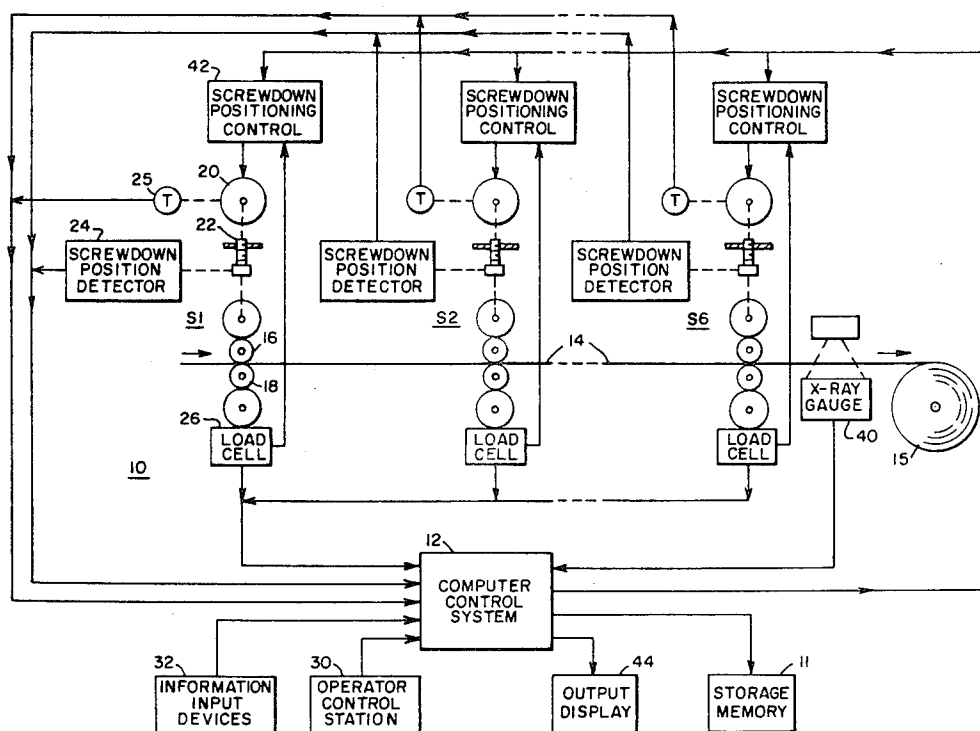


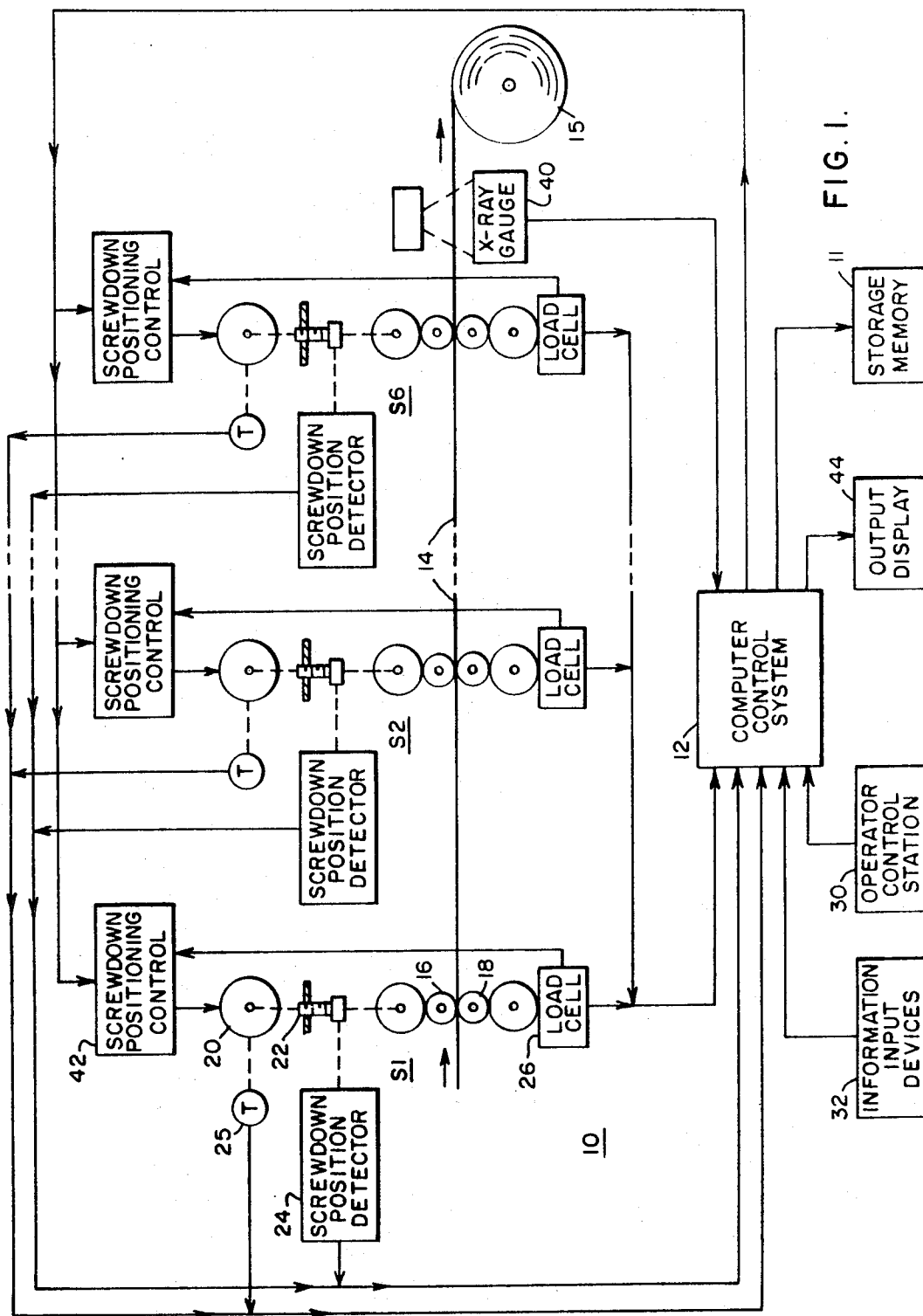
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[21] Appl. No. **830,636**
[22] Filed **June 5, 1969**
[45] Patented **July 13, 1971**
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[54] **ROLLING MILL STAND SCREWDOWN POSITION CONTROL**
14 Claims, 7 Drawing Figs.
[52] U.S. Cl..... **72/8,**
72/16, 72/19, 72/21
[51] Int. Cl..... **B21b 37/00**
[50] Field of Search..... 72/8—12,
16, 19, 21

ABSTRACT: There is disclosed a method and apparatus to determine the proper unloaded screwdown setting for at least one stand of a rolling mill prior to a work strip entering that mill stand and in relation to the predicted flattening of the work rolls that will occur, when the required total roll-separating force is applied to that mill stand to obtain the desired delivery thickness of the work strip passing through that mill stand.





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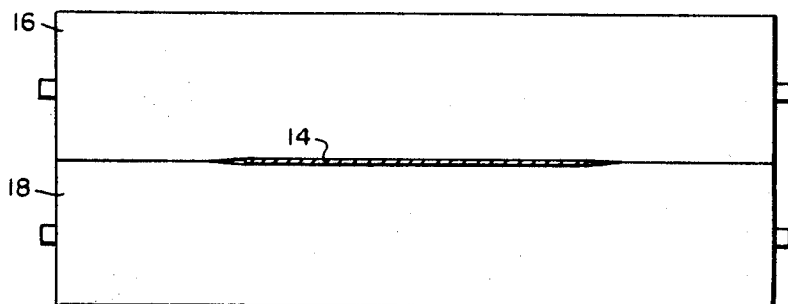


FIG. 2.

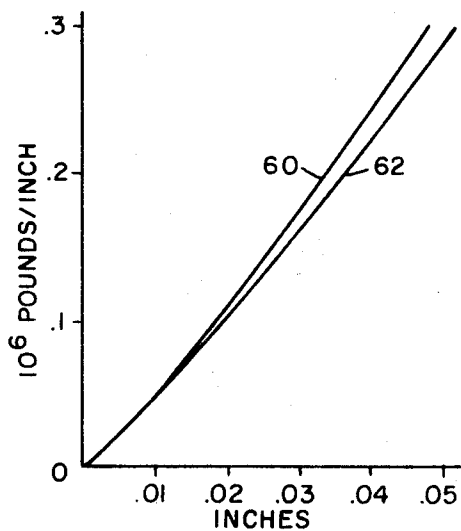


FIG. 3.

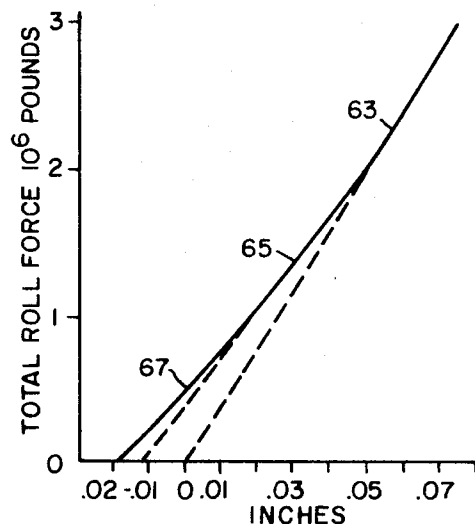


FIG. 4.

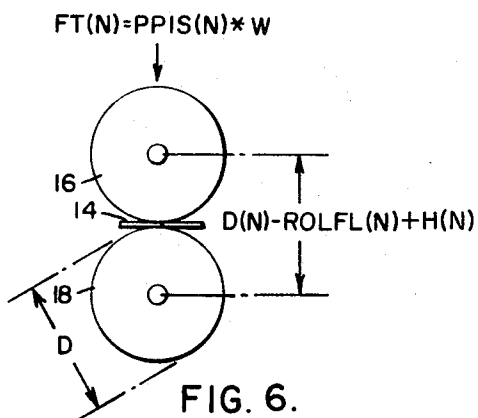


FIG. 6.

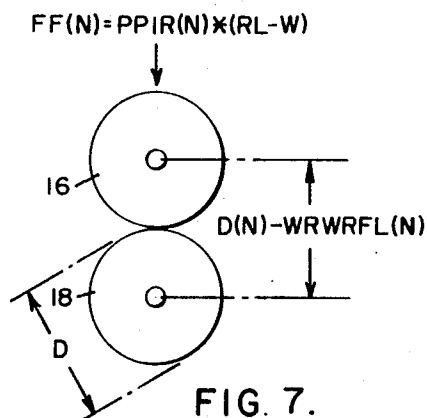


FIG. 7.

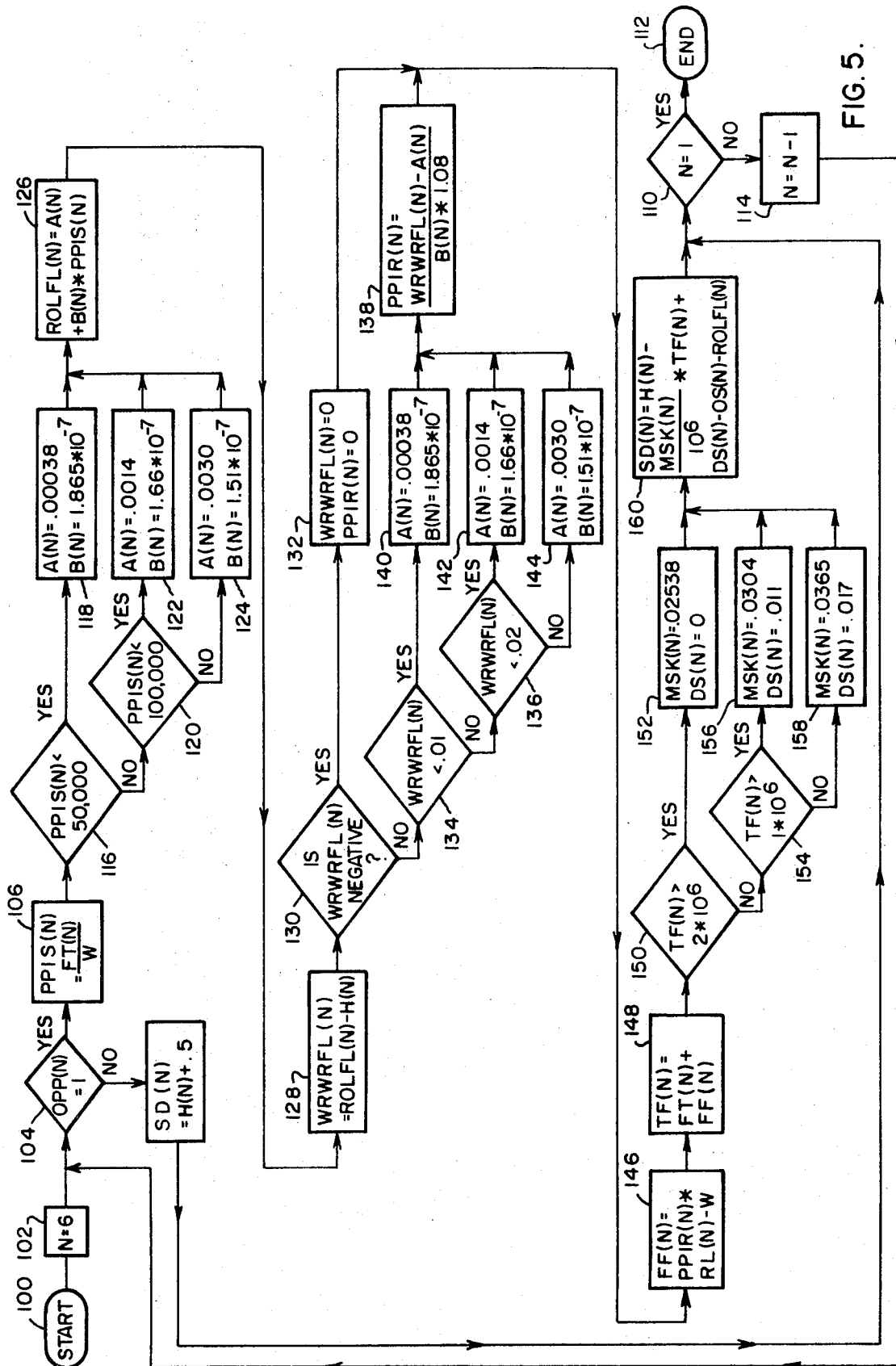


FIG. 5.

ROLLING MILL STAND SCREWDOWN POSITION CONTROL

BACKGROUND OF THE INVENTION

In the operation of a rolling mill stand, and particularly each stand of a cold-rolling mill, every effort should be made to choose the proper unloaded screwdown setting for each stand so that the whole length of the work strip passing through the rolling mill, including the head end of the work strip, will be on gauge and of the proper thickness. This will require that the proper roll-separating force and screwdown setting be calculated for the thread speed of the rolling mill stand, in that the operation of the stand will be a function of operating speed. It is assumed that if the stand screwdown position and speed are chosen to cause the head end of the workpiece strip to be on gauge, the cooperative and attendant conventional gauge control system will be sufficiently fast in operation to maintain the proper gauge as the rolling mill is accelerated above thread speed to the desired run speed.

If for some reason it is found in actual practice with some particular mill that the changes in mill conditions during acceleration are not acceptable in that the cooperative conventional gauge control cannot maintain the proper and desired delivery thickness from the mill stand during acceleration of the stand between thread speed and run speed, the screwdown setting calculation here described could instead be made at some interim speed higher than thread speed and between thread speed and run speed, and the off gauge material that would then result would have to be accepted at operative speeds below this interim calculation speed. For example if the mill is threaded by jogging the individual stands at substantially zero speed, and desired run speed is 4,000 feet per minute, a suitable interim speed might be in the order of 1,000 feet per minute.

The flattening of the work roll, where it comes in contact with the workpiece strip, not only affects the magnitude of the stand drive motor torque and the roll separating force required to obtain a desired delivery strip thickness from the stand, but it also affects the choice of the screwdown setting. There will be cases on the later stands particularly, when rolling the thinner work strip, where the roll flattening will be more than the thickness of the strip and will cause the work rolls to touch beyond the width of the strip with a resulting additional flattening force which becomes a component part of the total roll separating force applied to the stand. This additional force will cause additional stretch of the mill stand.

In the operation of a cold mill, with a stand roll force in the order of 3 million pounds, there results a flattening of the work rolls. When the work strip is thin enough the work rolls also touch together beyond the width of the work strip to cause an additional stand roll force loading due to the work roll to work roll flattening effect and this additional force must be included for a given stand when using the well-known mill spring stretch relationship $h = S_0 + F/m$ in regard to the calculation of the unloaded screwdown setting S_0 , to obtain the proper delivery gauge from the stand relative to the work strip. This mill spring stretch relationship is described in U.S. Pat. No. 2,726,541 of R. B. Sims. If the work rolls are flattened in this manner, the stand housing will undergo additional stretch as the work strip goes through a given stand.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved screwdown control operation of at least one mill stand, and in particular where the work strip product is thin enough that the work rolls touch together beyond the width of the work strip.

Another object is to better control the operation of the screwdown apparatus of at least one rolling mill stand, and particularly to better compensate for the effect of the work rolls touching together beyond the width of the workpiece strip passing through the stand to thereby effect an improved roll separation force loading of the stand.

In accordance with the teachings of the present invention, the operation of at least one rolling mill stand is controlled in accordance with a predicted roll separating force $FT(N)$ required to effect the desired work strip reduction and thereby to provide the desired delivery thickness of the workpiece strip from that mill stand at a selected operating speed. This roll separating force is predicted in accordance with well known model equation relationships relative to the work strip gauge and grade characteristics, the desired thickness reduction to be taken in the stand and so forth. The use of model equation relationships for this purpose is well known and has been described in several published articles; for example, such an article appeared in the Iron and Steel Engineer for Oct. 1965 at pages 75 to 87 entitled A Simplified Cold Rolling Model by William L. Roberts.

From this predicted roll separating force for a given stand N , the magnitude of the flattening of a single work roll against the work strip is first predicted. This work roll flattening is then checked relative to the desired delivery thickness of the work strip from the mill stand to see if the work rolls are touching, and if they are touching a prediction is made of how much extra roll-separating force results from this work roll touching and consequential flattening. The total stand roll separating force required is then determined as the combination of the first roll force component for rolling the desired gauge of the workpiece strip and the second roll force component caused by the work rolls touching beyond the width of the work strip. From this required total stand roll force, the unloaded screwdown setting for the mill stand to deliver the workpiece out of the mill stand at the desired delivery thickness is then determined.

These and other objects and features of the present invention will become apparent from the following detailed description taken in connection with the accompanying drawings, which form a part of this specification and in which:

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic showing of a multiple stand tandem rolling mill of the type suitable to be controlled in accordance with the teachings of the present invention;

FIG. 2 illustrates a stand operation condition where the work rolls are touching on each side of the work strip beyond the width of the work strip;

FIG. 3 includes an upper curve to illustrate a typical deformation or flattening of a mill stand work roll, and the lower curve illustrates the effective combined roll flattening of the two work rolls of the mill stand touching beyond the width of the work strip;

FIG. 4 shows a typical mill stand stretch or modulus of elasticity curve;

FIG. 5 is a functional flow chart to set forth the control program operative with the computer control system shown in FIG. 1 and in accordance with the teachings of the present invention;

FIG. 6 is an illustration of the work roll flattening condition relative to the reduction of the work strip by the work rolls; and,

FIG. 7 is an illustration of the work roll flattening condition relative to the work rolls touching together beyond the width of the work strip.

DESCRIPTION OF AN EMBODIMENT OF THE PRESENT INVENTION

In FIG. 1 there is shown a tandem-rolling mill 10, which is controlled in its operation by a computer control system 12 in accordance with a control program stored within its storage memory 11. The present invention is applicable to various types of mills in which individual stand roll force load sensors are employed such as hot strip rolling mills, cold strip rolling mills and other types of mills. However, it is here described in relation to a multiple stand tandem cold rolling mill.

The tandem mill 10 could include six reduction-rolling stands S1 through S6, with only three of the stands S1, S2 and

the last stand S6 being shown in FIG. 1. A workpiece strip 14 enters the rolling mill 10 at the entry side of the stand S1 and is reduced in thickness as it is passed through the successive stands S1 through S6 to the delivery end of the rolling mill where it is coiled as a strip on a down coiler 15. The entry workpiece strip would be of known steel grade and would typically have a thickness of about 0.10 inch and a width within some limited range such as 20 inches to 80 inches. The delivery work strip leaving the last stand S6 of the rolling mill would have approximately the same width and a predetermined thickness, typically 0.03 inch, determined by the production order for which it is intended.

The sum of the unloaded stand roll opening S_0 and the mill stretch relationship F/M , where F is the stand roll force and M is the stand mill spring modulus, substantially defines the workpiece strip gauge or thickness $H(N)$ delivered from any given stand (N) in accordance with the well known Hooke's law as described in the Sims patent. To vary the unloaded work roll opening S_0 at any stand, a pair of screwdown motors 20, with only the screwdown motor for one side of the stand being shown in FIG. 1, position the respective screwdowns 22 which apply forces against the opposite ends of the backup rolls and thereby apply work strip reduction force or pressure to the work rolls. Normally the two screwdowns at a particular stand would be in identical positions. A screwdown position detector or encoder 24 provides an electrical output signal representative of the screwdown position at each stand. To provide a desired correspondence between the screwdown position and the unloaded roll opening between the associated work rolls, the screwdown positioning system is periodically calibrated in relation to the proper zero position.

The digital computer control system 12 can include a central integrated process control computer or central processor with associated input and output equipment such as generally described in an article entitled "Understanding Digital Computer Process Control" by B. H. Murphy, which appeared in Automation Magazine for Jan. 1965 at pages 71 to 76.

Each computer processor can be associated with predetermined input systems not specifically shown, which typically may include a conventional contact closure input system to scan contact or other signals representing the status of various process operations, a conventional analogue input system which scans and converts process analogue signals and operator controlled or other input signals into the computer, and other input devices and systems such as the operator control station 30 and the information input devices 32 which could include page tape, typewriter and dial input devices. It is noted that the information input devices 32 are generally indicated by a single block in FIG. 1 although different input devices can and typically would be associated with the computer control system 12. Various kinds of information are entered into the computer control system 12 through the information input devices 32, including for example desired strip delivery gauge, strip entry gauge and width by entry detectors, grade of steel being rolled, any selected plasticity tables, hardware-oriented programs and control programs for the programming system and so forth. The contact closure input system interfaces the computer control system 12 with the process through the medium of measured or detected variables. For the purpose of the present invention, these mill signals can include the following: (1) a total stand actual roll force signal $TF(N)$ from the load cell 26 operative with each of the respective stands S1 through S6 and proportional to the individual stand roll separating force, (2) a multiple bit actual screwdown position signal generated by the respective screwdown position detectors 24 for each stand S1 through S6 for use in the desired computer control.

To effect the desired process control actions, control devices are operated directly by means of output system contact closure or by means of analogue signals derived from output system contact closures through a digital-to-analogue converter. One such control action outputs from the computer control system 12 the screwdown position command signals

$SD(N)$ which are supplied to the respective screwdown-positioning controls 42 for each of stands S1 through S6, to determine the operation of the screwdown motors 20 for each stand to provide the desired unloaded work roll positional movement at each stand.

At the start up of the rolling mill operation, the computer control system 12 generates the respective screwdown position output signals $SD(N)$ which are coupled as position reference signals to the respective screwdown-positioning control 42 for each stand. The screwdown motors 20 for each stand are thereby controlled to drive the screwdown 22 and produce the respective desired unloaded roll openings S_0 in accordance with the preset screwdown reference signal $SD(N)$ at each of the stands S1 through S6.

In FIG. 2 there is illustrated the operation of a rolling mill stand when the work product strip rolled is thin enough such that there results a flattening of the work rolls, which are shown touching beyond the width of the work strip. The work rolls 16 and 18 for a typical stand are shown operative with a work strip 14, and showing the work rolls 16 and 18 touching together beyond the width of the work strip 14.

Where the work rolls 16 and 18 are touching beyond the width of the work strip 14, the thickness of the strip $H(N)$ out of the stand (N) is known and the thread-rolling force $FT(N)$ is predicted for stand N in accordance with known work strip gauge and grade characteristics, desired thickness reduction to be taken in stand N and so forth, in accordance with the well known utilization of rolling process model equations, stored within the storage memory 11 operative with the computer control system 12 as shown in FIG. 1. A model equation is used to predict the stand roll force $FT(N)$ to make the desired strip thickness reduction in the stand N.

In FIG. 3 there is shown an upper curve 60 which is used to determine the work roll deformation; by the use of the upper curve 60, the resulting roll flattening relative to the portion of the work roll in contact with the work strip 14 is calculated. This work roll flattening is then checked relative to the desired delivery thickness of the work strip 14 to see if the resulting roll flattening is greater than the delivery thickness of the work strip. The lower curve 62 is used when the work roll flattening is greater than the work strip such that the rolls 16 and 18 are thereby touching together beyond the width of the work strip 14 and is utilized to determine the additional flattening force $FF(N)$ relative to the work roll to work roll flattening beyond the work strip. The total roll separating force $TF(N)$ in the mill stand housing is the sum of the rolling force $FT(N)$ plus the roll touching force $FF(N)$, which latter force can be zero if the work rolls are not touching together or a substantial force. The curves 60 and 62 are determined in accordance with the equations given on page 320 of a 1965 handbook by Raymond J. Roark entitled "Formulas For Stress and Strain"; the curve 60 is relative to condition and case number 4, where the work roll is equivalent to a cylinder between flat plates, and the curve 62 is used for determining the work roll to work roll flattening determined by condition and case number 5 for a cylinder on cylinder condition. Using the first curve 60, since the total stand roll force $TF(N)$ is a known empirical operation relative to similar work strip rolling and from the stand load cell, a calculation can be made of how much force per inch of roll width is involved and this permits a determination of the roll flattening. The first component rolling force $FT(N)$ equals the product of PPIS which is pounds per inch of width across the strip times the width W of the strip. If the value of PPIS is, for example, 200,000 pounds per inch of strip width by going to the curve 60 the resulting roll flattening is predicted to be 0.033 inch. If the desired delivery thickness from the stand $H(N)$ is for example assumed to be 0.012 inch and is thinner than the 0.033 roll flattening, the difference is determined as $(0.033 - 0.012 = 0.021$ inch), and the 20 mills that the work rolls are touching will indicate an additional roll force component on the second curve 62 about 105,000 pounds per inch of roll (PPIR).

The curve shown in FIG. 4 is used to determine the stretch of the mill housing due to the total force $TF(N)$ applied to the mill stand, since the actual screwdown setting is dependent upon the deflection of the parts of the mill. In FIG. 4 the curve portion 63 shows the mill modulus to be 0.02538 inch per million pounds above a roll force of 2×10^6 pounds. It is known that the mill modulus becomes nonlinear at lower roll forces; for this purpose, an increase of 20 percent in the modulus has been introduced to provide the curve portion 65 for roll forces between 1 million and 2 million pounds, and a further increase to 40 percent has been introduced to provide the curve portion 67 below one million pounds to approximate this nonlinear characteristic of the mill modulus line for a typical roll stand. The exact shape of the curve shown in FIG. 4 can be readily determined once the mill is in operation by driving the work rolls below face and measuring the roll separation force and corresponding screwdown position for a plurality of roll force values; the constants shown in FIG. 4 can then be readily adjusted to agree with the actual mill stand test results. The total mill stand roll-separating force is determined by the sum of the component roll flattening force $FF(N)$ caused by pressure exerted by the rolls touching beyond the work strip width and the component rolling force $FT(N)$ predicted for deforming the strip to give the desired delivery strip thickness from a given stand. The mill modulus curve shown in FIG. 4 is broken into three segments; however, the mill can be calibrated such that the straight line portion of the mill spring line will pass through zero. As shown in FIG. 4 the linear curve portion 63 passes through zero on the horizontal axis, and the nonlinear portions 65 and 67 pass through negative intercepts. The calibration of the screwdowns can be periodically adjusted by changing the value of the offset $OS(N)$, which number along with the roll flattening $ROLFL$ is used in determining the predicted screwdown setting for each stand of the rolling mill, as will be later explained in greater detail.

In FIG. 5 there is shown a functional flow chart of the control program loaded into the storage memory of the computer control system to determine the screwdown position control operation in accordance with the present invention. The control program is suitably initiated at step 100 by an operator or some other initiation condition. At step 102 the control program is started relative to stand number 6, and then sequentially follows through stands 5, 4, 3, 2 and finally 1, to make a determination of roll flattening and the work roll to work roll flattening for each stand in accordance with the present invention. At step 104 a decision is made to see if the particular stand (N) is operating; if it is, the program proceeds to step 106 where the pounds per inch of width across the strip $PPIS(N)$ is determined in accordance with the predicted roll force $FT(N)$ determined from model equation information in relation to the known width W of the work strip. At step 104, if the stand (N) is not operating, the program proceeds to step 108 where the screwdown position reference setting $SD(N)$ for the particular stand (N) is set at the thickness of the work strip $H(N)$ plus one-half inch, and then proceeds to the step 110 where a check is made to see if the particular stand is stand number 1. If it is stand 1, the program proceeds to step 112 which is the end of the program. If it is not stand 1, the program proceeds to step 114 where the number of the stand (N) is reduced by one, for example, if the program started with the sixth stand of the six-stand tandem-rolling mill, at program step 114 stand (N) would now become the fifth stand.

Going back to the program step 106, where the pounds per inch of width across the strip $PPIS(N)$ is determined for stand N, the program advances to step 116 where a check is made to see if this quantity $PPIS(N)$ is less than 50,000. If it is, the program proceeds to step 118 where two predetermined quantities A and B, the respective intercepted slope of the curve 60, are set to specific values. If the check made at step 116 shows that the quantity $PPIS(N)$ is greater than 50,000, the program advances to step 120 where a check is made to see if the quantity $PPIS(N)$ is less than 100,000. If it is, the program ad-

vances to step 122 where the quantities A and B are given different predetermined values. If the check made at program step 120 shows that the quantity of $PPIS(N)$ is greater than 100,000, the program advances to program step 124 where the quantities A and B are given still different predetermined values. It should be noted that the program steps 116 through 124 in effect linearize the first curve 60 as shown in FIG. 3.

The control program now advances to step 126 where the roll flattening $ROLFL(N)$ is predicted as equal to A plus the quantity B times the pounds per inch of width across the strip $PPIS(N)$. The control program then proceeds to the step 128 where a calculation is made of the work roll to work roll flattening $WRWRFL(N)$ in relation to the delivery thickness $H(N)$ of the strip leaving the stand (N) and the previously determined roll flattening $ROLFL(N)$. How much the work rolls touch is determined as the roll flattening $ROLFL(N)$ minus the delivery strip height or thickness $H(N)$ for stand N. The program proceeds to decision step 130 where a check is made to see if the work roll to work roll flattening quantity $WRWRFL(N)$ is negative. If it is negative, the delivery strip thickness is presumed to be greater than the roll flattening so the stand work rolls are not touching out beyond the width of the work strip, and the program proceeds to block 132 where the quantity $WRWRFL(N)$ is set equal to zero and the quantity $PPIR(N)$, or the pounds per inch of roll length, is set equal to zero. On the other hand, if the work roll to work roll flattening $WRWRFL(N)$ is a positive number the rolls are touching. The work roll to work roll flattening versus force per unit on the lower curve 62 of FIG. 3 and it is linearized at program steps 134 and 136 depending upon the magnitude of quantity $WRWRFL(N)$ to give the pounds per inch width of the rolls $PPIR(N)$ at program step 138 as equal to the quantity

$$\frac{WRWRFL(N) - A}{B \times 1.08}$$

where the quantities A and B are determined at one of the program steps 140, 142 or 144 depending upon the magnitude of the quantity of $WRWRFL(N)$ to effectively linearize the lower curve 62 shown in FIG. 3 into three predetermined linear portions.

The control program proceeds to step 146 where the roll flattening force $FF(N)$ is determined as the product of the pounds per inch of roll $PPIR(N)$ times the roll length $RL(N)$ minus the strip width W , which indicates the portion of the work rolls for stand N which extend beyond the width of the strip. In program step 148, the total roll force of the mill stand $TF(N)$ is determined as the thread rolling force $FT(N)$ to effect the desired reduction in the work strip plus the roll flattening force $FF(N)$ to flatten the portion of the work rolls which extend beyond the width of the work strip. In program step 150, a determination is made to see if the total stand roll force $TF(N)$ is greater than two million pounds. If it is, the program proceeds to block 152 where the mill modulus of elasticity or the stand mill spring constant $MSK(N)$ is set equal to 0.02538 from the first linear portion 63 of the curve shown in FIG. 4 and the quantity $DS(N)$, the intercept for the chosen linear portion of the curve, is set equal to zero. On the other hand, if the total stand roll force $TF(N)$ is less than 2 million pounds, but greater than 1 million pounds as determined in decision step 154, the program proceeds to block 156 where the mill spring constant $MSK(N)$ is set equal to 0.0304 relative to the slope of the curve portion 65 and the quantity $DS(N)$ set equal to 0.011. If the total stand roll force $TF(N)$ is less than 1 million pounds, the stand mill spring constant $MSK(N)$ is set in step 158 equal to 0.0365 relative to the slope of the curve portion 67 and the quantity $DS(N)$ is set equal to 0.017. The program then proceeds to block 160 where the desired stand unloaded screwdown position reference $SD(N)$ is set equal to the desired delivery thickness from the stand $H(N)$, minus the mill stand constant $MSK(N)$ times the total stand force $TF(N)$ divided by 10^6 , plus the quantity $DS(N)$ minus any offset $OS(N)$, minus the roll-flattening quantity $ROLFL(N)$. The offset $OS(N)$ is determined by a comparison

of the stand roll force determined delivery gauge from the stand N with the mass flow determined delivery gauge out of stand N as ratioed back from an X-ray reading of the gauge out of the last stand and the strip speed out of the last stand. This is per se a well-known operating procedure. The program then proceeds to block 110 where a check is made to see if the just-completed calculation was relative to the first stand. If it was, the program proceeds to block 112 which is the end of the program. If it was not, the program recycles itself back through block 114 where the next preceding stand, namely stand N-1, becomes stand N, for another calculation of the described quantities described relative to the previous stand, which for example could have been stand 6 and now through operation of block 114 would become stand 5, or stand 6 minus 1. The control program in this manner repeats the above calculations for each of stands 5, 4, 3, 2 and 1 before it terminates the calculations.

In FIG. 6, there is illustrated the work rolls 16 and 18 operative with a work strip 14, with an applied stand roll force $FT(N)$ equal to the quantity $PPIS(N)$ times W to indicate the roll force provided to effect the desired reduction in the thickness of the strip. It is assumed that the strip width W will be substantially the same for each of the stands. The distance between the respective centers of work rolls 16 and 18 is the difference between the roll diameter and the roll flattening.

In FIG. 7 there is illustrated the condition for the work rolls 16 and 18 are in contact with each other, and the applied stand roll force component here is now the roll flattening force $FF(N)$ which is equal to the pounds per inch of roll $PPIR(N)$ times the portion of the roll $(RL-W)$ extending beyond the width of the strip. The distance between the respective centers of the work rolls 16 and 18 is the difference between the roll diameter and the work roll to work roll flattening.

In general, whenever the work rolls have become worn, they touch together earlier than when they are new, because the work rolls that have worn tend to touch sooner beyond the width of the work strip. For example, if a plurality of 20-inch wide workpieces have been repeatedly rolled through a given mill stand and set of work rolls, there tends to form a localized wearing or grooving of the work rolls in the portion that was predominantly exposed to these 20-inch wide workpieces. This happens because in normal operation of a rolling mill stand, the position of each workpiece is more or less centered and controlled relative to the mill stand and is not laterally shifted to spread and somewhat equalize the wear of the work rolls along the length of the work rolls. This practice tends to make the less worn end portion of the work rolls touch sooner, since the central portion of the work rolls have had greater activity and hence have suffered greater wearing away of the roll surface. This can be corrected in one of two ways. In FIG. 5 a nominal roll wear magnitude quantity can be determined through operation of a suitable subroutine program and included before the program step 130, or a measured and empirically determined wear factor relative to the rolling activity of the work roll can be introduced at this location to influence the $WRWFL(N)$ quantity. This wear is sometimes difficult to determine, but can be related to the monitored amount of work strip that has passed through a given mill stand. Empirical data can be analyzed by trial and error such that corrected values for this wear factor can be included. It is known that work rolls wear somewhat linearly as a function of mill stand usage, so a program to estimate the roll wear as a function of monitored mill stand workpiece rolling activity can be provided so roll wear is calculated from known relationships. For example, in about four hours of typical steady mill stand use, a given work roll surface has been known to wear about 20 mils which is a substantial amount compared to the desired delivery thickness, typically 0.030 inches, of work strip passing through the mill stand; this wear is known to be substantially linear, so seven mils of roll wear would occur for this example at about $7/20 \times 4$ or about $1\frac{1}{2}$ hours of mill stand use.

It should be understood that any of the breaking up of the respective curves shown in FIGS. 2 and 3, for example, into three straight approximation lines could be done in several ways; for example, an exponential equation relationship could be used or if desired some points provided and interpolating between these points and so forth.

Although the present invention has been shown in relation to a specific embodiment, it should be readily apparent to those skilled in this art, that various changes in form and arrangement of the described apparatus and operations may be made to suit specific application requirements without departing from the spirit and scope of the present invention.

I claim:

1. In apparatus for determining the unloaded work roll position setting of at least one rolling mill stand in relation to a known stand roll force to effect a desired delivery thickness of a work strip from said mill stand, the combination of first means for estimating the roll flattening of at least one work roll in relation to said roll force applied to the stand, second means for determining if the work rolls will touch together beyond the width of the work strip in relation to the application of said known stand roll force, and third means for calculating the stand screwdown setting to provide a desired delivery work strip thickness from the mill stand in accordance with a first operation relative to said stand roll force and said work roll flattening if the work rolls are not touching together upon the application of said known stand roll force and in accordance with a second operation relative to said stand roll force and said work roll flattening in conjunction with an additional stand roll force in relation to said work roll touching condition if the work rolls are touching together upon the application of said known stand roll force.

2. In the method of controlling the screwdown position of a rolling mill stand having a pair of work rolls and in relation to a predetermined rolling operation to effect a desired delivery thickness of a work strip leaving said stand, the steps of calculating the first roll flattening condition of at least one of said work rolls in relation to a predetermined first roll force component, determining if said work rolls are touching beyond the width of said work strip, predicting a second roll force component in relation to a second roll-flattening condition when said work rolls are touching, and calculating the screwdown position of said mill stand in accordance with the sum of said first and second roll force components.

3. The method of claim 2, with the work roll flattening calculation being in accordance with a predetermined relationship between said predetermined rolling operation and the width of said work strip.

4. The method of claim 2, with the prediction of said second roll force component being in accordance with the magnitude of said work roll flattening in relation to the magnitude of the desired delivery thickness of said work strip from said mill stand.

5. The method of claim 2, with said screwdown position calculation including a consideration of the difference between the length of said work rolls and the width of said work strip.

6. An apparatus for controlling the screwdown position of a rolling mill stand in relation to a stand roll force required to deliver a desired thickness of work strip from said stand, the combination of first means for determining the work roll flattening in relation to the desired operation of said stand to deliver said desired work strip thickness from said stand, second means for determining the screwdown position of said stand to provide said desired operation of said stand in consideration of said work roll flattening so the resulting screwdown position of said stand permits said work roll flattening to occur when the desired work strip thickness is delivered from said stand.

7. The apparatus of claim 6, with said first means determining the work roll flattening in accordance with the width of said work strip and a predetermined work roll force required to roll said work strip to deliver said desired thickness from said stand.

8. The apparatus of claim 6, including third means for comparing said desired work strip delivery thickness from said stand and said work roll flattening to determine if said screwdown position should be modified in relation to the touching of the work rolls beyond the width of said work strip.

9. The apparatus of claim 7, with said second means determining the screwdown position in relation to the sum of said predetermined work roll force and any additional roll force provided in relation to the work rolls touching beyond the width of said work strip.

10. The apparatus of claim 6, including third means operative to determine if the work rolls of said mill stand are touching together beyond the width of said work strip and determining the modification of said screwdown position required to compensate for this touching condition.

11. The apparatus of claim 6, including third means for calculating the roll force component relative to said work rolls touching together beyond the width of the work strip, with said second means being responsive to said roll force component for the calculation of said stand screwdown setting.

12. In apparatus for establishing the unloaded work roll position of a rolling mill stand in relation to a predetermined roll force to effect a work strip desired delivery thickness from said stand, the combination of means for determining a first flattening condition of at least

one work roll relative to said work strip and the application of said predetermined roll force,

means for comparing said first flattening condition with said desired delivery thickness to determine if the work rolls touch together beyond the width of said work strip,

means for determining a second flattening condition of at least one work roll relative to the touching together of said work rolls, and

means for determining said unloaded work roll position to provide one of a first operation of said mill stand in accordance with said first flattening condition when the work rolls do not touch together and a second operation of said mill stand in accordance with said first flattening condition and said second flattening condition when the work rolls do touch together.

13. The apparatus of claim 1, with said second means determining said additional stand roll force in accordance with the additional roll flattening related to the rolls touching together beyond the width of the work strip.

14. The method of claim 2, with said screwdown position calculation being in accordance with said sum and said first roll flattening condition when the work rolls are touching and being in accordance with said first roll force component and said roll flattening condition when the work rolls are not touching beyond the width of said work strip.

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