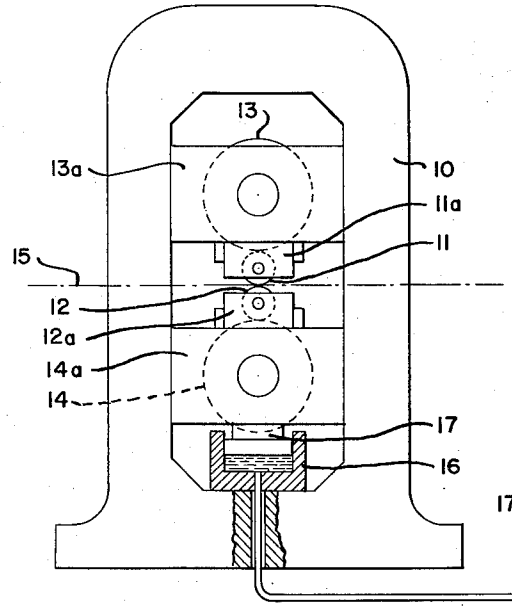
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SKIN PASS MILLS AND METHOD OF ROLLING

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Fig. 1.



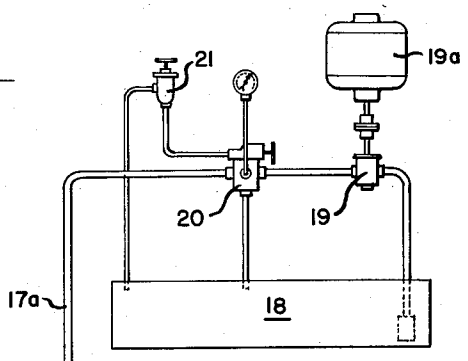




Fig. 2.

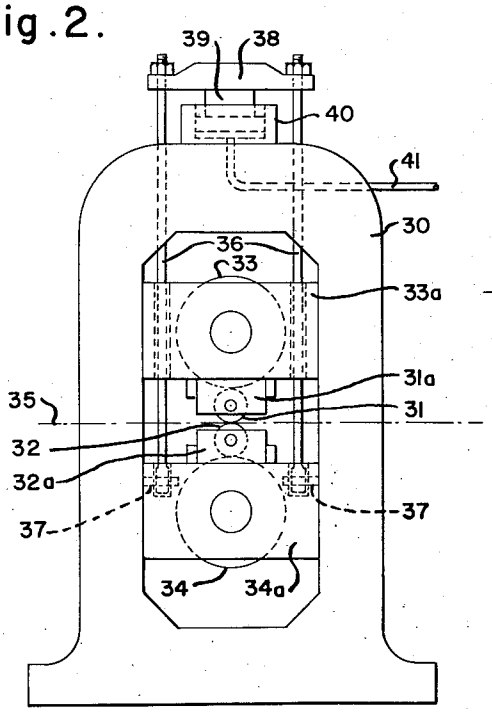
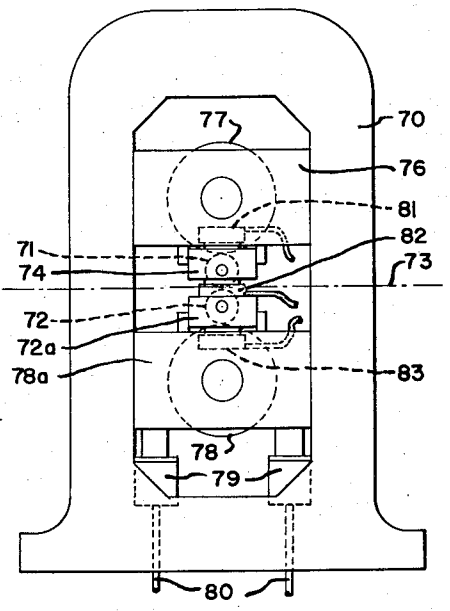



Fig. 4.




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Fig. 5.

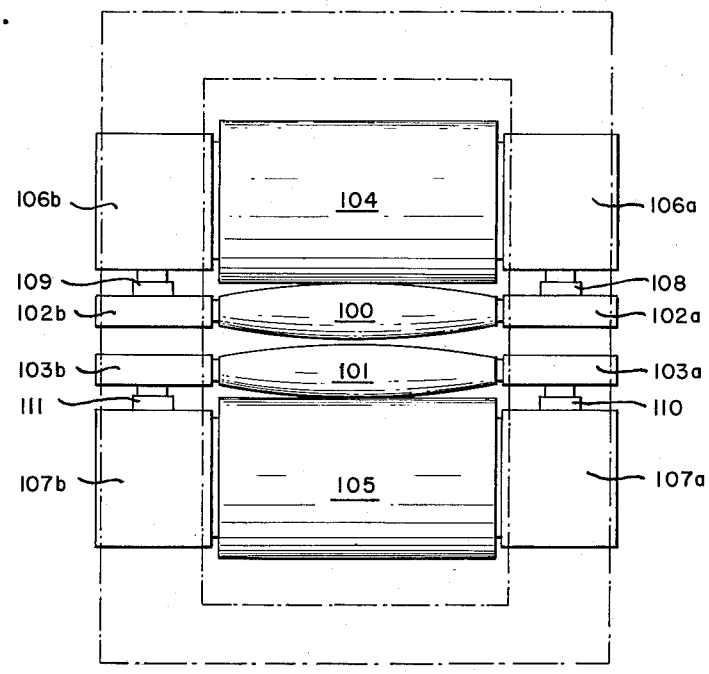



Fig. 6A.

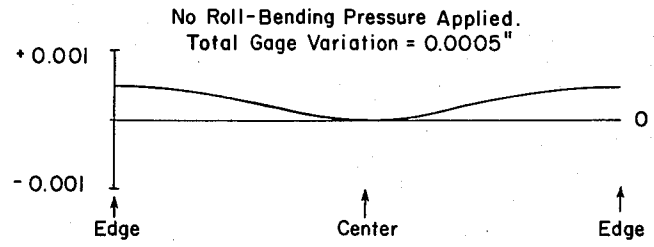
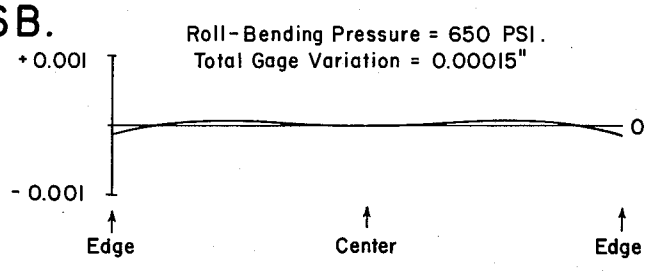



Fig. 6B.



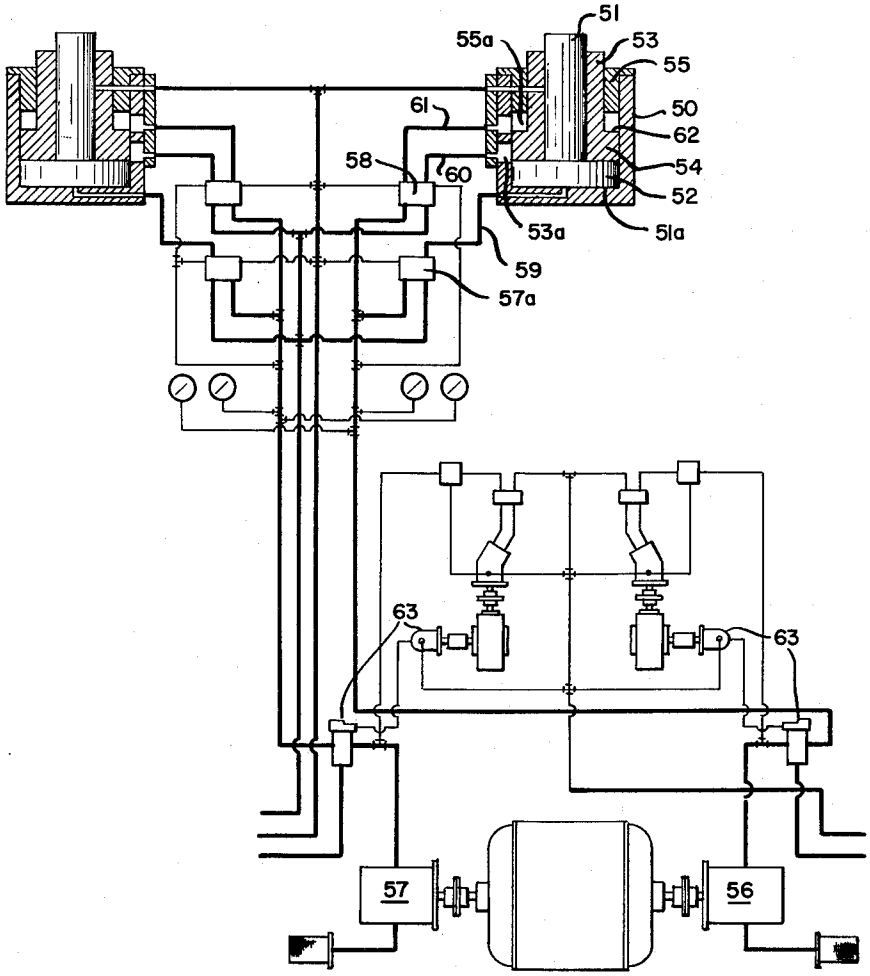

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Fig. 3.




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3,024,679

# SKIN PASS MILLS AND METHODS OF ROLLING

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4 Claims. (Cl. 80—56)

This invention relates to skin pass mills and particularly to a skin pass mill capable of maintaining substantially constant pass pressure on a strip regardless of variations in strip thickness. It has long been the practice in strip rolling to pass the strip after reductions through a skin pass or temper mill in order to impart a desired surface finish to the product, to produce uniform flatness and to develop desired mechanical properties. The object is to flatten the strip and to impart the proper surface in a single pass while imparting a desired hardness to the strip. Conventionally, skin passing has been done on 4-high single stand temper mills, although temper rolling or skin rolling has more recently been to an increasing extent, done on 2-high stand tandem temper mills by careful control and handling of the mills. Difficulty has, however, been experienced in maintaining uniformity over the entire surface of the temper roll product because of variations in the strip thickness fed to the mill regardless of whether a 4-high mill or a 2-high mill is used for the temper pass.

I have found that these problems of non-uniformity can be solved by providing a skin pass mill of particular structure and by following certain method steps.

I provide a mill having a housing, a pair of work rolls mounted in the housing for rotation and adapted to receive the strip to be temper rolled between them, yieldable means acting on at least one of the rolls urging said one roll toward the other under substantially constant pressure. Preferably the yieldable means is a hydraulic cylinder actuated by a source of hydraulic fluid under constant pressure and means delivering said fluid to the hydraulic cylinder whereby the rolls are urged together under constant pressure. It is also desirable that there be provided flow control means to assure substantially identical volumes of hydraulic fluid to each cylinder. The yieldable means preferably works on the lowermost roll of the pair. The work rolls may be backed up by back-up rolls and the pressure applied to the lowermost back-up roll. I have found that more uniform temper passing can be obtained over the entire width of the mill by applying hydraulic pressure in both directions to the working rolls when the rolls are used with crowned back-up rolls. In this way, the work rolls can be induced to take a desired crown to follow the surface of the strip so that uniform work is applied to the entire surface of the strip.

I have found that with this apparatus I can use much smaller work rolls than are normally used in skin passing and can thereby produce the same effects with less reduction of the strip than can be done with conventional mills. I have also found that a more uniform surface hardening can be achieved with my apparatus and method than with conventional mills. For example, I have found that strip which by ordinary skin pass methods would have a 10 to 14 point edge to edge differential in rockwell hardness will have only a 3 to 5 point edge to edge differential when rolled by the method and apparatus of the present invention. Moreover, the method of rolling will produce unique products. For example, a normalized strip can be skin passed by my method to produce a uniform hardened surface from edge to edge.

While I have set out certain objects, advantages and purposes of this invention in the foregoing general description, other advantages, purposes and objects will be apparent from the following description and the accompanying drawings in which:



FIGURE 1 is a side elevation of a skin pass mill according to this invention;

FIGURE 2 is a side elevation of a second embodiment of skin pass mill according to this invention;

FIGURE 3 is a diagrammatic view of a preferred embodiment of control circuit and hydraulic cylinder for actuating the rolls in the skin pass mill of my invention; and

FIGURE 4 is a third embodiment of my invention including means for imparting crown to the work rolls.

FIGURE 5 is a schematic front elevation, showing work rolls in exaggerated contour, illustrating the general arrangement of a mill according to one form of my invention;

FIGURES 6A and 6B illustrate schematically the results to be obtained on strip rolled in a mill as illustrated in FIGURE 5.

Referring to the drawings, I have illustrated a roll housing 10 carrying work rolls 11 and 12 backed up by back-up rolls 13 and 14. The work rolls 11 and 12 are mounted on opposite sides of a strip pass line 15. The uppermost work roll 11 is backed up by an upper back-up roll 13 and each of the rolls 11 and 13 is mounted in chocks 11*a* and 13*a* in the housing 10. The lower work roll 12 is backed up by a lower back-up roll 14 and both are mounted in chocks 12*a* and 14*a* movable in the housing 10 in the vertical direction. An hydraulic cylinder 16 is mounted beneath each of the chocks 14*a* of the lowermost back-up roll 14 and is provided with a piston 17 bearing against the chock 14*a* of the back-up roll 14. Hydraulic fluid under constant pressure is delivered to the cylinder 16 through an hydraulic line 17*a* from a reservoir 18 through pump 19 and a relief valve 20 which maintains a constant pressure on the cylinder 16. The pump 19 is driven by an electric motor 19*a*. The desired pressure is regulated by a pressure control 21. When a strip of steel is passed between the work rolls 11 and 12, the pressure control is adjusted to the desired pressure to force the chocks 14*a* of the back-up roll 14 upwardly so that back-up roll 14 bears against the work roll 12, pressing the strip between the work rolls 11 and 12 at a pressure such as will perform the desired amount of work to produce a given finish and the desired work-hardening effects. As the strip moves through the work rolls 11 and 12 this constant pressure is maintained between rolls 11 and 12 without regard to variations in strip thickness so that all parts of the strip receive the same amount of work, thus eliminating the undesirable unevenness in treatment which results from conventional screwdown temper pass or skin pass mills.

In FIGURE 2 I have illustrated a second embodiment of my invention. In this embodiment, I show a housing 30 carrying work rolls 31 and 32 backed up by back-up rolls 33 and 34. The work rolls 31 and 32 are mounted on opposite sides of a strip pass line 35. The upper work roll 31 and its associated back-up roll 33 are mounted in chocks 31*a* and 33*a* respectively in the housing 30. The lower work roll 32 and its back-up roll 34 are mounted in chocks 32*a* and 34*a* movable vertically in housing 10 below the pass line 35. A pair of vertical hanger arms 36 are connected to the chock 34*a* of the back-up roll 34 by means of pivot pins 37 which permit movement of the chocks with respect to the hanger. Each arm 36 is fixed to an end of a saddle beam 38 which is raised and lowered by a hydraulic piston 39 in cylinder 40 mounted on housing 30. Hydraulic fluid is introduced into the cylinder 40 by means of a line 41 corresponding to line 17 of FIGURE 1. Line 41 receives fluid under pressure from a pump, relief valve and pressure control assembly identical with the assembly of pump 19, relief valve 20 and pressure control 21 of FIG-

URE 1. Pressure applied to the piston 39 urges the lower work roll 32 unwardly against the strip 35 under constant pressure.

In FIGURE 3, I have illustrated a preferred form of cylinder and control for use in the skin pass mill of FIGURE 1. I have found that when rolling a single width and thickness on the mill of this invention an ordinary single stage hydraulic cylinder is satisfactory. I have found that when various widths of strip are to be rolled in the same mill with different thicknesses, it is desirable to have an hydraulic cylinder having several stages of control. I provide a cylinder 50 having mounted therein an axial piston 51 having an enlarged head 52 in sliding contact with the wall of the cylinder 50. Surrounding the piston 51 is a second annular piston 53 having an enlarged head 54 bearing against the wall of the cylinder 50 in sliding contact therewith. Surrounding the psiton 53 is a cap 55. Hydraulic fluid is supplied from hydraulic pumps 56 and 57 to the pistons 52 and 53 through the valves 57*a* and 58. The arrangement of pistons 51 and 53 is such that fluid may be introduced selectively to the several pistons. Fluid may be introduced through line 59 from valve 57*a* to chamber 51*a* beneath only the head 52. In this way, the maximum pressure is applied to piston 51. Alternatively, fluid may be supplied both through valve 57*a* and line 59 to chamber 51*a* beneath head 52 and through line 60 and valve 58 to chamber 53*a* above the head 52 and beneath the head 54. This reduces the pressure applied by piston 51 by the difference between the area of head 54 and the area of the head 52. This provides the minimum pressure applicable by piston 51. As a third alternative, fluid may be introduced through line 61 and valve 58 to chamber 55*a* above head 54 at the same time fluid is introduced through valve 57*a* and line 59 to chamber 51*a* so that the pressure applied to the head 52 is counterbalanced by pressure applied to the head 54 on the shoulder 62. In this way, the pressure applied by piston 51 is the differential between the pressure on head 52 less the pressure on the area formed by the shoulder 62. It is thus seen that in the same pressure cylinder 50 there may be achieved three different pressures on the working piston 51 without any change in the pressure supplied by the pumps 56 and 57. This permits a selection of a variety of pressures to be applied to the chocks on the bottom roll without any change in the source of pressure fluid. The volume of fluid passing to the several chambers is regulated by volume controls 63 of conventional design.

In FIGURE 4, I have illustrated a housing 70 having a pair of work rolls 71 and 72 on opposite sides of the pass line 73. The upper work roll 71 is mounted in movable chocks 74 and is backed up by a crowned back-up roll 77 mounted in chocks 76. The lower work roll 72 is mounted in movable chocks 72*a* on back-up roll chocks 78*a*. Chocks 78*a* are mounted on hydraulic pistons 79 at either end. Hydraulic fluid is supplied to the cylinders 79 by an hydraulic line 80 receiving fluid under constant pressure from an hydraulic pump, relief valve and pressure control similar to pump 19, valve 20 and pressure control 21 of FIGURE 1. The upper work roll chocks 74 are spaced from the chocks 72*a* of the lower work roll 72 and spaced from the chocks 76 of the back-up roll 77. Hydraulic cylinders 81 are inserted between the chocks 74 and the chocks 76 of the upper work roll and the upper back-up roll. Hydraulic cylinders 82 are mounted between the chocks 74 of the upper work roll and the chocks 72*a* of the lower work roll. Hydraulic cylinders 83 are mounted between chocks 72*a* and 78*a* of the lower work roll and lower back-up roll. Hydraulic fluid is delivered to the cylinders 81, 82 and 83 through conventional control valves from a source of hydraulic pressure (not shown). By applying pressure to one of the hydraulic cylinders 81, 82 and 83, the work roll 71 can be forced toward or away from the back-up roll 77 so as to control its contour by bending the work roll around the crown of the back-up roll. In this way, the work roll 71 can be made to take a desired contour to follow a given strip surface contour. The lower work roll 72 could be similarly provided with a crowned back-up roll (as in FIGURE 1) and hydraulic cylinders similar to cylinders 81 placed between the chocks 72*a* of the lower work roll and the chocks of its back-up roll so as to cause it to take a given desired contour in the same manner as described for upper work roll 71.

In FIGURE 5, I have illustrated in exaggerated front elevation a pair of crowned work rolls 100 and 101, journaled at opposite ends in chocks 102*a* and *b* and 103*a* and *b* in a housing shown in phantom. The work rolls 100 and 101 are backed up by back-up rolls 104 and 105 journaled respectively in chocks 106*a* and *b* and 107*a* and *b* in the usual manner. A pair of hydraulic cylinders 108 and 109 are placed between chocks 102*a* and 106*a* and 102*b* and 106*b* respectively and a second pair of hydraulic cylinders 110 and 111 are placed between chocks 103*a* and 107*a* and 103*b* and 107*b* respectively. Hydraulic fluid is delivered equally to the cylinders 108, 109, 110 and 111 to cause the work rolls 100 and 101 to bend about a strip passing between them as a fulcrum. The relative results of such bending on the strip are schematically illustrated in FIGURES 6A and 6B. It is clear from these figures that with a single set of crowned work rolls it is possible to roll strip which would have required many different sets of work rolls with the corresponding many roll changes. The advantages in capital costs, labor expense and lost time in the mill are obvious.

While I have illustrated certain preferred embodiments of my invention, it will be understood that this invention may be otherwise embodied within the scope of the following claims.

I claim:

1. A rolling mill comprising a housing, a pair of convex work rolls in the housing on opposite sides of a pass line each having a larger diameter at the middle than at the ends, said work rolls being adapted to receive strip therebetween and exert a working force transversely to the path thereof, journals for each end of said work rolls, a back-up roll journaled in the housing adjacent each work roll and bearing on said adjacent work roll, and pressure means at the ends of said work rolls acting on and moving the journals of said work rolls transversely to the path of the strip to cause the ends of said work rolls to move toward each other so as to cause the middle thereof to engage a strip being rolled as a fulcrum and to bend said work rolls to decrease the convexity of said rolls to provide a desired strip contour.

2. A rolling mill as claimed in claim 1 wherein additional pressure means are provided between the work roll journals selectively urging said journals apart.

3. A skin pass and temper rolling mill comprising a housing, a pair of convex work rolls in the housing on opposite sides of a pass line each having a larger diameter at the middle than at the ends, said work rolls being adapted to receive strip therebetween and exert a working force transversely to the path thereof, journals for each end of said work rolls, a back-up roll journaled in the housing adjacent each work roll and bearing on said adjacent work roll, pressure means at the ends of said work rolls acting on and moving the journals of said work rolls transversely to the path of the strip to cause the ends of said work rolls to move toward each other so as to cause the middle thereof to engage a strip being rolled as a fulcrum and to bend said work rolls to decrease the convexity of said rolls to provide a desired strip contour, and constant pressure means acting on the journals of a back-up roll urging it and the adjacent work

roll yieldably toward the pass line whereby to exert a selected substantially constant working pressure on a strip passing between the work rolls.

4. A skin pass and temper rolling mill as claimed in claim 3 having additional pressure means between the work roll journals selectively urging said journals apart.

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