APPARATUS FOR CONTROLLING THE ROLLING OF TAPERED SHEETS

Filed Sept. 18, 1951

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APPARATUS FOR CONTROLLING THE ROLLING OF TAPERED SHEETS

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Application September 18, 1951, Serial No. 247,169

5 Claims. (Cl. 80—56)

1 This invention relates to apparatus for con-
trolling sheet thickness in rolling mills, presses, 
forges and the like. In such devices a slab of 
metal is sent through the mill or press and pres-
sure is applied thereto for the purpose of thinning 
out the slab into a longer sheet of uniform thick-
ness.

The present invention however, has for one of 
its principal objects the provision of apparatus 
whereby there may be automatically obtained a 
final product in the form of a metal strip having 
any desired taper in either direction.

Further objects and advantages of this inven-
tion will become apparent from the following de-
tailed description thereof.

The accompanying drawing is in part a side 
elevation of a rolling mill stand and in part an 
electric wiring diagram, embodying the inven-
tion.

Referring to the drawing, my invention is dis-
closed as applied to a rolling mill stand indicated 
generally at 10. Such stand includes side frame 
members 11 and a central cutout portion 12 in 
which are slidably mounted bearing blocks 13 
and 14 which form the bearing members for large 
back-up rollers 17 and 18. Other bearing blocks 
15 and 16, slidable in the first bearing blocks, 
form the bearing members for work rollers 19 
and 21. Pressure is applied to the work rollers 
through the back-up rollers by means of a screw-
down motor M which through suitable reduction 
gearing 21 operates a screw 22 which applies 
pressure to the bearing blocks in which rollers 
17 are journalled. The sheet S may be fed to 
the mill stand on rollers 25 and it is desired 
that the sheet shall leave the mill stand with 
a predetermined taper. The simplest method of 
achieving a continuous taper is either to apply 
continuously increasing pressure to the back-
up roll 17 by causing the screw 22 to screw dow-
wardly continuously, or to start with the gap 
between rollers 15 and 16 small and continuously 
reduce the pressure on work roll 17 by continuous 
rotation of screw 22 in the opposite direction. 

The first will give a gradually decreasing thick-
ness to the strip as it leaves the mill stand while 
the second will give a gradually increasing thick-
ness to the strip.

The problem of obtaining a uniform taper of 
any desired rate of increasing or decreasing thick-
ness would be a simple one if equal increments 
of pressure on the work rolls resulted in linear 
displacement of the mill frame and if there were 
no slippage between the strip and the rolls. How-
ever, as is well-known in this art there are many 
factors which make the displacement of the 
stand non-linear, and therefore merely operating 
the screw-down motor in one direction or the 
other at a predetermined rate will not necessarily 
yield a strip having a uniform taper upon leav-
ing the mill stand. The slippage also cannot be 
accurately predetermined.

In order to obtain such uniformity of taper 
at any desired rate of increase or decrease of 
thickness I have provided the following apparatu-
s: The screw-down motor M is continuously 
energized from a suitable source of A. C. supply 
which energizes the motor field coil 30. The 
motor may be operated in either direction by 
means of switch 31 which in its lowered position 
as shown in the drawing makes contact at 32, 
33 to energize the motor in one direction, and 
in its raised position makes contact at 33, 34 
to energize the motor in the reverse direction.

The energization of the motor is controlled by 
means of a switch 35 and the rate of speed of the 
motor may be controlled by a rheostat 36.

By the above described mechanism the screw-
down motor will run continuously in one direction 
or the other, as desired, to yield a predetermined 
taper in one direction or the other as the strip 
leaves the mill stand. However, as stated here-
before, uniform increments of movement of the 
screw 22 do not yield uniform increments 
or decrements of mill stand pressure and it will 
be found that the strip as it leaves the mill will 
vary from the predetermined or calculated taper.

Therefore it is necessary to provide means re-
sponsive to the thickness of the strip as it leaves 
the mill stand for controlling motor M in such 
direction as to vary the rate of screw-down pres-
sure so as to compensate for such variations 
in thickness. For this purpose I provide means 
in the form of a potentiometer P having a con-
tact arm C which is driven over the rolls of P to 
tap a varying voltage which is a function of the 
length of strip which has passed out of the mill 
stand. Thus for example contact C may tap 
from zero to 50 volts in the time that 50 ft. of 
a strip has passed through the mill stand. In 
this example each increment of one volt tapped 
by contact arm C corresponds to a foot of move-
ment of the strip, and since the rate of rotation 
of screw 22 is predetermined, each increment of 
voltage tapped by contact arm C corresponds to 
an increment of taper desired on strip S. The 
movement of arm C therefore represents the de-
sired rate of taper on strip S. For this purpose 
it is necessary that the rate of movement of con-
tact arm C be correlated with the rate of move-
ment of the strip or of the mill stand. Therefore there is provided a serrated roller in engagement with the strip as it leaves the mill, the linear travel of roller is being equal to that of the strip. The movement of roller is communicated to the contact arm C through a system of selsyn transmitter 41 and selsyn receiver 42 which drives through an electromagnetic clutch 43 and a reduction gear train 44 so that contact arm C will cover a predetermined angular distance on potentiometer P corresponding to the length of strip S which is leaving the mill stand.

Thus the travel of contact arm C of potentiometer P represents the desired taper. A potentiometer with constant pitch of winding would represent a linear taper. Any type of taper can be obtained by suitable design of the potentiometer winding. To find out whether the desired taper matches the actual taper and therefore whether any change in speed of motor M is necessary, there is provided a second potentiometer P' whose contact arm C' may be driven by a galvanometer G which is energized from any suitable thickness gauge, such as an X-ray receiver 47 which receives the rays transmitted through the strip S by an X-ray transmitter 48. The output of the X-ray transmitter 48 is applied to the coil 49 of galvanometer G and by this means, the degree of movement of its armature C' is a function of the thickness of the strip as it leaves the mill. Thus, for example, as the thickness of the strip is continuously decreasing, contact arm C will be driven continuously in the same direction as contact arm C, and the constants of the circuit may be made such that when the actual thickness is the same as the calculated thickness contact arm C' will tap the same voltage supplied by a source 50 as contact arm C. The potentiometers P and P' are connected in parallel to source 51 so that if contact arms C and C' tap the same voltage, there will be no output across the leads 52. However, if the actual thickness deviates from the calculated thickness in one direction or the other, there will be a differential voltage signal in the direction or the other which when amplified by amplifier 51 yields an output which is applied to the control of motor M in such a direction as to increase or decrease the rate of operation of motor M in one direction or the other to bring the thickness of the strip back to the calculated thickness.

The output of amplifier 51 may be caused to control the speed of motor M by the following mechanism: The field coil 53 of motor M is continuously energized from the D. C. source, but the armature A may be controlled from a standard Ward-Leonard motor control. The latter comprises a D. C. excited motor M' which may be driven at a speed determined by a rheostat 55, the motor driving a generator G' whose field F' is excited from the D. C. source. The output of the generator is applied to the armature A of motor M. In order that the output of amplifier 51 shall vary the speed of motor M, the amplifier is of the type wherein the polarity of the output voltage corresponds to the polarity of the input voltage. Thus, a positive or negative voltage from the output of amplifier 51 may be applied to a field coil F" to vary the voltage which is generated by the generator G' and applied to armature A. The connections are, of course, such that the variation applied to armature A is in the direction to tend to eliminate the differential between members C and C'.

When the rear end of the strip is about to pass through the mill it is necessary to return the screw 25 to its initial position. Thus in the case where the strip is being pulled by increasing the screw-down pressure continuously, it is necessary to reverse the direction of rotation of the windings 25 to raise the same. The operation of the motor is controlled as follows: When the forward end of the strip is about to enter the mill, a finger 60 pivoted at 54 rides upon the strip and is tilted in a counterclockwise direction to cause contact 62 carried thereby to engage contact 63. This energizes a coil 64 by way of leads 66, 65 and a suitable source of E. M. F. 68, to pull down switch 21 against the action of spring 67 to close the circuit through motor M at 32, 33 to cause the motor to operate in a screw-down direction. At the same time there is energized in the circuit of coil 65 a coil 69 which opens contacts 71 against the action of spring 72 to deenergize coil 73 and permit main switch 35 to close. When the end of the strip has passed finger 60, spring 74 will cause contact 62 to leave contact 63 and break the circuit through coil 63. This will permit spring 69 to raise switch 21 and close contacts 33, 34 which will reverse the direction of operation of motor M. When the motor is re-energized, coil 63 will close to permit coil 73 to be energized from source 64, the deenergization of coil 70 having permitted spring 72 to close contacts 71, and the energized coil 73 will open switch 35 to stop the motor.

When the strip has left the mill, there is energized means for returning contact arm C to its initial position. For this purpose there is provided a finger 80 adapted to ride on the strip S. Finger 80 is pivoted at 61 and carries contact 62'. When finger 82 rides on the strip, contact 82' engages contact 83' to close a circuit through coil 99 of electromagnetic clutch 83. The circuit of coil 99 includes leads 88, 87, 86 and source of voltage 92. When the strip S has left the mill, spring 86' causes contact 82' to leave contact 83' and engage contact 84. This energizes coil 99 to permit spring 93 to disengage the clutch and energizes a motor M'. The latter drives the gearing 66 in a reverse direction until contact arm C engages contact 95 to close the circuit through coil 98, said circuit including source of voltage 96, to break contacts 85 against the action of spring 100. The contact arm C' will turn to the lower end of the scale by reason of the fact that the X-ray receiver receives maximum transmission from the X-ray transmitter when the strip has passed through the mill.

On starting again, a strip moves to the mill stand, and the finger 60 is tilted to cause contacts 62, 63 to engage to energize coil 93 to pull switch 31 down to make contacts 32, 33 for screw-down operation of motor M. The energization of the circuit through coils 88 and 96 breaks contact 71 to deenergize coil 73 and permit switch 35 to close. When the strip engages finger 60, contact 62' leaves contact 83' and engages contact 85 to energize the electromagnetic clutch. A manually operated double throw switch 110 enables the operator to actuate motor M normally as a screw-down or screw-up motor, depending upon the direction of taper desired.

The elements 69, 80, 87, 47-56 have been shown spaced substantially from the frame 11 for the purposes of better illustration, but it will be understood that in practice these ele-
ments are positioned as close to the frame as practicable.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. Apparatus for imparting a predetermined taper to a strip of material as it passes through a rolling mill stand or the like, said mill stand having work rolls through which the strip is passed, comprising means including a motor for causing one work roll to advance toward and recede from the other work roll, said motor being adapted to operate continuously as the strip passes through the stand for applying pressure continuously in a given direction to provide continuous increase or continuous decrease in pressure between the rolls to taper the strip in the desired direction, a first actuated means actuated as a function of the speed of the strip through the work rolls, a second actuated means actuated by said first actuated means as a function of the desired taper, a third actuated means actuated as a function of the actual taper, a fourth actuated means actuated in accordance with the differential of actuation of said second and third actuated means, and a fifth actuated means actuated by said fourth actuated means for varying the rate of application of pressure applied to the strip in a direction to eliminate the differential between the second and third actuated means.

2. A device as specified in claim 1, characterized by a sixth actuated means responsive to passage of the strip through the mill stand, and means actuated by said sixth actuated means for restoring said second actuated means to initial position when the strip leaves the mill stand.

3. A device as specified in claim 1, which includes a seventh actuated means responsive to passage of the strip through the mill stand, and means actuated by said seventh actuated means for restoring said work rolls to initial positions when the strip leaves the mill stand.

4. A device as specified in claim 1, which includes a seventh actuated means responsive to passage of the strip through the mill stand, and means actuated by said seventh actuated means for reversing the direction of operation of said motor when the strip leaves the mill stand.

5. A device as specified in claim 4, which includes means for stopping the motor when the rolls reach their initial positions.

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