducing roll of a pair being of less diameter than the other roll of the pair, and means for supporting said rolls to locate the axes of the intermediate rolls laterally displaced relative to a line connecting the axes of the two outer rolls, the axis of each intermediate roll being on the same side of the connecting line, the amount of displacement of one of such rolls being greater than that of the other roll.

2. A mill as in claim 1 characterized in that the amount of displacement of the upper roll is greater than that of the lower roll of the pass.

3. In a rolling mill of the four-high type wherein the single reducing pass divides the rolls into pairs of rolls on opposite sides of the pass, means for supporting the rolls to locate the axes of the intermediate rolls laterally displaced relative to a line connecting the axes of the outer rolls of the mill, whereby a line connecting the axes of a pair of rolls will be inclined relative to the con-

necting line of the outer rolls, the converging lines setting up a definite angle value of the rolls of a pair relative to the set of rolls, the value of the angle of one pair of rolls differing from that of the other pair of rolls.

4. A mill as in claim 3 characterized in that the value of the angle of the lower pair of rolls is less than that of the upper pair of rolls.

5. In a rolling mill of the four-high type and wherein the single reducing pass divides the rolls into pairs of rolls on opposite sides of the pass, means for supporting the rolls to locate the axes of the intermediate rolls laterally displaced relative to a line connecting the axes of the outer rolls of the mill, the axes of the intermediate rolls being located relative to each other in such manner that a line crossing the pass and connecting the intermediate roll axes will be inclined relative to the connecting line of the outer rolls.

6. A mill of the type of claim 5 characterized in that the axes of the intermediate rolls are located to cause the direction of convergance of the two lines to be toward the axis of the lower intermediate roll.

7. In a rolling mill of the four-high type and wherein the single reducing pass divides the rolls into pairs of rolls on opposite sides of the pass, means for supporting the rolls to locate the axes of the intermediate rolls laterally displaced relative to a line connecting the axes of the outer rolls of the mill, the axes of the intermediate rolls being located relative to each other in such manner that a line crossing the pass and connecting the intermediate roll axes will be inclined relative to the connecting line of the outer rolls and to another line connecting the axes of the two rolls of the lower pair.

8. A mill of the type of claim 7 characterized in that the line crossing the pass is also angular to a line connecting the axes of the rolls of the upper pair.

9. In a rolling mill of the four-high type wherein the lower roll is the driver, and wherein the intermediate rolls contact the work during work reduction, means for supporting the rolls in a manner to establish the characteristics of a wedge space for and individual to each of the intermediate rolls and operative to produce wedging activity therein when the pass is active in work reduction, the direction of wedging activity of one roll being opposite that of the other roll.

10. In a mill adapted to roll sheet packs, wherein a set of four rolls in four-high arrangement provides the reduction and wherein the lower roll is the driver with the intermediate rolls forming the pass and being contact-driven, means for supporting the rolls in such manner as to locate the axes of the several rolls in position to establish a wedge space characteristic for and individual to each of the intermediate rolls with the direction of increasing wedging activity of one of such spaces opposite in direction to that of the other space.

11. In a mill adapted to roll sheet packs, wherein a set of four rolls in four-high arrangement provides the reduction and wherein the lower roll is the driver with the intermediate rolls forming the pass and being contact-driven, means for supporting the rolls in such manner as to locate the axes of the several rolls in position to establish a wedge space characteristic for and individual to each of the intermediate rolls with the direction of increasing wedging activity of such spaces extending in opposite directions from a plane extending through the axes of the intermediate rolls, with the wedging space for a roll located on one side alone of such plane.

12. In a rolling mill wherein the reduction rolls of the pass are of substantially equal diameter and form the intermediate rolls of a set with one of the outer rolls active as the driver of the set when the set is inactive and for one of the reduction rolls when the set is active in work reduction, means for supporting the rolls to locate the intermediate rolls in wedge spaces for and individual to the several intermediate rolls and in which wedging activity is produced during movement of the work through the pass, presence of the work in the pass causing the work to become the driver for the other of such reduction rolls, the arrangement of the roll axes being such that the direction of increasing wedging activity for each reduction roll corresponds to the general direction of movement of its driver.

In testimony whereof I affix my signature in presence of two witnesses.

JAMES M. PERRY.

Witnesses:
HORACE G. SEITZ,
KARL H. BUTLER.