Aug. 8, 1967 J. P. HICKS 3,334,506

ROLLING MILL

Filed April 24, 1964 3 Sheets-Sheet 1

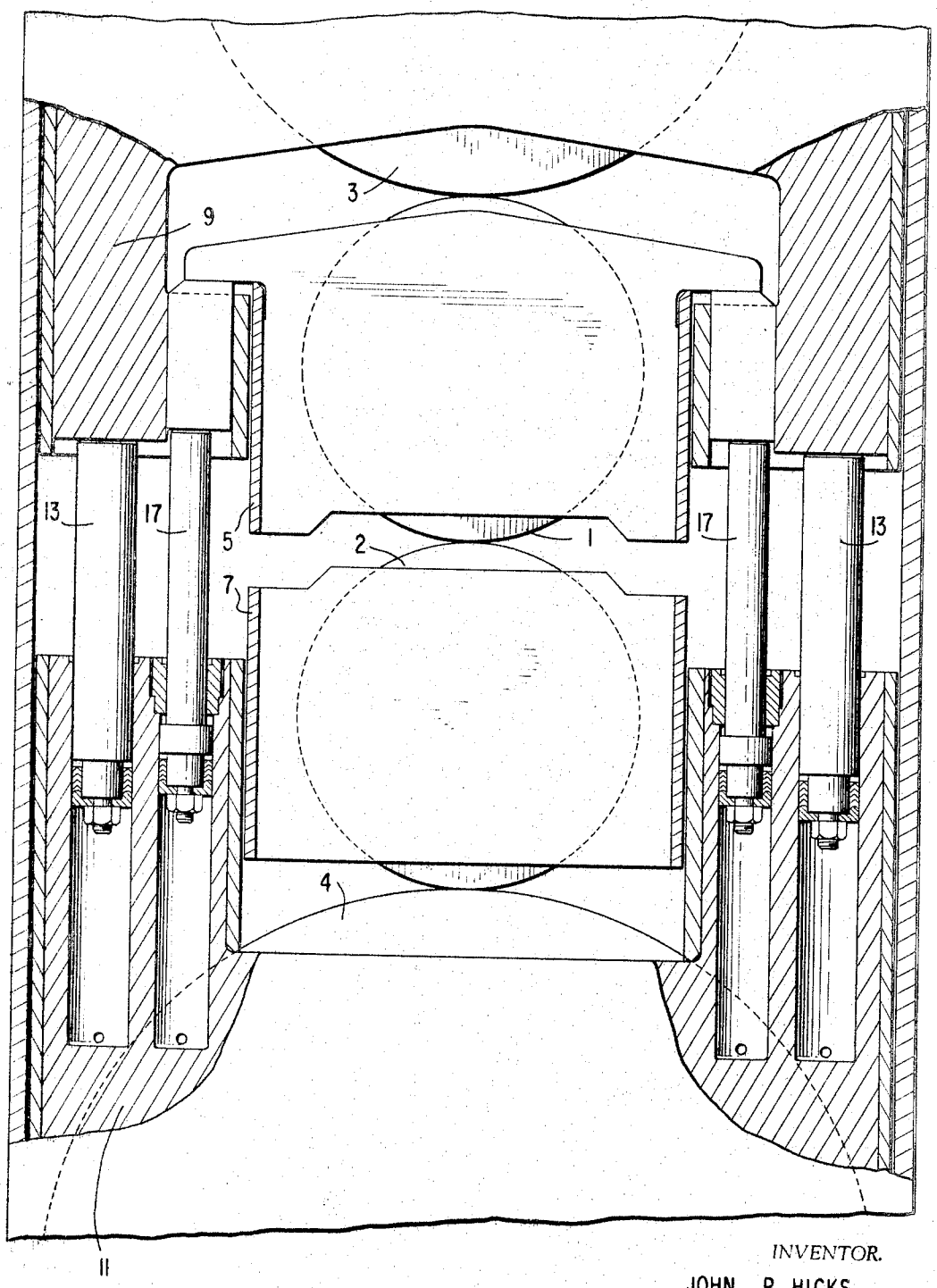


FIG. 1

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FIG. 2

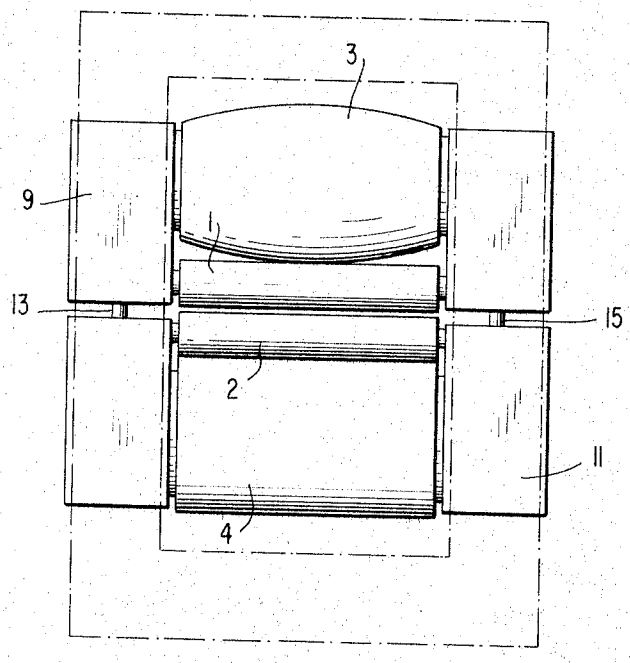


FIG. 3A

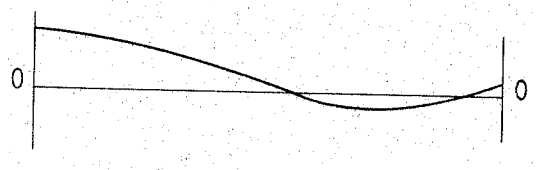
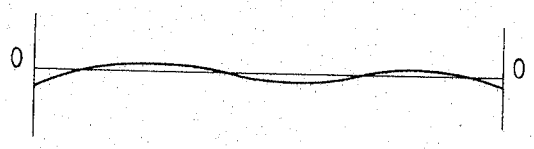


FIG. 3B



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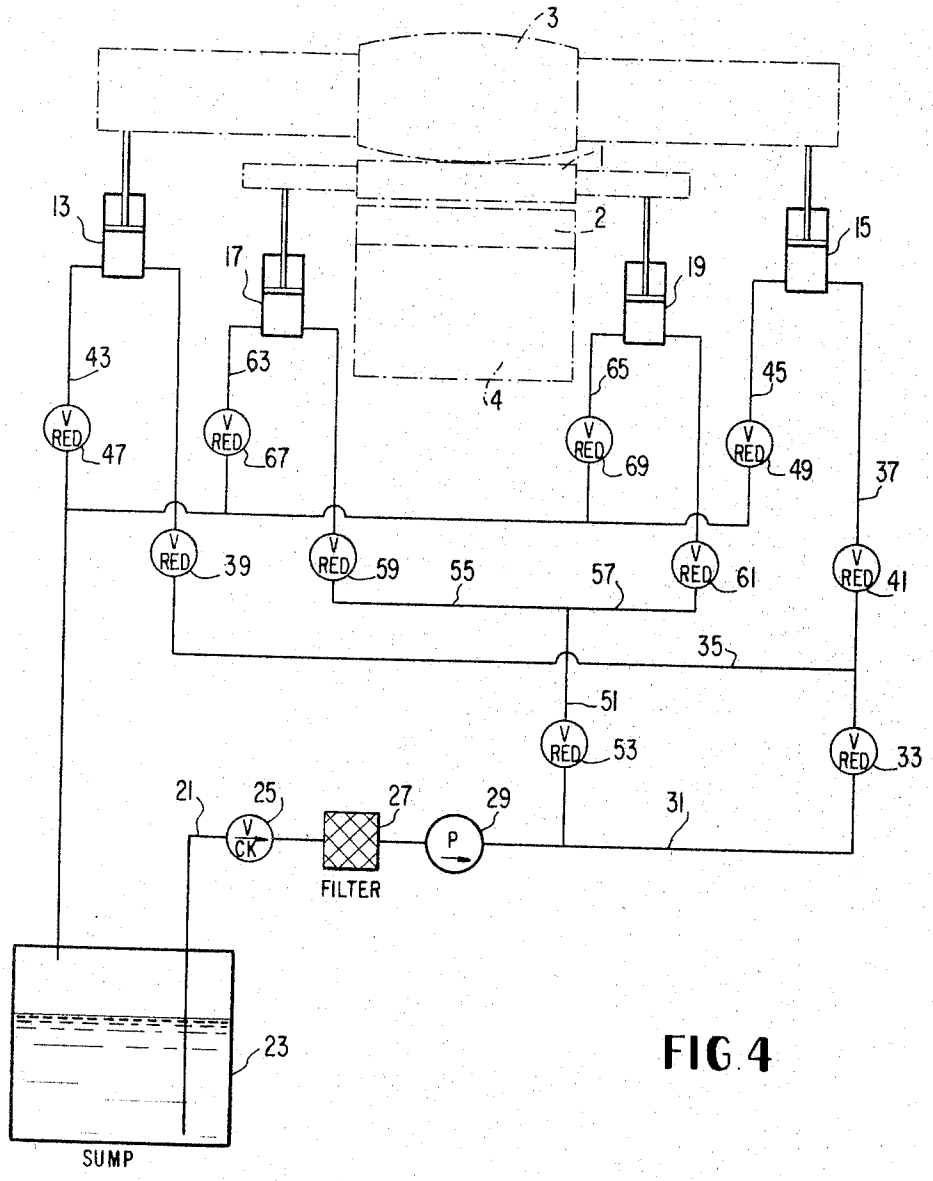


FIG. 4

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3,334,506

ROLLING MILL

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2 Claims. (Cl. 72—243)

The present invention relates to rolling mills, more particularly of the skin pass mill or temper mill type, in which a desired surface finish is imparted to the product and uniform flatness and desirable mechanical properties are also obtained.

Rolling mills of the type of the present invention may be of the four-high type employing a pair of work rolls that between them define a line pass for the sheet or strip. The work rolls are backed up by larger backup rolls which press against the work rolls to maintain uniformity of effectiveness of the work rolls.

However, as the rolls wear or as the sheet or strip supplied to the rolls varies in thickness or other characteristics, the product emerging from the mill will vary unless adjustments to the mill can be made to compensate for such variations. This is because the mills are theoretically limited to a single width, gage, extension or reduction, and degree of flatness.

Such adjustment of the mills is particularly troublesome in temper rolling wherein the metal sheet of strip is work-hardened to the proper degree, as the product must also be imbued with the required gage, width and flatness. If the width of the product changes, or if other characteristics of the product change, then the same extension or reduction and flatness cannot be attained, and some adjustment becomes necessary in order to produce a satisfactory product with the same rolls. Expedients that have in the past been practiced in order to maintain uniformity of the product despite changes in the characteristics of the material fed to the mill have included efforts to change the shape of the work rolls during the course of the operation. This has been done by applying heat as by open gas flames to the backup rolls to expand them in selected zones so as to bend the work rolls thereby to alter the pressure applied to the strip across the width of the strip. It has also been proposed to form one or both of the work and backup rolls with a crowned configuration so that pressure can be applied to the ends of the work rolls thereby to bend the work roll about the backup roll.

However, such practices as heretofore known to the prior art, and as disclosed for example in U.S. Patents No. 2,430,410 and 3,024,679, have suffered from the disadvantages that the equipment necessary to their practice is quite costly and that they are useful to correct only some but not all of the undesirable shapes the product may assume.

Accordingly, it is an object of the present invention to provide rolling mills of the type described, which can be adapted from existing rolling mills with only a minimum of reconstruction and expense.

Another object of the present invention is the provision of rolling mills of the type described, which are adapted to correct a much wider variety of strip deformities than was possible with such equipment as known heretofore.

Finally, it is an object of the present invention to provide rolling mills which will be relatively simple and inexpensive to manufacture, install, operate, maintain and repair, and which will be rugged and durable in use.

Other objects and advantages of the present invention will become apparent from a consideration of the following description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a fragmentary cross-sectional side view taken endwise of the work and backup rolls of a rolling mill according to the present invention;

FIGURE 2 is a schematic view of rolling mill structure according to the present invention, viewed in elevation perpendicular to the axes of the backup and work rolls;

FIGURES 3A and 3B are diagrams showing variations in the thickness of a strip from a desired gage, and how such variations are reduced according to the present invention. Specifically, FIGURE 3A shows an example of variation in the thickness of strip fed to a rolling mill according to the present invention, while FIGURE 3B shows the reduction in such variations that can be accomplished by the practice of the present invention; and

FIGURE 4 is a fluid circuit diagram showing the power sources and power controls of the present invention.

Referring now to the drawings in greater detail, there is shown a four-high single stand temper mill comprising a pair of cylindrical work rolls **1** and **2** that define between them a horizontal pass line. Work roll **1** is the upper work roll and work roll **2** is the lower work roll, and the axes of work rolls **1** and **2** lie in a common vertical plane. Upper work roll **1** is backed up by a crowned backup roll **3** that has a center portion of greater diameter than its end portions and that is convex over substantially all its outer peripheral surface. Lower work roll **2** is backed up by a cylindrical backup roll **4** that is not crowned. It will be understood, of course, that backup roll **4** can be crowned or uncrowned but in any case need only be conventional. Similarly, lower work roll **2** need only be conventional. As to upper work roll **1** and crowned backup roll **3**, these can take the illustrated form of an uncrowned work roll **1** and a crowned backup roll **3**, or a crowned work roll **1** and an uncrowned or cylindrical backup roll **3**, or a crowned work roll **1** and a crowned backup roll **3**.

Upper work roll **1** is journaled for rotation at its ends in a bearing box **5**, while lower work roll **2** is journaled at its ends in a bearing box **7**. Upper backup roll **3** is journaled at its ends for rotation in a bearing frame **9**. Bearing boxes **5** and **7** and bearing frame **9** are supported for vertical sliding movement on and relative to a main frame **11** which is fixed and is the main frame and principal supporting structure of the rolling mill. Lower backup roll **4** is journaled for rotation on and relative to main frame **11** and hence is not freely vertically slidable as are work rolls **1** and **2** and backup roll **3**. However, lower backup roll **4** can be removed for replacement or repair as desired.

Lower work roll **2** thus rests on lower backup roll **4**, while upper work roll **1** can rest on lower work roll **2**. Upper backup roll **3**, in turn, can rest by its weight on upper work roll **1**, as bearing boxes **5** and **7** and bearing frame **9** are all freely vertically slidable relative to main frame **11**. A conventional screw-down jack or the like (not shown) is provided for adjustably applying downward pressure to bearing frame **9** thereby to cause backup roll **3** to press against work roll **1** so as to vary the total pressure applied to strip material passing through the mill.

Means are provided for selectively and adjustably exerting upward pressure against each end of each of rolls **1** and **3**, comprising hydraulic jacks **13**, **15**, **17** and **19**. As can be seen from FIGURE 1, a pair of jacks **13** is disposed both at one end of the rolls and bearing upwardly against one end of bearing frame **9**. Jacks **13** have their pressure fluid chamber recessed in main frame **11** and have each a plunger or ram that bears against the underside of bearing frame **9**. As can be seen from FIGURE 2, the structure and arrangement of jacks **13** is duplicated at the other end of the rolls in the case of jacks **15**. There

is thus a pair of jacks **13** disposed one on either side of one end of backup roll **3**, and a pair of jacks **15** disposed one on either side of the other end of backup roll **3**, the jacks **13** serving to raise one end of bearing frame **9** with its associated backup roll **3**, and the jacks **15** serving to raise the other end of bearing frame **9** and the associated backup roll **3**.

A similar construction is provided for raising upper work roll **1** by means of its associated bearing box **5**. A pair of hydraulic jacks **17** is provided adjacent one end of the bearing box on opposite sides of roll **1**, and each jack **17** has its pressure fluid chamber recessed in main frame **11** while a plunger may be raised under that fluid pressure in contact with brackets carried by one end of bearing box **5**. Hydraulic jacks **19** at opposite sides of the other end of the upper work roll **1** similarly bear against the other end of bearing box **5**. It is important to note that the chambers of all of jacks **13**, **15**, **17** and **19** are provided by recesses in main frame **11**, so that jacks **13** and **15** act between main frame **11** and bearing frame **9**, while jacks **17** and **19** act between main frame **11** and the upper work roll **1**. All the jacks act upwardly, that is, perpendicular to the pass line of the work rolls.

An important feature of the present invention is the pressure control arrangement for the various jacks. As will be seen from FIGURE 4, fluid under pressure, such as a hydraulic fluid, is drawn through a supply conduit **21** from a sump **23**. The fluid passes through a check valve **25** which maintains the system pressurized in the event of pump failure, through a filter **27**, and through a pump **29** from which the fluid is delivered under pressure to the rest of the system.

From pump **29**, the fluid can follow one of two paths. It can flow through a conduit **31** under the control of a pressure reducing valve **33** by which the pressure drop upstream and downstream of valve **33** may be carefully regulated as desired. From conduit **31**, the fluid then passes through conduits **35** and **37** in parallel. Conduit **35** is controlled by a pressure reducing valve **39** while conduit **37** is controlled by a pressure reducing valve **41**. As in the case of valve **33**, the pressure drop through valves **39** and **41** can be carefully selectively controlled.

Conduit **35** is the supply conduit for hydraulic jacks **13**, while conduit **37** is the supply conduit for hydraulic jacks **15**. The jacks **13** and **15** are in fluid circuit not only with conduits **35** and **37** on their supply side, but also with conduits **43** and **45**, respectively, on their discharge side. Conduit **43** is controlled by a pressure reduction valve **47**, while conduit **45** is controlled by a pressure reduction valve **49**. Conduits **43** and **45** both exhaust to sump **23**.

It will thus be noted that it is possible, by manipulation of valves **33**, **39**, **41**, **47** and **49**, to regulate the magnitude of the pressure in each of jacks **13** and **15** thereby to raise the backup roll **3** as desired. The backup roll will be raised when it is desired to thread strip between work rolls **1** and **2**. If it is acceptable simply to raise and lower backup roll **3** by means of equal pressure in jacks **13** and **15**, then valves **39**, **41**, **47** and **49** can be replaced by a single valve just upstream of sump **23** on the discharge side of jacks **13** and **15**.

In addition to conduit **31**, fluid under pressure can also pass through a conduit **51** in parallel to conduit **31** and under the control of a pressure reduction valve **53** by which the pressure in conduit **51** upstream and downstream of valve **53** may be carefully selectively regulated. From conduit **51**, the fluid under pressure passes through two conduits **55** and **57** in parallel with each other to the supply side of jacks **17** and **19** of upper work roll **1**. Conduits **55** and **57** are under control of pressure reducing valves **59** and **61**, respectively, so that the pressure upstream and downstream of valves **59** and **61** may be carefully selectively controlled. On their discharge side, jacks **17** and **19** discharge fluid to discharge conduits **63** and **65** which are controlled by pressure reduction valves **67** and **69**, respectively, thereby to regulate the pressure in conduits **63** and **65** upstream and downstream of valves **67** and **69**, respectively. The discharge from conduits **63** and **65** downstream of valves **67** and **69** joins the discharge from jacks **13** and **15** to the sump **23**.

It is thus possible to regulate the pressure in jacks **17** and **19** in a variety of ways. By manipulation of valves **53**, **59** and **63**, any desired pressure up to full pump discharge pressure can be set and maintained in jack **17**. Similarly, by manipulation of valves **53**, **61** and **69**, any fluid pressure up to full pump discharge pressure can also be maintained in jack **19**. It is therefore possible to perform a number of operations with the work roll. In the first place, by giving valves **67** and **59** the same setting as valves **69** and **61**, respectively, it is possible, by manipulation of valve **53**, to raise or lower work roll **1**, assuming that backup roll **3** is raised and that the screw jack hold down is released. It is also possible, by raising the pressure in the chambers of jacks **17** and **19**, not only to raise and lower the work roll **1** but also to change its shape as it contacts the sheet or strip. Higher pressure exerted by jacks **17** and **19** will tend to bend roll **1** about the convex curvature of backup roll **3**. Similarly, if work roll **1** is already convex, then the pressure of jacks **17** and **19** will tend to increase this apparent convexity as concerns the work piece between the work rolls.

But if one side of the strip is thicker than the other side, then it is also possible by the use of the present invention to correct this condition. This is because the jacks **17** and **19** can be operated independently of each other. In other words, valves **67** and **59** can be manipulated independently of valves **69** and **61**. Thus, if, say, the left side of the strip is thicker than the right side as seen in FIGURE 4, jack **19** can be actuated independently of jack **17** to press upwardly on the right-hand side of work roll **1**. Incidentally, it should be noted that the long cantilevered portions of the ends of rolls **1** and **3** are entirely fanciful and are provided simply to enhance the clarity of the schematic diagram which is FIGURE 4. Upward pressure by jack **19**, perhaps coupled with an increase in downward pressure of the screw-down jack (not shown) will cause the left-hand side of work roll **1** as seen in FIGURE 4 to bear more heavily against the work piece than before.

The effect of such increased pressure on one side only of the strip can be seen in FIGURES 3A and 3B. Let it be assumed that the zero line in FIGURE 3A is optimum gage, but that the strip actually has a cross-sectional contour better represented by the curved line in FIGURE 3A, that is, the left side of the strip is a little thicker in gage while the right side is not appreciably thicker. What happens when the present invention is utilized as just described above is shown in FIGURE 3B. The high left side of the strip has been rolled flatter and the strip then tolerably approaches desired gage. Naturally, if the excessive thickness were on the other side of the sheet, jack **17** could instead be manipulated to press upwardly against the associated end of work roll **1**, thereby to cause increased pressure on the right-hand end of the roll to reduce any increased thickness of the right-hand side of the sheet of work.

It will be appreciated, therefore, that by the practice of the present invention it is no longer necessary to force the work rolls apart, as in the above-identified Patent No. 2,430,410, or to force them together, as in the above-identified Patent No. 3,024,679. Instead, all that it is necessary to do is to employ jacks that act between the main frame and the respective rolls **1** and **3**. It is not necessary to include the lower work roll in the roll deforming system.

Moreover, it is a very simple and inexpensive procedure to make the ends of the upper work roll selectively operable to raise the separate ends of the work roll as desired. Only the simplest changes in the pressure lines need be made to bring out this result.

It will therefore be apparent from a consideration of the foregoing disclosure that all of the initially recited objects of the present invention have been achieved.

Although the present invention has been described and illustrated in connection with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit of the invention, as those skilled in this art will readily understand. Such modifications and variations are considered to be within the purview and scope of the present invention as defined by the appended claims.

What is claimed is:

1. In a rolling mill comprising a main frame, a pair of adjacent work rolls disposed on opposite sides of a pass line, a pair of backup rolls one bearing against each work roll to urge the work rolls toward each other, the work and backup rolls on one side of the pass line being mounted for movement relative to the main frame toward and away from the work and backup rolls on the other side of the pass line, at least one of said work and backup rolls on said one side of the pass line having a larger diameter at its middle than at its ends, the longitudinal axes of the work rolls and backup rolls being located in a common plane substantially vertically disposed in perpendicular relationship to the pass line; the combination comprising means acting only in the substantially vertically disposed common plane between the main frame and the work roll on said one side of the pass line both to urge said work rolls apart and to bend the work roll on said one side of the pass line by contact with its contiguous backup roll, said means including separately controllable hydraulic pressure means for opposite longitudinal ends of the work roll on said one side of the pass line for urging the opposite longitudinal ends of the work roll on said one side of the pass line toward its contiguous backup roll at substantially different pressures.

2. A rolling mill comprising a main frame, a pair of adjacent work rolls disposed on opposite sides of a pass line, a pair of backup rolls one bearing against each work roll to urge the work rolls toward each other, the longitudinal axes of the work rolls and backup rolls being located in a common plane substantially vertically disposed in perpendicular relationship to the pass line, a hydraulic jack means in supporting relation to each end of the work roll on the upper side of the pass line, means associated with the main frame mounting each jack means for lifting the upper work roll relative to the main frame toward and away from the lower work roll, at least one of said work and backup rolls on the upper side of the pass line having a larger diameter at its middle than at its ends, a source of hydraulic fluid, pump means for raising the pressure of the hydraulic fluid to a high pressure, separate high pressure hydraulic fluid conduits connecting each said hydraulic jack means to the means for raising the pressure of the hydraulic fluid, hydraulic fluid pressure control means in each high pressure hydraulic fluid conduit between the means for raising the pressure of the hydraulic fluid and the hydraulic jack means for controlling the pressure of the fluid actuating the jack, the pressure of the hydraulic fluid produced in the pump means acting through the jacks being great enough to bend the upper work roll during rolling to thereby control the shape of the rolled product.

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