March 7, 1944. E. B. HUDSON ET AL 2,343,554

GAUGE CONTROL

Filed April 5, 1938 3 Sheets-Sheet 1

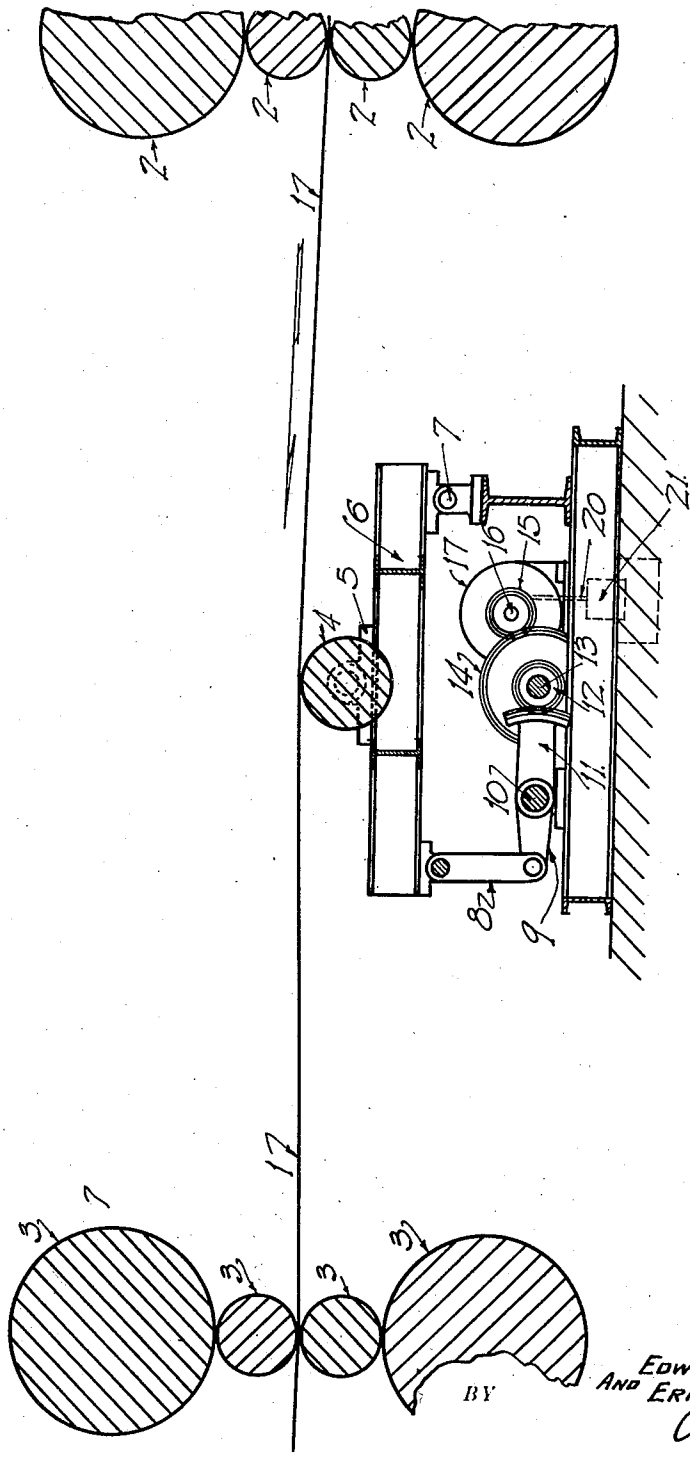

FIG. 1.

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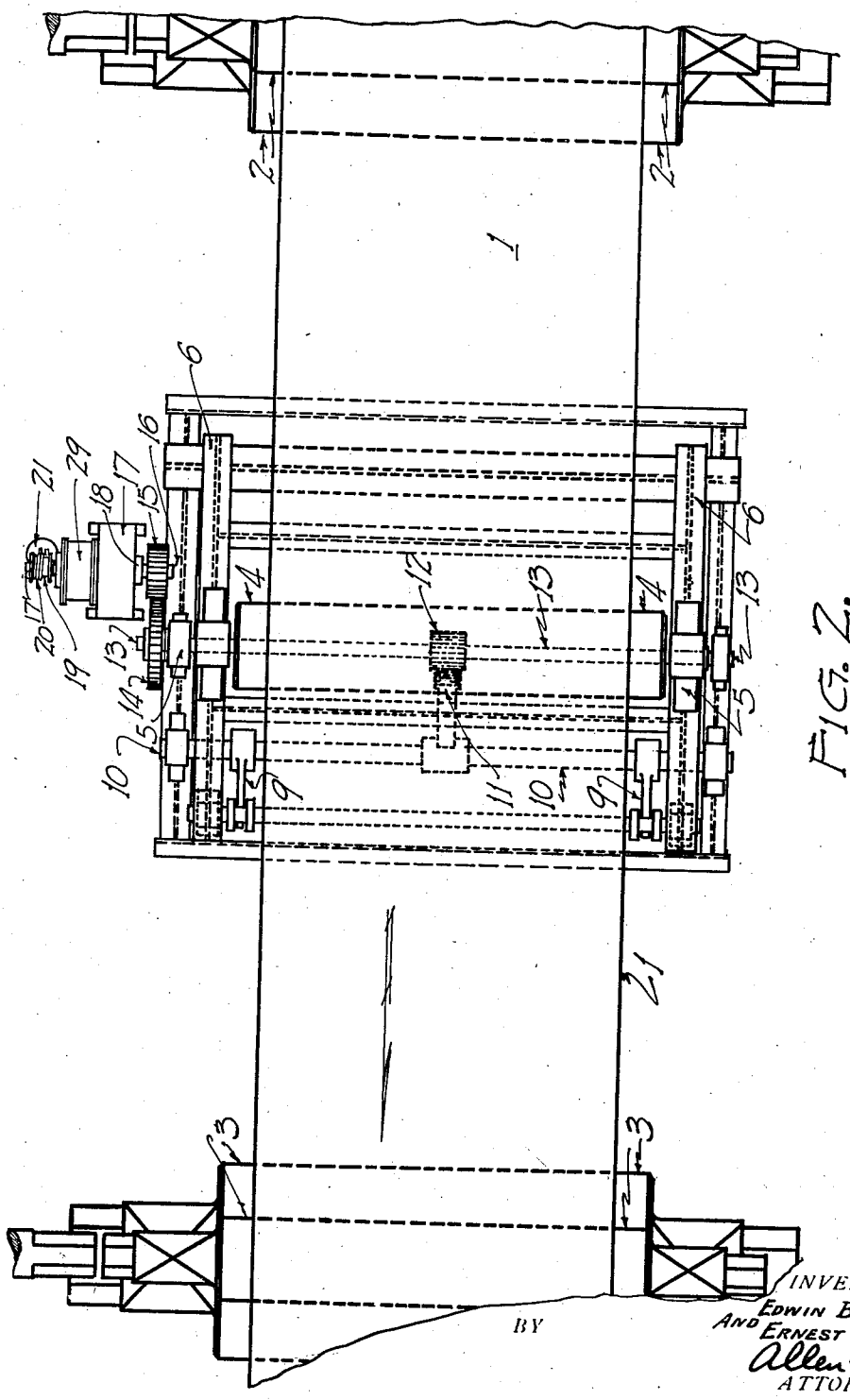

FIG. 2.

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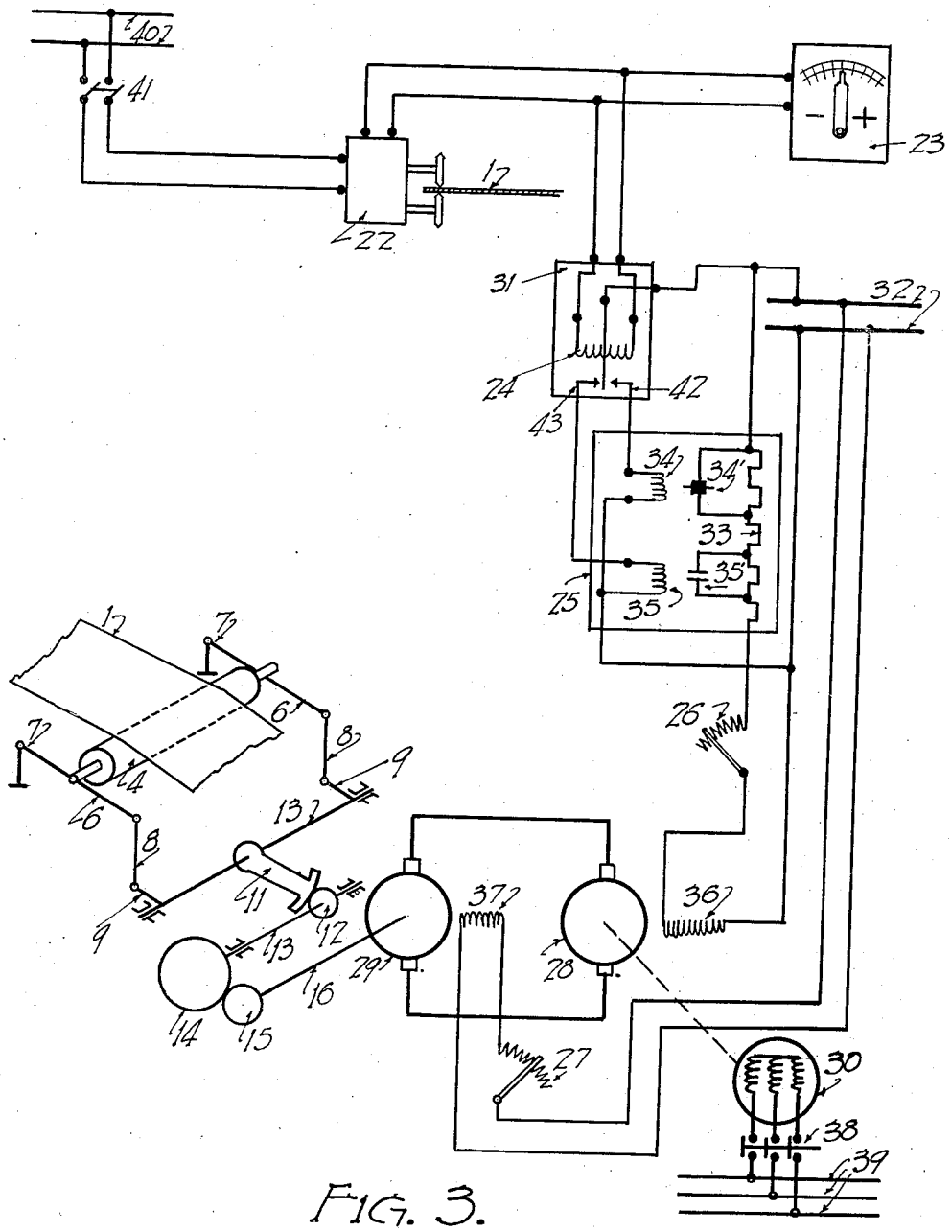

FIG. 3.

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UNITED STATES PATENT OFFICE

2,343,554

GAUGE CONTROL

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Application April 5, 1938, Serial No. 200,155

5 Claims. (Cl. 80—35)

Our invention relates to the control of gauge thickness in a cold reduction mill or the like, and it includes a method of controlling gauge as well as apparatus suitable for carrying out the method.

It is known by those skilled in the art that where strip is being reduced in a mill, the gauge produced will vary with the tension on the strip on the entering side of the mill. If the entering tension of the strip is increased, the separating force between the rolls is decreased, with the result that spring in the elastic mill structure is reduced, thereby causing the mill rolls to more closely approach each other and produce a thinner gauge. Conversely a decrease in the entering tension causes an increase in the separating force between the rolls which in turn causes increased spring in the elastic mill structure, with the result that the mill rolls move farther apart, and so produce a thicker gauge.

It is an object of our invention therefore to control the gauge produced within reasonable limits by a variation of the entering tension without the necessity of making any adjustments to the mill screw. In carrying out this object, we provide means for applying tension on the entering side of the mill, which are controlled directly by the actual gauge being rolled at any particular instant.

It has been attempted in the past to control gauge by automatically adjusting the mill screws. This method has not proved practicable for various reasons, among which are the lag in the electrical control and the inertia of the moving parts. Other attempts have been made to improve gauge by maintaining constant tension on a strip. These methods likewise have not proved practicable, since the strip being rolled is in practice imperfect in gauge, and therefore constant tension cannot remove these variations. In these devices, the tension is set at some predetermined value and means are provided for maintaining that value. But no controlling means are provided between the constant tension device and the strip because in these apparatuses the objective is constant tension rather than constant gauge.

As distinguished from these prior attempts we are concerned with the production of constant gauge by automatically varying the entering tension and more specifically by controlling the tension through a gauging means which is in direct contact with the strip.

Other objects of our invention include the provision of means for controlling gauge, which are substantially immediate in operation so that there is no appreciable time lag, and the provision of an apparatus which is relatively simple and not likely to get out of order.

These and other objects of our invention which will be described more in detail hereinafter, or which will appear to one skilled in the art upon reading these specifications, we accomplish by that method and by that construction of which we shall now describe an exemplary embodiment.

Reference is now made to the drawings in which:

Figure 1 is an elevational view showing in a diagrammatic manner a pair of mill stands, and showing the tension controlling device in operative position.

Fig. 2 is a plan view of the device of Fig. 1 shown in the direction of passage of the strip.

Fig. 3 is a schematic view of the tension applying device together with a wiring diagram showing the operation.

Briefly in the practice of our invention, we provide means in advance of a stand of rolls for applying tension to the strip. These means preferably include a roller adapted to be urged against the strip to force the strip to assume a non-linear path. We then provide a gauging device on the exit side of the mill, and means responsive to the indications on the gauging device to cause the tension exerting device to exert greater or less tension.

In Figure 1 we have shown a strip 1 being operated upon in a tandem train of rolling mills, indicated respectively at 2 and 3. Intermediate the mills 2 and 3 is a device including a roller 4, positioned somewhat higher than the pass line so that the strip 1 is at all times in contact with the roll 4. This roll is mounted in bearings 5, supported on a frame 6, which is hinged to a part of the frame on one side as indicated at 7. The opposite side of the frame 6 carries the links 8 which are connected to levers 9, which are fixedly mounted upon the shaft 10. The shaft 10 carries a lever 11 which is provided with a segment gear which is in meshing relationship with a segment pinion 12 on the shaft 13. Shaft 13 is operatively connected to the shaft 16 by means of the gear 14 and pinion 15. The shaft 16 in turn is directly connected to the gear head 17 and torque motor 29, by means of the coupling 18. The tail shaft 17' of the motor 29 is provided with a sheave 19, rope 20, and weight 21, arranged to revolve the armature of the motor 29 in the direction which will cause the roll 4 to be lowered when the torque output of the motor 29 is reduced.

From the above description it will be clear that by variation in the torque output of the motor 29, the tension in the strip can be varied by means of the roll 4, so that if means are now provided to cause variation in the torque output of the motor 29, in response to variations in the gauge being produced, the gauge of the strip will be automatically controlled.

The control of the torque output of the motor 29 is accomplished in the following manner:

Referring to Fig. 3, the strip gauge being produced is measured by an electro-limit gauge 22, having an indicator 23, which is preferably of the under and over type. The gauge and indicator do not form any part of our invention, and since they are well known commercial instruments, we shall not describe them further, except to state that variation in strip thickness resulting in variations in voltage output from the gauge 22, cause the pointer of the indicator 23 to move to one side or the other of the zero position. A sensitive relay of known construction is connected across the terminals of the indicator 23, so that the variations in voltage output of the gauge 22 will affect the moving contactor of the sensitive relay 31, by means of the relay coil 24. The function of the sensitive relay and its contactor will be described hereinafter.

A motor generator set comprising a motor 30 and generator 28 is provided, the motor 30 being fed through the starter 38 from a power source 39. The armature of the generator 28 is electrically connected to the armature of the torque motor 29, which as above described, actuates the roller 4. The torque motor 29, which is designed to have a low inertia of its moving parts, is provided with a shunt field 37, which is fed from an external power source 32 through a shunt field rheostat 27. The generator 28 is provided with a shunt field 36 in the circuit of which is placed a field rheostat 26, and a regulating resistor 33 which will be described in more detail hereinafter.

From the foregoing it will be clear that an increase in the field current of the generator shunt field coil 36, will result in a higher voltage output on the armature of the generator 28, whereby the armature voltage of the torque motor 29 is increased, thus producing an increase of torque on a shaft of the torque motor 29. As previously described, such torque increase results in the application of greater tension by means of the roll 4. Conversely if the yield current of the generator shunt field coil 36 is decreased, a lower voltage output of the armature of the generator 28 will result in a lower impressed armature voltage on the torque motor 29, so that the torque on the shaft of the torque motor 29 is reduced. It is to be noted that the direction of the torque, whether it be increased or reduced, remains the same. The counterweight 21 is adapted to act in the opposite direction to that of the impressed torque, whereby when the torque of the motor 29 is decreased, the counterweight 21 acts to lower the tension roll 4, so as to reduce tension in the strip 1.

The regulating resistor 33 in the shunt field circuit of the generator 28, includes contactor coils 34 and 35, with their respective contacts 34' and 35'. The contacts 34' and 35' respectively shunt out portions of the regulating resistor 33. The coils 34 and 35 are respectively in circuits with the contacts 42 and 43 of the sensitive relay 31. As will be clear from the drawing, this entire portion of the system is fed from an external source 32.

It will be noted that in the de-energized condition of the coils 34 and 35, the contact 34' is normally closed and the contact 35' is open. This condition obtains when contact is not being made either at 42 or at 43. Thus contact 34' serves to short circuit a portion of the regulating resistor 33. Now if the strip thickness increases so as to require greater back tension, the sensitive relay 31 actuated from the gauge 22 causes contact circuit 43 to close energizing the coil 35, and closing the contact 35'. An additional portion of the coil 33 has thus been short circuited out whereby an increased field current for the generator shunt field coil 36 is provided. As hereinabove described, this will result in causing the roller 4 to exert increased back tension on the strip 1.

If the strip thickness decreases, the sensitive relay 31 causes the contact 42 to be closed, energizing the coil 34 and opening the contact 34'. In the meantime of course, the coil 35 has been de-energized and the contact 35' is again open. The opening of the contact 34' adds a portion of the regulating resistor 33 into the field circuit of the generator 28, whereby as previously described, the torque of the motor 29 is reduced, so that the counterweight 21 causes the roll 4 to be lowered, whereby the back tension on the strip 1 is reduced.

In practice and in setting up, the motor generator set and the motor 29 are running, the shunt field rheostat 26 is in its "all in" position, resulting in a relatively low output voltage on the armature of the generator 28. By a certain adjustment of the generator field rheostat 26 and the torque motor field rheostat 27, the torque motor 29 is caused to develop a certain torque so as to cause the roll 4 to be pressed upwardly against the moving strip 1, thereby bringing the strip 1 under tension. The desired amount of tension for the particular rolling conditions such as mill screw setting, gauge, etc., are then established. The gauge head 22 is placed on the strip, and the switch 41 is closed, whereby the gauge 22 is energized from a power source 40. From this point on the system is fully automatic, as has been previously described.

We have described only the basic elements of the torque regulator which we indicated generally at 25, and it is to be understood that various refinements such as anti-hunting coils, quick make and quick break contacts, are desirable, but have not been described since they form no part of this invention.

Various modifications of our invention will suggest themselves to those skilled in the art. For example, the torque regulator instead of being in the generator shunt field circuit, might be connected into the shunt field of the torque motor, or a torque regulator might be employed affecting both the generator and the torque motor shunt fields.

It is also within the scope of our invention to eliminate the counterweight 21 and employ a torque regulator which functions in two directions with reference to the shunt fields so as to produce a clock-wise and a counterclock-wise torque on the torque motor shaft. It would also be within the scope of our invention to provide vernier rheostats for fine regulation, and it would be practicable to provide a small exciter for the motor generator set, thus eliminating the external power source 32.

In view of the various modifications discussed above, and others which will suggest themselves to one skilled in the art, we do not intend to limit ourselves otherwise than as pointed out in the claims which follow.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is:

1. In a mill for rolling strip, a gauging device on the exit side of said mill, a roller mounted in a position to bear against said strip on the entering side, a shaft, operative connections from said shaft to the mounting of said roller whereby a torque on said shaft causes said roller to be urged against said strip, and electrical means acting directly on said shaft to vary the torque thereon in accordance with variations in the gauge being produced by said mill as determined by said gauging device.

2. In a mill for rolling strip, a gauging device on the exit side of the mill, a roller mounted in a position to bear against said strip on the entering side, a separately excited torque motor operatively connected to said roller mounting whereby a torque produced by said motor will cause said roller to be urged against said strip as a function of the value of the armature current supplied to said motor, means for supplying armature current to said motor to produce a torque, and means for varying the armature current supplied to said torque motor in accordance with the variations in gauge being produced by said mill as determined by said gauging device.

3. In a mill for rolling strip, a gauging device on the exit side of said mill, a roller mounted in a position to bear against said strip on the entering side, a separately excited torque motor operatively connected to said roller mounting whereby a torque produced by said motor will cause said roller to be urged against said strip, a generator and motive means therefor, electrical connections between the armatures of said generator and torque motor, a field for said generator, and means for varying the field current of said generator in accordance with the variations in the gauge being produced by said mill as determined by said gauging device.

4. In a mill for rolling strip, a gauging device on the exit side of said mill, a roller mounted in a position to bear against said strip on the entering side, a separately excited torque motor operatively connected to said roller mounting whereby a torque produced by said motor will cause said roller to be urged against said strip, a generator and motive means therefor, electrical connections between the armatures of said generator and torque motor, a field circuit for said generator, said circuit including a resistor a portion of which is normally by-passed and another portion of which is normally in the circuit, and means operative in response to an increase in gauge being produced by said mill, as determined by said gauging device, for shunting out that portion of said resistor which is normally in the circuit, and means operative in response to a decrease in gauge being produced by said mill, also as determined by said gauging device, for putting into the said field circuit that portion of said resistor which is normally by-passed.

5. In combination with a rolling mill for rolling strip, in which the strip tension on the entering side of the mill may be controlled by varying the output of a generator, means for varying said output in accordance with variations in the gauge being produced by said mill, comprising a field circuit for said generator including a resistor a portion of which is normally by-passed and another portion of which is normally in the circuit, contactors for respectively putting into the circuit said by-passed portion and by-passing said normally in portion, a relay having two contacts, operative respectively to open the one and close the other of said contactors, an under-and-over type gauge on the exit side of said mill and connected to said relay, whereby an increase in gauge will cause said relay to make one of its contacts, and a decrease in gauge will cause said relay to make the other of said contacts.

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