

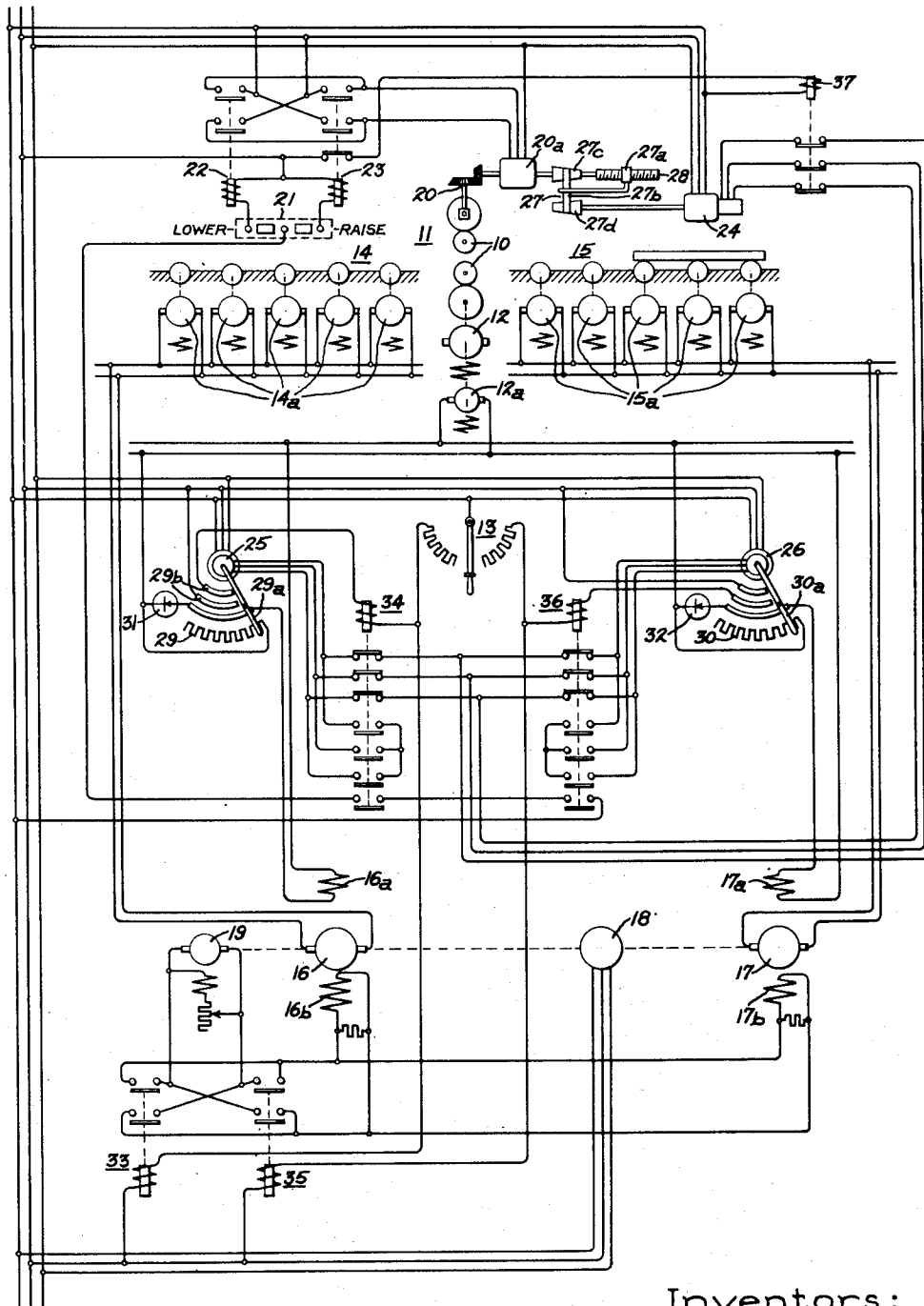
June 15, 1943.

H. WICKLER ET AL

2,322,080

CONTROL FOR RUN-OUT TABLES OF REVERSING MILLS

Filed Nov. 6, 1940



Inventors:
Herbert Wickler,
Hugo Heymann,
by *Harry C. Dunkan*
Their Attorney.

UNITED STATES PATENT OFFICE

2,322,080

CONTROL FOR RUNOUT TABLES OF
REVERSING MILLS

Herbert Wickler, Berlin-Hohenschonhausen, and
Hugo Heymann, Berlin-Lankwitz, Germany,
assignors to General Electric Company, a cor-
poration of New York

Application November 6, 1940, Serial No. 364,588
In Germany December 15, 1939

11 Claims. (Cl. 80—33)

This invention relates to control systems, more particularly to control systems for reversing rolling mills, in the operation of which a close synchronization between the delivery speed of the material and the peripheral speed of the rolls of the run-out tables must be established, in order to avoid scratching of the material by sliding it over the rolls. In view of the reduction in thickness through rolling, the speed of the material entering the mill stand is lower than the speed of the material leaving the mill stand and therefore the speeds of the run-out table motors on opposite sides of the roll stand must be correspondingly different. Using individual run-out table motors with Ward-Leonard drive, the speeds of the motors are adjusted in accordance with the mill motor speed by varying the voltage of the Ward-Leonard generator by means of a tachometer generator, coupled to the mill motor. The foregoing conditions are fulfilled by feeding the run-out table motors of the two tables on opposite sides of the mill stand from one of two Ward-Leonard generators and by additionally regulating the voltage of one of the two Ward-Leonard generators by means of a rheostat adjusted according to the set roll opening (pass reduction of the thickness of the material) in such a way that the two run-out tables are operated with speed differing in accordance with the pass reduction (in thickness).

Furthermore, the individual driving motors of both run-out tables must adapt themselves to the speed of the main rolling mill motor. In this connection it must also be taken into account, that the material runs through the mill stand in several passes successively in opposite directions and undergoes, according to the adjusted roll opening, various reductions. In view of the lower speed of the material entering the mill as contrasted with the speed of the material leaving the mill, which difference results from the reduction in thickness of the material, the feeding rolls must run slower than the rolls of the run-out table at the delivery side of the stand, in accordance with each of the various reductions in the thickness of the material.

In carrying the invention into effect in one form thereof, means are provided for adjusting the speeds of the run-out tables in accordance with the speed of the mill rolls, and in varying the relative speeds of the run-out tables in accordance with the amount of the reduction of the thickness of the material that is to be effected.

For a better and more complete understanding of the invention, reference should now be had

to the following specification and to the accompanying drawing, the single figure of which is a simple, diagrammatic sketch of an embodiment of the invention.

Referring now to the drawing, the thickness reducing rolls 10 of the mill stand 11 are driven by the rolling mill motor 12, which, by moving the master switch 13 in one or the other direction from its central or "off" position, can be started in either direction of rotation and its speed adjusted as desired. Run-out tables 14 and 15 driven by individual table driving motors 14a and 15a are provided on each side of the mill stand 11. The run-out table motors 14a and 15a are supplied separately from the adjustable voltage generators 16 and 17 respectively, which are driven by any suitable driving means such as the constant speed three-phase motor 18. For adapting the voltage of the adjustable voltage generators and thereby the speed of the run-out table motors to the speed of the main mill motor 12, the field windings 16a and 17a of the two generators are supplied from a tachometer generator 12a mechanically coupled to the main mill motor 12. In order to compensate the voltage drop in the armature circuits of the run-out table motors, the adjustable voltage generators 16 and 17 are each provided with second field windings 16b and 17b, respectively, which are excited with constant voltage by a special exciter 19.

For adjusting the roll opening on the mill stand a roll screw-down mechanism 20 is provided, which is driven by the screw-down motor 20a, which can be started in the one or other direction by means of the master control device 21 and the contactors 22 and 23 controlled thereby. Coupled with the screw-down motor 20a is an electrical motion transmitting device 24 which is electrically connected with electrical motion receiving devices 25 and 26 for synchronized operation, the coupling being made through a continuously variable speed transmission device 27, the ratio of which can be varied by means of a nut 27a riding on the screw 28 which is driven by the screw-down motor 20a, and the purpose of which will be explained in the following. The receivers 25 and 26 are intended for operating the two rheostats 29 and 30 in circuits of the field windings 16a and 17a of the adjustable voltage generators 16 and 17, respectively.

In order to explain the operation of the control, it is assumed that a rod of 100 mm. thickness is first to be rolled down to a thickness of 50 mm. by passing from right to left and then by

a second pass in the opposite rolling direction from 50 mm. down to 25 mm. This requires, therefore, that in each of the two passes a 50 per cent thickness reduction is to be effected. Accordingly the run-out table 15 must run during the first pass only half as fast as the run-out table 14, while during the second pass the run-out table 14 must run only half as fast as the run-out table 15. Therefore the voltages of the adjustable generators 16 and 17 must be regulated by adjusting the excitations of fields 16a and 17a differently from each other. This is accomplished by correspondingly different effective settings of the rheostats 29 and 30 in accordance with the amount of operation of the screw-down, i. e., the amount of reduction to be effected. This adjustment of the rheostats 29 and 30 can, however, not be carried out simply according to a linear function of the screw-down movement because during the first pass a screw-down distance of 50 mm. corresponds to a 50 per cent thickness reduction but during the second pass a 50 per cent thickness reduction corresponds to a screw-down distance of only 25 mm. For both passes, however, an equally large adjustment of the rheostats 29 and 30 must be made, because in each case one run-out table must run only half as fast as the other. In order now to obtain this equally large adjustment of the rheostats for the screw-down distances of different magnitudes, the variable transmission 27 is connected between the screw-down motor 20a and the transmitter 24. When moving the screw-down in the closing direction, the ratio is changed by turning the screw 28 and thereby moving the nut 27a riding on it to shift the belt 27b on the cone pulleys 27c and 27d in such a direction that with the roll opening becoming smaller the transmitter 24 is driven with increasingly higher speed.

Initially, the screw-down motor 20a of the mill stand, whose rolls 10 may originally have an opening of 100 mm., is started in the downward direction by the control switch 21 and the closing of contactor 22, and this is done until the new roll opening is adjusted to a distance of 50 mm. At the same time the rotor of the transmitter 24 is rotated and the rotors of the receivers 25 and 26 are rotated corresponding amounts in a direction against the rotation of the rotating magnetic fields of their stator windings, so that an especially large synchronizing torque results. The number of poles of the transmitter 24 is preferably smaller than that of the receivers. In accordance with the ratio of the number of poles on the transmitter and receivers a corresponding transmission for slower speed and a correspondingly larger adjustment torque on the receivers is obtained. If, for example, the transmitter 24 has two poles and the receivers have eight poles, the rotors of the receivers rotate through a quadrant only, while the rotor of the transmitter rotates through a complete revolution.

By changing the position of the movable contacts 29a and 30a of the rheostats 29 and 30 from the illustrated original positions, a part of the resistance of the rheostats is connected into the field circuits 16a and 17a and thereby a weakening of the field of both Ward-Leonard generators is prepared.

By moving the master switch 13 to the left the main mill motor 12 is started for rolling in the direction from right to left. The tachometer generator 12a will now excite the field windings 16a and 17a of the two adjustable voltage gener-

ators 16 and 17 in accordance with the speed of the mill motor as adjusted by the master switch 13, and the run-out table motors assume a speed corresponding to the mill motor speed and to the additional regulation resulting from the adjustments of the rheostats 29 and 30. The rectifiers 31 and 32 connected in parallel to the resistances of the rheostats 29 and 30 respectively, which pass current in only one direction, permit the adjustment of only one of the two rheostats to be effective, i. e., the adjustment of rheostat 30. If it is assumed that by moving the master switch 13 to the left and that for the corresponding rotations of the mill motor 12 and the tachometer generator 12a the polarity plus is established on the left armature terminal of the tachometer generator and the polarity minus on the right armature terminal, the rectifier 32 blocks the current in this direction and the resistance of rheostat 30 which is connected into the circuit of field winding 17a becomes effective. At the same time the resistance of the rheostat 29 is short circuited by the rectifier 31, passing current in this direction, and therefore the rheostat adjustment is made ineffective. In this way, therefore, a weakening of the field of the adjustable voltage generator 17 is effected, which corresponds to the percentage thickness reduction of the material being rolled, and thereby a correspondingly lower speed of the run-out table motors 15a with respect to the speed of the run-out table motors 14a is obtained.

When the master switch 13 was moved to the left the contactor 33 was closed simultaneously with the starting of the mill motor, and this contactor in closing connected the auxiliary field windings 16b and 17b of the two adjustable voltage generators 29 and 30 to the special exciter 19 for the purpose of compensating for the armature voltage drops of the run-out table motors. The polarity of field of these auxiliary windings corresponds to the direction of the mill motor rotation. Furthermore, by moving the master switch to the left, the contactor 34 is energized through the bridge contact 29a and contact bars 29b of the rheostat 29. This contactor in picking up opens its upper three contacts to interrupt the rotor circuit between the transmitter 24 and the receiver 25 and at the same time its lower three contacts close to short circuit the rotor circuit of the receiver 25. Since the rotors of the receivers were rotated in a direction opposite to that of their stator rotating magnetic fields, when the movable contacts 29a and 30a of the rheostats were moved from their original position, the receiver 25, operating as an induction motor, will now rotate its rotor in the same direction as that of its stator rotating magnetic field, so that the rheostat arm is returned to its original position. In this position the energizing circuit of the contactor 34 is interrupted, because the bridge contacts 29a run off the contact bars 29b and the receiver 25 is stopped again and connected with the transmitter 24. Since the rheostat 29 is made ineffective because of the short circuiting of its resistance by the rectifier 31, the return of the rheostat arm 29a to its original position has no effect on the existing operating conditions.

After the first pass is finished the master switch 13 is returned to central or off position and the screw-down motor 20a is operated by the master device 21 for the second pass. For this purpose the rheostats 29 and 30 are again adjusted by means of the transmitter and the

receivers an amount corresponding to the percentage thickness reduction to be effected. That is, the rheostat 29 is moved from the original position by the same amount as for the first pass, while the rheostat 30 receives an additional adjustment. If now the master switch 13 is moved to the right, the main mill motor 12 is started in the opposite direction of rotation from that of the first pass. Thereby also the direction of rotation of the tachometer generator 12_a and of the run-out table motors is reversed. Furthermore the contactor 35 is energized through the master switch 13. In response to energization it picks up and closes its contacts thereby to reverse the field polarity of the auxiliary field windings 16_b and 17_b. Since the direction of the current in the field windings 16_a and 17_a of the adjustable voltage generator has been changed, the rectifier 32 passes current and the rheostat 30 is thereby made ineffective, while the rectifier 31 blocks the current and the adjustment of the rheostat 29 is effective. Therefore the field 16_a of generator 16 is weakened and the run-out table motors 14_a are caused to operate at a lower speed than that of the table motors 15_a, the difference in speed corresponding to the percentage thickness reduction. When the master switch 13 was moved to the right the contactor 36 was closed and thereby the movable contact arm of the ineffective rheostat 30 is now returned to its original position in the manner described in the foregoing with respect to rheostat 29.

When opening the rolls 10 of the mill stand 11 by switching the master control switch 21 to the "raise" position, the normally closed energizing circuit of a contactor 37 is interrupted by an auxiliary contact on the contactor 23. The contactor 37 opens its contacts to interrupt the rotor connections between the transmitter 24 and the receivers 25 and 26, so that no movement of the contact arms 29_a and 30_a of the rheostats beyond their original position occurs.

The connection can also be made so as to cause, instead of the described field weakening of the adjustable voltage generator that supplies the feeding run-out table motors, a field strengthening of the adjustable voltage generator that supplies the delivery run-out table motors in order to give to this run-out table a higher speed than that of the other run-out table corresponding to the percentage thickness reduction.

Although in accordance with the provisions of the patent statutes this invention is described as embodied in concrete form and the principle thereof has been described together with the best mode in which it is now contemplated applying that principle, it will be understood that the elements and connections shown are merely illustrative and that the invention is not limited thereto, since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of this invention or from the scope of the annexed claims.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A control system for a rolling mill having run-out tables on each side of the rolls and a screw-down mechanism for varying the opening between the rolls, individual driving means for each of said run-out tables, means for actuating said screw-down mechanism to effect a predetermined reduction in the thickness of the material

being rolled, and means responsive to the actuation of said screw-down mechanism for controlling the relative speeds of said driving means so that the speeds of operation of said run-out tables differ from each other in accordance with the pass reduction being effected by said rolls.

2. A control system for a rolling mill having a pair of thickness reducing rolls, screw-down mechanism for varying the opening between said rolls and run-out tables on both sides of said rolls comprising in combination individual driving means for each of said tables, means for varying the speeds of said driving means with variations in the speed of said mill rolls, means for actuating said screw-down mechanism to effect a predetermined reduction in the thickness of the material being rolled, and means responsive to the actuation of said screw-down mechanism for controlling the relative speeds of said driving means so that the speeds of operation of said run-out tables differ from each other in accordance with the amount of the reduction being effected by said rolls.

3. A control system for a rolling mill having a pair of thickness reducing rolls, a run-out table on each side of said rolls and screw-down mechanism for varying the opening between the rolls, comprising in combination, separate electric motors for driving said run-out tables, means for actuating said screw-down mechanism to effect a predetermined reduction in the thickness of the material being rolled and means responsive to the actuation of said screw-down mechanism for controlling the speed of one of said motors thereby to vary the relative speeds of said run-out table mechanism in accordance with the amount of the reduction being effected by said rolls.

4. A control system for a rolling mill having a pair of thickness reducing rolls, a screw-down mechanism for varying the opening between said rolls and a run-out table on each side of said rolls comprising in combination individual electric motors for driving each of said run-out tables, an electric motor for driving said screw-down mechanism to effect a predetermined reduction in the material to be rolled, means responsive to the speed of said rolls for varying the speed of said table driving motors and means responsive to the operation of said screw-down mechanism for varying the relative speeds of said table driving motors in accordance with the amount of the reduction being effected.

5. A control system for a rolling mill having a pair of thickness reducing rolls, a screw-down mechanism for varying the opening between said rolls and a run-out table on each side of said rolls comprising in combination, individual motors for driving said run-out tables, an adjustable voltage generator for supplying the drive motors of one of said run-out tables, a second adjustable voltage generator for supplying the drive motors of the other of said run-out tables, means for operating said screw-down mechanism to effect a predetermined reduction in the thickness of the material being rolled, and means responsive to operation of said screw-down mechanism for controlling the relative excitations of said generators to vary the relative speeds of said run-out tables in accordance with the amount of the reduction being effected by said rolls.

6. A control system for rolling mills and the like having a pair of thickness reducing rolls, a run-out table on each side of said rolls and screw-down mechanism for varying the opening between said rolls comprising in combination, a plu-

rality of electric motors for driving the rolls of one of said tables, a plurality of electric motors for driving the rolls of the other of said tables, driving means for operating said screw-down mechanism to effect a predetermined reduction in the thickness of the material being rolled, an adjustable voltage generator for supplying the drive motors of one of said tables, a second adjustable voltage generator for supplying the drive motors of the other of said tables, a rheostat in the field circuit of each of said generators, and means responsive to the operation of said screw-down mechanism for operating said rheostats to vary the relative excitations of said generators to vary the relative speeds of said run-out tables in accordance with the amount of the reduction to be effected by said rolls.

7. A control system for rolling mills and the like having a pair of thickness reducing rolls, a run-out table on each side of said rolls and screw-down mechanism for varying the opening between said rolls comprising in combination, a plurality of electric motors for driving the rolls of one of said tables, a plurality of electric motors for driving the rolls of the other of said tables, driving means for operating said screw-down mechanism to effect a predetermined reduction in the thickness of the material being rolled, an adjustable voltage generator for supplying the drive motors of one of said tables, a second adjustable voltage generator for supplying the drive motors of the other of said tables, a rheostat in the field circuit of each of said generators, means responsive to the operation of said screw-down mechanism for adjusting both said rheostats for the same change in the excitation of said generators, and means for rendering one of said rheostats ineffective thereby to vary the relative excitations of said generators to vary the speeds of said run-out tables in accordance with the amount of the reduction being effected by said rolls.

8. A control system for rolling mills having a pair of thickness reducing rolls, a screw-down mechanism for varying the opening between the rolls and a run-out table on each side of said rolls comprising in combination, driving means for said rolls, individual motors for driving said run-out tables, a pair of adjustable voltage generators for supplying said motors, a tachometer generator driven from said roll driving means for supplying the field windings of said generators to vary the speeds of said run-out tables in accordance with the speed of said rolls, a rheostat in the field circuit of each of said generators, means for operating said screw-down mechanism to effect a predetermined reduction in the thickness of the material being rolled, means responsive to operation of said screw-down mechanism for making substantially the same adjustment in each of said rheostats, and a rectifier operatively associated with the field circuit of each of said generators, said rectifiers being reversely connected with respect to said tachometer generator so that one or the other of said rheostats is rendered ineffective in accordance with the direction of rotation of said roll driving means thereby to vary the relative excitations of said generators and the relative speeds of said tables in accordance with the amount of the reduction to be effected by said rolls.

9. A control system for rolling mills having a pair of thickness reducing rolls, screw-down mechanism for varying the opening between said

rolls and a run-out table on each side of said rolls comprising in combination electric motor driving means for one of said tables, a second electric motor driving means for the other of said tables, an electric motor for operating said screw-down mechanism to effect a predetermined reduction in the thickness of the material being rolled, means driven by said screw-down motor and means controlled by said driven means for varying the relative speeds of said table driving means in accordance with the amount of the reduction to be effected by said rolls, and means responsive to said operation of said screw-down motor for varying the ratio of the driving connections between said screw-down motor and the means driven by said motor so that the changes in speed of said table motors have a non-linear relation to the amount of the reduction in the thickness of the material being rolled.

10. A control system for a rolling mill having a pair of thickness reducing rolls, a screw-down mechanism for varying the opening between said rolls and a run-out table on each side of said rolls comprising in combination electric motor means for driving one of said run-out tables, a second electric motor means for driving the other of said run-out tables, separate rheostats for controlling the relative speeds of said table motors, an electric motor for operating said screw-down mechanism for varying the opening between said rolls, means driven by said screw-down motor for operating said rheostats, a variable speed transmission included in the driving connections between said screw-down motor and said driven means, and means responsive to operation of said screw-down motor for varying the ratio of said transmission so that the changes in speed of said table motors have a non-linear relation to the amount of the reduction of the material to be rolled.

11. A control system for a rolling mill having a pair of thickness reducing rolls, a screw-down mechanism for varying the opening between said rolls and a run-out table on each side of said rolls comprising in combination electric motor means for driving one of said run-out tables, a second electric motor means for driving the other of said run-out tables, separate rheostats for controlling the relative speeds of said motors, an electric motor for operating said screw-down mechanism to effect a desired reduction in the thickness of the material to be rolled, an electrical motion transmitting device driven by said screw-down motor and individual electrical motion receiving device mechanically connected to each of said rheostats and electrically connected to said transmitting device so that said rheostats are operated in response to operation of said screw-down motor, one of the windings of each of said receiving devices being connected to a source so that the rotating fields of the stator windings rotate in a direction opposite to the direction of rotation of the rotor members during a roll closing operation of said screw-down motor, and means responsive to the starting of said thickness reducing rolls for disconnecting one of the windings of one of said receiving devices from said transmitting device and for shortcircuiting said disconnected winding thereby to provide for return of the rheostat operated by said last mentioned receiving device to its original position.

HERBERT WICKLER.
HUGO HEYMANN.