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JP-A-57 199 501 **JP-A-59 039 408**
JP-A-61 279 305 **JP-A-62 134 102**
JP-A-62 263 802 **JP-B-52 017 515**
US-A- 3 208 253

• **IRON AND STEEL April 1971, GUILDFORD GB**
pages 103 - 104; G. NEPORT: 'Application of a
working lubricant on a wide hot strip rolling mill'
• **IRON AND STEEL ENGINEER. vol. 61, no. 10,**
October 1984, PITTSBURGH US pages 26 - 33;
HIDEHIKO TSUKAMOTO ET AL.: 'Shape and
crown control mill - Crossed roll system'

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Description

The invention relates to a four-high hot rolling mill which shows an excellent ability for controlling the crown of flat materials, a hot rolling system, a hot rolling method and a method for revamping hot rolling mills.

This type of rolling mill, which has already been known for some time (see, for instance, JP-A-47-27159) differs from conventional four-high rolling mills in that the two work rolls are with their longitudinal axes inclined relative to one another in the horizontal rolling plane by predetermined small angles to the rolling direction so that their longitudinal axes cross each other in the central portion of the material being rolled. This roll arrangement is particularly intended to improve the thickness control of the material being rolled across the width thereof because the offset of the ends of the work rolls with respect to the ends of the back-up rolls results in some compensation of the roll bending caused, in a known way, by the rolling force. However, this oppositely directed inclination of the work rolls has led to serious technical problems. Especially the excessive axial thrust loads acting on the roll bearings of the work rolls and the excessive wear of the back-up roll barrels are the reasons that this type of rolling mill has never been put into practical use.

In EP-A-0 184 481 there is described a further four-high rolling mill of this work roll crossing type comprising in a common housing a pair of back-up rolls arranged perpendicularly to the length axis of the flat rolled material and a pair of work rolls oppositely inclined in the horizontal planes, so that the axes of these work rolls cross each other and also the axis of the rolled material. The small inclination angle of 0.2 to 2° between the work roll axis and the axis of the flat material can be controlled or adjusted by setting means in form of wedges or hydraulic cylinders disposed between the side surfaces of the work roll chocks and of the windows in the housing.

Since in this type of four-high rolling mill the work rolls cross the back-up rolls an enormous amount of axial thrust is exerted to both the work rolls and the back-up rolls along the axis of the rolls, as described in "Research of Machines", Vol. 42, No. 10 (1990), pages 71, 72. This thrust which changes depending on the cross angle is about 30 % of the rolling loads. The thrust bearing of the large diameter back-up roll may sustain this thrust. However, it is very difficult for the work roll, the roll chocks and bearings of which are much smaller than that of the back-up rolls, to sustain such high axial thrust loads. Further the crossing of the work roll and the associated back-up roll causes a relative slip between the contact areas of the rolls, which generates a wear on both roll barrels. Since the work rolls must be changed every two or three hours due to wear caused by the material which is much greater than the wear caused by relative slip, the changing of the work rolls causes no problem. However, the changing of the back-up roll normally takes place every ten to twenty days

and requires a long time. Therefore, a frequent changing of the back-up rolls due to rapid wear greatly reduces the productivity of the whole rolling mill system.

Another type of crossing rolling mill is disclosed in the publication "Technical Report", Vol. 21, No. 6 (1984), pp. 61 to 67 of Mitsubishi Heavy Industrial Co., Ltd., in which a roll pair consisting of an upper work roll and an upper back-up roll and a roll pair consisting of a lower work roll and a lower back-up roll are arranged in a housing such that the axes of the two roll pairs cross each other. In said pair cross type rolling mill the generation of an extreme axial thrust between the back-up roll and the work roll is suppressed. Since the centers of the metal chocks of the back-up rolls which are directly subjected to the rolling load shifts from the center of the reduction screw, a rotational moment is exerted to the metal chock, generating a local load to the mill stand. Consequently, smooth rolling operation is prohibited and wear of the metal chock and of the bearing is accelerated. To prevent these drawbacks, a very rigid beam may be provided to balance the driving side and the operating side of the rolling mill. However, provision of such a rigid beam increases the overall size of the rolling mill.

In this pair crossing rolling mill adjustments of the cross angle during rolling is necessary, as reactions of changes of the rolling load or of the crown of the material or for correcting the pre-set cross angle. The metal chock of the upper and the lower back-up roll must be laterally moved during rolling under the enormous rolling loads, thus necessitating special bearings and heavy adjusting equipment for this lateral adjustment. This makes the structure of the pair crossing mill more complicated. Also, a troublesome maintenance is necessary due to scales entering the special bearing of the lower metal chock.

In the commercial four-high rolling mills in which the work rolls are in parallel to each other, the axial thrust force on the work rolls is generally 1 to 2 % of the rolling loads in the case of hot rolling. In the pair crossing rolling mills the axial thrust exerted to the work rolls which cross each other is about 5 % of the rolling load.

A generally known possibility of reducing wear of the roll barrels is to reduce the friction between the respective pairs of roll surfaces by supplying a lubricant either directly to the material and/or to the barrel surfaces of the work or back-up rolls.

In recent years, a so-called hot rolling oil (at a concentration of 1 % or less) has been used in the hot rolling for the purpose of reducing wear of the work rolls and rolling load and rolling power. This hot rolling oil is characterized in that it can maintain its lubricating effect on a high-temperature material present in the roll bite of 700 °C or above, and contains a large amount of fatty oil, such as beef tallow. A lubricating oil mainly composed of a mineral oil, which maybe a soluble oil containing an emulsifier, greatly degrades or looses the lubricating effect at high temperatures, and thus has no

adverse effect on biting.

The US-A-3 208 253, for instance, describes a system for supplying a rolling lubricant and cooling water to the barrels of work and back-up rolls in an alternate sequence during the rolling operation. In the time periods when the material is not present in some of the roll stands the lubricant application is interrupted and a non-lubricating coolant, advantageously water, is supplied to the roll barrels. Simultaneously with the entering of a new material into a rolling stand the supply of the lubricant is started again and the application of the cooling water is stopped.

It is true that this system can avoid a slipping effect in the biting moment when the new material enters the roll gap. However, this document neither addresses the thrust problem encountered in a work roll crossing type of rolling mill nor the specific requirements for the lubricant in hot rolling.

The object of the invention is to provide a hot rolling method and a hot rolling mill for rolling flat materials by work roll crossing, wherein excessive axial thrust loads of the work rolls as well as high wear of the back-up roll barrels and of the further components are prevented.

According to the invention this object will be solved by a hot rolling mill defined in claim 1 and also by the methods defined in claim 10 and 13.

An essential aspect of the invention is based on the discovery that owing to the inclination of only the two work rolls an effect for compensating the undesirable roll bending of the work rolls caused by the rolling force is achieved so that an effective flatness control of the material being rolled across the entire width thereof is possible already with small angles of inclination in the order of 1°. The crossing of the work rolls only produces a first axial thrust force acting between the back-up roll and the associated work roll and a second axial thrust force acting between the material and the work roll. The first and the second axial thrust forces are directed in opposite directions, so that the actual thrust load acting on one of the work roll bearings is the difference of the first and the second thrust force and is, therefore, smaller than the first axial thrust force. The controlled introduction of the mineral-based lubricant into the contact portion between the respective work roll and the back-up roll reduces the coefficient of friction in this contact portion only, so that the first axial thrust force will be reduced also and the roll chocks of the work rolls and of the back-up rolls can be designed smaller according to the reduced amount of thrust loads.

By using a mineral-based lubricating oil normally having a low viscosity, the lubricating effect will be restricted to this contact portion only and the lubrication being ineffective in the drawn-in zone of the roll gap so that sufficient friction between the barrel surface of the work roll and the material being rolled will be retained. The above-mentioned criteria has the effect that excessive axial thrust loads on the rolls and their bearings are reduced right to the limits of conventional four-high rolling mills while wear of the roll surfaces is reduced effectively.

ing mills while wear of the roll surfaces is reduced effectively.

The lubricant supply means should be provided for controlled injecting suitable lubricant at the inlet side of the gap area between the work roll and the back-up roll along the entire length of the gap area.

Further advantages of the invention are the relatively simple structure, the allowance of schedule free rolling and the possibility of changing or adjusting the crown of the rolled material during the rolling operation by controlling the inclination of the axes of the work rolls.

The inventors have discovered that in the hot rolling the draw-in properties in the roll gap are not impaired when lubricants according to the invention are used. Even if after passage through the contact portion between work roll and back-up roll some of the lubricant adheres to the surface of the hot work roll and burns, a corresponding amount of lubricant will adhere to the surface of the relatively cooler back-up roll, even if a coolant is transferred from the work roll to the back-up roll surface. In addition or alternatively measures may be provided for preventing the coolant for the work rolls from reaching the respective roll surfaces of the back-up rolls. In certain cases lubricant supply may take place only during the actual rolling operation and be shut off in the periods between successive materials being rolled.

Further advantages, in particular in respect of a schedule free rolling operation, result from an additional axial displacement of the inclined work rolls during the rolling operation, which results in an improved distribution of the barrel wear and accordingly in a longer service life. This adjustment of the work rolls in the axial direction and the adjustment of their crossing inclined position is suitably effected by separate means of hydraulic cylinders which require only relatively little space and can produce high actuating forces.

The invention can be used in particular as a at least one stand in the finish rolling set. It is also possible and does not cause any difficulties to retrofit existing rolling mills with the measures and components according to the invention at a later time.

The above and other objects, features and advantages of the present invention will be made more apparent by the following description with reference to the accompanying drawings.

Fig. 1 is a schematic view of an embodiment of a work roll cross type four-high rolling mill according to the present invention, as seen in the direction of an axis of a roll;

Fig. 2 illustrates a device for moving a work roll in the axial direction thereof in the work roll crossing type four-high rolling mill shown in Fig. 1;

Fig. 3 is a graph showing the results of the experiments conducted to examine how the crown changes as a result of changes in the cross angle during rolling;

Fig. 4 illustrates a roll grinder for the back-up roll

incorporated in the work roll crossing type four-high rolling mill shown in Fig. 1;

Fig. 5 illustrates how a roll lubricant and a coolant are supplied in the work roll crossing type four-high rolling mill shown in Fig. 1;

Fig. 6 is a graph showing the relation between the cross angle of the work roll in the work roll crossing type four high rolling mill, the thrust coefficient between the work roll and the back-up roll, and the thrust coefficient between the work roll and the material being rolled;

Fig. 7 is a graph obtained under a circumstance in which a roll lubricant is supplied between the rolls and showing the relation between the cross angle of the work roll in the work roll crossing type four high mill of the present invention, the thrust coefficient between the work roll and the back-up roll, and the thrust coefficient between the work roll and the material being rolled;

Fig. 8 is a view as seen when looking the rolls from above, illustrating the direction of the thrust generated by crossing the work rolls in the work roll crossing type four high rolling mill;

Fig. 9 is a view as seen when looking the rolls in the axial direction thereof, illustrating the direction of the thrust generated by crossing the work rolls in the work roll crossing type four high rolling mill;

Fig. 10 is a graph showing the relation between the cross angles of the work rolls which differ depending on the type of roll lubricant supplied between the rolls in the work roll crossing type four high rolling mill, which is the embodiment of the present invention, and the wear of back-up roll;

Fig. 11 is a graph showing the results of the experiments conducted to examine how the lubricating property (frictional coefficient) changes by the temperature of the lubricant;

Fig. 12 is a view as seen when looking in the axial direction of the roll, illustrating the experiments shown in Fig. 11;

Fig. 13 is a schematic view of the roll axis as seen when looking from above, illustrating an influence of the shift of the axis of a back-up roll which is generated by crossing the work roll in the work roll crossing type four high rolling mill;

Fig. 14 is a schematic view of roll axes as seen when looking in the axial direction thereof, illustrating an influence of the deviation of the axis of the back-up roll which is generated by crossing the work roll in the work roll crossing type four high rolling mill;

Fig. 15 is a schematic view explaining a difference in the forces applied to the hydraulic jacks on the operating and driven sides of the rolling mill, which are generated on the basis of the thrust generated by crossing the work roll in the work roll crossing type four high rolling mill; and

Fig. 16 is a schematic view of a hot rolling system

which employs, as the finish rolling mill, the embodiment of the work roll crossing type four high rolling mill according to the present invention.

Referring to Figs. 1 and 2, a cross type four high rolling mill includes upper and lower work rolls 7 and upper and lower back-up rolls 8 which support the work rolls. Work roll chocks 16 are provided at the roll ends of each of the work rolls 7 so as to rotatably support the work roll 7. Each of said work roll chocks 16 has two vertical side surfaces 16a and lateral projections 16b on its upper and lower end of said side surfaces. A hydraulic cylinder means or jack 11 acts on each of said side surfaces 16a in the horizontal direction. Said jacks 11 comprise a cylinder member 11a and a piston 10 having a piston head 10a and a spherical press portion 10b. The cylinder member 11a is provided on its inner side with an enlarged end plate 11b which presses against the vertical side surfaces 16a of the work roll chocks 16. Each of said cylinder means 11 is slidably disposed in a separate housing chamber 11c. The cylinder means 11 of each work roll chock act against another symmetrical axis to its horizontal axis to avoid lateral moments and displacements. Further the contact-faces of said cylinder end plates 11b are large enough for uniformly transmitting a strong pressure force to the work roll chocks 16. The cylinder means 11 are securely guided in the chambers 11c, so that they can compensate and withstand the transverse forces produced by vertical movements of the work rolls 8 and its roll chocks 16. The free end portions of the end plates 11b of the cylinder member 11a can act as stopper means for limiting the movement of said cylinder member 11a in said chamber 11c. As shown in Fig. 2 each of said work roll chocks 16 is provided on its outer end with two parallel axial projections 16c having outer transverse end portions 16d.

The two back-up rolls 8 of the rolling mill are rotatably supported by back-up roll chocks 17. The rolling load will be transmitted through said roll chocks 17 to the back-up rolls 8. As shown in Fig. 1, on the lateral sides of said back-up roll chocks 17 are provided members 18 in form of a pressing plate, which are disposed in cutouts 20a of the housing 20. Each pressing plate 18 acts at least on hydraulic jack 19 in the horizontal direction transversely to the length axis of the back-up roll 8. On the outer sides of said pressing plates 18 there are secured guiding members 18a, which are displaceably engaged in slots 18b formed in the housing in parallel to said jack 19.

The work roll chocks 16 and the back-up roll chocks 17 are disposed such that they oppose window surfaces 20a of a pair of stands 20 provided erect in spaced relation in the roll axial direction of the rolling mill. Rolling loads are exerted to the individual rolls by means of jacks (not shown) provided in an upper or lower portion of the housing 20 to roll a material to be rolled 9.

To incline the axes of the upper and lower work rolls 7 relative to the axes of the back-up rolls 8 on a horizon-

tal plane and to make the axes of the upper and lower work rolls 7 cross each other, the hydraulic jacks 11 are provided on project blocks 30 of the housing 20 which oppose the two side surfaces of each of the work roll chocks 16 provided at the two ends of each of the upper and lower work rolls 7. The upper and lower work rolls 7 can be made to cross each other by operating both of the hydraulic jacks 10 and 11, namely the hydraulic jacks 10 and 11 have pistons and cylinders. The pistons of the jacks have piston heads disposed in engagement with the project blocks 30, while the cylinders of the jacks are engaged with the upper and lower work rolls chocks 16. Accordingly, the hydraulic jacks 10 and 11 can be operated to move the cylinders of the jacks so that the upper and lower work roll chocks 16 are relatively moved to cross the upper and lower work rolls. A hydraulic oil is supplied to the hydraulic jack 10 through a switch-over valve 14. To detect the movement of a ram of the hydraulic jack 10, a sensor 13 detects a displacement of a rod 12 mounted on the ram. The hydraulic jack 10 is driven by a work roll cross angle controller 40 which adjusts the switch-over valve 14 on the basis of a signal corresponding to the rolling conditions. The work roll cross angle controller 40 also performs feedback control of the hydraulic jack 10 using the signal from the sensor 13 to obtain a desired cross angle of the upper and lower work rolls 7.

The cross angle can be changed during rolling, i.e., under enormous rolling loads.

Fig. 3 illustrates the results of the experiments conducted to examine how the crown of the material being rolled changes by a change in the cross angle during rolling. It can be seen that a change in the cross angle from 0.5 degree to 0.9 degree can change a flat material to one having a concaved crown.

A hydraulic oil is supplied to the hydraulic jack 11 through a pressure reduction valve 15 so that the hydraulic jack 11 can press against the work roll chock 16 with a required force.

Two hydraulic cylinders 22 for driving the work roll along the axis thereof are provided on the stand 20 on the two sides of each of the work roll chocks 16 to move the work roll 7 in the axial direction thereof. A hydraulic oil is sealed in the hydraulic cylinders 22 by means of a pilot check valve 31 so as to allow the position of the hydraulic cylinders 22 to be maintained. The rods of the hydraulic cylinders 22 are coupled to a common movable block 21. Locking portions 21a provided detachably on the common movable block 21 engage with projecting portions 16d formed at the end portion of the work roll chock 16, by which the driving force of the hydraulic cylinders 22 are transmitted to the work roll chock 16 and the work roll 7 can thereby be moved in the axial direction thereof.

Although not shown, the operation of moving the work roll 7 in the axial direction is controlled according to the rolling conditions by a movement control device.

As shown in Figs. 1 and 2, lubricant supply nozzles

1 are respectively disposed along the roll axes to supply a lubricant between the upper work roll 7 and the upper back-up roll 8 and between the lower work roll 7 and the lower back-up roll 8. The position of the lubricant supply nozzle 1 is not limited to that illustrated in Figs. 1 and 2 but the nozzle 1 can be located at any position where it can supply a lubricant, which is a lubricating agent, to between the two rolls. As will be seen in Fig. 2, the nozzle 1 has a plurality of nozzle orifices disposed in a row extending in the axial direction of the rolls 7 and 8 so that these rolls can be uniformly supplied with the lubricant.

Since a large amount of coolant is supplied to the work roll 7 from a nozzle 2, provision of a scraper 32 for preventing washing away of the lubricant is desired (s.Fig.5).

To prevent generation of backlash in the upper and lower back-up rolls 8 during rolling, a hydraulic jack 19 is provided on the window surface 20a of the stand 20 which opposes the side surface of the back-up roll chock 17 provided at each of the roll ends of each of the upper and lower back-up rolls 8. A pressing plate 18 for transmitting the driving force of the hydraulic jack 19 is slidably mounted on the stand 20. The hydraulic pressure of the hydraulic jack 19 is exerted to the back-up roll chock 17 through the pressing plate 18 so as to eliminate backlash of the upper or lower back-up roll 8.

A roll grinder 6 is provided near the roll surface of each of the upper and lower back-up rolls 8 so as to grind the roll surface during rolling. The roll grinder 6 is moved in the axial direction of the back-up roll 8 by means of a driving motor 24, as shown in Fig. 4. The degree at which the roll is ground is adjusted by means of a grinding quantity operator 6a.

As shown in Fig. 5, in the work roll cross type four high rolling mill, the lubricant reserved in a tank 26 is supplied from the lubricant supply nozzle 1 in a spray to between the work roll 7 and the back-up roll 8 by means of a pump 27 through a change-over valve 28. When a lubricant controller 50 receives a signal representing the rolling conditions, such as ending or beginning of supply of the material to be rolled, it changes over the change-over valve 28 and thereby suspends spraying of the lubricant onto the roll surface from the lubricant supply nozzle 1.

Roll cooling nozzles 2 and 3 are used to cool the work roll and the back-up roll.

In the aforementioned work roll cross type four high rolling mill, whereas the back-up rolls 8 are not moved in the horizontal direction, the work rolls 7 are moved in opposite directions and are thereby made to cross each other. This cross type mill is suitable for use in the hot strip mill in which a large crown must be set in the material to be rolled 9, particularly, suitable for use as the front stand of the finish mill. In the hot rolling, a cooling water is mainly ejected to the upper and lower work rolls 7 from the roll cooling nozzles 2 and 3 due to the biting property of the materials to be rolled 9.

In the work roll crossing type rolling, the utmost requirement is concerned with how the thrust exerted to the work rolls can be coped with. Fig. 6 are graphs respectively showing the cross angle θ of the work rolls in the work roll crossing type four high rolling mill, the thrust coefficient μ_{TR} between the work roll and the back-up roll, and the thrust coefficient μ_{TM} between the work roll and the material being rolled. In Fig. 6, the abscissa axis represents the cross angle θ of a single work roll relative to a line perpendicular to the direction of rolling. The ordinate axis represents the thrust coefficient μ_T . The coefficient μ_{Tm} is a percentage obtained by dividing an axial thrust force exerted to a single work roll 7 from the material 9 by the rolling load. This coefficient μ_{Tm} is a function of the cross angle θ and other conditions, such as the draft. In general, the larger the draft, the lesser is this thrust coefficient μ_{Tm} . In the case in which crossing of only the upper and lower work rolls 7 is performed, the thrust generated between the back-up roll 8 and the work roll 7 differs depending on the rolling conditions. In Fig. 6, three examples of such thrusts are given as curves μ_{TR1} , μ_{TR2} and μ_{TR3} . The curve of the thrust coefficients μ_{TR1} indicates the results of the experiments in which only water was supplied between the back-up roll 8 and the work roll 7. The curve μ_{TR2} indicates the results of the experiments in which the concentration of the lubricating oil present in the water supplied to the two rolls was low. The curve μ_{TR3} indicates the results of the experiments in which the concentration of the lubricating oil in the water was higher than that in μ_{TR2} . As can be seen from Fig. 6, the thrust μ_{TR} can be greatly reduced by the supply of the lubricating oil between the rolls. The thrust μ_{TR} can be selected by selecting the concentration of the lubricating oil. In the aforementioned experiments, the concentration was changed. However, the amount of emulsion of lubricating oil and water may be changed to change the thrust.

Fig. 7 shows the thrust coefficient μ_{WT} exerted to the work roll 7 when the axes of the work rolls cross the material 9 and the axes of the back-up rolls 8 while the back-up rolls 8 are fixed in the horizontal direction, i.e., the value obtained by dividing the actual thrust acting on one work roll by the rolling load. The thrust coefficient μ_{WT} is a percentage representing the sum of the thrust coefficient μ_{TR} in Fig. 6 exerted from the back-up roll to the associated work roll and the thrust coefficient μ_{Tm} exerted from the material to this work roll.

It is to be noted that the direction of the thrust exerted to the work roll 7 from the material being rolled 9 and that of the thrust exerted from the back-up roll 8 oppose each other.

This will be discussed in detail with reference to Figs. 8 and 9.

Fig. 8 shows the relation between the speed at a contact portion A between the work roll 7 and the material being rolled 9 and that at a contact portion B between the work roll 7 and the back-up roll 8 shown in

Fig. 9. V_M indicates the speed of the material being rolled at the contact portion, V_W indicates the peripheral speed of the work roll, and V_B indicates the peripheral speed of the back-up roll.

The work roll 7 is subjected to both the thrust in a direction of a relative speed ΔV_A between the work roll 7 and the material being rolled 9 and the thrust in a direction of a relative speed ΔV_B between the work roll 7 and the back-up roll 8. The directions of these relative speeds are opposite to each other.

At the contact portion A, the material 9 is rolled and the thrust coefficient μ_{Tm} shown in Fig. 6 is relative small. Further, in the case of water spray, as shown in Fig. 6 the maximum amount of the thrust coefficient μ_{TR1} is about 30% and the direction of μ_{TR1} is opposite to that of μ_{Tm} the thrust exerted from the back-up roll 8 to the associated work roll is large, and the work roll thrust coefficient μ_{WT1} is about 25%. In a practical rolling mill, the thrust must be 5% or less due to the designing of the thrust bearing. In this method, such a thrust therefore cannot be achieved. Also, wear of the back-up roll and that of the work roll are great. In the case of the supply of the lubricating oil having a low concentration, μ_{WT2} is 2% or less, which is almost the same as that obtained in the normal rolling. When the concentration of the lubricating oil is increased it is possible to reduce the thrust to values obtained in the normal type of rolling mill in which the work rolls do not cross each other by adequately setting the concentration of the lubricating oil.

Although $\mu_{TR} = \mu_{Tm}$ is the most desirable from the viewpoint of reduction in the thrust exerted to the work roll, $\mu_{TR} < \mu_{Tm}$ is desirable from the viewpoint of elimination of wear of the roll.

Fig. 10 shows the results of the experiments in which wear of the back-up roll 8 was greatly reduced by lubrication between the work roll 7 and the back-up roll 8 from the lubricant supply nozzle 1. The material of the back-up rolls 8 was a special steel having a hardness of HS60°, while that of the work rolls 7 was high chrome of HS75°. The contact stress P_0 between the rolls was 180 kg/mm. The total number of rotations was 250,000. The cross angle between the rolls was 0, 0.6° and 1.2°. In the hot strip mill, when the back-up roll used in the finish front stage mill has been rotated 200,000 times, it is replaced with a new one. The back-up roll in the finish rear stage is rotated 200,000 times before it is replaced with a new one. As can be seen from Fig. 10, when the lubricant is supplied, wear of the back-up roll can be reduced to 1/5th through 1/10th of that obtained when water is supplied. In the normal four high rolling mill in which the rolls do not cross each other, several tens of μm of wear occurs on the back-up roll due to the scale which flies from the material being rolled or the like by the time the roll has been rotated 250,000 times. The wear which occurs when the work rolls cross each other may also be considered the sum of the wear which occurs in the conventional case and that shown in Fig. 10. However, lubrication is effective to reduce the con-

ventional wear as well.

In the rolling mill in which only the work rolls 7 cross each other, it may be considered that an equivalent crown will occur between the rolls, increasing the pressure at the central portion. However, it does not happen for the following reason. When the roll surface length is 2000 mm, the diameter of the work roll 7 is 700 mm, the diameter of the back-up roll 8 is 1500 mm, and the cross angle θ of the work roll 7 is 1.2° , gap C_R of the end portions of the two rolls is expressed as follows:

$$C_R = \frac{\delta^2}{2(R_1 + R_2)} \quad 1$$

$$\delta = \theta \frac{L}{2} = \frac{1.2}{57} \times \frac{2000}{2} = 21 \text{ (mm)}$$

$$C_R = \frac{21^2}{2(350 + 750)} = \frac{441}{700 + 1500} = 0.200 \text{ mm}$$

where $R_1 R_2$ are respectively the radius of the work roll 7 and that of the back-up roll 8.

This gap corresponds to that obtained when 0.40 mm of crown is grounded on to the back-up roll 8. In a practically employed mill, a safe operation is assured even when a crown of 1 mm or more is provided.

A cross angle of 1.2° is enough to assure the sufficient control ability. Moreover, it can assure the advantage resulting from a change in the crown of the back-up roll 8 (it has been estimated that a cross angle of 1.2° is 10 to 20% more advantageous). Therefore, the cross angle θ can be less than that in the pair cross mill.

The second requirement of the work roll crossing type rolling mill is lubrication between the rolls.

In recent years, a so-called hot rolling oil (at a concentration of 1% or less) has been used in the hot rolling for the purpose of reducing wear of the work rolls and rolling load and rolling power. This hot rolling oil is characterized in that it can maintain its lubricating effect on a high-temperature material present in the roll bite of 700°C or above, and contains a large amount of fatty oil, such as beef tallow. A lubricating oil mainly composed of a mineral oil, which may be a soluble oil containing an emulsifier, greatly degrades or loses the lubricating effect at high temperatures, and thus has no adverse effect on biting.

This will be discussed in detail using the results of the experiments shown in Fig. 11. In Fig. 11, (A portion) and (B portion) respectively correspond to (A portion) and (B portion) in Fig. 12. That is, a mineral oil type lubricant oil (including soluble oils) has a very low lubricating performance which ensures a frictional coefficient as high as that obtained when lubrication is not provided at (B portion) at which it is in contact with the material being hot rolled, but shows a good lubricating performance which ensures a low frictional coefficient at

(A portion) of low temperatures. An example of the lubricant oil is "Daphne Roll Oil SL-2" (trade name) manufactured by IDEMITSU KOSAN, Japan. The lubricant is based on mineral oil, includes a special emulsifier, an oiliness-improving material and an anti-corrosion material and has following physical properties:

Specific Gravity	15/4°C	0.9295
Color Order	(ASTM)	20
Flash Point	(COC)°C	164
Coefficient of Viscosity cSt		
	@ 40°C	22.94
	@ 100°C	4.11
Viscosity Index		58
Fluidizing point	°C	-175
Total Acid Value	mgKOH/g	3.58
Residual Carbon	wt %	0.5
Ash	wt %	0.17
Saponification Value	mgKOH/g	12.30
Copper Plate Corrosion	(100°C x 3 h)	1

A fatty oil type lubricating oil, such as beef tallow, has a lubricating performance not only at (A portion) but also at (B portion) of high temperatures. Hence, presence of this type of lubricating oil when biting of the material to be rolled begins may generate biting failure.

If a lubricant of the type which can be washed by the cooling water supplied from the roll cooling nozzles 2 and 3 is selected, the application of lubricant can be performed throughout the rolling. That is, when acceleration or deceleration is performed after the rolled material leaves the roll, lubricant supply is suspended, the work rolls are retracted to a position where the cross angle is 0, and then roll balancing force is increased. Because of crossing of only the work rolls 7, crossing resistance is less and crossing operation can be quickly performed during rotation of the rolls. Therefore, reduction of the cross angle to zero after the rolled material 9 has left the roll is desired.

Wear of rolls, which would be caused by a great degree due to slippage of rolls when only water is supplied between the rolls, can be greatly reduced by supply of the lubricant in the manner mentioned above. However, this increases the degree at which the central portion of the roll wears. Hence, the on-line grinder 6 shown in Fig. 5 is used to grind the outer surface of the back-up roll 8 such that it is straight or has a predetermined crown.

On-line grinders for grinding the work roll 7 which is frequently replaced with a new one have been proposed. However, maintenance of the work roll 7 is very

difficult, because the work roll 7 is very hard, because high quality is required for the finish of the surface, and because the space is not enough due to provision of guide or cooling water. In the case of the back-up roll 8, polishing is not so a hard work, because space is enough, because the roll is not so hard as the work roll, and because a surface quality as high as that for the work roll is not required. Even when correction of roll profile is not necessary, the back-up roll 8 is replaced for polishing because a fatigue layer generated by the contact of two rolls due to Hertz's stress must be removed. Therefore, if profile correction and removal of the fatigue layer can be performed at the same time, the roll exchange pitch of the back-up roll 8 can be greatly increased. Changing of the backup roll 8 is so a hard work that it is generally conducted at the periodic repair. In an practical operation, changing of the back-up roll is conducted periodically. The use of the aforementioned method, however, allows the polishing work of the back-up roll 8 conducted by the rolling plate to be eliminated. In that case, the rolling plant performs polishing of the back-up roll 8 using the on-line grinder without using an expensive large back-up roll grinder. The back-up roll grinder can be employed for the back-up roll not only in the aforementioned work roll cross type four high mill but also in all types of mills, such as four, five or six high mill.

Regarding shift of the cross point due to backlash of the roll bearing, the largest backlash occurs in a gap between the metal chock of the roll and the stand 20 or project block 30. The crossing mechanism for the work rolls 7 may be provided with a mechanism for reducing backlash. In the case of the back-up roll 8, since the gap thereof is normally fixed, it is set to a small value during rolling and to a large value during roll changing in this invention. Alternatively, the chock of the back-up, roll 8 may be pressed against the stand on one direction under a fixed hydraulic pressure during rolling while pressing is released during roll changing.

The need for such a structure will be discussed with reference to Figs. 13 and 14.

Inclination of the back-up roll 8 about the crossing center of the work roll 7 due to the backlash between the bearing of the back-up roll 8 and the stand 20 may cause slight displacement of the cross angle of the work roll 7 but causes no serious problem. However, displacement of the axis of the back-up roll 8 by e in the direction of rolling shifts the cross point of the two rolls in the axial direction by $a = e/\theta$, generating a difference in the gaps of the upper and lower work rolls 7 which leads to zigzagging of the material being rolled 9. To eliminate this, the reduction level must be corrected by S_{df} . Where R_1 is the radius of the work roll 7, R_2 is the radius of the back-up roll 8, and L is the distance between the reduction screws, offset of the center of the two rolls by c , shown in Fig. 14, increases the roll pass g to $c^2/2(R_1 + R_2)$, thus increasing the difference G in the gaps at the right and left reduction positions as

follows:

$$G = \frac{1}{2(R_1 + R_2)} \left[\left\{ \left(\frac{L}{2} + a \right) \theta \right\}^2 - \left\{ \left(\frac{L}{2} - a \right) \theta \right\}^2 \right] \quad 2$$

$$= \frac{La\theta^2}{R_1 + R_2} = \frac{Le\theta}{R_1 + R_2} \quad 5$$

A reduction screw difference S_{df} corresponding to G is obtained by the following equation.

$$S_{df} = \frac{L}{R_1 + R_2} \cdot e\theta \quad 3$$

In a large hot strip mill, if $R_1 = 700/2 = 350$ mm, $R_2 = 1500/2 = 750$ mm, $L = 3000$ mm and $\theta = 1.20$, S_{df} is obtained by the following equation in which the unit of e is mm.

$$S_{df} = 0.05 e \quad 4$$

Since it is practically impossible to correct S_{df} , i.e., the reduction level, according to e , e must be reduced to a value which can be neglected in a practical operation. From the experiences, in the case of the hot strip finish mill which rolls thick strips, S_{df} in the front stage mill stand is 0.05 mm, and that in the rear stage mill stand is about 0.025 mm. At that time, the allowable displacement e of the center of the back-up roll in the front stage mill stand is ± 1 mm, and that in the rear stage mill stand is ± 0.5 mm. However, the smaller, the better.

In the presently practiced hot strip mill, schedule free rolling is the important element, and shift of the work rolls in the axial direction is essential in order to disperse wear thereof. Therefore, crown control capability and wear dispersion function are the requirements of the hot strip mill. In this embodiment, since the axial thrust force exerted to the work roll 7 in the axial direction is reduced, the work roll shifting mechanism can be made simple.

Difference of the rolling force applied to the screw-down jack by the thrust will be explained. In Fig. 15, when thrust F_1 is applied from the material 9 while thrust F_2 is generated between the rolls 7 and 8, a load difference ΔQ occurs between the right and left screw-down jacks. ΔQ is obtained in Fig. 15 as follows:

$$\Delta Q = \frac{1}{L} \left\{ \frac{1}{2} (F_1 + F_2) D_W + \frac{1}{2} F_2 D_B \right\} \quad 5$$

If $L = 3000$ mm, $D_W = 700$ mm, $D_B = 1500$ mm, $F_1 = F_2 = 0.05 \times P$, i.e., if thrust is 5%,

$$\Delta Q = 0.024P \quad 6$$

That is, 2.4% of the rolling load is generated. If the

thrust is 10%, ΔQ reaches 4.8%.

Hence, reduction in the thrusts F_1 and F_2 , particularly, thrust F_2 between the rolls, is advantageous.

Difference in the reduction forces adversely affects correction of zigzagging, because in the correction a difference in the loads is detected and reduction forces are adjusted such that difference is reduced to zero. Although it is possible to perform correction of zigzagging using load difference ΔQ obtained from the thrust and stored beforehand, variations in the thrust causes disturbance of zigzagging correction, and reduction in the thrust as much as possible is thus desired.

The operation of the aforementioned embodiment, which is the work roll cross type four high rolling mill, will be described below.

Referring to Figs. 1 through 2, the upper and lower work rolls 7 which roll the material 9 are pressed from two sides thereof by means of the hydraulic jacks 10 and 11 such that the axes thereof are respectively inclined by θ in the opposite directions. During rolling, the work rolls 7 are maintained at that position. Cross angle of the work roll 7 will be set in the manner described below. The sensor 13 provided on the hydraulic jack 10 through the rod 12 detects stroke of the jack, i.e., the position of the work roll chock 16. The other hydraulic jack 11 presses the work roll chock 16 by a pressing force which is adjusted by the pressure reduction valve 15. After the cross angle of the work roll is set with the change-over valve 14 opened, the change-over valve 14 is closed to maintain the set cross angle.

The chocks 17 of the back-up rolls 8 which hold the work rolls 7 are pressed against the window surfaces 20a of the stand 20 which are remote from the hydraulic jacks 19 by means of the hydraulic jacks 19 through the pressing plates 18 during rolling so that the back-up rolls 8 can be held in a fixed state. A work roll 7 shifting device will be described in detail below. The chock 16 of the work roll 7 is held by the movable transverse block 21. The chock 16 can be shifted, together with the movable block 21, in the axial direction of the work roll 7 while being guided by a fixing frame 23 by means of the hydraulic cylinders 22 incorporated in the movable block 21. Since the chock 16 of the work roll 7 is shifted toward the direction of rolling as a result of crossing, the movable block 21 must be rotated according to the position of the chock 16. Hence, the guiding portion of the movable block 21 is made cylindrical so that it can follow the roll crossing operation.

To compensate for wear of the back-up roll 8 caused by relative slide speed ΔV_B (Fig. 9) generated between the rolls by making the work rolls 7 cross each other, the roll grinder 6 shown in Fig. 3 is provided. The grinder 6 moves together with the drive motor 24 in the axial direction of the back-up roll 8 while polishing the surface of the back-up roll 8, by which the roll surface is polished in a straight or curved fashion. Lubrication of the roll surface will be described below with reference to

Fig. 5. Coolant is supplied to the work roll 7 from the roll cooling nozzles 2 and 3 to cool the work roll. A lubricant of an adequate concentration is supplied to the vicinity of the entrance of the pass between the work roll 7 and the back-up roll 8 from the lubricant supply nozzle 1 in order to reduce the thrust between the rolls. The lubricant is supplied to the lubricant supply nozzle 1 from the tank 26 by the pump 27 through the change-over valve 28. Thus, supply of the lubricant can be suspended at suitable times, e.g., when the material being rolled leaves the roll or when the material to be rolled is supplied to the roll, by closing the change-over valve 28.

The most desirable position to which the lubricant is supplied from the lubricant supply nozzle 1 is shown in Fig. 5. However, a lubricant may also be supplied to other positions, e.g., to the circumference of the back-up roll 8, so that it can be finally supplied between the rolls therefrom.

As will be understood from the foregoing description, the work roll cross type four high rolling mill according to the present embodiment is capable of overcoming the drawbacks caused by making only the work rolls cross each other and can thus be put into practical use.

The mechanisms and structures which are necessary to accomplish the necessary functions have been described. It is, however, to be noted that the object of the present invention can also be achieved by other similar mechanisms. For example, a worm jack or a wedge mechanism may be used in place of the hydraulic jacks 10, 11 to achieve crossing of the work rolls 7.

The aforementioned work roll cross type four high rolling mill can be provided by revamping the existing four high rolling mill without providing a new stand by reusing the housing 20 of the existing rolling mill. The existing four high rolling mill in which the pair of work rolls 7 and the pair of back-up rolls 8 for respectively supporting the work rolls 7 are provided on the rolling housing 20 will be revamped into the work roll cross type four high rolling mill in the manner described below: the hydraulic jacks 10 and 11, which are the hydraulic device that can be operated in the direction in which the material to be rolled 9 is fed, are provided at the positions on the rolling stand 20 which oppose the roll chocks 16 of the work rolls 7 so that the work rolls 7 can be inclined relative to the back-up rolls 8 on the horizontal plane in such a manner that the axes of the work rolls 7 cross the axes of the back-up rolls 8 and such that the axes of the work rolls 7 cross each other. Also, the hydraulic cylinders 22, which are the hydraulic devices that can be operated in the axial direction of the work roll 7, are provided so that the engagement of the hydraulic cylinders 22 with the roll chock 16 of the work roll 7 enables the work roll 7 to be moved in the axial direction thereof. The lubricant supply device 1 for supplying a lubricant is provided between the work roll 7 and the back-up roll 8.

Thus, a rolling mill in which crossing of only the work rolls 7 is provided can be obtained by utilizing the

housing 20 of the existing rolling mill. In this rolling mill, since the work rolls 7 can be moved in the axial direction thereof during rolling, schedule free rolling is allowed for. Furthermore, since the thrust exerted to the work roll 7 can be reduced to a degree which does not cause problems even when the work rolls 7 cross each other by the action of the lubricant supplied from the lubricant supply device 1 between the work roll 7 and the back-up roll 8, the rolling roll can show an excellent ability with which it controls crown of the materials to be rolled 9.

An example of application of the aforementioned work roll cross type four high rolling mill to the hot rolling system will be described below with reference to Fig. 16.

Fig. 16 shows a hot rolling system in which a joining device 63 is provided between rough rolling mills 61 and finish rolling mills 62 for sequentially joining the materials being rolled 9, and in which after the materials which have been rolled by the rough rolling mills 61 are joined to each other by the joining device 63, the joined materials are continuously rolled by the finish rolling mills 62. At least one of the finish rolling mills 62 is constituted by the aforementioned rolling mill which includes the pair of work rolls 7 and the pair of back-up rolls 8 for respectively supporting the work rolls 7, in which the axes of the back-up rolls 8 are not inclined on the horizontal plane while the work rolls 7 can be inclined relative to the back-up rolls 8 on the horizontal plane such that the axes of the work rolls 7 cross the axes of the back-up rolls 8 and such that the work rolls 7 cross each other, in which the work rolls 7 are movable in the axial direction thereof, and in which the lubricant supply device 1 for supplying a lubricant between the work roll 7 and the back-up roll 8 is provided.

Thus, it is possible to provide a rolling mill in which crossing of only the work rolls 7 is provided.

Furthermore, since the work rolls 7 are movable in the axial direction thereof, they can be moved in the axial direction during rolling, thus making schedule free rolling possible.

Furthermore, since the lubricant supply device 1 for supplying a lubricant between the work roll 7 and the back-up roll 8 is provided, the thrust exerted to the work roll 7 can be reduced to a degree which causes no problem in a practical operation even when the work rolls are made to cross each other by the action of the lubricant supplied between the work roll 7 and the back-up roll 8. It is therefore possible to provide a work roll cross type rolling mill which shows an excellent ability with which it controls crown of the material to be rolled 9.

Thus, the work roll cross type rolling mill can be used as the finish rolling mill of the hot rolling system in which the materials rolled by the rough rolling mills are continuously rolled by the finish rolling mills.

The aforementioned rolling mill according to the present embodiment has a simpler structure than the conventional pair cross type four high mill and is capable of controlling crown of the sheet more effectively.

The aforementioned rolling mill according to the invention has another advantage in that it can greatly reduce the thrust exerted to the work roll, which is the utmost requirement of the cross type mill. Consequently, the thrust bearing can be made simple, reduction in the diameter of the work roll is made possible, and shift of the work roll is facilitated. The last one is essential in the continuous rolling operation in which the work roll must be shifted during rolling. In the present embodiment, changes in the cross angle can be easily and quickly performed because they are the changes in the cross angle of the rotating rolls. Therefore, the present embodiment is suited to continuous rolling. Also, wear of the rolls, which would be caused by the slip of the rolls, can be greatly reduced by the use of an adequate lubricant. The use of the on-line grinder improves the problem involving the wear and allows for removal of the fatigue layer, and hence greatly increases the pitch of the back-up roll changing operation which is a troublesome task.

Claims

1. A four-high hot rolling mill comprising

- a rolling housing (20),
- a pair of work rolls (7) adjustably inclined in horizontal planes by adjusting means (10, 11) acting between the work roll chocks (16) and projecting blocks (30) of the housing (20), so that the axes of said work rolls (7) cross each other and also the axis of the rolled material (9), and
- a pair of back-up rolls (8) arranged perpendicularly to the axis of the rolled material (9), wherein
- a first axial thrust force F_2 acts from each back-up roll (8) to the associated work roll (7) and a second thrust force F_1 acts from said material (9) to the work roll (7) so that an actual thrust force acting on the work roll (7) is equal to a difference ($F_2 - F_1$) between said first and second thrust forces (F_2 and F_1),

characterized in that

a lubricant supply device (1, 26-28, 50) is provided for controlledly supplying an axial thrust reducing lubricant which contains a lubricating oil mainly composed of a mineral oil to the entire length of the contact zone between each work roll (7) and the associated back-up roll (8) for reducing the first thrust force (F_2), so that said actual thrust force acting on said work roll (7) will be reduced to 5 % or less of the maximum rolling load.

- ### 2. Rolling mill according to claim 1,
- characterized** in that
- a work roll cross angle controller (40) is provided for

- performing a feedback control of the adjusting means (10, 11) acting on the work roll chocks (16) using the signals of a sensor (13) to obtain a desired cross angle of the upper and lower work rolls (7) during rolling. 5
3. Rolling mill according to claim 1 or 2, characterized in that the work rolls (7) are shiftable in the opposite axial directions thereof. 10
4. Rolling mill according to one of the claims 1 to 3, characterized in that one of the chocks (16) of each work roll (7) is removably connected with a transverse block (21) which is connected to the housing (20) by two hydraulic cylinders (22) and guided on a fixing frame (23). 15
5. Rolling mill according to one of the claims 1 to 4, characterized in that roll cooling nozzles (2, 3) are provided for ejecting cooling water against the work rolls (7). 20
6. Rolling mill according to claim 5, characterized in that a scraping member (32) is provided on each work roll (7) for preventing the mixing of the cooling water with the lubricant. 25
7. Rolling mill according to one of the claims 1 to 6, characterized in that a hydraulic device (19) is provided on one surface of a window of the housing (20) for pressing a roll chock (17) of the back-up roll (8) against the other side of said window. 30 35
8. Rolling mill according to anyone of the claims 1 to 7, characterized in that grinding devices (6) for grinding the barrel surface of the back-up rolls (8) are provided to be movable in the axial direction of the back-up rolls. 40
9. Rolling mill according to anyone of claims 1 to 8, characterized in that a control device (50) is provided for controlling the supply of the lubricant to the contact zone between the work roll (7) and the back-up roll (8) according to rolling conditions. 45 50
10. A hot rolling system comprising a group of rough rolling mills (61) and a group of finish rolling mills (62), characterized in that at least one rolling mill of the group of said finish rolling mills (62) is designed according to one of the claims 1 to 9. 55
11. Method for hot rolling a flat material in a four-high rolling mill, wherein for controlling the crown of the material (9) during rolling the axes of the work rolls (7) will be inclined relative to the axes of the back-up rolls (8) in a horizontal plane such that the axes of the work rolls cross the axes of the back-up rolls and the axes of the work rolls cross each other, wherein a first thrust force (F_2) acts from each back-up roll (8) to the associated work roll (7) in an axial direction opposite to an axial direction in which a second thrust force (F_1) acts from said material (9) to said work roll (7) so that an actual thrust force acting on said work roll (7) is equal to a difference ($F_2 - F_1$) between said first and second thrust forces, **characterized** in that a lubricant which contains a lubricating oil mainly composed of a mineral oil is controlledly supplied to the entire length of the contact zone between each work roll (7) and each back-up roll (8) during rolling for reducing said first axial thrust (F_2) so that said actual thrust force acting on said work roll (7) will be reduced to 5 % or less of the maximum rolling load.
12. Rolling method according to claim 11, characterized in that the work rolls (7) will be shifted in the axial opposite directions thereof.
13. A method of revamping a four-high hot rolling mill comprising the steps of: providing a hydraulic devise (10) on a position on the housing (20) which opposes a roll chock (16) of each work roll (7) in such a manner that said device can be operated in a direction in which a material (9) proceeds, so that said device (15) can incline the axes of the work rolls (7) relative to the back-up rolls (8) in a horizontal plane such that the axes of the work rolls cross axes of the back-up rolls and such that the axes of the work rolls cross each other, providing another hydraulic device (21, 22) on the housing (20) in such a manner that the other device (21, 22) can be operated in an axial direction of each work roll (7), so that the other device (21, 22) can engage with the roll chock (16) of the work roll (7) to thereby move the work roll in the axial direction thereof, said work rolls and said back-up rolls are arranged such that a first thrust force acts from each back-up roll to an associated work roll in a direction opposite to a direction in which a second thrust force acts from said material to the work roll so that an actual thrust force acting on the work roll is equal to a difference between said first and second thrust forces, and

providing an axial thrust reducing lubricant supply device for controlledly supplying an axial thrust reducing lubricant which contains a lubricating oil mainly composed of a mineral oil to the entire length of the contact zone between said work rolls and an associated back-up roll, so that said actual thrust force acting on said work roll under the lubrication in said zone is not greater than 5 % of a maximum rolling load acting on material being rolled during rolling operation of said rolling mill.

Patentansprüche

1. Quarto-Warmwalzgerüst mit

- einem Walzenständer (20)
 - einem Paar von in horizontalen Ebenen verstellbar schräg ausgerichteten Arbeitswalzen (7), deren Stellorgane (10, 11) zwischen den Einbaustücken (16) der Arbeitswalzen und Anlageblöcken (30) des Walzenständers (20) wirken, so daß sich die Achsen der Arbeitswalzen (7) untereinander und auch mit der Achse des Walzguts (9) kreuzen, und
 - einem Paar quer zur Walzgutachse ausgerichteten Stützwalzen (8),
 - wobei eine erste axiale Schubkraft F_2 von jeder Stützwalze (8) auf die zugehörige Arbeitswalze (7) ausgeübt wird und eine zweite axiale Schubkraft F_1 vom Walzgut (9) auf die Arbeitswalze (7) einwirkt, so daß eine auf die Arbeitswalze (7) tatsächlich einwirkende Schubkraft gleich einer Differenz ($F_2 - F_1$) zwischen der ersten und der zweiten Schubkraft (F_2 und F_1) ist,
- dadurch gekennzeichnet, daß
- eine Schmiermittelzufuhreinrichtung (1, 26-28, 50) zum gesteuerten Zuführen eines die axiale Schubkraft reduzierenden Schmiermittels über die gesamte Länge der Kontaktzone zwischen jeder Arbeitswalze (7) und ihrer zugehörigen Stützwalze (8) vorgesehen ist, das hauptsächlich aus Mineralöl bestehendes Schmieröl enthält, um die erste axiale Schubkraft (F_2) so weit zu reduzieren, daß die auf die Arbeitswalze (7) tatsächlich einwirkende axiale Schubkraft auf 5 % oder kleiner der maximalen Walzkraft reduziert wird.

2. Walzgerüst nach Anspruch 1, dadurch gekennzeichnet, daß zum Erhalt eines gewünschten Kreuzungswinkels zwischen den oberen und unteren Arbeitswalzen (7) während des Walzbetriebes eine Arbeitswalzenkreuzungswinkelsteuerung (40) zur Durchführung einer Rückkopplungssteuerung der auf die Arbeitswalzeneinbaustücke (16) einwirkenden Stellorgane (10, 11) unter Verwendung der

Signale eines Sensors (13) vorgesehen ist.

3. Walzgerüst nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Arbeitswalzen (7) gegenseitig axial verschiebbar sind.
4. Walzgerüst nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß eines der Einbaustücke (16) jeder Arbeitswalze (7) mit einem Querblock (21) lösbar verbunden ist, der mit dem Ständer (20) durch zwei Hydraulikzylinder (22) verbunden und an einem festen Rahmen (23) geführt ist.
5. Walzgerüst nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß Walzenkühl Düsen (2, 3) zum Aufsprühen von Kühlwasser gegen die Arbeitswalzen (7) vorgesehen sind.
6. Walzgerüst nach Anspruch 5, dadurch gekennzeichnet, daß ein Schaber (32) an jeder Arbeitswalze (7) vorgesehen ist, um ein Vermischen des Kühlwassers mit dem Schmiermittel zu verhindern.
7. Walzgerüst nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß an einer Fläche eines Ständerfensters eine hydraulische Vorrichtung (19) vorgesehen ist, welche ein Einbaustück (17) der Stützwalze (8) gegen die andere Seite dieses Fensters preßt.
8. Walzgerüst nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß in Axialrichtung der Stützwalzen (8) verfahrbare Schleifvorrichtungen (6) zum Abschleifen der Ballenfläche der Stützwalzen (8) vorgesehen sind.
9. Walzgerüst nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß eine Steuereinrichtung (50) zur Steuerung der Schmiermittelzufuhr zur Kontaktzone zwischen der Arbeitswalze (7) und der Stützwalze (8) entsprechend den Walzbedingungen vorgesehen ist.
10. Warmwalzanlage mit einer Gruppe von Grobwalzgerüsten (61) und einer Gruppe von Fertiggerüsten (62), dadurch gekennzeichnet, daß mindestens ein Walzgerüst der Gruppe der Fertiggerüste (62) gemäß einem der Ansprüche 1 bis 9 ausgebildet ist.
11. Verfahren zum Warmwalzen von Flachgut in einem Quartogerüst, bei welchem zur Steuerung der Balligkeit des Flachguts (9) die Achsen der Arbeitswalzen (7) während des Walzens relativ zu den Achsen der Stützwalzen in der Horizontalen schräg ausgerichtet werden, so daß sich die Achsen der Arbeitswalzen untereinander und mit den Achsen

der Stützwalzen kreuzen,
wobei eine erste Schubkraft (F_2) von jeder Stützwalze (8) auf die zugehörige Arbeitswalze (7) in einer axialen Richtung ausgeübt wird, die einer axialen Richtung entgegengesetzt ist, in welcher eine zweite Schubkraft (F_1) vom Flachgut (9) auf diese Arbeitswalze einwirkt, so daß eine auf diese Arbeitswalze (7) wirkende tatsächliche Schubkraft gleich der Differenz ($F_2 - F_1$) zwischen den ersten und zweiten Schubkräften ist, dadurch gekennzeichnet, daß

ein Schmiermittel, das ein hauptsächlich auf einem Mineralöl aufgebautes Schmieröl enthält, der Kontaktzone zwischen jeder Arbeitswalze (7) und jeder Stützwalze (8) über deren gesamte Länge während des Walzens gesteuert zugeführt wird, um die erste axiale Schubkraft (F_2) so weit zu reduzieren, daß die auf diese Arbeitswalze (7) tatsächlich wirkende Schubkraft auf 5 % oder weniger der maximalen Walzkraft verringert wird.

12. Walzverfahren nach Anspruch 11, dadurch gekennzeichnet, daß die Arbeitswalzen (7) in gegensinnigen Axialrichtungen verschoben werden.

13. Verfahren zum Umrüsten eines Quartogerüsts mit den Stufen

- Vorsehen einer hydraulischen Vorrichtung (10) in einer einem Walzeneinbaustück jeder Arbeitswalze (7) gegenüberliegenden Position am Ständer (20), so daß mittels dieser in Durchlaufrichtung des Flachguts (9) betreibbaren Vorrichtung die Achsen der Arbeitswalzen (7) gegenüber den Achsen der Stützwalzen (8) in der Horizontalen schräg gestellt werden können, so daß sich die Achsen der Arbeitswalzen untereinander und mit den Achsen der Stützwalzen kreuzen,
- Vorsehen einer anderen in einer Axialrichtung jeder Arbeitswalze wirksamen hydraulischen Vorrichtung (21, 22) am Gehäuse (20), die zum Bewegen der Arbeitswalze in ihrer Axialrichtung an dem Einbaustück (16) der Arbeitswalze (7) angreifen kann, und
- Vorsehen einer Zufuhrvorrichtung für ein gesteuertes Zuführen eines die axialen Schubkräfte reduzierenden Schmiermittels, das ein hauptsächlich aus Mineralöl zusammengesetztes Schmieröl enthält, in die Kontaktzone zwischen den Arbeitswalzen und der zugehörigen Stützwalze über deren gesamte Länge,
- so daß die auf die Arbeitswalze durch Schmieren dieser Zone tatsächlich wirkende axiale Schubkraft nicht größer als 5 % der im Walzbetrieb des Gerüsts auf das zu walzende Flach-

gut ausgeübten maximalen Walzkraft ist.

Revendications

1. Laminoir à chaud à quatre cylindres, comprenant :

- une cage de laminage (20),
- une paire de cylindres de laminage (7) inclinés de façon ajustable dans des plans horizontaux par des moyens d'ajustage (10, 11) agissant entre les cales de cylindres de laminage (16) et des blocs saillants (30) de la cage (20), de telle sorte que les axes desdits cylindres de laminage (7) se croisent mutuellement et croisent également l'axe du matériau laminé (9), et
- une paire de rouleaux presseurs (8) disposés perpendiculairement à l'axe du matériau laminé (9), dans lequel :
- une première force de poussée axiale F_2 agit de chaque cylindre presseur (8) au cylindre de laminage associé (7), et une deuxième force de poussée F_1 agit dudit matériau (9) au cylindre de laminage (7), de telle sorte qu'une force de poussée réelle agissant sur le cylindre de laminage (7) soit égale à la différence ($F_2 - F_1$) entre lesdites première et deuxième forces de poussée (F_2 et F_1),

caractérisé en ce que :

un dispositif de délivrance de lubrifiant (1, 26 à 28, 50) est présent pour délivrer de façon contrôlée un lubrifiant de réduction de poussée axiale qui contient une huile de lubrification principalement composée d'une huile minérale sur toute la longueur de la zone de contact entre chaque cylindre de laminage (7) et le cylindre presseur associé (8) pour réduire la première force de poussée (F_2), de telle sorte que ladite force de poussée réelle agissant sur ledit cylindre de laminage (7) soit réduite à 5% ou moins de la charge de laminage maximale.

2. Laminoir selon la revendication 1, caractérisé en ce qu'un dispositif de commande d'angle de croisement de cylindres de laminage (40) est présent pour effectuer une commande de rétroaction des moyens d'ajustage (10, 11) agissant sur les cales de cylindres de laminage (16), en utilisant les signaux d'un détecteur (13) pour obtenir un angle de croisement désiré des cylindres de laminage supérieur et inférieur (7) durant le laminage.

3. Laminoir selon la revendication 1 ou 2, caractérisé en ce que les cylindres de travail (7) peuvent être décalés dans les directions axiales opposées de ceux-ci.

4. Laminoir selon l'une des revendications 1 à 3, caractérisé en ce que l'une des cales (16) de chaque cylindre de laminage (7) est raccordée de façon amovible à un bloc transversal (21) qui est raccordé à la cage (20) par deux cylindres hydrauliques (22) et guidé sur un bâti de fixation (23). 5
5. Laminoir selon l'une des revendications 1 à 4, caractérisé en ce que des tuyères de refroidissement de cylindres (2, 3) sont présentes pour éjecter de l'eau de refroidissement sur les cylindres de laminage (7). 10
6. Laminoir selon la revendication 5, caractérisé en ce qu'un élément de raclage (32) est présent sur chaque cylindre de laminage (7) pour empêcher le mélange de l'eau de refroidissement avec le lubrifiant. 15
7. Laminoir selon l'une des revendications 1 à 6, caractérisé en ce qu'un dispositif hydraulique (19) est présent sur une surface d'une fenêtre de la cage (20) pour appuyer une cale de cylindre (17) du cylindre presseur (8) contre l'autre côté de ladite fenêtre. 20 25
8. Laminoir selon l'une quelconque des revendications 1 à 7, caractérisé en ce que des dispositifs de meulage (6) pour meuler la surface de fût des cylindres presseurs (8) sont disposés de façon à être mobiles dans la direction axiale des cylindres presseurs. 30
9. Laminoir selon l'une quelconque des revendications 1 à 8, caractérisé en ce qu'un dispositif de commande (50) est présent pour commander la délivrance du lubrifiant à la zone de contact entre le cylindre de laminage (7) et le cylindre presseur (8) en fonction des conditions de laminage. 35 40
10. Système de laminage à chaud comprenant un groupe de laminoirs grossiers (61) et un groupe de laminoirs de finition (62), caractérisé en ce qu'au moins un laminoir du groupe desdits laminoirs de finition (62) est conçu selon l'une des revendications 1 à 9. 45
11. Procédé pour laminier à chaud un matériau plat dans un laminoir à quatre cylindres, 50

dans lequel, pour contrôler la couronne du matériau (9) durant le laminage, les axes des cylindres de laminage (7) seront inclinés par rapport aux axes des cylindres presseurs (8) dans un plan horizontal, de telle sorte que les axes des cylindres de laminage croisent les axes des cylindres presseurs et que les axes des cylindres de laminage se croisent mutuel-

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lement,

dans lequel une première force de poussée (F_2) agit de chaque cylindre presseur (8) au cylindre de laminage associé (7) dans une direction axiale opposée à une direction axiale dans laquelle une deuxième force de poussée (F_1) agit dudit matériau (9) audit cylindre de laminage (7), de telle sorte qu'une force de poussée réelle agissant sur ledit cylindre de laminage (7) soit égale à la différence ($F_2 - F_1$) entre lesdites première et deuxième forces de poussée,

caractérisé en ce que :

un lubrifiant qui contient une huile de lubrification principalement composée d'une huile minérale est délivré de façon commandée à toute la longueur de la zone de contact entre chaque cylindre de laminage (7) et chaque cylindre presseur (8) durant le laminage pour réduire ladite première poussée axiale (F_2), de telle sorte que ladite force de poussée réelle agissant sur ledit cylindre de laminage (7) soit réduite à 5% ou moins de la charge de laminage maximale.

12. Procédé de laminage selon la revendication 11, caractérisé en ce que les cylindres de laminage (7) sont décalés dans les directions opposées axiales de ceux-ci.

13. Procédé de rénovation d'un laminoir à chaud à quatre cylindres, comprenant les étapes suivantes :

la disposition d'un dispositif hydraulique (10) dans une position sur la cage (20) qui est opposée à une cale de cylindre (16) de chaque cylindre de laminage (7), de telle sorte que ledit dispositif puisse être actionné dans une direction dans laquelle un matériau (9) avance, de telle sorte que ledit dispositif (15) puisse incliner les axes des cylindres de laminage (7) par rapport aux cylindres presseurs (8) dans un plan horizontal, de telle sorte que les axes des cylindres de laminage croisent les axes des cylindres presseurs, et de telle sorte que les axes des cylindres de laminage se croisent mutuellement,

la disposition d'un autre dispositif hydraulique (21, 22) sur la cage (20), de telle sorte que l'autre dispositif (21, 22) puisse être actionné dans la direction axiale de chaque cylindre de laminage (7), de telle sorte que l'autre dispositif (21, 22) puisse venir en prise avec la cale de cylindre (16) du cylindre de laminage (7), de façon à déplacer par conséquent le cylindre de laminage dans la direction axiale de celui-ci,

lesdits cylindres de laminage et lesdits cylindres presseurs étant disposés de telle

sorte qu'une première force de poussée agisse de chaque cylindre presseur à un cylindre de laminage associé dans une direction opposée à une direction dans laquelle une deuxième force de poussée agit dudit matériau au cylindre de laminage de telle sorte qu'une force de poussée réelle agissant sur le cylindre de laminage soit égale à la différence entre lesdites première et deuxième forces de poussée, et la disposition d'un dispositif de délivrance de lubrifiant de réduction de poussée axiale pour délivrer de façon commandée un lubrifiant de réduction de poussée axiale qui contient une huile de lubrification principalement composée d'une huile minérale sur toute la longueur de la zone de contact entre lesdits cylindres de laminage et un cylindre presseur associé, de telle sorte que ladite force de poussée réelle agissant sur ledit cylindre de laminage sous la lubrification dans ladite zone ne soit pas supérieure à 5% d'une charge de laminage maximale agissant sur le matériau laminé durant l'opération de laminage dudit laminoir.

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FIG. 1

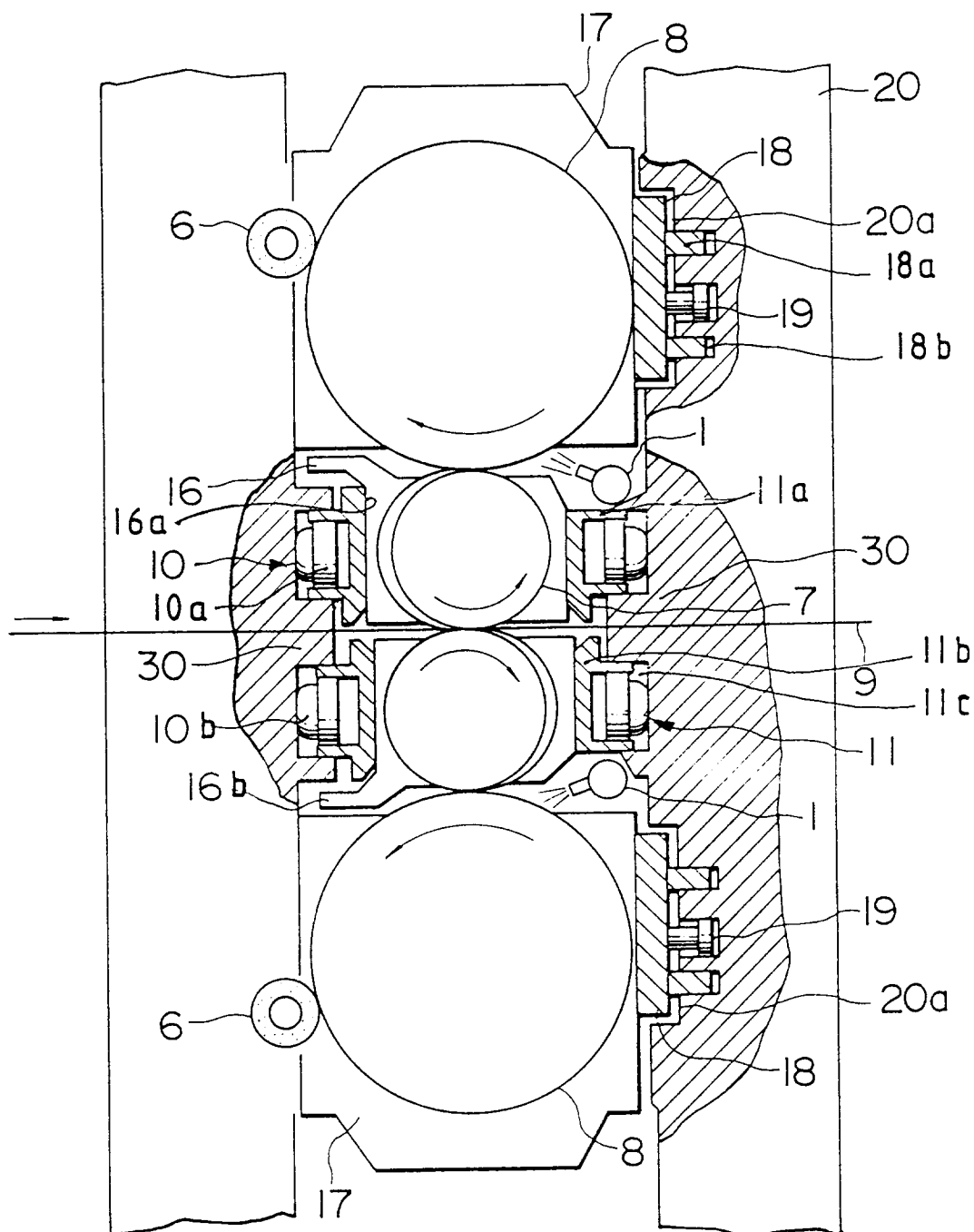


FIG. 2

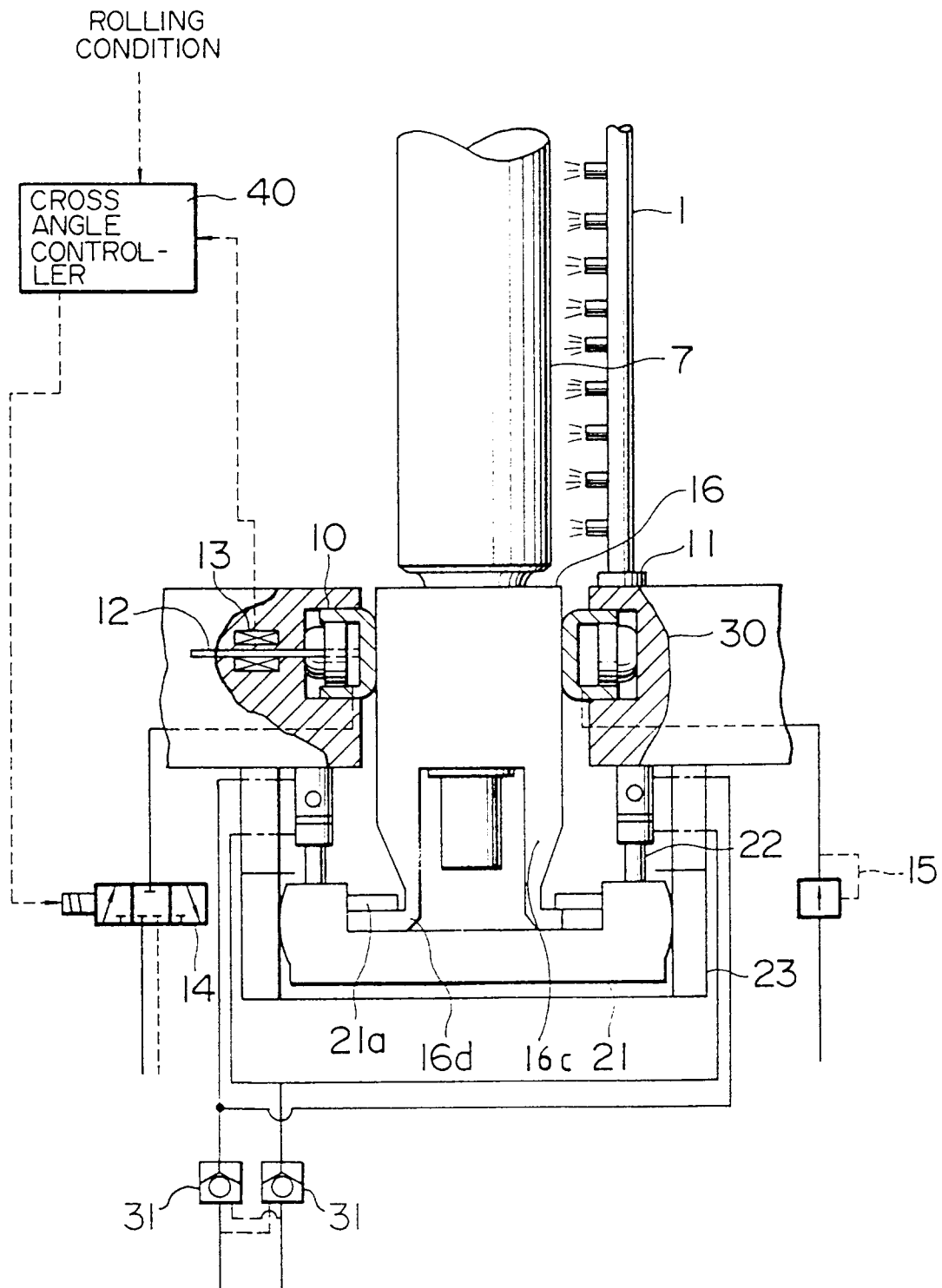


FIG. 3

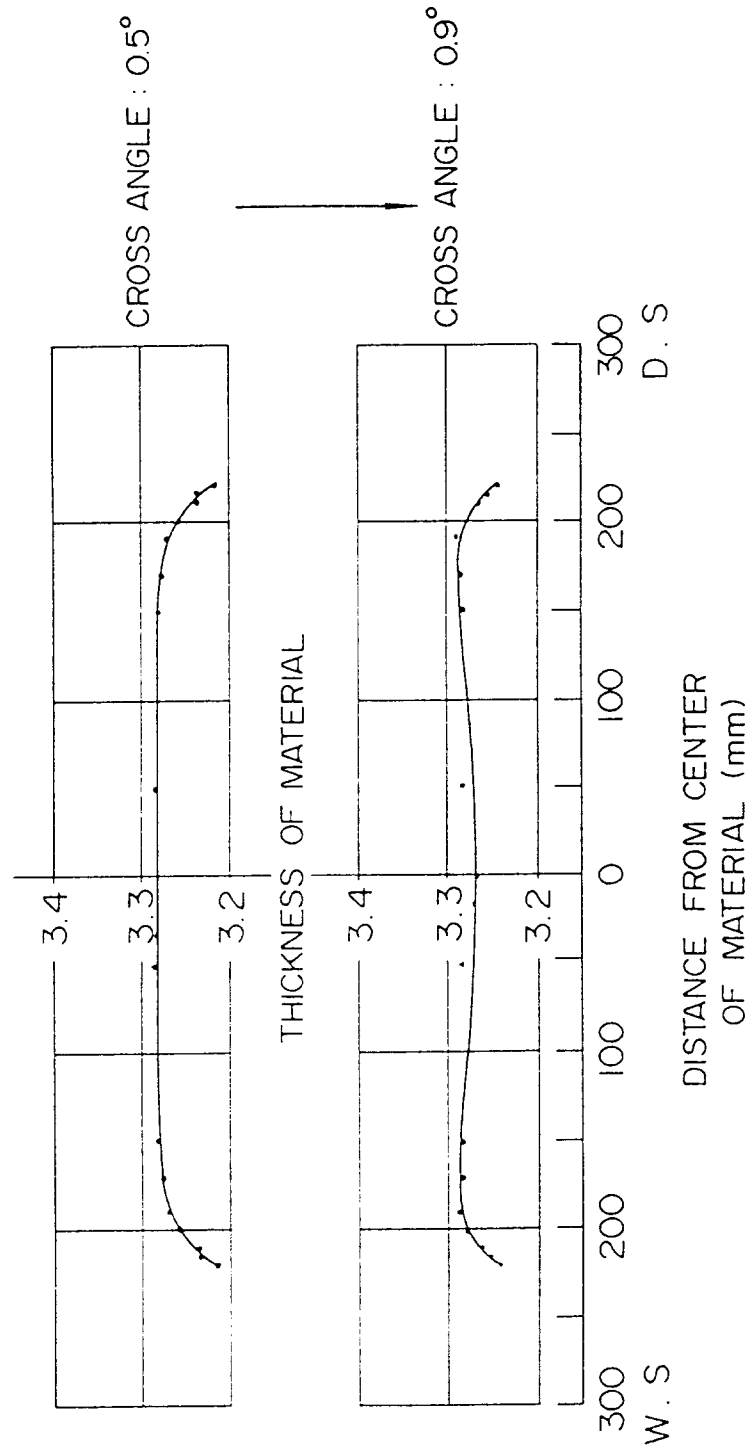


FIG. 4

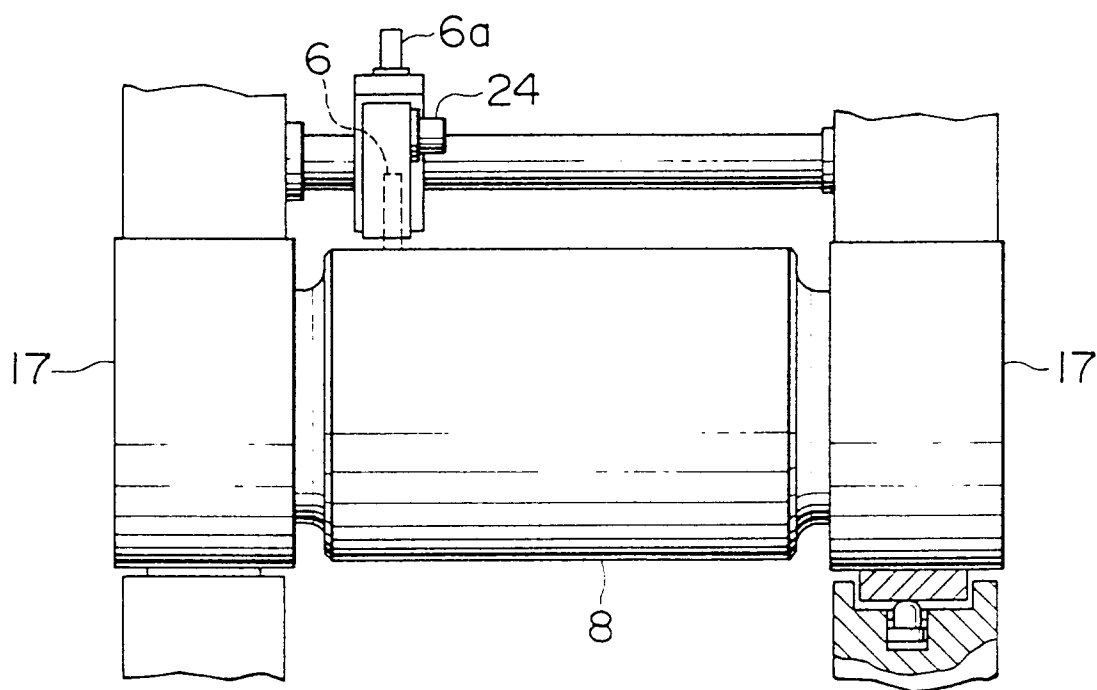


FIG. 5

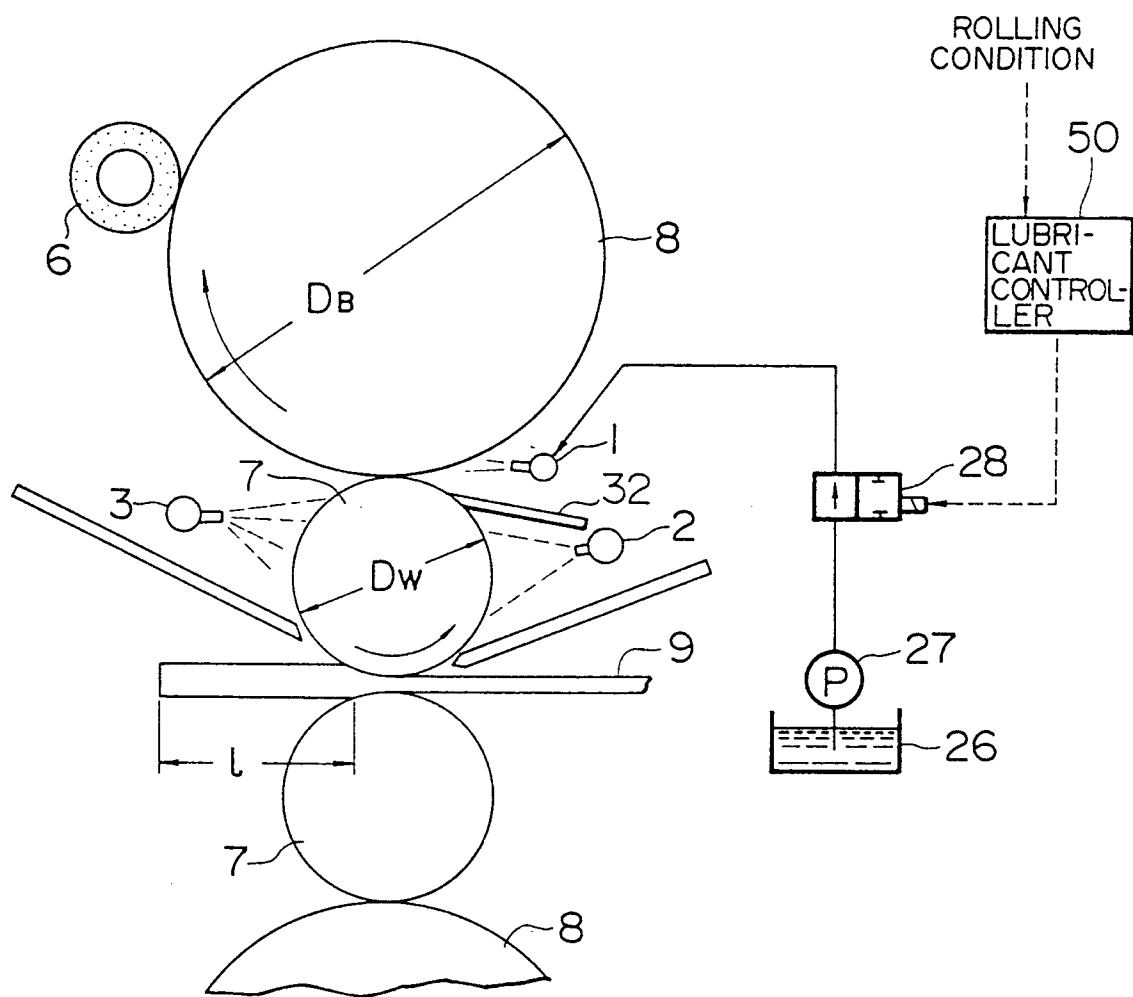


FIG. 6

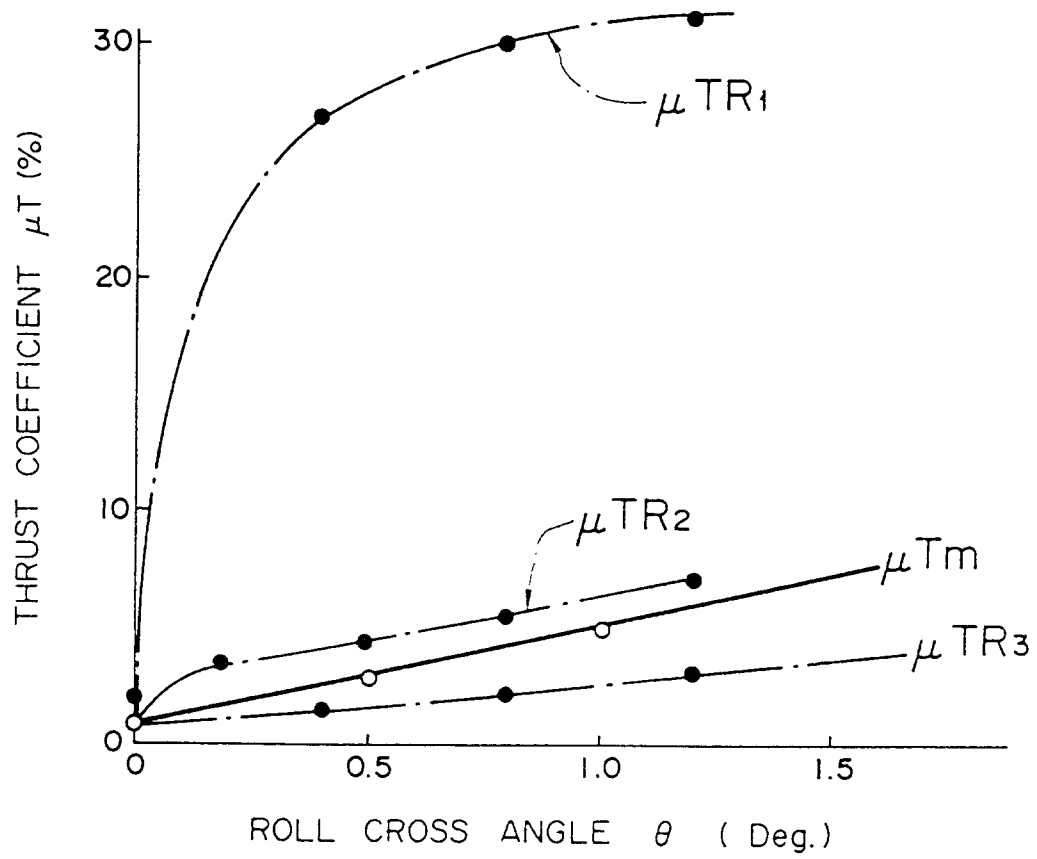


FIG. 7

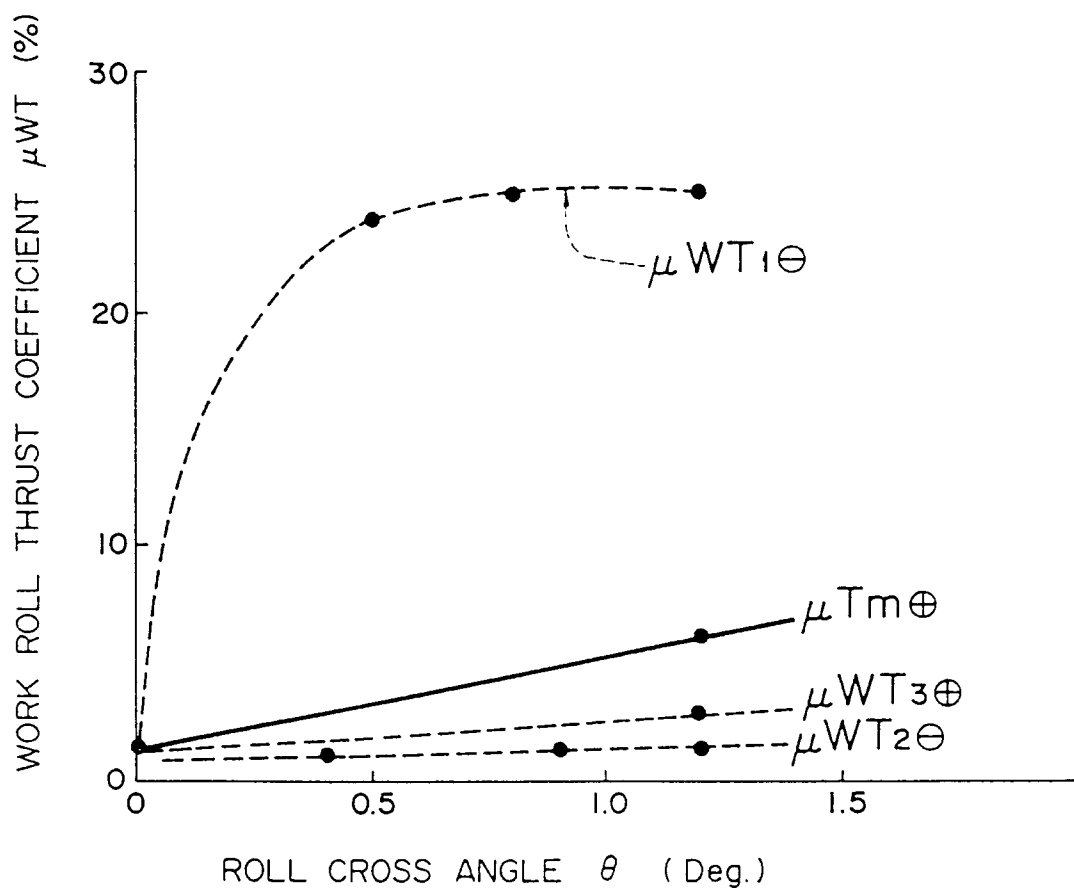


FIG. 8

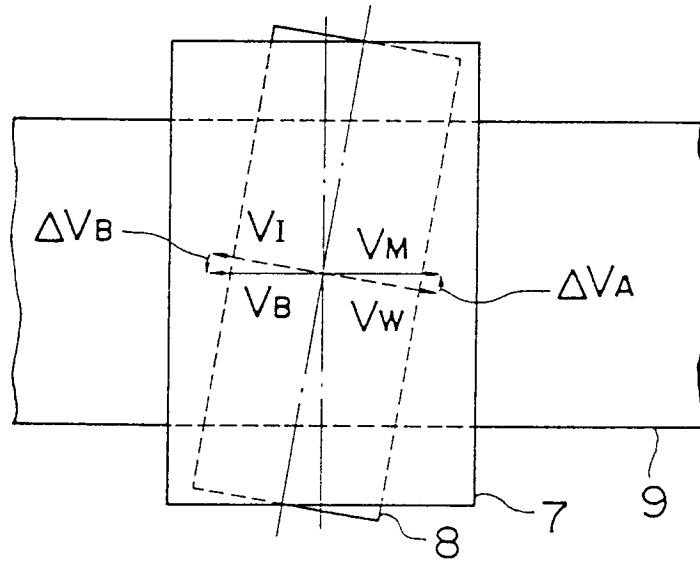


FIG. 9

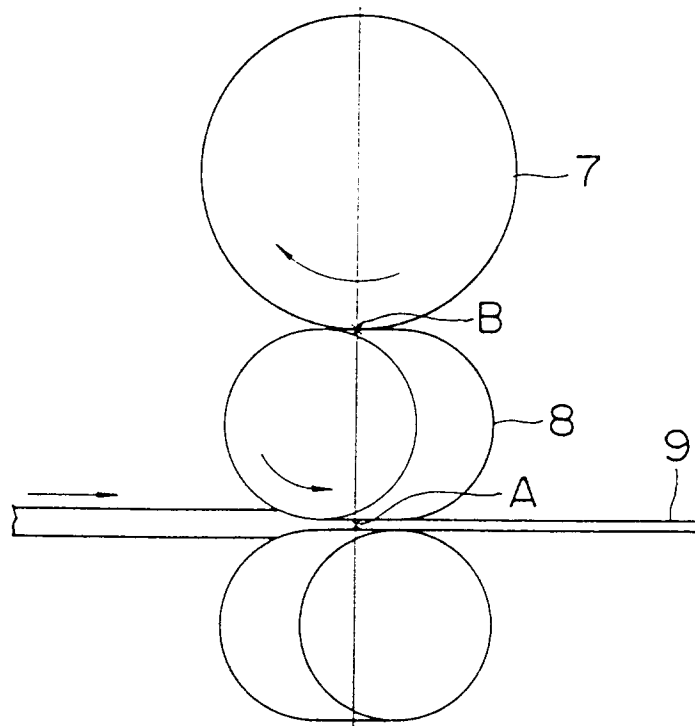


FIG. 10

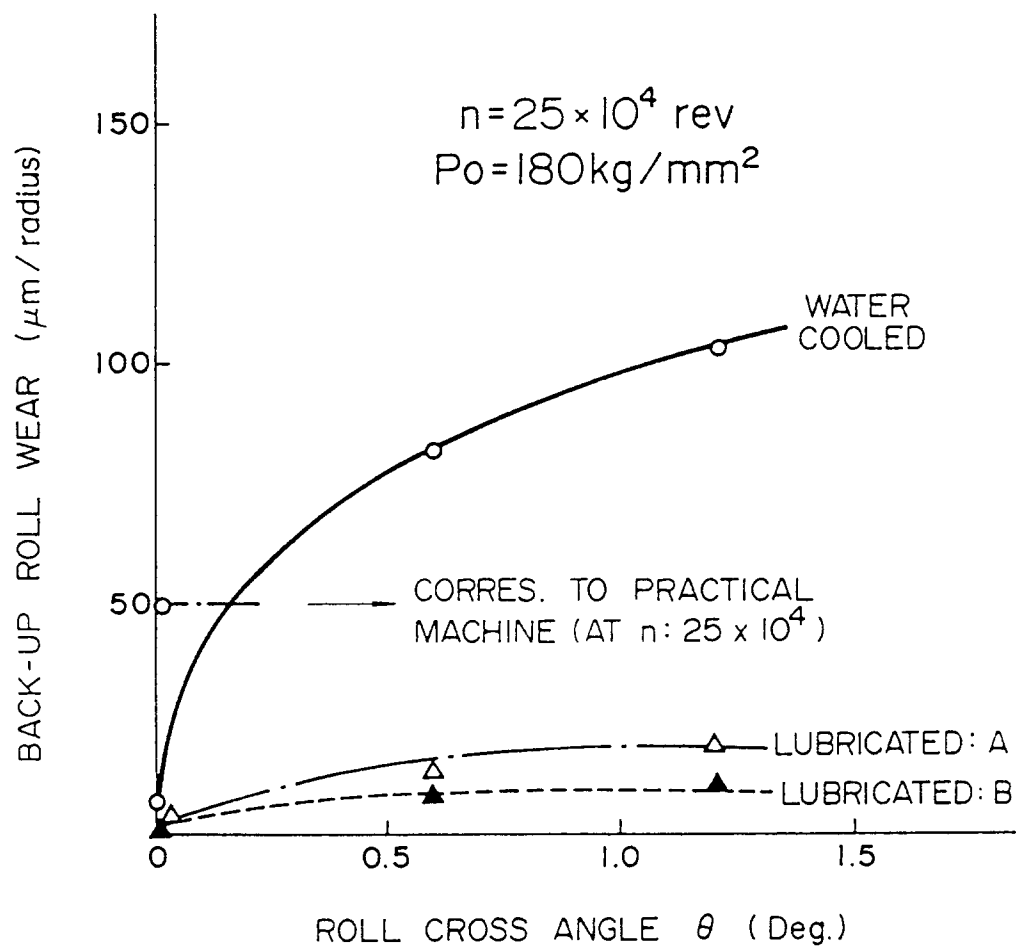


FIG. 11

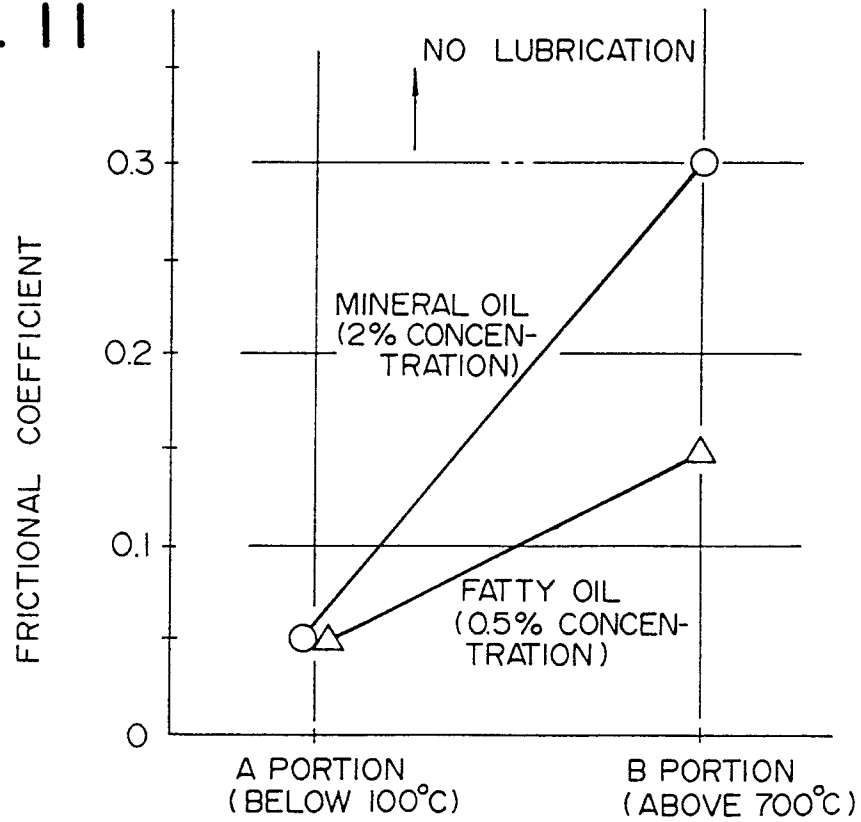


FIG. 12

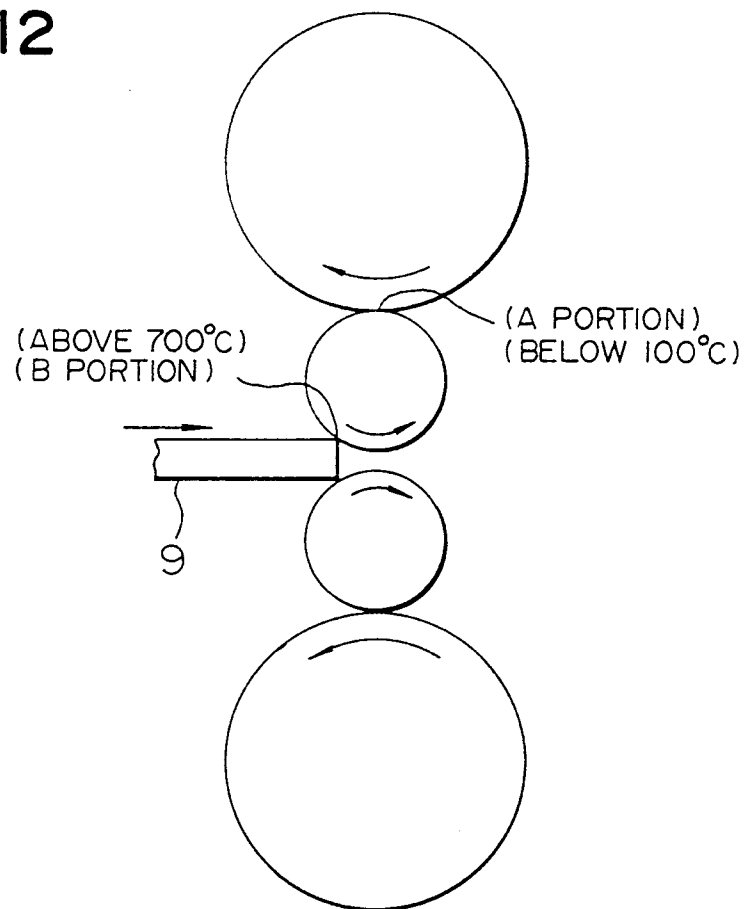


FIG. 13

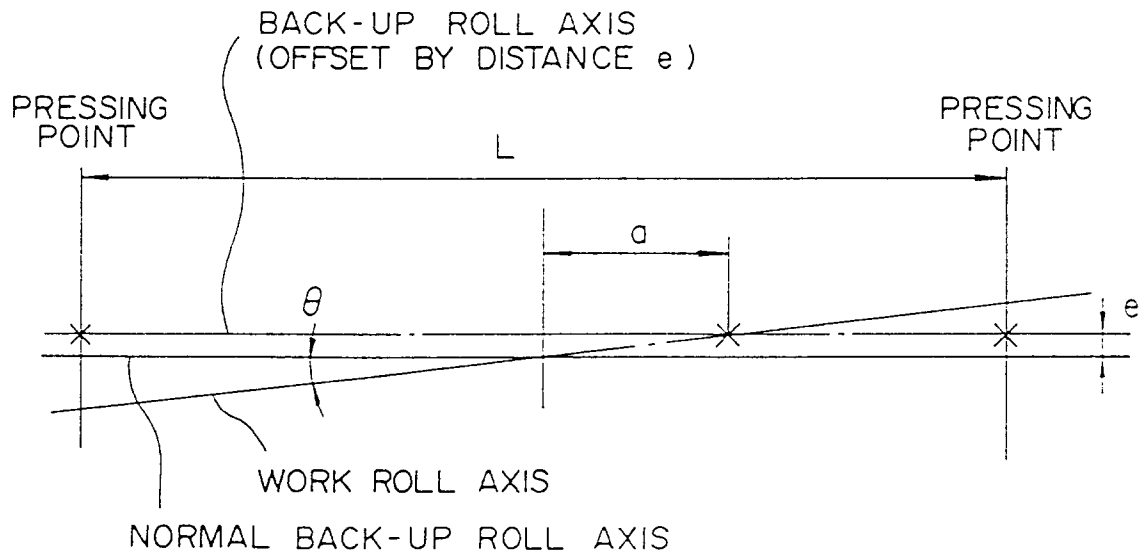


FIG. 14

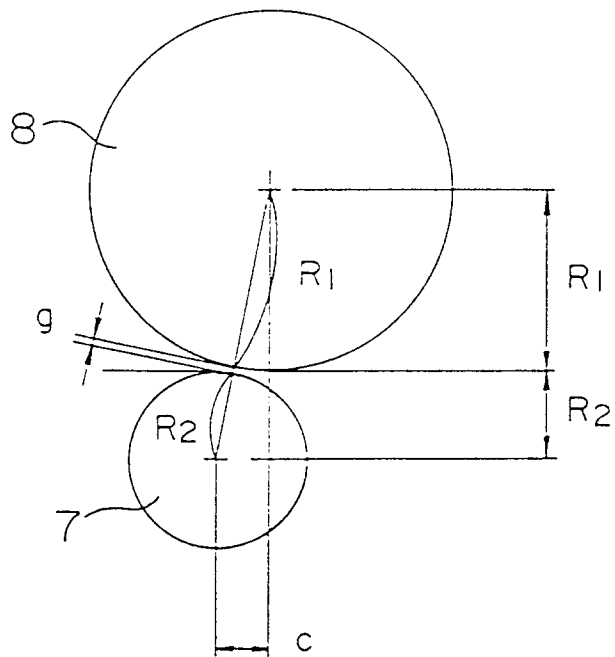


FIG. 15

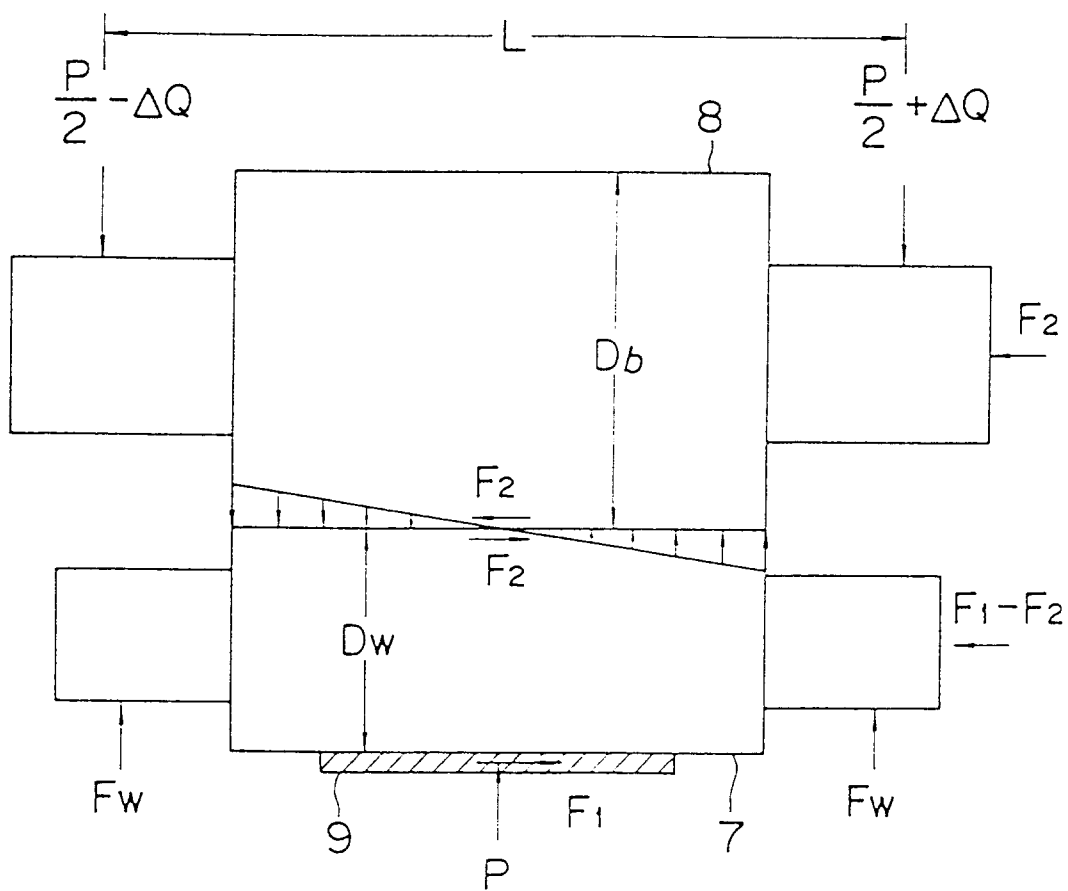


FIG. 16

