Aug. 1, 1967 C. GUILLOT 3,333,453

ROLLING MILLS HAVING HYDRAULIC PRESSURE CONTROL

Filed April 24, 1964 2 Sheets-Sheet 1

Fig. 4

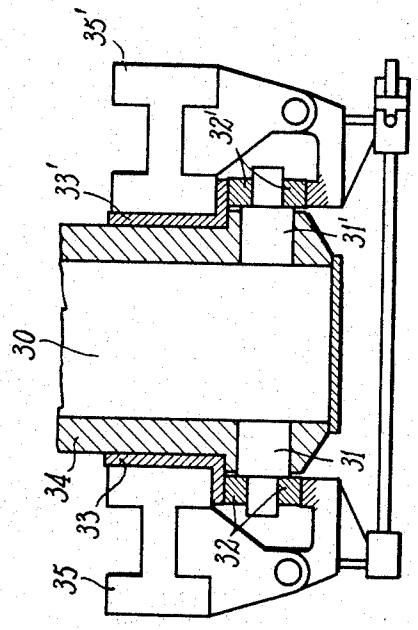
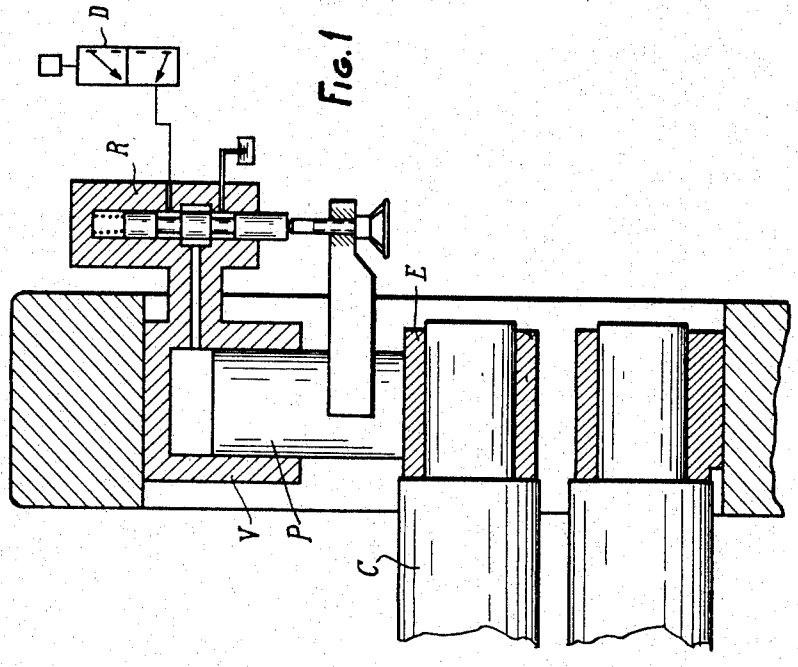



Fig. 1




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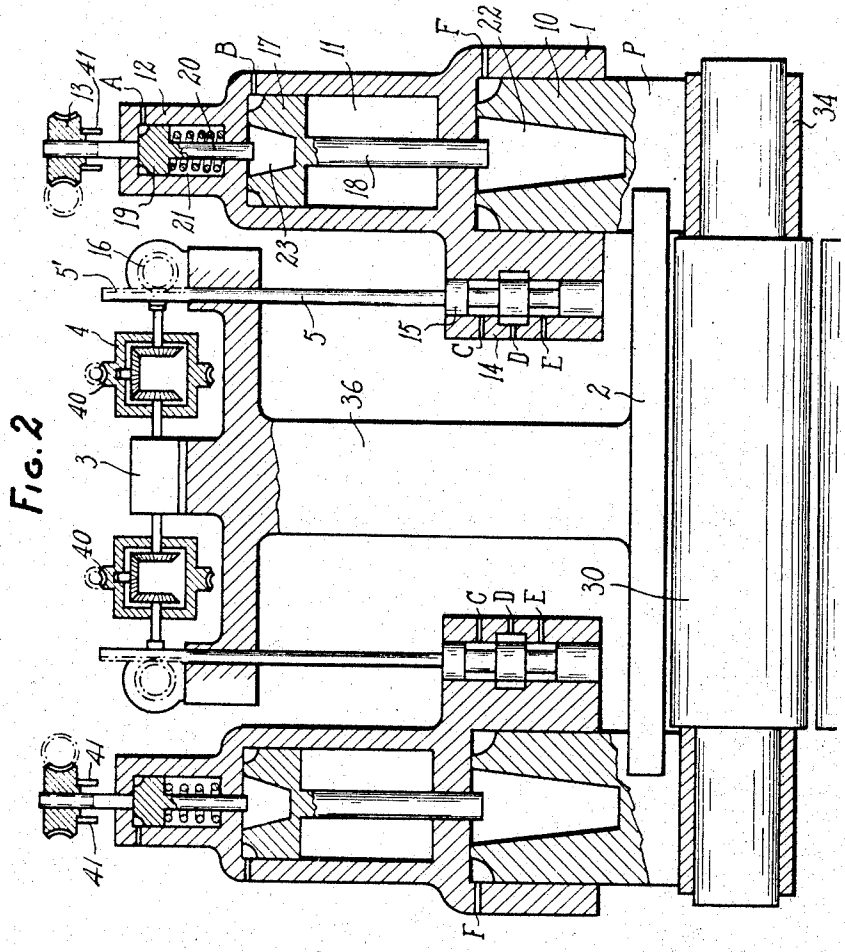


FIG. 2

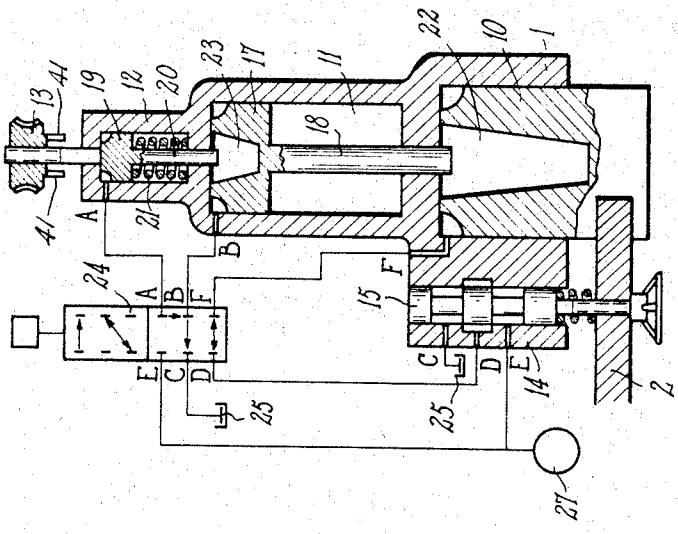


FIG. 3

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# ROLLING MILLS HAVING HYDRAULIC PRESSURE CONTROL

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14 Claims. (Cl. 72—345)

This invention relates to rolling mills having hydraulic means for applying the requisite rolling pressure to the rolls during the rolling process. A general object of the invention is to improve the operating efficiency and reliability of such hydraulic pressure systems, and thereby to increase the quality of the rolled products especially in regard to dimensional accuracy.

In conventional rolling mills it is customary to use hydraulic pressure rams associated with the end bearing chocks of the rolls for forcibly applying the rolls against the work under a prescribed pressure. The ram cylinders are supplied with liquid from a pressure source by way of regulating valve means controlled to maintain the pressure applied by the ram to the roll at a prescribed value in spite of variations in rolling resistance encountered during the rolling process. An object of the invention is to improve the precision and response speed with which the control and regulation of the hydraulic pressure system can be accomplished.

At the commencement of a rolling pass, as when a bloom or other work is first engaged between a pair of rolls, there is a large and sudden increase in rolling resistance producing a corresponding surge in the pressure of the hydraulic fluid in the pressure system. Because the fluid is not incompressible under the extremely high overpressures involved in large-capacity rolling mills, such pressure surge will result in an appreciable reduction in the volume of the fluid, so that the ram piston advances a substantial amount in the ram cylinder. This effect, which will herein be termed hydraulic sag, is in due time compensated by the operation of the regulating valve which is automatically actuated in a sense to admit additional pressure fluid into the ram cylinder to readjust the ram pressure to the prescribed level. However, such compensatory action occurs with an appreciable time lag and as a result the gauge thickness of the rolled product may be oversize over a substantial end length thereof. A specific object of the invention is to minimize hydraulic sag (as the term is hereinabove defined) in a rolling mill and reduce its objectionable consequences on the rolled product.

In addition to hydraulic sag there is another objectionable effect encountered during a rolling pass which may be termed mechanical sag. This is due to the unavoidable electric deformation of metallic parts of the rolling mill due to the high rolling resistance, and is another source of dimensional inaccuracy in the rolled products. An object of this invention is to provide improved compensating means for the elimination of the undesirable effects of mechanical sag.

A related object is to provide a safety mounting arrangement for a roll having hydraulic pressure control means associated with it and specifically an arrangement whereby such roll is mounted with some freedom of rocking movement about an axis parallel to the direction of feed of the work, whereby the roll will be automatically capable of rocking somewhat about such axis in case e.g. of unequal operation of the sag compensating means as between the two ends of the roll, so as to avoid nonuniformity in product thickness in a transverse direction,



and/or damaging strains in the roll and other components of the rolling mill.

In conventional rolling-mill hydraulic pressure systems of the type outlined above, it is usual to provide two pressure sources for the hydraulic fluid, one source at low or moderate pressure for normal operation and one high-pressure source for use whenever the rolling resistance exceeds a predetermined value. The two sources are then connected to the pressure inlet port of the afore-mentioned regulator valve by way of a two-way selector valve arranged to be shifted between its two positions according to requirements. Such an arrangement has a number of drawbacks. The use of two separate fluid pressure sources is a complication. The remote location of the high-pressure source increases control response time as well as increasing the amount of troublesome high-pressure piping. The flow of fluid under very high pressure from the high-pressure source through the regulator valve subjects the delicate valve parts to considerable wear and causes a loss of regulating accuracy with time. Objects of the invention include the provision of a high-pressure generating means incorporated in the pressure system, thereby to eliminate the requirement of a separate remotely positioned high-pressure source with its attendant disadvantages.

The above and further objects of the invention as well as the novel features thereof will become apparent from the ensuing description made with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic view in partial vertical section of a conventional two-high rolling-mill arrangement showing the one end of the rolls and hydraulic pressure control means associated with the upper roll;

FIG. 2 is a schematic view in vertical section of a rolling mill according to the invention showing the uppermost roll together with the improved hydraulic pressure control means associated with both ends thereof;

FIG. 3 is a view corresponding to part of FIG. 2 showing the hydraulic pressure means associated with one side of the rolling mill and schematically indicating the hydraulic flow connections establishable therein for each of two different settings of a selector valve; and

FIG. 4 is a partial view in horizontal axial section of a roll provided with improved inclinable mounting means according to a feature of the invention.

Reference will first be made to FIG. 1 which relates to prior art and serves to set out in greater detail some of the drawbacks the invention is designed to overcome. The figure shows a pair of rolls or cylinders the upper one of which is designated C and has its ends journalled in bearing cases or end chocks, only one of which is shown at E. Associated with the uppermost roll C is a hydraulic pressure system including a ram having a ram cylinder V suitably supported from the roll stand or frame and having a piston P projectable from its lower end and engaging the upper surface of end chock E so as to apply the requisite rolling pressure downwardly thereto and through roll C to the underlying work. It will be understood that means including a further ram, not shown, acting upwardly on the chock E, would normally be provided for raising the cylinder bodily with the pressure ram piston P when required.

The fluid pressure in the upper chamber of single-acting pressure ram cylinder V is controlled by way of a conventional regulator valve unit generally designated R and here shown as being of the reciprocable piston or spool variety. The valve R has a cylinder port connected with the upper end of ram cylinder V, an inlet port connected to a pressure source by way of a selector valve D later referred to, and an exhaust port connected to a reservoir as schematically indicated. The valve spool of valve unit R is axially shiftable in the conventional way to vary the

degrees of communication between the cylinder port and each of the inlet and exhaust ports, in reverse senses as may be required.

As earlier indicated the inlet port of regulator valve R is selectively connectable by way of selector valve D to either a moderate or a high-pressure source of fluid. When the connection is with the high-pressure source, it will be seen that high-pressure fluid flows through the regulator valve R, subjecting the spool and valve port surfaces to considerable erosion. Since the static accuracy of the pressure regulating action depends on extremely precise dimensional tolerance at said surfaces, it will be realized that the arrangement of FIG. 1 leads quite rapidly to a loss in regulating accuracy with adverse effects on the dimensional accuracy of the rolled work. It will also be noted that the high-pressure source is located at a relatively remote point, requiring an objectionable expanse of high-pressure piping and increasing response time lag. It will also be noted that the arrangement of FIG. 1 includes no effective means for compensating the hydraulic and mechanical sag effects earlier described.

Referring now to FIG. 2 for a description of an exemplary embodiment of the invention, there is shown at **30** the uppermost roll of a rolling frame which may be similar to the one shown in FIG. 1 and having its ends journalled in the bearing cases or end chocks **34**. With each end chock **34** is associated an improved hydraulic pressure control arrangement, the two arrangements being identical. Each such arrangement includes a single-acting ram having a downwardly-opening fixed cylinder **1** in which a ram piston **10** is slidable, the projecting lower end of the piston engaging the upper surface of the related chock **34**. The ram piston **10** of both hydraulic arrangements are interconnected by a crosshead **2** which supports a central stand or support **36**, carrying control, and regulating mechanism according to the invention, later described.

Associated with each ram cylinder **1** is a regulator valve unit **14** shown as being of the same type as that described with reference to FIG. 1. The casing of valve **14** is formed with three ports as previously mentioned, viz a pressure or inlet port E, a reservoir or exhaust port C and a cylinder port D. The manner in which the cylinder port D controls the pressure within the upper chamber **22** of pressure ram cylinder **1** will be later described with reference to FIG. 3. However, it should already at this point be understood that upward displacement of the valve spool **15** of regulator valve **14** increases the communication between cylinder port D and pressure port E so as to increase the pressure in ram chamber **22** and hence increase the pressure exerted by ram **10** on the roll chock **34**, while downward displacement of valve spool **15** has the reverse effects and reduces rolling pressure.

Regulator valve spool **15** has a stem **5** projecting upwardly from and extending slidably through a suitable guideway in the support **36**. The upper end of stem **5** is formed with a rack **5'** meshing with a gear **16**. Gear **16** is driven by way of a suitable reducer gearing, e.g. a worm and wormgear, from the outlet shaft of a differential gearing **4** which according to this invention is provided for the purpose of compensating "mechanical sag" as earlier explained. Differential **4** is herein shown as being of the epicyclic gearing type with two bevel sungears respectively secured on its outlet and inlet shafts and one or more planetary bevel gear meshing with both sungears and rotatably supported in the planet-carrier cage or casing of the differential gearing. The inlet shaft is driven from a reversible electric motor **3** of suitable type mounted on support **36**. It will be noted that motor **3** drives the one input shafts of both differential gearings such as **4** forming part of the respective hydraulic pressure control arrangements of the system. It will be understood that the motor **3** is reversibly controlled through conventional servo-means, not shown, to impart to both regulator valve spools **15**, by way of differentials **4**, reducer gearings **16** and stems **5**, reciprocatory displacements under control of the existing rolling pressure at the related end of the roll so as to vary the pressure in ram chamber **22** in the senses required to remain said rolling pressure substantially constant. Such means for controlling the motor **3** do not per se form part of the invention. In addition however to such conventional positional control of regulator valve spool **15**, a supplementary control is provided according to the invention in the form of rotational movement imparted to the planet-carrier cage (or other differential input) of differential **4**, e.g. by way of a worm and worm gear mechanism **40** as shown. Such additional positional control of valve spool **15** may thus be accomplished entirely independently of the primary control exerted by motor **3**, and provides a means, in particular, of compensating mechanical sag in the rolling mill components at each side of the rolling frame as well as other disturbing factors. The controlling means for the rotation of differential planet-carrier **4** may according to the invention assume various forms not here illustrated since they will be readily understood by those familiar with the art from the ensuing explanations. Thus in one embodiment of the invention the rotation of the planet carrier (or other differential control input) may be made dependent on the deformation or strain sensed in the related upright of the rolling frame, by way of any suitable force-or strain-sensing device, connected to rotate the differential planet carrier by way of a motor or otherwise.



It is also within the scope of the invention to displace the controlling input (e.g. plane carrier) of the differential **4** in response to other factors, such as the pressure within the pressure ram chamber **22**. Thus there may be provided a secondary single-acting ram having its cylinder chamber connected with the pressure ram chamber **22** and having its piston rod connected through rack gearing or the like to rotate the planet-carrier of differential **4** in opposition to a spring.

Overlying the pressure ram cylinder **1** and preferably formed integrally with it is another ram cylinder **11** which forms part of a pressure-multiplier arrangement according to the invention. The ram **11** has a piston **17** slidable in it, said piston having a rod **18** projecting downwardly from its centre and extending slidably through a passage formed in the horizontal separating wall between the ram cylinders **1** and **11**. It will be noted that the main or pressure ram piston **10** has a deep recess formed centrally of its upper surface, into which the pressure rod **18** can variably project. It will be understood that when pressure is applied to the upper end of ram cylinder **11** in a manner presently described to lower piston **17**, the penetration of rod **18** into the cylinder space **22** of the main pressure ram **1** will create therein a sudden and sharp overpressure, so that in effect the tandem arrangement of rams **1** and **11** provides a high-pressure source incorporated in the hydraulic system.

For applying pressure into the upper chamber **23** of pressure multiplier ram **11**, there is provided above ram **11** a third ram **12** which is similarly related to ram **11** as ram **11** is related to ram **1**. That is, the cylinder of ram **12**, which overlies and is integral with the cylinder of ram **11**, has a piston **19** slidable in it and having a rod **20** projecting downwardly from it and into a recess formed in the upper surface of piston **17**. Piston **19** is urged upwardly in cylinder **12** by a spring **21**. Pressure can be applied to the upper end of ram **12** by way of a cylinder port A in a manner soon to be described. According to a preferred form of the invention, as shown, means are provided for presetting, or regulating, the amount of downward displacement imparted to the uppermost ram piston **19** on application of pressure fluid into port A, and such means may comprise as shown a rod projecting upward from piston **19** outward of the cylinder **12**, and having a wormgear **13** threadedly mounted thereon by way of a screw threaded bore of the wormgear engaging a threaded upper part of said shank or rod. Abutment means shown as a pair of parallel fingers **41** project down-

wardly from wormgear **13** so as to be engageable with the upper surface of cylinder **12** to limit the downward stroke of piston **19**. The wormgear **13** is shown as meshing with a worm which may be rotated manually and/or automatically, through means not shown. This arrangement provides a means of controlling the maximum over-pressure that will be generated in the main pressure ram as a function of the "hydraulic sag" in the system. The uppermost or control ram **12** of the three-stage pressure-multiplying ram assembly constitutes in effect an improved device for compensating hydraulic sag according to the invention.

Referring to FIG. 3, it will be seen that there is provided in this embodiment of the invention a two-positional selector valve **24** operable e.g. automatically to establish either one of two different sets of flow circuit connections between the pressure source **27**, reservoir **25** and the various ports of each of the three rams **1, 11** and **12**. Specifically, the arrows in FIG. 3 indicate the flow connections that are established in selector valve **24**. The valve **24** is shown in its normal position which is used so long as only moderate rolling pressures are required. In this position, it will be seen that the selector valve establishes connection from the cylinder port D of regulator valve **14** to the inlet port F at the upper end of the pressure ram cylinder **1** while the inlet ports B and A at the upper ends of the multiplier ram cylinder **11** and hydraulic-sag compensator ram cylinder **12** respectively, are both connected to the reservoir **25** through selector valve **24**. The pistons **17** and **19** of the last mentioned two rams **11** and **12** are therefore brought to their idle upper positions within the related ram cylinders, while the position of pressure piston **10** is regulated through the action of regulator valve **14** as earlier explained. In this condition the rolling pressure is regulated and held at a substantially constant value in a generally conventional manner except of course for the additional control preferably introduced by way of the differentials **4** according to the invention as described earlier herein.

At times when extremely high rolling pressures may be required as for hydraulic sag compensation, the selector valve **24** is shifted manually or automatically to its lower position, in which the flow connections are set up in the pattern indicated by the arrows shown in the upper portion of valve **24** in FIG. 3. In this position the inlet port F of pressure ram **1** is isolated; inlet port B of pressure-multiplier ram **11** is connected through valve **24** to the cylinder port D of regulator valve **14**; and inlet port A of compensator ram **12** is connected to the moderate-pressure source **27**. Pressure fluid is now delivered to the upper end of compensator ram **12** so that its piston **19** is displaced downwardly by an amount determined by the adjustment of abutment member **13**, and the projecting rod **20** penetrates a corresponding amount into the upper chamber **23** of multiplier ram **11**, creating therein a sharp and sudden pressure increase which in turn displaces the multiplier piston **17** rapidly downwards, whereupon its projecting rod **18** in turn penetrates into the upper chamber **22** of pressure ram **1** greatly increasing the pressure therein. The pressure ram piston **10** is therefore driven rapidly in a downward direction to apply a sudden pressure pulse to the roll, capable of effectively compensating for any amount of hydraulic sag liable to occur. The selector valve **24** is preferably arranged to be automatically shifted to its lower position in response to the sensing of a condition indicative of the commencement of effective rolling, e.g. the pressure in ram cylinder **1**. It will be understood that the cascaded actions of the pressure-surge rods **20** and **18** occur in very rapid succession and result in the application of a large and sudden pressure surge into the ram cylinder **1** an extremely short time after the shift of selector valve **24** in response to the sensed condition. This permits of effectively compensating for hydraulic sag with a time lag that is considerably less than that achievable with conventional arrangements.

After the surge rods **20** and **18** have thus been displaced to their lower positions by the shift of selector valve **24**, normal regulation of the rolling pressure by way of regulator valve **14** may proceed or be resumed, such regulation now being accomplished under increased pressure through the intermediary of the pressure-multiplier or booster ram **11**.

In view of the high rolling pressures capable of being developed by the hydraulic pressure arrangements described especially on activation of the hydraulic-sag compensating devices, it is found desirable according to the invention to provide safety means that become operative in the event of a substantial difference in value between the pressures developed in the respective hydraulic arrangements associated with the respective ends of the roll. Otherwise such pressure differences, as may result from an accidental and momentary malfunction of one of the two hydraulic arrangements, would be liable to impose damaging stresses on the rolling equipment. According to the invention, as shown in FIG. 4, the roll **30** with which the hydraulic pressure system shown in FIGS. 2 and 3 is associated, is preferably mounted so as to be inclinable to the horizontal plane about an axis parallel to the direction of the rolling pass. As shown in FIG. 4, the uppermost roll **30** has its one end bearing-case or chock, not shown, freely mounted for up-and-down movement in the rolling stand in the usual way, while its other end chock **34** is fitted with a pair of transverse trunnions **31, 31'** journalled in bearings **32, 32'** which are formed as slideblocks slidable in vertical ways **33, 33'** respectively, secured to vertical uprights **35**, such as I-sections, of the rolling stand. With this arrangement, in case of a substantial unequality as between the hydraulic pressures applied to the respective roll end chocks such as **34**, the roll **30** will rock about the axis of trunnions **31–31'**, in addition to its bodily downward displacement under pressure, so as to take up the momentary pressure differential without damage. In the mounting arrangement thus described in order to facilitate dismounting of the roll **30**, one of the slideways such as **33** may be secured directly to the related upright **35**, while the other way e.g. **33'** is preferably secured to the related upright by way of a retractable fixture. As shown in FIG. 4, the vertical slideways **35, 35'** in which the bearing blocks **32, 32'** are slidable are each provided in two interpivoted parts, one part secured to the related upright **35** and the other parts being latchable in their operative positions by means of a common latching arrangement.

It will be apparent from the foregoing disclosure that the invention has provided notable improvements in the hydraulic pressure control systems of rolling mills, whereby more effective and precise control can be exerted and the quality of the rolled product thereby considerably enhanced. Thus the interposal of the differential devices **4** in the control linkages of the regulator valves **14** provides a simple and efficient means of injecting a supplementary control factor, particularly for the compensation of so-called mechanical sag. The pressure-multiplying arrangement including the booster ram **11** with its overpressure rod **18** constitutes a source of extremely high pressure incorporated within the hydraulic system and hence inherently possessing rapid response. The elimination of an external source of very high pressure as used in the prior art being with it, in addition to the reduction of response lag, a desirable simplification of the plant, elimination of troublesome high-pressure piping, and also protects the delicate regulator valve **14** from the eroding action of high-velocity fluid flow through it, thereby ensuring more accurate regulation over long periods of time. The final-stage pressure multiplier, or hydraulic-sag compensator, ram **12**, provides a means of injecting sharp and sudden pressure pulses capable of achieving compensation of hydraulic sag at shorter notice than was heretofore

possible and thus also contributing to the maintenance of closer dimensional tolerances throughout the rolled work. The inclinable mounting of the hydraulically controlled roll cylinder is an efficient protection against damaging unbalanced stresses.

It will be evident that various departures and modifications may be made from and in the single embodiment illustrated without departing from the scope of the invention. Certain of the novel featuers of the invention may be applied independently of others. The regulator valves used are not necessarily of the spool type shown. The differentials **4** used according to the invention may assume forms other than that of epicyclic gearings. Thus, electrical differential devices may be used. The pressure-multiplier arrangement may include in all only two stages, or on the other hand it may include more than the three stages shown. The various servo-controls, broadly described but not illustrated herein, especially those usable to control the differential **4**, selector valve **24**, and regulator **14**, may be constructed and operated in various ways that will be well understood by those familiar with the art on becoming acquainted with the present disclosure.

What is claimed is:

**1.** In a rolling mill including a pair of rolls between which work can be passed, a hydraulic rolling pressure control system including a ram cylinder and a piston projectable therefrom into engagement with one of said rolls to force it towards the other roll, and hydraulic flow means connected with said cylinder and with a source of pressure fluid and including a regulator valve having a member displaceable for controlling the fluid pressure applied from said source to said ram cylinder and hence the rolling pressure, the combination comprising a rolling pressure control motor, a drive transmission connecting said motor to said displaceable valve member, means for operating said motor to displace said valve member for maintaining a prescribed rolling pressure in the ram cylinder, and a differential device interposed in said drive transmission and including a first input connected for movement by the motor and an output connected to displace said valve member and including a second input operable for imparting corrective displacements to said valve member independently from the displacements imparted by said motor.

**2.** A rolling mill assembly comprising in combination a rolling frame, at least two rolls mounted for rotation in the frame about horizontal axes and adapted to receive work to be rolled therebetween, a pair of ram cylinders supported from said frame above the respective ends of the uppermost one of said rolls and having pistons downwardly projectable from said cylinders into engagement with said uppermost roll ends to force said roll against the underlying roll, regulator valves associated with the respective ram cylinders and each connected in hydraulic circuit with a source of pressure fluid and with the related ram cylinder, said valves including valve members displaceable therein to vary said circuit connections and hence the pressure in the respective ram cylinders, a cross member interconnecting both ram pistons, a common rolling pressure control motor supported on the cross member, drive transmissions connecting the motor with the displaceable members of the respective valves, means for operating the motor to displace both valve members for maintaining a prescribed rolling pressure in both ram cylinders, and differential means interposed in the respective drive transmissions and operable for imparting corrective displacements to the respective valve members supplementary to the displacements imparted by said motor.

**3.** The assembly claimed in claim **2**, including means sensing the strains developed in each side of the rolling frame due to rolling resistance, and means connecting each sensing means to a related one of said differential means for imparting corrective displacements to the respectively related valve members on the corresponding sides of the frame.

**4.** The assembly claimed in claim **2**, including means sensing the pressure developed in each of said ram cylinders due to rolling resistance, and means connecting each sensing means to a related one of said differential means for imparting corresponding corrective displacements to the respectively related valve members.

**5.** The assembly claimed in claim **2**, wherein each of said differential means comprises an epicyclic gearing.

**6.** The assembly claimed in claim **2**, wherein each of said differential means comprises differential gearing having two input shafts and an output shaft, one of said input shafts being driven from said common motor and the output shaft being connected to displace the related valve member, and including means responsive to rolling resistance developed at a related side of said rolling frame and connected to rotate the other of said input shafts.

**7.** In a rolling mill including a pair of rolls between which work can be passed, a hydraulic rolling pressure control system including a ram cylinder and a piston projectable therefrom into engagement with one of said rolls to force it towards the other roll, and hydraulic flow means connected with said cylinder and with a source of pressure fluid and including means for controlling the fluid pressure applied from said source to said ram cylinder and hence the rolling pressure, the improvement comprising a second, pressure-multiplier ram having a cylinder mounted coaxially with said first ram cylinder and a piston slidable therein, a pressure rod extending from said second piston and variably projectable into said first ram cylinder to boost the pressure therein, and means connected in said hydraulic flow means for controllably connecting the pressure source with said second ram cylinder to variably project said pressure rod into said first ram cylinder for controlling the pressure in said first ram cylinder.

**8.** A rolling mill system including a pair of rolls between which work can be passed, a first hydraulic ram cylinder and a piston projectable therefrom into engagement with one of said rolls to force it towards the other roll, at least one further hydraulic ram cylinder coaxial with said first cylinder and a further piston slidable therein and having a pressure rod extending therefrom and projectable into said first cylinder to boost the pressure therein, and hydraulic flow circuit means connected to a source of moderate pressure fluid and to said further ram cylinder and including valve means for controlling the pressure in said further ram cylinder.

**9.** A rolling mill system as claimed in claim **8** wherein said valve means includes a regulator valve having an inlet port connected to said port, an exhaust port and a cylinder port, and a regulator valve member displaceable to vary reversibly the connections of said cylinder port with each of said inlet and exhaust ports, and a selector valve operable between two positions in a first one of which said further ram piston is retracted and said regulator valve cylinder port is connected to said first ram cylinder while in the other position of the selector valve said further ram piston is projected and said cylinder port is connected to the further ram cylinder.

**10.** The combination claimed in claim **9**, including means responsive to rolling resistance and connected with said selector valve to displace the latter from its first to its second position when said resistance exceeds a prescribed value.

**11.** The combination claimed in claim **9**, including motor means connected for reversibly displacing said regulator valve member so as to maintain the pressure in said first ram cylinder substantially constant, and a differential device interposed in the connection from the motor means to said valve member and having a differential control input operable for imparting corrective displacements to the valve member independent from the displacements imparted by the motor means.

12. A rolling mill system including a pair of rolls between which work can be passed, a first hydraulic ram cylinder and a piston slidable therein projectable therefrom into engagement with one of said rolls to force it towards the other roll, a second hydraulic ram cylinder coaxial with the first cylinder and a second piston slidable therein having a pressure rod extending therefrom and projectable into said first cylinder to boost the pressure therein, a third hydraulic ram cylinder coaxial with the second cylinder and a third piston slidable therein having a pressure rod extending therefrom and projectable into said second cylinder to boost the pressure therein, and hydraulic flow circuit means connected to a source of moderate fluid pressure and to said third ram cylinder and including valve means for controlling the pressure in said third ram cylinder.

13. A rolling mill system as claimed in claim 12 including a regulator valve having an inlet port connected to said source, an exhaust port and a cylinder port and a valve member displaceable to vary reversibly the connections from the cylinder port to each of the inlet and exhaust ports, and a selector valve having ports connected to said regulator valve ports and to each of said ram cylinders and displaceable between two positions in a first one of which said second and third cylinders are both connected to said exhaust and said first cylinder is connected to said cylinder port, and in the second one of which said second cylinder is connected to said cylinder



port and said third cylinder is connected to said inlet port.

14. The combination claimed in claim 13, including adjustable means connected with said third ram piston and adjustable to vary the amount by which said associated pressure rod is projected into the second ram cylinder by the source pressure in said second position of the selector valve.


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