Feb. 24, 1970 M. D. STONE 3,496,743

ROLLING MILL FOR PRODUCING CONSTANT GAUGE

Filed Aug. 21, 1967 3 Sheets-Sheet 1

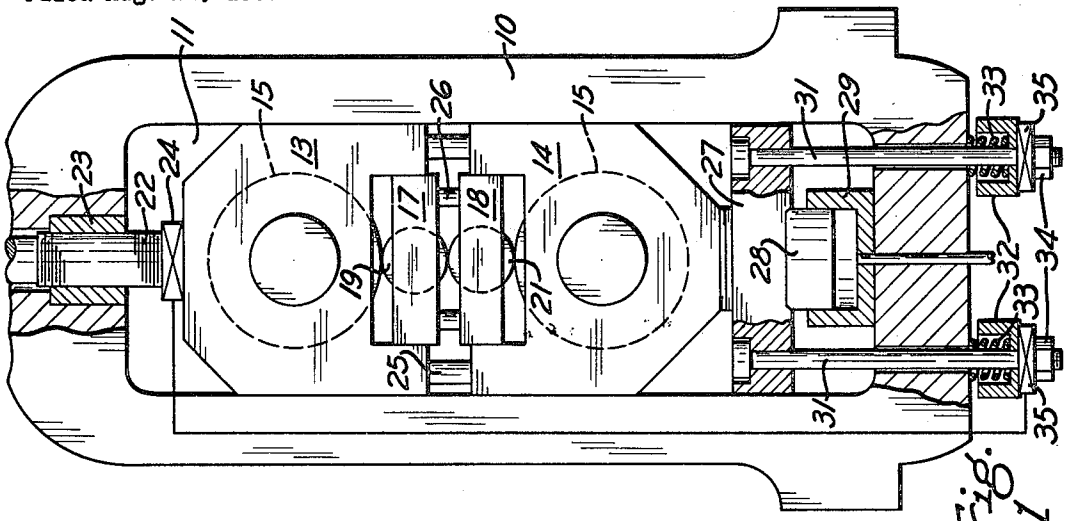


Fig. 1

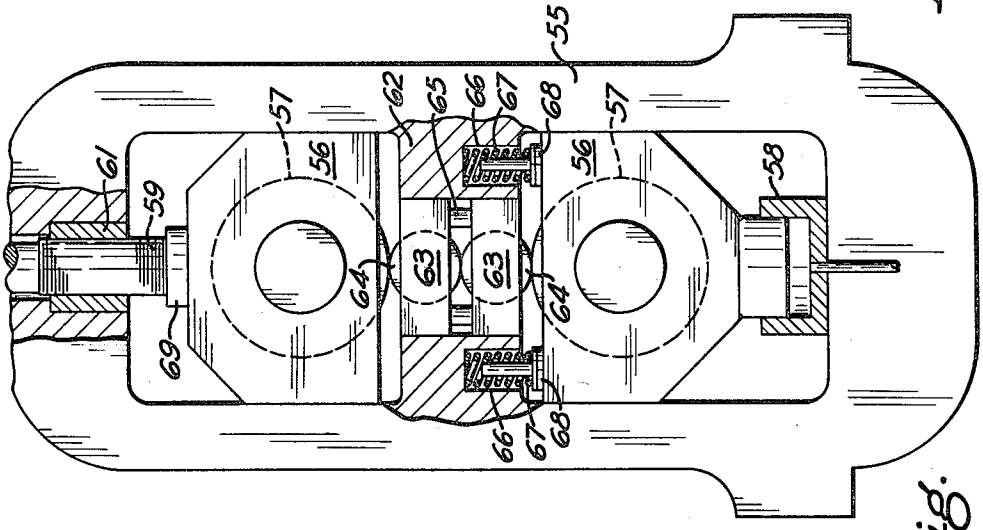


Fig. 2

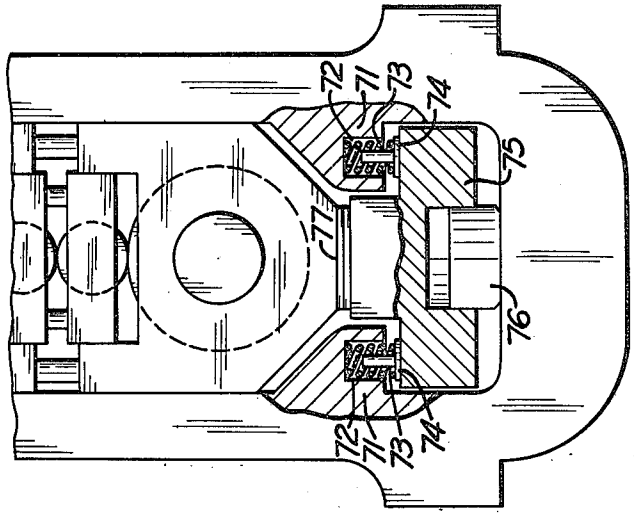


Fig. 3

INVENTOR.
MORRIS D. STONE

BY

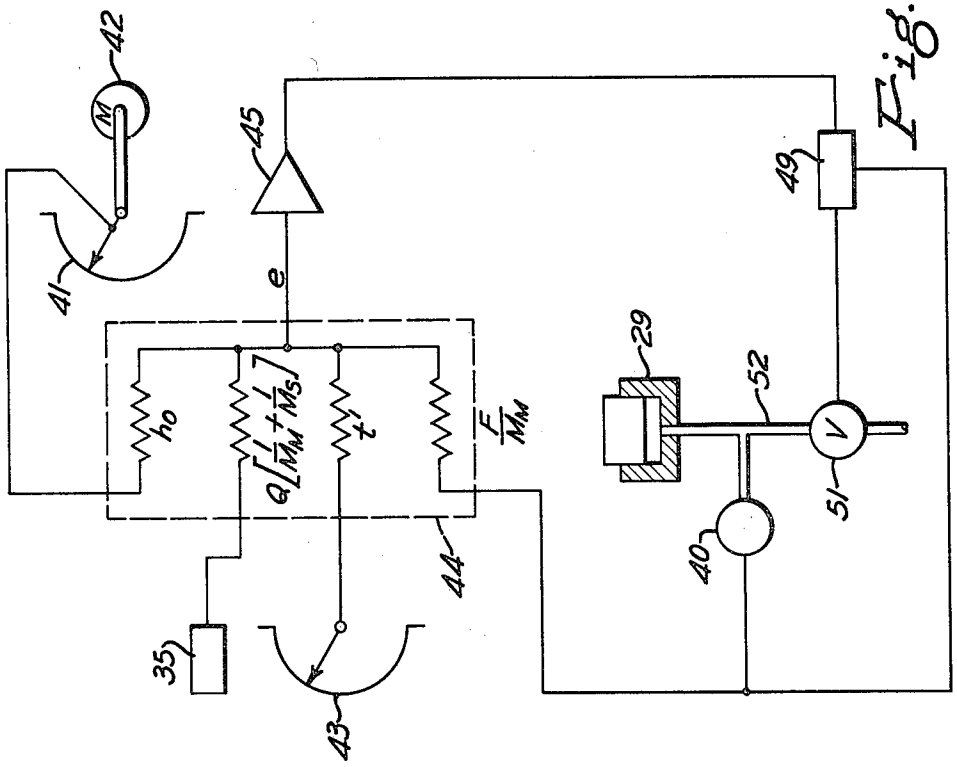
Henry C. Westin

ATTORNEY.

ROLLING MILL FOR PRODUCING CONSTANT GAUGE

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Fig. 6



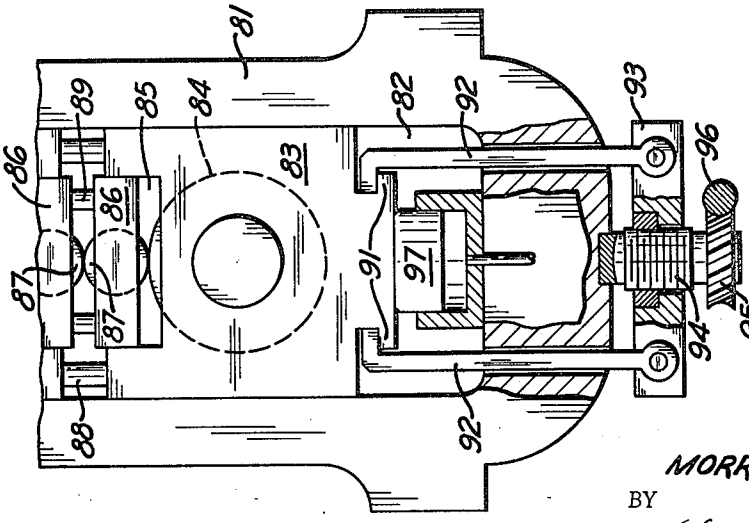


Fig. 4

INVENTOR.
MORRIS D. STONE
BY
Henry C. Austin
ATTORNEY.

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ROLLING MILL FOR PRODUCING CONSTANT GAUGE

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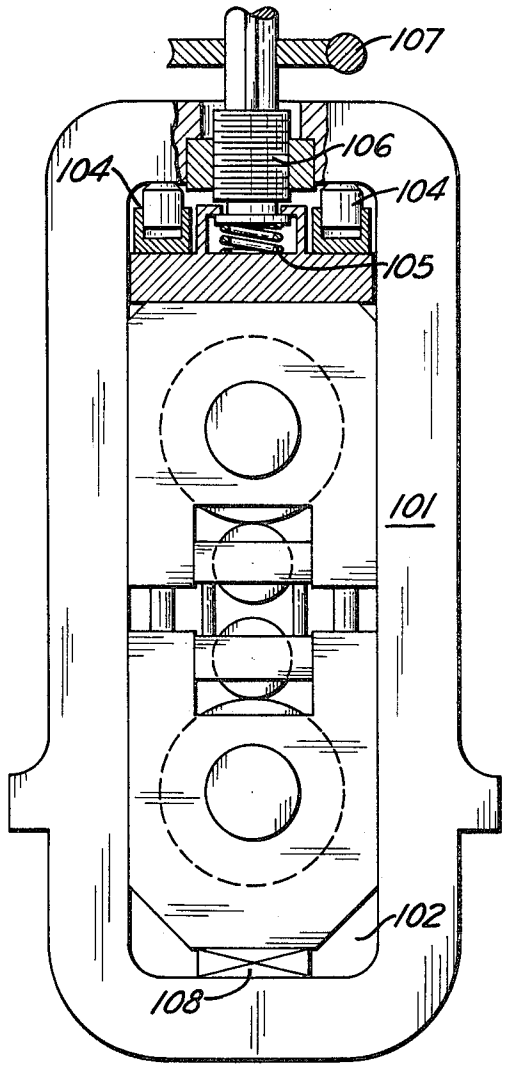


Fig. 5

INVENTOR.
MORRIS D. STONE
BY
Henry C. Westin
ATTORNEY.

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3,496,743

ROLLING MILL FOR PRODUCING CONSTANT GAUGE

Morris Denor Stone, Pittsburgh, Pa., assignor to United Engineering and Foundry Company, Pittsburgh, Pa., a corporation of Pennsylvania

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Claims priority, application Great Britain, Sept. 9, 1966, 40,488/66
Int. Cl. B21b 37/08
U.S. Cl. 72—8 14 Claims

ABSTRACT OF THE DISCLOSURE

The invention relates to a rolling mill of the type designed to produce a constant thickness workpiece, such as metallic strip. The mill is provided with a piston cylinder assembly for subjecting a first group of mill parts, such as the bearing chock assemblies of one of the rolls, to a roll gap controlling force which is applied in a direction to resist the rolling force of the mill. The cylinder is constructed and arranged so that the force difference between its total force and the rolling force is applied to a second group of mill parts, which may include a tension or compression member. In this mill construction only a portion of the housing of the mill is subject to the rolling force.

In one form there is provided in a rolling mill having a housing, an elongated window in said housing, a pair of rolls between which a rolling force is developed, including mounting means for each roll received in said window of said housing, wherein a portion of the housing receiving the mounting means and said mounting means is subject only to the rolling force of the mill, means arranged at one end of said window of said housing and between one of the mounting means and housing for applying to a first group of mill parts, including one of said mounting means, a substantial part of a roll gap controlling force, said force being applied in a direction to resist the rolling force of the mill, the force applying means being constructed and arranged so that the force differential between its total force and the rolling force is applied to a second group of mill parts, which excludes at least said other mounting means, and wherein the elastic characteristics of said two groups of mill parts have a predetermined relationship.

This rolling mill can be employed in combination with a control means for continually measuring the force imposed on either said first or second group of parts and varying the applying force proportional to a change in the force being imposed on said first or second group of mill parts to maintain a predetermined relationship between either of these forces and the applied force.

In another form, the present invention provides in a rolling mill, or like apparatus, having a housing, a pair of rolls between which a rolling force is developed including means arranged in said housing at one side thereof for applying to a first group of mill parts, including said mounting means, a substantial part of a roll gap controlling force, said roll gap controlling force being applied in a direction to resist the rolling force of the mill, the force applying means being constructed and arranged so that the force differential between its total force and the rolling force is applied to a second group of mill parts, which excludes at least one of said mounting means, and wherein the elastic characteristics of said two groups of mill parts have a predetermined relationship, means separate from said force applying means and associated with the mounting means arranged on the side of the housing opposite said force applying means for adjusting the associated mounting means and its roll to adjust the position of the roll independent of said force applying means.

This rolling mill can be employed in a combination with a control means for continually measuring the force imposed on either said first or second group of parts and varying the applying force proportional to a change in the force being imposed on said first or second group of mill parts to maintain a predetermined relationship between either of these forces and the applied force.

In a still further form of the invention said second group of mill parts comprises one or more tension rods associated with the lowest roll assembly of the mill, said tension rod subject to a tension force by said force applying means, and wherein the tension imposed on said tension rods is measured by a force measuring means. In certain cases a spring or equivalent device can be used in conjunction with the tension rods compressible by said rods to give added flexibility to the system.

In still another form of the present invention, there is provided alternately either a force measuring device associated with the tension rods or with the mill housing that receives the separating force from the roll assemblies.

A still further object of the present invention is to provide in a rolling mill of the above-described construction a readily yieldable means received in the housing of the mill and so associated with the force applying means to be subject to a compression force. In one form the housings are provided with projections having openings to which there are received a plurality of springs, one end of which engages one of the roll chocks of the roll assembly, this spring being compressed by the application of said force applying means and wherein said housing projections are in the vicinity of the work rolls of the mill.

In another form the housing projections are at the base of the mill wherein the springs engage a member associated with said force applying means and is compressible upon the movement thereof.

In one form the yieldable means is arranged between the mill screw and a crosshead against which a compression force is exerted.

A still further embodiment of the present invention comprises, either at the top or bottom of a rolling mill, a pair of substantially parallel arms connectable to one of the roll chocks of the mill and extending through or alongside the housing at which place they are connected with a cross member, means for adjusting the cross member relative to the pass line of the mill in which construction the force applying means in applying a force on the roll chock to which the arms are associated imposes a tension force on said arms, a portion of which is taken into the cross member and into the housing.

As noted above, the present invention relates to a rolling mill for producing constant gauge and, more particularly, uniformity of longitudinal gauge, such as, metallic sheet or strip. It has been well recognized for many years that the degree of gauge accuracy in a rolling mill is dependent upon the stiffness of the mill, i.e. to say, the resistance the mill has to stretch under the rolling load generated in the rolling of the material. In this regard the art early in its history sought to add stiffness to the mill by providing one or more backup rolls for the reducing rolls. The most common form of such a mill is the well known and universally employed 4-high mill. While the multi-high mill improved the stiffness of the rolls and, hence, of the mill and yielded a more uniform product, it leaves much to be desired. This is by reason of the fact that, notwithstanding the added stiffness afforded by the backup rolls, the rolls and housing and other components stretch considerably under the rolling load, which stretch varies as the rolling load varies, resulting in a product having a non-uniform gauge.

Since the housing itself represents a substantial amount

of the elastic stretch of the mill, the prior art sought to eliminate the housing as a factor in the obtaining of uniform gauge by providing a "prestressing" means, an example of which is shown in U.S. Patent No. 581,078 issued to F. Menne on Apr. 20, 1897. This, too, was an improvement in obtaining more uniform gauge. However, since it did not compensate for the elastic deformation of the other components of the mill, such as, roll body and neck deflection, chock deflection, screw compression, roll compression, which in the aggregate far exceeded the elastic influence of the housings themselves, the result was that objectionable gauge variations were experienced.

To further improve the performance of a rolling mill with respect to obtaining constant gauge, the art then developed an automatic gauge control means, whereby, as the rolling load changes, the position of the rolls was changed to compensate for variation in the rolling load. An illustration of this is U.S. Patent No. 2,680,978 issued W. C. F. Hessenberg et al. on June 15, 1954. It is of interest to note that in the Hessenberg patent reference is made to still other automatic gauge control approaches which were found unsuccessful.

The most recent attempt to obtain automatic gauge control was to combine the "prestressed" concept with an automatic gauge control concept whereby, as the rolling load changes, the distance between the rolls would be maintained constant. This approach has taken two forms; one of which is illustrated in British Patent No. 955,164 for "Improvements in and Relating to Rolling Mills," published on Apr. 15, 1964, and the other, as illustrated, in U.S. Patent No. 2,736,217 for "Adjusting Device in Rolling Mills," issued to P. Blain on Feb. 28, 1956.

In the first patent the attempt is made to maintain the distance between the axes of the backup rolls or the distance between the backup chocks of a 4-high mill constant. In this construction a change in the rolling load will, if appropriate correction is not effected, change the distance between the axes of the backup rolls. Hence, this patent teaches making an appropriate correction. The second attempt is to literally measure the distance between the axes of the work rolls of the 4-high mill and to adjust continually the rolls as the measured distance is detected to have varied from a predetermined distance. In the first case, it will be noted that while the invention has eliminated not only the housing but the backup chocks, there still remains the elastic characteristics to be reckoned with, having to do with roll bending, roll compression and roll flattening. These factors are substantial and, therefore, cannot be overlooked. The second form, where the actual distance is measured between the work rolls, has been found unacceptable as being unreliable and very cumbersome in addition to the limitations it imposes upon the operation of the mill, say, for example, from the standpoint of changing the rolls.

With this in mind, attention is now directed to the present invention which presents a substantial improvement over the previous mills in obtaining constant gauge, several forms of which are illustrated in the accompanying drawings of which:

FIGURE 1 is an elevational view, partly in section, of a 4-high rolling mill incorporating the features of the present invention;

FIGURE 2 is a similar view of a second embodiment of the present invention;

FIGURE 3 is a further embodiment of the form illustrated in FIGURE 2;

FIGURE 4 is an elevational view, partly in section, of a still further embodiment of the present invention;

FIGURE 5 is a further embodiment of the present invention; and

FIGURE 6 is a typical control circuit for the mill shown in FIGURES 1–5.

With reference now to FIGURE 1, there is shown one of the housings **10** of a 4-high mill, it being appreciated that according to normal mill construction a similar housing will be provided for the other side of the mill and that it will contain all the components of the illustrated housing. The housing **10** has a window **11** into which there is received backup chocks **13** and **14** which rotatably support backup rolls **15**, the backup chocks have recesses into which there is received work roll chocks **17** and **18** that rotatably support work rolls **19** and **21**. The upper backup chock **13** is adjustable relative to the pass line of the mill by a conventional mill screw **22** received in a nut **23** secured to the housing. The motor and gear for rotating the screw are not shown since they follow conventional designs. Between the upper chock **13** and screw **22**, as further noted hereinafter, there may be provided in one alternative form a load cell **24** for measuring the separating force of the mill. According to usual mill designs, the backup and work roll chocks are separated by balance cylinder assemblies **25** and **26**.

Attention is now directed to the lower backup chock **14**. It will be noted that immediately below the chock there is provided a block in the form of a variable spacer and below the spacer there is provided a crosshead **27**. The crosshead, at its underneath surface, is engaged by the piston **28** of a piston cylinder assembly **29** which is positioned betwen the bottom of the housing and the crosshead. The cylinder is adapted to be fed by a variable pressure which, at all times, either equals or exceeds the separating force of the mill. On the two opposite sides of the crosshead there is connected a tension rod **31** which extends downward through or alongside the mill housing and at their lower ends carry spring retainer elements **32**, into which there are received compression springs **33**. The tension rods at their lower ends and beyond the retaining elements are either enlarged to form heads, or threaded to receive nuts **34**, and between the lower surfaces of the spring retainers and nuts are provided load cells **35**. The load cells **35** may be employed in place of the load cells **24**, and are designed to measure the tension force imposed on the rods **31**, and could take the form of conventional strain gauges, if such were desirable.

As noted above, the piston cylinder assembly **29** is adapted to apply to the bottom roll **15** a force which may be identified as F. It will be noted that during rolling, the force F is divided into two components, one component being identified as P (the rolling force) and the other component as Q (the by-pass component) which is imposed on the rods **31** as a tension force, and which force eventually is transmitted to the housing and is resisted by the reaction force of the cylinder. Thus, we find in the illustrated mill that

$$F=P+Q \tag{1}$$

In the operation of the mill the initial no-load gap condition rolls h_o is set by the mill screw **22**, and the force of the piston cylinder assembly **29** will act to stretch the rods **31**, bend the crosshead **27** and compress the springs **33**, wherein the initial hydraulic force may be identified as F_o and the initial force on the rods as Q_o, so that $Q_o=F_o$, since P_o=no-load rolling force=0.

The gauge of the outgoing strip which, for purposes of description, will be identified as t is determined by the following relationship:

$$t=h_o+\frac{P}{M_m}-\frac{Q}{M_s} \tag{2}$$

where M_m equals the spring constant of the mill composed of rolls, backup chocks, screws, and housings, and M_s equals the spring constant for the crosshead, rods, and springs. It is an object of the present invention, as will be later emphasized, to make the value M_s small by proper design of the springs with respect to M_m.

With the above remarks in mind, consideration will now be given to what takes place when a heavy or hard spot appears in the strip as it enters the roll gap. This will result in a change in the delivery gauge of the material as represented by a change in the force P and Q,

since no change in h_o moving the screws takes place, such that

$$t+\Delta t=h_o+\frac{P+\Delta P}{M_m}-\frac{Q+\Delta Q}{M_s} \quad (3)$$

In subtracting Equation 2 from Equation 3 it can be seen that the change in gauge is:

$$\Delta t=\Delta P\left(\frac{1}{M_m}\right)-\Delta Q\left(\frac{1}{M_s}\right) \quad (4)$$

For Equation 4, the relationship of the change in the rolling force P and the spring force Q to the cylinder force F in terms of Equation 1 can be written:

$$(F+\Delta F)=(P+\Delta P)+(Q+\Delta Q) \quad (5)$$

which, by subtracting Equation 1 from Equation 5 the following is derived:

$$\Delta F=\Delta P+\Delta Q \quad (6)$$

Therefore, it is the prime object of the present invention to provide a mill control wherein the variation in $t=0$, i.e., the roll gap of the mill is maintained constant, except for some minor factors such as roll eccentricities. This is objective is achieved by the present invention by making Δt equal zero, in Equation 4, i.e.,

$$\Delta t=0 \quad (7)$$

To achieve this, it follows from Equation 4 and Equation 7 that the following relationship must be maintained:

$$\Delta Q=\left(\frac{M_s}{M_m}\right)\Delta P \quad (8)$$

Looked at another way, by defining the operating equivalent mill stiffness as $\Delta P/\Delta t$, it follows from Equation 7 and Equation 8 that

$$\frac{\Delta t}{\Delta P}=0 \text{ or } \frac{\Delta P}{\Delta t}=\infty \quad (9)$$

i.e., the mill operates as if it had infinite stiffness. Substituting Equation 8 in Equation 6, it follows that

$$\Delta F=\Delta P+\underbrace{\left(\frac{M_s}{M_m}\right)\Delta P}_{\Delta Q}=\Delta P\left(1+\frac{M_s}{M_m}\right) \quad (10)$$

Alternatively, Equation 8 may be transformed to give

$$\Delta P=\left(\frac{M_s}{M_m}\right)\Delta Q \quad (11)$$

which, substituted in Equation 6, gives

$$\Delta F=\left(1+\frac{M_s}{M_m}\right)\Delta Q \quad (12)$$

The above shows that to make $\Delta t=0$, ΔF must be varied as ΔP or ΔQ varies to keep the ratio between either ΔF and ΔP or ΔF and ΔQ constant at all times, that is,

$$\left.\begin{aligned}\frac{\Delta F}{\Delta P}&=\left(1+\frac{M_s}{M_m}\right)\\ \text{or}\\ \frac{\Delta F}{\Delta Q}&=\left(1+\frac{M_m}{M_s}\right)\end{aligned}\right\} \quad (13)$$

As noted above, the spring load cells **35** will read ΔQ or the alternate load cell **24** under the screw will read ΔP, so that either one may be used during rolling as the actuating signal and the ratio of a change in force represented by $\Delta F/\Delta P$ or $\Delta F/\Delta Q$ must be maintained, as stated in Equation 13 to obtain constant gage control.

It will be noted at this point that one of the operational advantages of the arrangement shown in FIGURE 1 is that the action involves no machine elements between the backup chocks since the tension rods, springs, etc., are arranged below the chocks and yield the very significant advantage of allowing roll changing to be handled as it is presently done in conventional mills.

With reference now to the electrical-hydraulic circuit provided for solving Equation 14 stated below, it will be noted that this formula can be expressed in terms of a gauge error which takes the following form:

$$\begin{aligned}e=t-t'&=\left[h_o+\frac{P}{M_m}-\frac{Q}{M_s}\right]-t'\\ &=\left[h_o+\frac{(F-Q)}{M_m}-\frac{Q}{M_s}\right]-t'\\ &=\left[h_o+\frac{F}{M_m}-Q\left(\frac{1}{M_m}+\frac{1}{M_s}\right)\right]-t'\end{aligned} \quad (14)$$

where t' equals the thickness, and e the gauge error, that is the departure of the thickness of the rolled material from the desired thickness, t'.

It will be appreciated that the reduction of the error in accordance with the Equation 14 is based upon the relationship set out in Equation 13, in which the relationship between the ΔF and ΔP or ΔQ is held constant when the error is made to be zero.

The control circuit illustrated in FIGURE 6 is designed to solve Equation 14, the value Q being derived from the load cells **35**, the value F from a pressure transducer **40** connected to the cylinder **29**, and the value h_o from the potentiometer **41** coupled to the mill screw **22** (in FIGURE 6 the potentiometer is shown as coupled to the motor **42** that drives the screw **22**). The required material gauge t' is set up on a manually controlled potentiometer **43**. Electrical signals representing h_o, F/M_m

$$Q\left(\frac{1}{M_m}+\frac{1}{M_s}\right)$$

and t' are summer in a summing circuit **44** to produce an error signal e, which is amplified in amplifier **45** and sent to a differentiating circuit **49**, the difference signal being applied to a pressure control valve **51** in the supply line **52** of the cylinder to reduce the error signal to equal zero.

In referring to the other embodiments of the present invention, reference is made to FIGURE 2 where there is illustrated a housing **55** having a window in which there is received backup chocks **56**, the chocks adapted to rotatably support backup rolls **57**, the lower chock, it being noted, is in engagement with a force applying piston cylinder assembly **58** which exerts a force greater than the rolling load. The upper chock **56** is engageable by the bottom end of a screw **59** being received in a housing via a nut **61** in which the screw is driven in the usual way. The housing is provided midway between its upper and lower portion with projections **62** forming in a reduced window section to which there is received the work roll chocks **63** and, accordingly, the work rolls **64** which constitute the mill.

In the usual manner, balance piston cylinder assemblies, such as **65**, are provided for the backup chocks and the work roll chocks so as to take up clearances prior to the material being introduced into the mill. In the lower portion of the projections **62** of the housing there are provided cavities **66** into which there are received readily yieldable means, such as springs **67**, the bottom surface of the springs engaging enlarged heads of plunger **68** which rest on the lower backup roll chock **56**. The relationship of the parts and the applied forces on this mill are similar to the mill of FIGURE 1 and may be represented as $F=P+Q$ where F is the cylinder force, P, the rolling force, and Q, the compression force on the spring. A ΔP signal will be developed as in the alternate form illustarted in FIGURE 1 from a load cell **69** arranged between the screw **59** and the upper chock **56**.

Aside from these distinctions the embodiments in FIGURE 2 will be similar to the arrangement in FIGURE 1.

With reference to FIGURE 3, which illustrates a further embodiment and a second embodiment of the principle illustrated in FIGURE 2, and in which only the lower half of the mill in FIGURE 2 is illustrated, where-

in it will be noted that the projections **71** of the housing are located at the bottom of the housing. In these projections there are provided cavities **72** for receiving springs **73** as in the case of FIGURE 2. The lower end of the springs engage enlarged heads of plunger **74** which are carried by a crosshead **75** forming the cylinder of a piston cylinder assembly **76**, the piston being in engagement with the bottom of the housing. Between the crosshead and the bottom chock there are provided variable spacers **77** to take care of a change in the diameter of the roll. The mill arrangement in FIGURE 3, aside from the structural differences, is similar in operation as that disclosed with respect to the FIGURE 2 embodiment.

The embodiment of the present invention illustrated in FIGURE 4 will now be described. It will be appreciated that while the equipment to be discussed is arranged at the bottom of the mill, it can be just as well arranged at the top. With reference to this figure there is provided a housing **81** which has a window **82** into which there is received backup chocks **83** of a 4-high mill, backup chocks rotatably supporting backup rolls **84**. The backup chocks, as in the case of FIGURE 1, are provided with cavities **85** into which there are received work roll chocks **86** which rotatably support work rolls **87**. The backup and work roll chocks are provided with the usual balance cylinder assemblies **88** and **89**. The upper backup chock is adapted to be adjusted by a mill screw, not shown, which is driven in the usual way. With respect to the lower backup chock **83**, it will be noted that it is provided with projections **91** that provide an opening for receiving the ends of the tension bars **92**, the tension bars extending downward through or alongside the mill and are connected to a common crosspiece **93**. The crosspiece itself is movable towards and away from the rolls by a power-driven screw **94** which is connected to a worm wheel **95** driven by a worm **96**, the drive for the worm not being shown. The screw **94**, it will be noted, engages the bottom of the housing **81**. The screw can be operated to maintain the pass line, set the initial roll gap, or change the gap during rolling. Between the lower backup chock and the housing is provided a piston cylinder assembly **97** adapted as in the other embodiments to deliver a force greater than the rolling load and which pressure is changed pursuant to the formula $F=P+Q$.

As pointed out above, while the present invention and the novel mechanism illustrated and described have been set forth as a procedure for obtaining constant roll gap, should for any reason the rolling mill illustrated be desired to be operated with a constant cylinder pressure, this can be performed. Also, should it be desired, in accordance with present practice, to operate the mill whereby the Q force in the formula $F=P+Q$ (Equation 1) is maintained constant, thereby, as for example in FIGURE 1, maintain the distance between the backup rolls constant, this method can also be carried out in the present invention without necessitating any change aside from what is required to control the cylinder in FIGURE 6 to maintain the cell reading constant. It will also be noted, as illustrated in FIGURES 1 and 5 that while in a given construction it may be desirable to provide readily yieldable means, such as springs, for maintaining a desired relationship between the moduli of the rolling mill parts subject to the rolling pressure, and the rolling mill parts subject to the Q force, this is not necessary in certain applications as illustrated in FIGURE 4.

It will be appreciated that the relationship of the spring or other yieldable means, such as tension rods, with reference to the cylinder can be changed from what is shown in FIGURES 1 and 4, so that the spring force acts in the same direction as the force of the cylinder. In this construction the cylinder force will be less than the rolling force by an amount equal to the spring force. In FIGURE 5 there is illustrated such an arrangement, wherein there is shown a housing **101** having a window **102** that receives the rolls and chocks of a 4-high mill. The upper chock is engaged by a cross member which is urged downward by a pair of force applying cylinders **104**. At the center of the cross member a spring **105** is rotated between the cross member and a screw **106**, which is driven by a motor wheel set **107**. In this arrangement the spring and cylinder act in concert, the force of the cylinder being controlled by the signal of a load cell **108** as in the other embodiments.

In accordance with the provisions of the patent statutes, I have explained the principle and operation of my invention and have illustrated and described what I consider to represent the best embodiment thereof. However, I desire to have it understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. In a rolling mill, or like apparatus having a housing, an elongated window in said housing, and

a pair of rolls between which a rolling force is developed, including mounting means for each roll received in said window of said housing, wherein a portion of the housing receiving the mounting means and at least one of said mounting means is subject only to the rolling force of the mill,

means arranged at one end of said window of said housing and between one of the mounting means and housing for applying to a first group of mill parts, including one of said mounting means, a substantial part of a roll gap controlling force,

said force being applied in a direction to resist the rolling force of the mill,

the force applying means being constructed and arranged so that the force differential between its total force and the rolling force is applied to a second group of mill parts, which excludes at least said other mounting means, and wherein the elastic characteristics of said two groups of mill parts have a predetermined relationship.

2. In a rolling mill according to claim **1**, wherein said second group is located in the one extreme of said window and outside the area defined by said mounting means and having a tension member for transmitting said differential force between said force applying means and said housing.

3. In a rolling mill according to claim **1**, including a control means for continually measuring the force imposed on either said first or second group of parts and varying the applying force proportional to a change in the force being imposed on said first or second group of mill parts to maintain a predetermined relationship between either of these forces and the applied force.

4. In a rolling mill, or like apparatus, having housings, and

a pair of rolls between which a rolling force is developed including mounting means for each roll,

means arranged in said housings at one side thereof for applying to a first group of mill parts, including said mounting means, a substantial part of a roll gap controlling force,

said force being applied in a direction to resist the rolling force of the mill,

the force applying means being constructed and arranged so that the force differential between its total force and the rolling force is applied to a second group of mill parts, which excludes at least one of said mounting means, and wherein the elastic characteristics of said two groups of mill parts have a predetermined relationship,

means separate from said force applying means and associated with the mounting means arranged on the sides of the housings opposite said force applying means for adjusting the associated mounting means and its roll to adjust the position of the roll independent of said force applying means.

5. In a rolling mill according to claim **4**, including a

control means for continually measuring the force imposed on either said first or second group of parts and varying the applying force proportional to a change in the force being imposed on said first or second group of mill parts to maintain a predetermined relationship between either of these forces and the applied force.

6. In a rolling mill according to claim 1, said second group of mill parts comprises one or more tension rods associated with the lowest roll assembly of the mill, said tension rod subject to a tension force by said force applying means, and wherein the tension imposed on said tension rods is measured by a force measuring means.

7. In a rolling mill according to claim 6, wherein a readily yieldable means is associated with said tension rods and arranged to be compressed thereby to give added flexibility to said second group of mill parts.

8. In a rolling mill according to claim 6, including a force measuring device associated with said housing arranged to receive and measure the separating force of said roll assemblies.

9. In a rolling mill according to claim 1, including readily yieldable means received in the housing of said mill and so associated with the force applying means to be subject to a compression force.

10. In a rolling mill according to claim 9, wherein said housing is provided with projections, openings in said projections for receiving a plurality of springs, one end of said springs engaging one of said roll chocks of the roll assembly, said springs being compressed by the application of said force applying means and wherein said housing projections are in the vicinity of the work rolls of the mill.

11. In a rolling mill according to claim 1, including a rotatable screw associated with one of said rolls for adjusting the initial gap of said roll assemblies.

12. In a rolling mill according to claim 9, in which said housing is provided with projections located at the base of the mill, the projections including openings for receiving springs and wherein said springs engage a member associated with said force applying means and are compressed upon movement thereof.

13. In a rolling mill according to claim 1, comprising a pair of substantially parallel arms connectable at one of their ends to one of the roll chocks of the mill and at the other of their ends to a cross member, means for adjusting the cross member relative to the pass line of the mill in which construction the force applying means in applying a force on the roll chock to which the arms are associated imposes a tension force on said arms, a portion of which is taken into the cross member and into the housing.

14. In a rolling mill according to claim 1, including a cross member arranged in said window and between a mounting means of one of said rolls and said housing,

said force applying means arranged between said cross member and said housing,

a rotable screw mounted in said housing on the same said thereof that said force applying means is located, and

a yieldable means arranged between the screw and said cross member.

References Cited

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CHARLES W. LANHAM, Primary Examiner

L. A. LARSON, Assistant Examiner

U.S. Cl. X.R.

71—21, 245

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,496,743 February 24, 1970

Morris Denor Stone

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 45,"(the by-pass component)" should read -- (the by-pass force component) --. Column 5, equation 11, should appear as shown below:

$$\Delta P = \left(\frac{M_m}{M_s}\right)\Delta Q$$

equation 12, should appear as shown below:

$$\Delta F = \left(1 + \frac{M_m}{M_s}\right)\Delta Q$$

Column 6, line 34, "summer" should read -- summed --. Column 10, line 22, "said" should read -- side --.

Signed and sealed this 16th day of February 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents