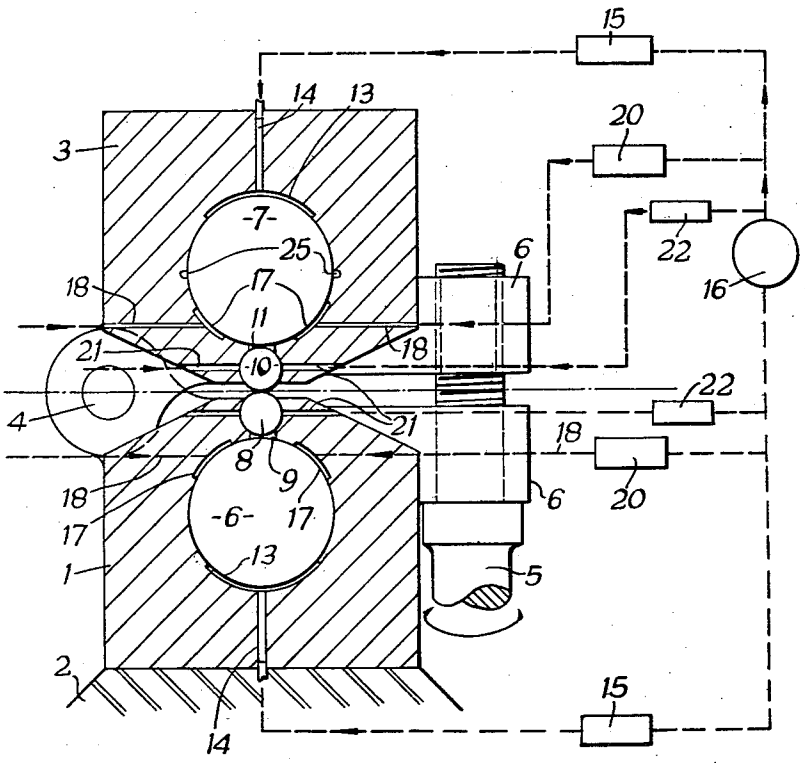
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ROLLING MILLS FOR ROLLING METAL SHEET AND STRIP

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Fig. 1.



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Fig. 2.

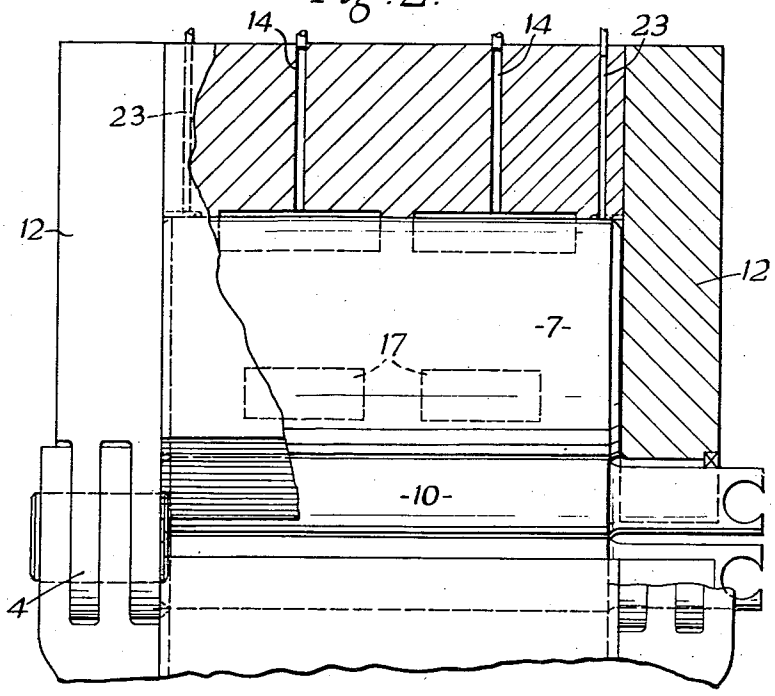
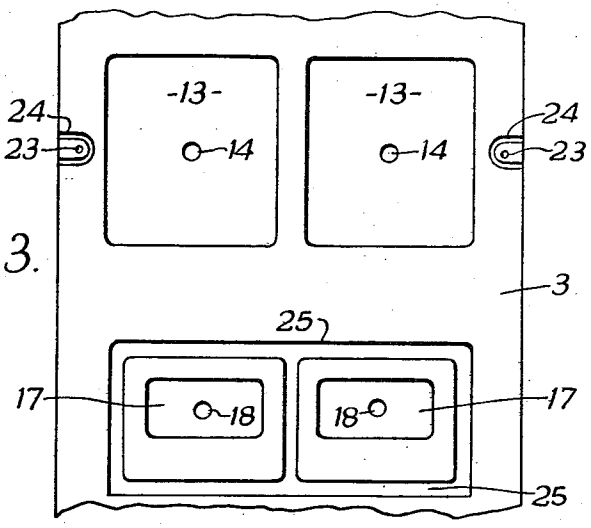


Fig. 3.



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ROLLING MILLS FOR ROLLING METAL SHEET AND STRIP

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This invention relates to rolling mills as used in hot or cold rolling or reduction of metal sheet and strip.

In the rolling of metal sheet or strip there are several factors that bear on the accuracy of gauge thickness and the attainable thinness of the rolled product. For example, the work rolls being elastic bodies, when they are journalled in the conventional manner through the intermediary of roll-neck bearings the roll bodies bend due to their flexing as short beams under the distributed load, and they bend to a greater extent at the roll necks, which are necessarily of smaller diameter than their associated roll bodies. A consequence of such bending is that the rolled sheet or strip is thicker at its midwidth than its edges. The bending can be counteracted to some extent by the use of backing rolls. On the other hand, the rolls tend to flatten where they contact the sheet or strip being rolled, and the flattening in conjunction with the bending imposes a limitation on the thinness to which metal sheet or strip can be rolled.

A further feature is the heat that accummulates in rolls in both hot and cold rolling; in the latter case due particularly to the work done in plastically deforming the sheet or strip. Unless large quantities of cooling medium are employed the thermal expansion of the rolls may be considerable, and the heat flow and distribution in the roll may be non-uniform so that differential expansion takes place, giving rise to irregular variation in the gauge of the work both across the width and along the length of the sheet or strip.

The object of the invention is to reduce or overcome the above-mentioned disadvantages, and in accordance with the invention the working surface of at least one of the rolls is provided with hydraulic pad bearing means to which fluid under pressure can be continuously supplied, said bearing means extending over a major part of the axial length of the roll and being disposed so that the pressure of the fluid in the bearing means is exerted in the direction of the nip between the work rolls.

In a preferred form of the invention the roll is journalled over its working surface or a part thereof in a chock that extends around the periphery of the roll, the pad bearing means comprising one or more recesses formed in the internal bearing surface of the chock and one or more ducts for the supply of fluid under pressure to said recess or recesses.

Desirably the roll is provided with additional hydraulic pad bearings disposed so as to impart improved lateral stability to the roll, that is to say stability in the direction at right angles to the plane containing the axis of the roll provided with the hydraulic pad bearings and the axis of the adjacent roll.

The said hydraulic pad bearings means may be constituted by a single hydraulic pad bearing extending over a major part of the axial length of the work roll, or by two or more hydrostatic pad bearings which are axially spaced along the work roll and the total lengths of which are a major fraction of the length of the roll.

The said pad bearing means may be associated with one or both work rolls, or where backing rolls are employed the bearing means may be associated with one or both backing rolls and/or one or both work rolls.

In order that the invention may be clearly understood and readily carried into effect it will now be described in more detail with reference to the accompanying drawings, in which:

FIGURE 1 is a view in side sectional elevation of a 4-high rolling mill embodying the invention;

FIGURE 2 is a view partly in rear elevation and partly in section on a vertical plane through the roll axes, of the upper part of the mill, and

FIGURE 3 is a developed view of that part of the surface of a chock of the mill that extends around the upper surface of the upper backing roll of the mill.

Referring to the drawings, the mill illustrated comprises a lower chock **1** firmly mounted on a base **2**, and an upper chock **3**, the chocks **1** and **3** being hinged to one another at the entry side of the mill by means of heavy hinge pins **4**, and being interconnected at the exit side of the mill by heavy screws, one of which is shown at **5** (FIG. 1), which engage in lugs **6** on the chocks, and which enable the width of the roll gap to be adjusted. The lower chock **1** has a cylindrical cavity within which is disposed a lower backing roll **6**, and the chock **3** has a cylindrical cavity within which is disposed an upper backing roll **7**. The lower chock **1** also has a cylindrical cavity within which is disposed a lower work roll **8**, the rolls **6** and **8** projecting into a slot **9** and into driving contact with one another and the roller **8** projecting through a slot in the upper surface of the chock **1**. The upper chock **3** is formed with a cylindrical cavity in which is disposed an upper work roll **10**, the upper backing and work rolls projecting into a slot **11** and into driving contact with one another, and the upper work roll **10** projecting through a slot in the lower surface of the chock **3**, the two work rolls **8** and **10** being separated from one another by a gap the size of which is determined by the setting of the screws **5**. The backing rolls **6** and **7** fit closely in the respective chocks **1** and **3**, in which they are journalled over substantially the whole of their cylindrical working surfaces, and the ends of the backing rolls are enclosed by end wall **12** of the chocks. The work rolls **8** and **10** also fit closely in their chocks and like the backing rolls are journalled therein over their working surfaces.

The upper part of the cylindrical surface of the cavity in the chock **3** in which the upper backing rolls **7** is disposed is formed with two recesses **13**, which are spaced from one another along the axial length of the backing roll **7**, as shown in FIGS. 2 and 3, and each of which extends symmetrically over about one half of the upper surface of the backing roll **7**. Ducts **14** connect the recesses **13** to constant flow controllers **15** which are fed with liquid under pressure by a high pressure pump **16**. The lower chock **1** is formed, similarly to the upper chock **3**, with recesses **13** which are also connected by ducts **14** to the output of the constant flow controllers **15**. The backing rollers **6** and **8** fit closely in the respective recesses in the chocks, which as shown enclose the cylindrical surfaces and also the ends of the backing rolls.

The cylindrical surface in which the upper backing roll **7** is journalled is formed with two pairs of auxiliary recesses **17** adjacent the lower surface of the upper backing roll **7**, and arranged symmetrically with respect to the vertical plane through the axes of the rollers. Ducts **18** connect the recesses to constant flow controllers **20** which are also fed with fluid under pressure from the pump **16**, or from a second pump. The lower chock **1** is similarly formed with pairs of auxiliary recesses **17** connected by ducts to the output of the constant flow controller **20**. Alternatively, capillary tubes or orifices can be used in place of the constant flow controllers to maintain the flow at a constant value or at a value determined by an external control.

Further ducts **21** lead from a constant flow controller **22**, also supplied by the pump **16**, or by a separate pump, to the sides of the work rolls **8** and **10**.

As shown, the chock **3** is provided with control ducts **23** the inner ends of which open at the working surface of the backing roll **7** adjacent the ends thereof, the ducts **23** leading to a control member of the appropriate constant flow controller **15**. The inner end of each duct is surrounded by a guard channel **24** formed in the cylindrical surface of the chock. Similar control ducts and guard channels are formed in the lower chock **1**.

Around each pair of auxiliary recesses **17** in the upper chock **3** is provided a guard channel **25** comprising two interconnected rectangular channels as shown in FIG. 3. Similar guard channels are provided in the lower chock **1** around the auxiliary recesses **17** therein.

In the operation of the mill, fluid under pressure e.g. lubricating oil, is supplied continuously through the ducts **14** to the recesses **13**, which are thus kept full of oil under pressure, which leaks from the sides and ends of the recesses **13**, around the backing rolls **6** and **7** to the guard channels **25** which by-pass the auxiliary recesses **17** and deliver the leakage oil to the slots **9** and **11** between the backing rollers **6** and **7** and their associated work rollers **8** and **10**, or if preferred, the oil can be made to by-pass the work rolls completely, being delivered directly to the nip of the rolls.

For the sake of clarity the description will for the present be confined to the operation of the invention in relation to the upper chock **3** and the upper backing and work rolls carried by it.

In normal operation, the oil supplied under pressure to the hydraulic pad bearing formed by the recess **13** leaks from the recess at the edges thereof by virtue of the very small running clearance between the backing roll **7** and its chock, and the leakage oil flows over the surface of the backing roll **7** and forms an oil film between the roller **7** and the chock **3**. Once the oil film has formed so that the roller **7** is lubricated for rotation in its chock, surplus oil drains into the upper ends of the guard channels **25** whence it flows to the lower sides of these channels, bypassing the auxiliary recesses **17**.

If during operation the clearance between the upper backing roll **7** and its chock changes, the hydrostatic pad bearings formed by the oil-filled recesses **13** respond immediately by a change of oil pressure within said bearings in such sense as to tend to restore the initial conditions. For example, if the backing roll **7** descends relatively to the chock **3**, the clearance between the edges of the recesses **13** and the roll **7** is increased, allowing a more rapid flow of oil from the recesses **13** with a consequent fall in the downward pressure on the roll. If on the contrary the backing roll rises, the clearance becomes smaller and the oil pressure on recesses **13** is increased. Since the rate of flow through the clearance varies with the size of clearance, a small vertical displacement of the backing roll relative to the chock will result in a large change in the rate of flow of oil from the pad bearings and therefore in the pressure of the oil in the pad bearings. If there were no sensing ducts **23** exerting an external control on the constant flow controller it would operate to vary the output pressure so as to maintain a constant flow. The resulting changes in pressure in the bearings would automatically alter the vertical displacement of the backing roll so as to tend to re-establish the original position of the backing roll relative to its chock. The clearance in this way would be kept substantially constant and hence the position of the roll relatively to the chock would be kept substantially constant. By suitable choice of the clearance and the pressure drop in the oil feed to the recesses **13** the curve of the pressure against change in clearance can be made very steep, providing almost complete compensation in the practical range of normal disturbances. Moreover, the response can be made extremely rapid.

The sensing ducts **23** need not necessarily be provided unless additional control is required over and above the automatic control of the vertical position of the backing roll **7** provided by the pad bearings **13**. If used, pressure changes in the ducts **23** consequent upon changes in roll position are used to operate a control member in the appropriate flow controller **15**, so that the flow to the recesses **13** is adjusted in accordance with variations in the vertical position of the backing roll relative to its chock. Instead of these sensing ducts **23** there may be used means that control the oil supply to the pad bearings in response to departures of the gauge thickness of the roller sheet or strip from the required value, or means responsive to differential pressure drop along capillary ducts leading to the hydraulic pad bearings, such means operating to control the oil fed to the pad bearings, e.g. by adjustment of the setting of flow control valves.

The oil pressure within the auxiliary recesses **17** serves to give lateral support to the backing roll **7** and to keep it centered with its axis in the vertical plane through the axes of the rolls, any change in the lateral position of the roll **7** increasing the rate of oil leakage from the recesses **17** on one side of the said plane and correspondingly increasing the rate of oil leakage from the recesses on the other side of the said plane, so that differential pressures are produced which tend to restore the roll **7** to its normal position. The auxiliary recesses can also serve as hydraulic pad bearings to modulate the downward thrust of the recesses **13** to maintain the roll **7** in a substantially constant vertical position, since any vertical movement of the roll **7** that produces a fall in pressure in the recess **13** will produce an increase in pressure in the auxiliary recesses **17**, and vice versa. Alternatively, the pressure in the recesses **17** can be controlled from an error signal indicative of change of strip gauge.

It will be understood that the hydraulic pad bearings associated with the lower backing roll **6** and work roll **8** serve to improve the vertical and lateral stability of these rolls, in the same way as has been described in connection with the upper backing and work rolls.

The oil fed through the ducts **21** serves to cool the work rolls **8** and **10**. This oil and the oil that leaks from around the backing rolls, through the slots **9** and **11** and the work rolls serves finally to lubricate the sheet or strip being rolled.

The oil flowing from the pad bearings through the clearance between the work rolls **8** and **10** and the chocks **1** and **3** respectively provides good heat transfer from the backing rolls and thus reduces the tendency to thermal deformation of these rolls. Cooling of the mill as a whole is thus improved due to the high rate of flow of oil to and away from the bearings. Since the action of the pad bearings can be made substantially independent of the viscosity of the liquid or of the temperature of operation, the oil or other liquid used in the bearings may be chosen primarily for its suitably as a lubricant and for coolant for the work, so avoiding the risk of contamination or straining as may occur with lubricants used with roll-neck bearings. Water may be used in some cases. No seals are required for confining the liquid.

The use of hydraulic pad bearings as described greatly reduces flexure of the rolls, particularly when the rolls are mounted in chocks, since the chocks become in effect parts of the associated rolls from the point of view of flexure.

The invention may be applied not only to the rolling of sheet or strip metal but also the formation by rolling of sheet or strip plastics or glass. In the case of glass the fluid fed to the pad bearings may be air.

We claim:

1. A rolling mill comprising: at least two rolls adapted to exert forces against opposite sides of work passed therebetween; and means for supporting at least one of said rolls to maintain the said one of the rolls against forces exerted by the passage of work between the two rolls,

said means including a chock having a cylindrical bearing surface disposed on the opposite side of said one roll from the work, said chock being held rigidly against movement away from the work, hydraulic pad bearing means defined by a recess formed in said chock and opening to the cylindrical bearing surface thereof, and means for supplying a continuous flow of hydraulic fluid under pressure to said pad bearing means, said one roll being freely movable from an initial position spaced slightly from said cylindrical bearing surface to establish a restricted passage for hydraulic fluid from said recess between said one roll and said cylindrical bearing surface whereby the fluid will escape from said recess at a rate dependent on the degree of movement of the roll with respect to said cylindrical bearing surface and thus cause a pressure change in the hydraulic pad bearing means tending to restore the roll to its initial position.

2. A rolling mill as claimed in claim 1 including sensing means responsive to displacement of the said one of the rolls relative to the pad bearing means and controlling said hydraulic fluid supply means to vary the supply of fluid to the bearing means in such sense as to create a pressure change in the bearing tending to restore the roll to its initial position.

3. A rolling mill as claimed in claim 1 in which said bearing surface extends over the major part of the axial length of the working surface of the roll.

4. A rolling mill having at least two rolls, hydraulic pad bearing means cooperatively disposed in relation to the working surface of one of the said rolls to maintain the said one of the rolls against forces exerted by the passage of work between the two rolls, flow-controlling means connected to supply a continuous flow of fluid under pressure to said pad bearing means, and means supporting the said one of the rolls relative to the hydraulic pad bearing means such that movement of the roll relative to the bearing will allow escape of fluid from the bearing at a rate dependent on the degree of movement of the roll and thus cause a pressure change in the bearing tending to restore the roll to its initial position, said supporting means comprising a chock having a cylindrical bearing surface extending over the major part of the axial length of the working surface of the roll, auxiliary hydraulic pad bearing means cooperatively disposed in relation to the working surface of the one said roll to increase the lateral stability of the roll, and flow controlling means for continuously supplying fluid under pressure to said auxiliary bearing means.

5. A rolling mill as claimed in claim 4 in which said first-mentioned hydraulic pad bearing means consist of a single hydraulic pad bearing coextensive with a major part of the axial length of the working surface of the roll and formed by a recess in said cylindrical bearing surface.

6. A rolling mill as claimed in claim 1 in which said hydraulic pad bearing means is coextensive with the major part of the axial length of the working surface of the roll.

7. A rolling mill as claimed in claim 6 in which the said hydraulic pad bearing means comprise a plurality of individual hydraulic pad bearings the total axial length of which is a major fraction of the length of the roll.

8. A roll mill as claimed in claim 1, including a pair of work rollers adapted to contact opposite sides of the work and in which said two rollers are backing rollers for supporting said work rollers.

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