June 17, 1930. H. C. JENKS 1,764,312

CONTROL SYSTEM FOR ROLLING MILLS

Filed Dec. 13, 1927 5 Sheets-Sheet 1

Fig. 1.

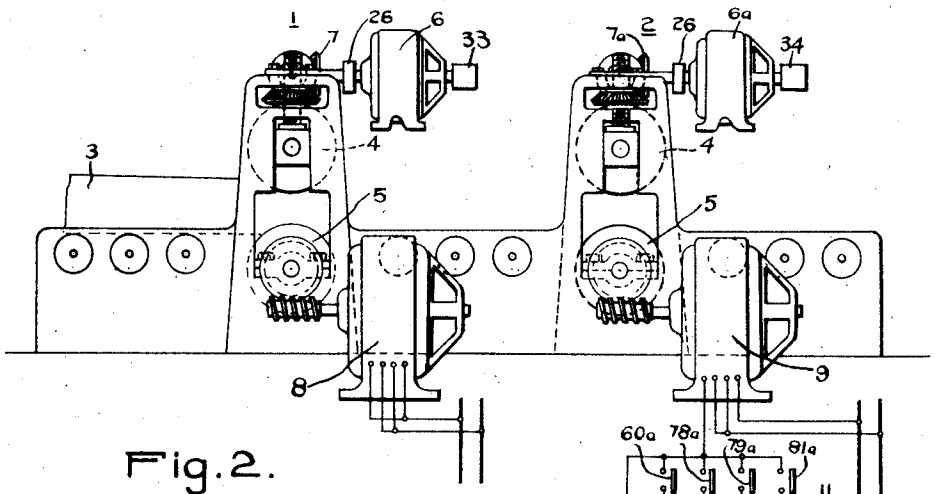
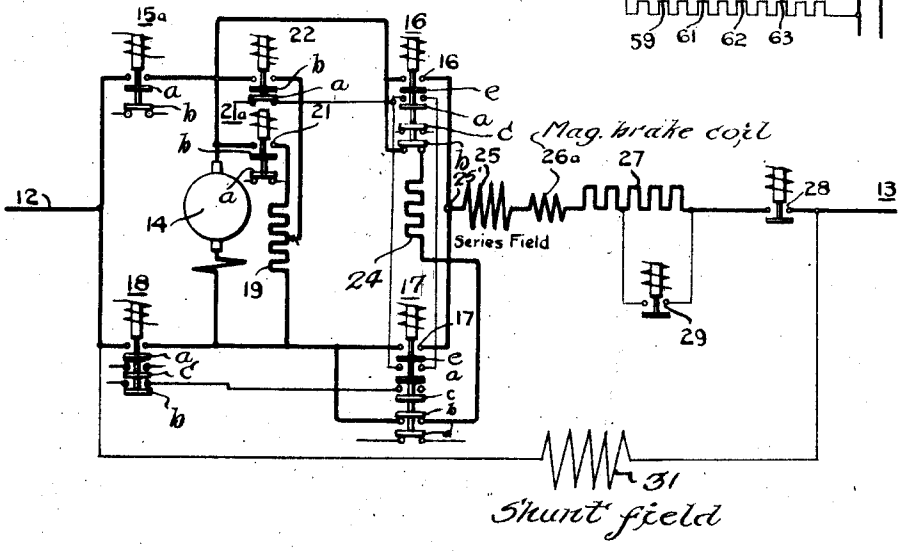


Fig. 2.



INVENTOR
Harold C. Jenks,
BY
Wesley G. Carr
ATTORNEY

June 17, 1930. H. C. JENKS 1,764,312

CONTROL SYSTEM FOR ROLLING MILLS

Filed Dec. 13, 1927 5 Sheets-Sheet 2

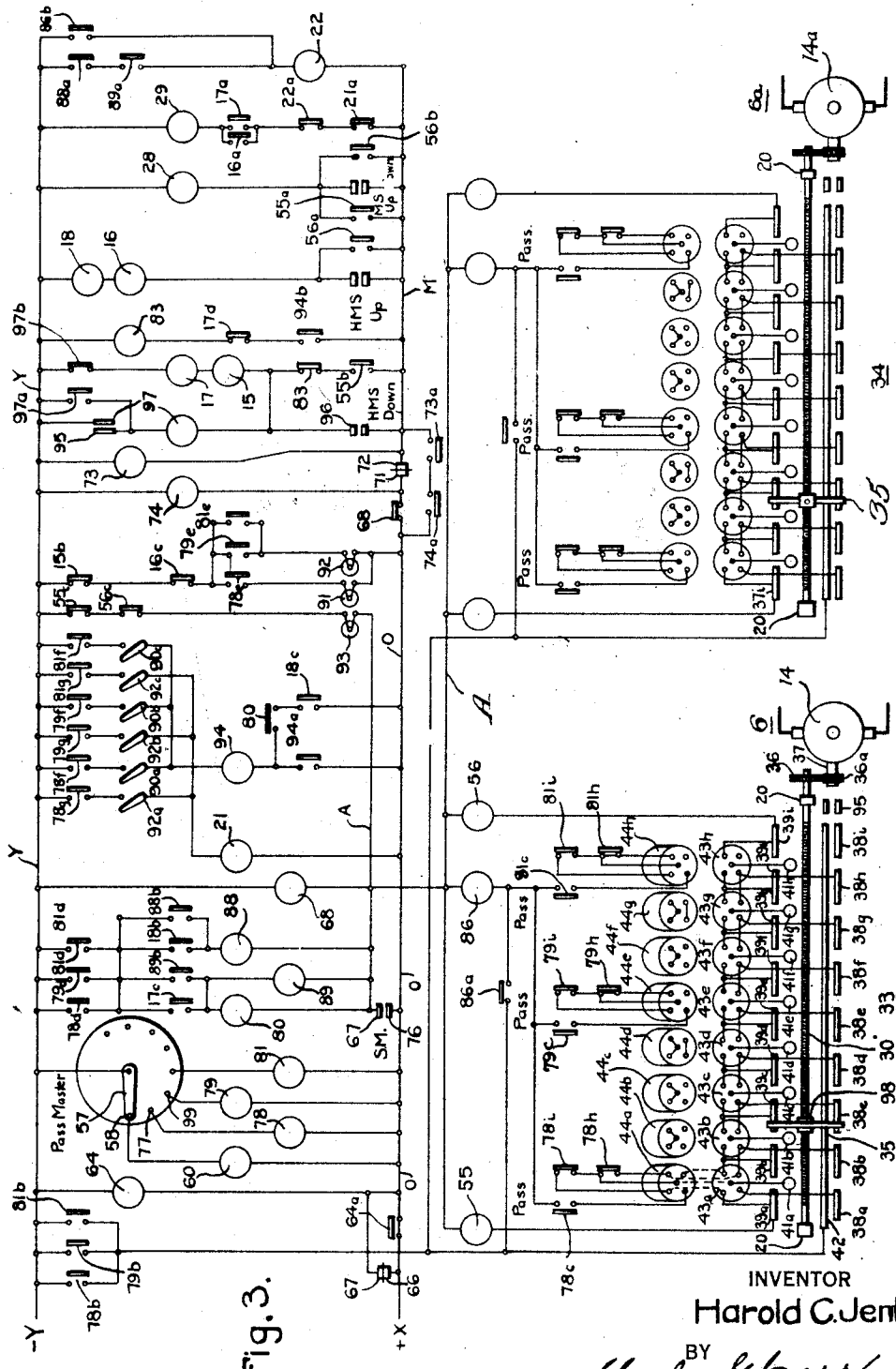


Fig. 3.

INVENTOR
Harold C. Jenks
BY
Wesley G. Carr
ATTORNEY

June 17, 1930. H. C. JENKS 1,764,312

CONTROL SYSTEM FOR ROLLING MILLS

Filed Dec. 13, 1927 5 Sheets-Sheet 3

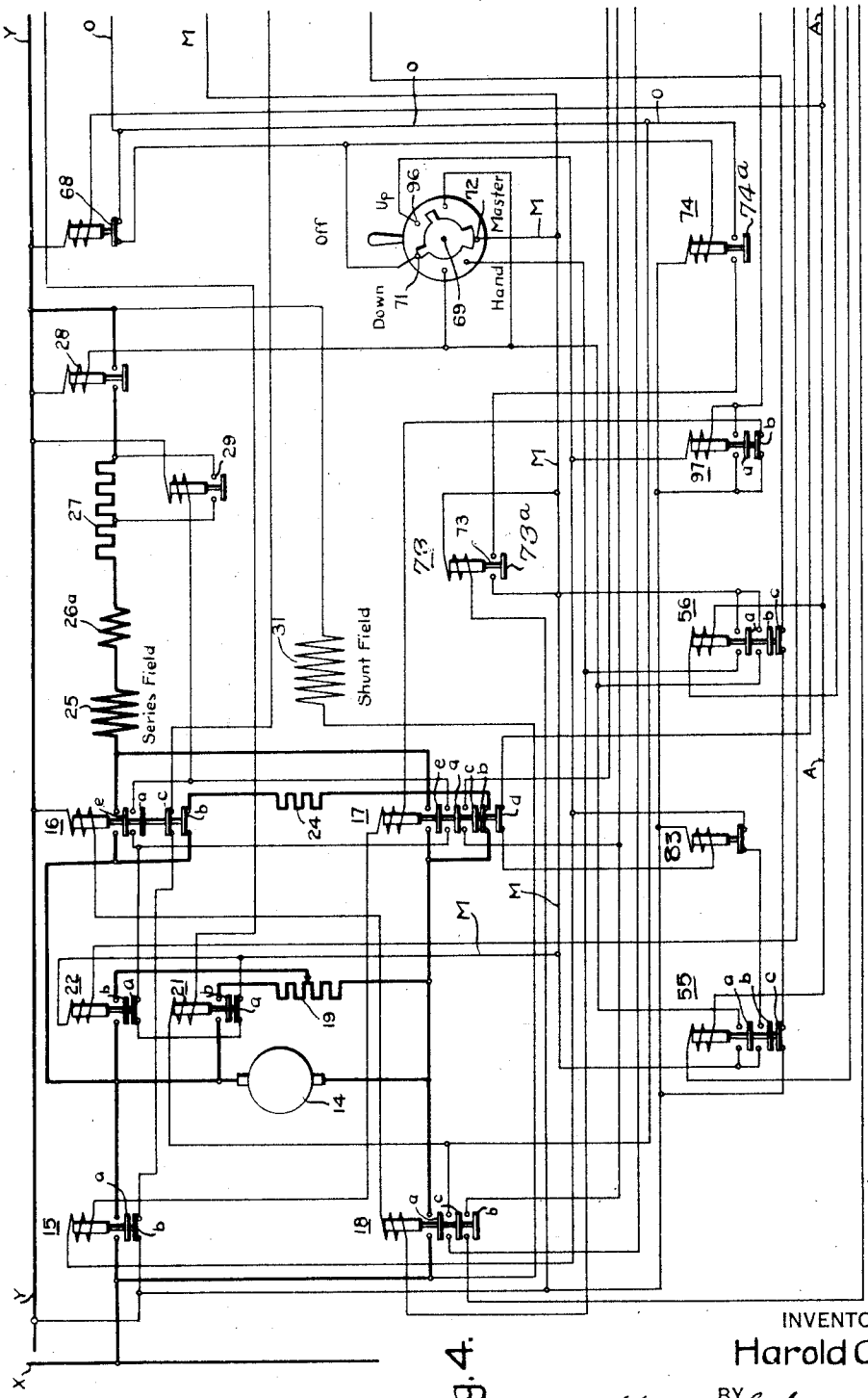


Fig. 4.

INVENTOR
Harold C. Jenks.
BY
Wesley G. Carr
ATTORNEY

June 17, 1930. H. C. JENKS 1,764,312

CONTROL SYSTEM FOR ROLLING MILLS

Filed Dec. 13, 1927 5 Sheets-Sheet 4

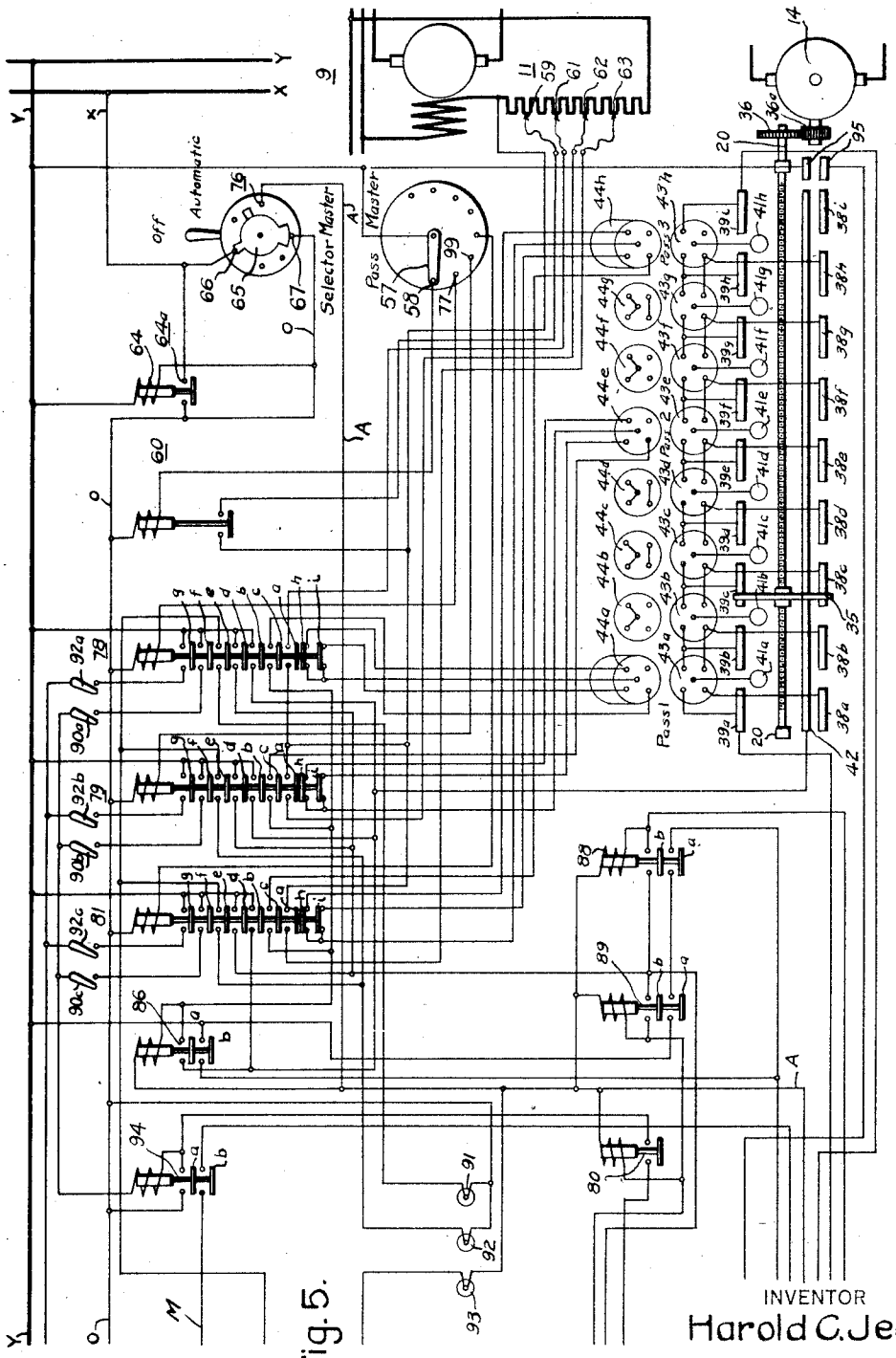


Fig. 5.

June 17, 1930. H. C. JENKS 1,764,312

CONTROL SYSTEM FOR ROLLING MILLS

Filed Dec. 13, 1927 5 Sheets-Sheet 5

Fig.6.

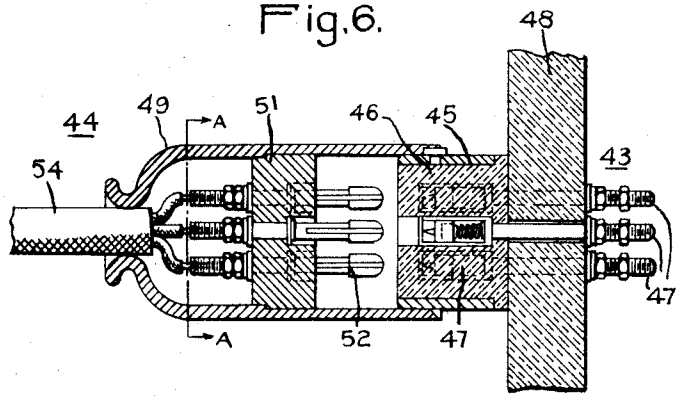


Fig.7.

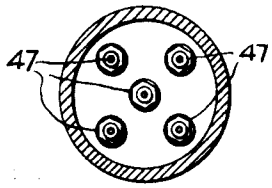


Fig.8.

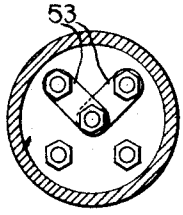


Fig.9.

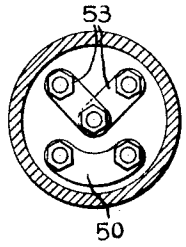


Fig 10

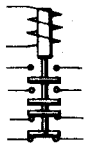
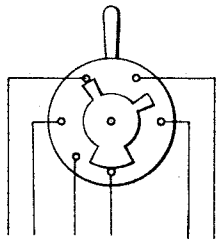


Fig.11.



INVENTOR
Harold C. Jenks.
BY
Overley & Carr
ATTORNEY

Patented June 17, 1930

1,764,312

UNITED STATES PATENT OFFICE

HAROLD C. JENKS, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

CONTROL SYSTEM FOR ROLLING MILLS

Application filed December 13, 1927. Serial No. 239,671.

The invention relates to systems of motor control and it has particular relation to such systems as are employed in the operation of steel mills.

The object of the invention, generally stated, is to facilitate the setting of the rolls of a rolling mill in predetermined positions to perform rolling operations.

A more specific object of the invention is to provide control means for a rolling mill that may be set to effect the performance of any desired series of operations in response to the actuation of a master switch.

It is also an object of the invention to provide for changing the speed of the main mill motors simultaneously with the changing of positions of the rolls, to effect the proper speed relation between the mills.

Any one experienced in the operation of rolling mills may readily determine the reduction that may be made on the stock being worked each time the latter is passed through a mill. Therefore, a schedule may be prepared showing the proper setting of the mill rolls to perform the proper rolling operations.

In this invention, mill control means is provided which may be set in accordange with any predetermined schedule to effect the desired positioning of the rolls and the proper speed of the mill motors when a plurality of mills are operated in tandem to perform the required rolling operations.

In order that the invention may be better understood, reference may be had to the accompanying drawings, wherein;

Figure 1 is a side elevation of two variable-pass rolling mills equipped with screw-down motors, and main driving motors.

Fig. 2 is a diagram showing the power circuits for the screw-down motors.

Fig. 3 is a cross-the-line diagram showing the various control circuits and apparatus for the screw-down motors in accordance with the invention.

Figs. 4 and 5 are, when taken together, a full-line schematic diagram of the system, shown in Fig. 3.

Fig. 6 is a view in cross-section, taken lengthwise through the middle of one of the plugging connectors employed in combination with the limit switch shown in Figs. 3, 4 and 5.

Figs. 7, 8 and 9, respectively, are cross-sectional views of a plug taken along the line A—A showing the contacts as they appear at the top of a cable plug, a three-point plug and a five-point plug, respectively.

Fig. 10 is a schematic diagram of one of the multiple-pole magnetic contactors utilized in the control circuits, and

Fig. 11 is a schematic diagram of a hand-operated master switch which conforms to the usual type of switch employed in systems of this character.

Referring more particularly to Fig. 1, two rolling mills 1 and 2 are illustrated for operating, in sequence, upon a piece of stock shown at 3. Each of the mills is provided with a pair of rolls 4 and 5 which may be adjusted to different relative positions by means of the screw-down motors 6 and 6*a*, which operate, through a set of beveled gears 7 and 7*a*, to raise and lower the upper rolls 4 in accordance with the direction of rotation of the screw-down motors. This feature may be extended to both rolls.

In order to drive the rolls 4 and 5, drive motors 8 and 9 are employed. In case a smaller amount of reduction is to be made by one of the mills than is to be made by the other, it will be understood that the two mills will have to be run at different speeds in order to have the metal run smoothly between them. Therefore, in order that the speed of one of the mills may be regulated to overcome this difficulty, a field resistor 11 is connected in the field circuit of the drive motor 9, the regulation of which will be more fully described hereinafter. However, such a resistor may be provided in the field circuit for each motor if it is so desired.

A power circuit suitable to be utilized in connection with each of the screw-down motors is illustrated in Fig. 2. The current for operating the motors may be obtained from any suitable source of supply, such as from line conductors 12 and 13.

In order to provide for reversing the

screw-down motors, the armature 14 is connected in the customary manner between reversing contactors 15, 16, 17 and 18, so that the current through the armature may be reversed by alternately closing pairs of these contactors. The speed of the motor may be controlled, particularly to decelerate it, by means of a resistor 19, the sections of which may be shunted by closing contactors 21 and 22, as will be described more fully hereinafter. To aid in decelerating the screw-down motors, provision is made for establishing dynamic-braking circuits. As illustrated, interlocks 17*b* and 16*b* are provided to connect the armature of each motor through a resistor 24 when the operating circuit on the reversing contactors 15 and 16 is disconnected.

In this particular application, a shunt field winding 31 and a series field winding 25 are provided for the screw-down motor. The shunt field winding is connected between conductors 12 and 13 and the series field winding is connected in a circuit which extends from junction point 25′ which point is common to the contactors 16 and 17, through the series field winding 25, the series brake actuating coil 26*a*, the starting resistor 27, and line contactor 28, to the line conductor 13. In order to short-circuit a section of resistor 27 to accelerate the motor, the accelerating contactor 29 is employed and controlled by circuits to be described hereinafter.

In view of the complexity of the system and in order to simplify the description, the different operations that may be performed will be described separately.

In this particular embodiment of the invention, limit switches 33 and 34 are provided for the screw-down motors 6 and 6*a*, respectively. A supporting frame for the limit switches may be constructed in any suitable manner. In this instance, a long section of insulating material, such as micarta-duck lumber or the like, which may be secured to the supporting frame, is employed to form a base for the switches. A plurality of contact members are mounted on the base and disposed so that they will make sliding contact with the current-carrying member 35. Mounted in suitable bearings located at the ends of the framework of the switch is a threaded shaft 30 on which is carried the travelling nut or circuit-making member 35. In order to rotate the shaft 30 and actuate the member 35, a gear wheel 36 is secured thereto and disposed to mesh with another gear wheel 36*a* fixed to the shaft 37 of the screw-down motor 6.

A row of equally spaced contact segments 38*a* to 38*i*, inclusive, are mounted on one side of the base of the limit switch and in parallel relation to the shaft 30 and, directly opposite to, and on the other side of, the base, a similar row of contact segments 39*a* to 39*i*, inclusive, are mounted. In juxtaposition with the row of segments 39*a* to 39*i* and disposed between them and the shaft 30 is mounted a row of contact members 41*a* to 41*h*, inclusive. These contact members are substantially equal in diameter to the distance between adjacent segments 39*a* to 39*i*. The purpose of the contact members 41*a* to 41*h*, inclusive, is to cooperate to establish circuits which will be traced hereinafter in conjunction with the segments 39*a* to 39*i*. They will be referred to as dead points in view of the manner in which they are utilized to control the circuits. In order to impress a voltage of selected polarity upon the limit switch, the contact segment 42 is provided and, like the other contact segments, it is disposed to engage the sliding contact member 35.

A plurality of plug sockets 43*a* to 43*h*, inclusive, may be mounted on a suitable panelboard to be utilized for completing circuits that will be referred to more specifically hereinafter. The number of plug sockets is equal to the number of contact segments 41*a* to 41*h*. The plug sockets are interconnected and each one is connected to corresponding contact segments of the respective groups of segments 38*a* to 38*i*, 39*a* to 39*i*, and 41*a* to 41*h*.

The respective groups of contact segments 38*a* to 38*i*, 39*a* to 39*i*, and 41*a* to 41*h*, and the travelling-nut mechanism 35 are so disposed that, upon a predetermined angular movement of the drive shaft 30, the movable contact 35 will be advanced from one contact member to another located in the group of contact segments 41*a* to 41*h*. Such angular movement of the shaft 30 effects a predetermined adjustment of the mill rolls 4.

In order to prevent damage to the sliding contact 35, in case it travels over the end of the limit switch, circumferential grooves 20 are machined in the shaft 30 at the ends of the thread.

The plugs and sockets referred to may be disposed on a separate panel from the limit switch and may be constructed as illustrated in Figs. 6, 7, 8 and 9.

The plug 44 and the receptacle are illustrated in detail in Fig. 6. The plug socket 43 comprises an outer cylindrical casing 45, within which is mounted an insulating contact-supporting section 46. Five contact members 47 are disposed in the insulating support 46 and secured to the panelboard 48 to which the leads of the limit switch may be connected. The contact members 47 are shaped to receive the contact members of the plug 44 when the latter is inserted in the socket 43. The plug 44 comprises the outer cylindrical casing 49 which, when in place, fits over the socket casing 45. Inside of the outer casing 49, an insulating contact

supporting member 51 is disposed. In the support 51 are mounted five contact members 52 to make contact with the base contact members 47 when the plug 44 is inserted in the socket 43. The contact members 52, as shown, project above the supporting member 51, and conductors may be attached to the contact members 52 and extended, through the top of the plug, into the cable conduit 54, for making what will be referred to hereinafter as a cable plug to be utilized in establishing circuits controlled by the limit switch when the plug is in place. The central and two of the other contact members of the plug may be connected together by connectors 53, as shown in Fig. 8, making a three-point plug which, when inserted into a selected socket of the group of sockets 43*a* to 43*h*, connects the corresponding contact segments 39*a* to 39*i* and 41*a* to 41*h* in series-circuit relation. By connecting the other two contact members of the plug together by means of a connector 50, as shown in Fig. 9, a five-point plug is provided which, when inserted into a selected socket, not only connects contact segments located in the groups 39*a* to 39*i* and 41*a* to 41*h* together but also the segments 38*a* to 38*i*, associated with the plug, are connected in series relation to establish the slow-down circuit of the screw-down motors, as will be set forth hereinafter.

Referring now to Figs. 3 and 5, the limit switch 33 is illustrated with plugs inserted for a selected schedule of operations. A cable plug, which will be referred to as "pass plug one," is inserted into socket 43*a*. When the pass selector master switch is on point 77, the contactor 78, as will be described hereinafter, will be closed, the interlocks 78*h* and 78*i* will be opened and interlock 78*c* will be closed, the effect of which will be to interrupt the control circuit through the contact segment 41*a* and stop the screw-down motor when the moving contact member 35 is on that segment. Three-point plugs are inserted in sockets 43*b* and 43*f*, and five-point plugs are inserted in sockets 43*c*, 43*d* and 43*g* and sable plugs 44*e* and 44*h* or pass plugs 2 and 3 are connected to sockets 43*e* and 43*h*. In accordance with the description set forth hereinbefore in connection with the limit switch and the description given hereinafter in connection with the control circuits, it will be understood that, in response to the position of the pass-selector master switch, the screw-down motor may be actuated to a position corresponding to that which it assumes when the travelling-nut mechanism 35 is on any one of the contact segments, comprising the group of segments 41*a* to 41*h* to which one of the cable plugs is attached. It will also be understood that deceleration of the screw-down motor may be effected in accordance with the number of five-point plugs employed.

In order for the system to operate, a plug must be inserted in each of the sockets 43*a* to 43*h* to provide a complete circuit through the contact segments 39*a* to 39*i* and 41*a* to 41*h*; otherwise, the control circuit to the screw-down motor stands interrupted at places other than those selected by the insertion of the cable plugs, which normally effect the circuit in the same manner as a three-point plug, resulting in its interruption only when the pass-selector switch is moved to cause a particular pass.

In order that the screw-down motor may be reversed when the rolls have reached their top or bottom positions, the end contact segments 39*a* and 39*i* are connected in direct circuit relation with direction-selecting relays 55 and 56, respectively. A circuit is thereby established through one of these relays when the travelling connector 35 reaches the one or the other end of the switch 33.

By making use of the plugs described in the manner and for the purpose set forth, the operation of the screw-down motor may be controlled in accordance with any desired schedule, within limits.

In the illustration, it will be observed that only three pass plugs are shown, representing a first pass, an intermediate pass, and a last pass. However, any number of intermediate pass plugs may be used simply by increasing the points on the pass-selector master switch and the pass-selector contactors, but, for the purpose of explaining the system, the three shown will suffice.

In describing the control system illustrated in Figs. 3, 4 and 5, embodying a preferred form of the invention, a description will first be given of the sequence of operations and the various circuits and apparatus utilized in substantially the order in which they occur, and the description will deal first with the control of the first screw-down motor 6.

It will be necessary, however, to deviate at times from the order in which the operations may occur, in order to introduce necessary explanatory remarks about special features.

In the description, mill 1 will be considered as the main mill, and the mill 2, which is provided with a variable speed shunt field resistor 11, will be considered as the second mill.

Since it is desired to utilize the same master switch to operate the limit switch control and the manual control, a selector switch, shown schematically in Fig. 4, is provided to change the master switch connections. A hand-master switch for each screw-down motor is also provided, as illustrated in Fig. 5.

In order to more clearly understand the complicated control circuits comprising the invention, reference should be had simultaneously to Figs. 3, 4 and 5, Fig. 3 being a straight-line diagram and Figs. 4 and 5, when taken together, being a full-line diagram of the system.

In order to provide for the utilization of the limit switches to control the operation of the rolling mills, a pass master switch, which is a simple multiple-contact circuit-making switch, such as illustrated in Figs. 3 and 5, is provided.

Assuming that the bridging member 57 of the pass master switch is actuated to its circuit-making position with the first point 58 of the pass master switch, which will be described hereinafter as the special-pass position. In this position of the pass master switch, a circuit is provided for the actuating coil of contactor 60. The purpose of contactor 60 is to close a shunt circuit for the field resistor 11 which is connected in series-circuit relation with the field winding of the second mill motor 9. The speed of the motor 9 may be regulated by shifting the movable contact member 59 to different positions on the resistor 11, thereby shunting different portions of the resistor. In this manner, the proper amount of resistance may be selected for the different speeds at which the second mill motor 9 will be operated to maintain the proper speed relation of the mills. It will be readily understood that predetermined speed relations are necessary where a plurality of rolling mills are operated in tandem, and a different reduction is made on the stock by each of the mills. The contact members 61, 62 and 63 may be connected to the resistor 11 at the predetermined points found by the shifting of the contact member 59. Therefore, the contact members 61, 62 and 63 are utilized to predetermine the ohmic value of the sections of the resistor that are to be shunted by the selector contact members *a* of the switches 78, 79, and 81, respectively, to effect automatic speed regulation of motor 9.

Assume now that a source of supply is connected to the main control conductors X and Y, and the master switches are all in their "off" positions; then the actuating coil of the low-voltage relay 64 will be energized, since it is connected in a circuit which extends from conductor X through contact members 66 and 67 bridged by the movable member 65 of the selector master switch, when the latter is in its "off" position and the actuating coil 64 is connected to line conductor Y. When the low-voltage relay 64 is closed, a holding circuit is established which may be traced from conductor X, through the contact member 64*a*, and the actuating coil, to the conductor Y. The relay 64 is maintained closed as long as sufficient potential is maintained across the source of supply XY.

When the hand master switch is in the "off" position, a circuit extends from conductor X through the contact members of relay 64; conductor O, the normally closed contactor 68 and the contact members 71 and 72, bridged by the contact member 69 of the switch, and the actuating coil of the low-voltage relay 73, to conductor Y, and the low-voltage relay 73 is closed. When the contactor 68 is in its normal circuit-closing position, the actuating coil of contactor 74 will be energized, inasmuch as it is connected between the energized contactor 68 and conductor Y. Therefore, the contactor 74 and the low-voltage relay 73 will be closed at the same time.

It will be observed that a circuit is completed which extends through the contact segments 38*b* and 39*b*, located at the right of the segment 41*a*, by means of the pass plugs and cable plugs, as illustrated in Figs. 3, 4 and 5, when the contact members *h* and *i* of the respective switches 79 and 81 are closed. When the relays 73 and 74 are closed, a holding circuit for the former may be established through the interlocks 73*a* and 74*a* carried by the relays 73 and 74, respectively, as is illustrated in Fig. 3. Since the actuating coil for contactor 68 is connected between conductors A and Y, contactor 68 will open when the selector master switch is thrown to the "automatic operating" position, in which position contact members 67 and 76 are connected by bridging member 65 to energize conductor A. When the contactor 68 is open, the actuating coil for relay 74 continues energized in a circuit leading from conductor O through interlocks 74*a* and 73*a*, the bridging member 69 of the hand master switch, when in its "off" position, and the actuating coil of relay 74 to conductor Y.

It will, accordingly, be seen that, if an effort be made to operate the screw-down motors manually when they are connected for automatic control, or vice versa, contactor 68 and relay 74 will open to interrupt the main control circuit and cause the screw-down motor to stop.

When the control circuit is energized in the manner hereinbefore described, the equipment is in readiness for the operator to make a set-up for automatic adjustment of the rolls. The selector master switch may now be thrown to its "automatic position", permitting current to flow from conductor O through the selector-master-switch contact members 67 and 76 to conductor A. When conductor A is energized, current may flow through the actuating coil of contactor 68 to line conductor Y, opening relay 68. The opening of relay 68, however, will not effect the circuits originally established,

since the relays 73 and 74 are maintained closed by holding circuits hereinbefore described.

The relay 68 is provided to prevent the operation of the manual and automatic control simultaneously. Accordingly, when the manual control is being utilized, an attempt to operate by the automatic control will result in a shutdown of the particular screw-down motors which are connected for manual control and vice versa.

Assuming, for example, that the rolls are being adjusted automatically and the operator moves the hand master switch for the main screw-down motor, then the reset contact members 71 and 72 on the hand master switch will open and cause contactor 74 to open, thus interrupting the connection to the motor-control circuit.

If the system had been set for hand-control operation and the operator inadvertently moved the selector master to the "automatic position", relay 68 would be actuated and the circuit to the actuating coils of relays 73 and 74 would be interrupted in the manner set forth hereinbefore, thus opening the screw-down motor-control circuit.

Assuming now that the contact members 61, 62 and 63 have been properly connected and proper speed adjustments made on the field resistor 11, and that the limit switches for the screw-down motors have been adjusted or plugged to give the desired automatic adjustment of the rolls for the desired passes of the metal being worked, then, upon moving the bridging member 57 of the pass master switch off the contact member 58, the circuit through the actuating coil of contactor 60 is interrupted and the latter drops open. Inasmuch as the main motors are not running when the pass master selector switch is disposed in the "special pass" position, the interruption of the circuit through contact member 58 will not effect the main motors.

In adjusting the rolls for the different passes, a number of circuits must be simultaneously completed and interrupted. To provide for this, a number of multiple-pole magnetic-type pass-selector contactors 78, 79 and 81 are employed.

In Fig. 5, three of the contactors 78, 79 and 81 are illustrated in their respective circuit-making positions. When it is desired to make the first pass, the bridging arm 57 of the pass-selector master switch may be actuated to engage contact member 77, completing a circuit from conductor O through the actuating coil of contactor 78 to conductor Y, closing the multiple-pole contactor 78. When contactor 78 closes and the normally open interlocks *a*, *b*, *c*, *d*, *e*, *f*, and *g* close and the normally closed interlocks *h* and *i* open, interlock 78*a* completes a circuit through movable contact member 61 on the field resistor 11, shunting a selected portion of that resistor to determine the speed at which the second mill motor will operate for the first pass.

The interlocks 78*h* and 78*i*, in opening, isolate the dead-point contact segment 41*a* from the limit switch circuit to effect the stopping of the screw-down motors when the rolls are in the desired positions. Another circuit is completed through contact segment 39*a* which is located to the left of the dead-point 41*a*. Therefore, the limit switch 33 is divided electrically into two parts, and the travelling-nut mechanism disposed to actuate the contact member 35 must come to rest at dead-point 41*a* to set the rolls for the first pass, because the circuit for the actuating coils of the switches 15 and 17 are deenergized, whereby the screw-down motor is deenergized.

In order to select the direction in which the screw-down motor will operate for each pass, a pair of direction-selector relays 55 and 56 complete a control circuit for the reversing contactors 15, 16, 17 and 18, depending on the position of the moving contact member 35 with respect to the dead-point selected which, in this instance, is 41*a*.

Assuming that the movable contact member 35 is in the position indicated in Figs. 3, 4 and 5 and that the pass-selector master switch is set at point 77 for the first pass, and the pass-selector contactor 78 is closed, as hereinbefore described, then a circuit for actuating the direction-selecting relay 56 will be completed. The relay circuit may be traced from conductor X through the low-voltage relay 64, the selector master switch, conductor A, the actuating coil of relay 56, the series of contact segments 39*i* to 39*c*, and 41*c*, the movable contact member 35, contact segment 42 and, through interlock 78*b*, to conductor Y. Therefore the relay 56 is closed.

The direction-selecting relays 55 and 56 may be located upon the main screw-down-motor-control panels. Upon the actuation of the relay 56, the contactors 18 and 16 are connected across the conductors M and Y and caused to close to establish a circuit for a screw-down motor. In this particular instance, the motor is rotated to move contact member 35 toward the dead spot 41*a* created by the pass-selector contactor 78, which, when closed, opens interlocks 78*h* and 78*i*. When the circuit through the bridging member 56*a* is completed, a second circuit through bridging member 56*b* is also completed, placing the actuating coil of the screw-down motor line contactor 28 across conductors M and Y, which cause the closure of the contactor 28 and the application of a voltage to the screw-down motor.

Referring now to the power circuit for

the first mill screw-down motor 6, as illustrated in Figs. 2, 3 and 4, when the reversing contactors 18 and 16 and the line contactor 28 are closed, the main mill screw-down motor 6 will start to rotate in such direction as to raise the rolls. In order to accelerate the motor, a section of resistor 27 is shunted by the accelerating contactor 29, which closes after the reversing contactors close. The actuation of the contactor 29 may be effected by a circuit traced from conductor M through interlocks 21*a*, 22*a*, 16*a* and the actuating coil of contactor 29 to conductor Y.

The closing of the accelerating contactor 29 will permit the screw-down motor to be brought up to full speed, which, in its operation, will cause the movable contact member 35 to be propelled towards the dead spot 41*a* created by the cable plug disposed to determine where the rolls will stop for the first pass. If the screw-down motor causes the rolls and contact member 35 to pass over the point selected for stopping, it will be reversed and caused to return the rolls and limit-switch member 35 to the selected position. It will be seen that, as member 35 travels toward pass point number one, as illustrated in the diagrams, it will interrupt the actuating circuit for the direction-selecting relay 56, as it passes out of circuit engagement with contact segment 39*b*, permitting the relay to open and cause the screw-down motor to be deenergized. However, as soon as the travelling contact member 35 engages contact segment 39*a*, a circuit will be established through actuating coil of the direction-selecting relay 55 which is similar to the circuit traced for relay 56. Upon the closing of relay 55, its interlocks 55*a* and 55*b* complete the actuating circuits for the reversing contactors 15 and 17 and the line contactor 28 effects the starting of the screw-down motor in the opposite direction. The control circuit for contactors 15 and 17 may be traced from conductor M through interlock 55*b*, normally closed relay 83, the actuating coils or contactors 15 and 17 and normally closed interlock 97*b* of relay 97 to conductor Y.

In order to slow down the screw-down motor as the rolls approach a selected position in the down direction, a relay 86 is provided which, when closed, establishes a circuit for closing contactor 22 and connecting a portion of resistor 19 across the armature 14. The actuating coil of the relay 86 is connected in a circuit extending from conductor A through the relay-actuating coil, interlock 78*c* through cable plug for pass 1, contact segment 38*a*, contact member 35, contact segment 42, interlock 78*b*, to conductor Y. When relay 86 closes, the interlock 86*a* establishes a holding circuit for the relay which extends from conductor A through the relay-actuating coil, interlock 86*a*, and interlock 78*b* to conductor Y, and relay 86 is retained closed as long as contactor 78 is closed. The closing of relay 86 connects the actuating coil of the motor slow-down contactor 22 between conductors M and Y, closing contactor 22 and connecting a portion of resistor 19 across the armature 14 of the motor 6 and thereby decelerates the motor.

The period during which the slow-down circuit will effect the screw-down motor may be increased by employing five-point plugs, as described hereinbefore, connecting a plurality of contact segments 38 in series, thereby closing contact 22 when the moving contact member 35 is in any selected position. As soon as the movable contact member 35 passes over the dead spot 41*a* created by the plug inserted for pass 1, the relay 55 will be deenergized, allowing the contactor 17, 15 and 28 to open and stop the motor.

In order to hasten the stopping of the screw-down motor, a dynamic-braking circuit is established which may be traced from one side of the armature 14, through interlock 16*b*, the dynamic-braking resistor 24 and the interlock 17*b*, to the other side of the armature. The dynamic-braking resistor 24 may be of low ohmic value and the field of the motor be energized from a constant-voltage source. Therefore, the desired dynamic braking may be obtained.

The stopping of the motor is also hastened by a magnetic brake 26 which may be coupled to the drive shaft of the screw-down motor. The magnetic brake is provided with a brake coil 26*a* which is connected in series relation with the motor armature 14 and holds the brake open when the motor circuit is energized, but, as soon as the motor circuit is interrupted, the brake is applied.

In order to decelerate the screw-down motor after it is reversed and is operating to return the rolls from an overtravel position, a circuit is established for varying the amount of the shunt resistor 19 connected across the armature 14. Upon the closing of the reversing contactors 16 and 18 in response to the operation of the direction-selector relay 56, a circuit is established extending from conductor A through the actuating coil of relay 88, interlock 18*b* on the reversing contactor 18 and interlock 78*d* on pass-selector contactor 78 to conductor Y, and the relay is closed. When the relay closes, an interlock 88*b* establishes a holding circuit which may be traced from conductor A through the relay coil, the interlocks 88*b* and 78*d* to conductor Y.

The provision of the holding circuit just mentioned permits relay 88 to be held closed even after the circuit to the motor has been interrupted by the opening of the reversing relays. In case of overtravel of the rolls in

the up direction, provision is made for effecting the closure of the reversing contactors 15 and 17 to start the motor to move the rolls in the down direction. In order to close the contactors 15 and 17, a relay 89, similar to relay 88, is utilized. When the contactors 15 and 17 are closed, an energizing circuit for the relay 89 may be established which may be traced from conductor A through the actuating coil of relay 89, interlock 17*c* on reversing contactor 17, and interlock 78*d* on contactor 78 to conductor Y. Upon the establishment of this circuit, the relay 89 closes, and a holding circuit is established by means of interlock 89*b* which connects the actuating coil in a circuit extending from conductor A through either interlock 17*b* or 89*b* and interlock 78*d* to conductor Y.

When the two relays 88 and 89 are closed at the same time, the interlocks 88*a* and 89*a*, respectively, are closed to establish a circuit which extends from conductor M through the actuating coil of slow-down relay 22 and the interlocks 88*a* and 89*a* to negative line conductor Y. The relay 22 is closed and a section of the resistor 19 is connected in the armature circuit so that the screw-down motor will run at a low speed. To insure control of the motor speed by the armature shunt resistor 19, contactor 22, in closing, opens an interlock 22*a* which interrupts the circuit from conductor M, that operates the accelerating relay 29, making it impossible for the accelerating contactor 29 to close, when relay 22 is closed. Therefore, the series resistor 27 will be connected in the armature circuit when the relay 22 is closed. Under these conditions, the screw-down motor will operate the rolls in the down direction at a low speed until the moving contact member 35 leaves the contact segments 38*a* and 39*a* and is moved onto the selected dead spot 41*a*, effecting the opening of relay 55 and, subsequently, contactors 15, 17 and 28 stopping the screw-down motor.

In order to provide means for indicating to the mill operator when the screw-down motors have functioned to move the rolls to their predetermined positions for each pass, a system of lamps is employed, as is illustrated in Figs. 3, 4 and 5. Circuits for lighting the lamps may be established by interlocks 78*e*, 79*e* and 81*e* provided on each of the pass-selecting relays 78, 79 and 81.

A lamp 91 is provided for indicating the setting of the rolls on the first mill for the first pass, and may be connected in a circuit which extends from line conductor O through the lamp 91, interlock 78*e*, interlock 16*c* on the reversing contactor 16, and interlock 15*b* on reversing contactor 15, to the negative line conductor Y. Therefore, the lamp 91 will be lighted only when the interlocks 78*e*, 16*c* and 15*b* are closed to indicate that the screw-down motor has been stopped. The lamp may be of any desired color to indicate the particular setting of the rolls. A lamp of any suitable color, such as 92, may be provided for the intermediate passes.

The lamp 92 is connected in a circuit which extends in parallel relation with the circuit for the lamp 91 when the circuit is completed upon the closure of an interlock *e* on an intermediate pass-selecting contactor. In this application, only one intermediate pass-selector contactor 79 is illustrated, and the interlock, in this case, would be 79*e*. It will be understood, however, that any number of intermediate steps of setting may be employed by adding any desired number of their intermediate pass-selector contactors and connecting their interlocks *e* in parallel-circuit relation with the interlock 79*e*.

Inasmuch as the rolls may not be stopped for each pass in exactly the position selected for them, a lamp is provided for indicating when the rolls have come to rest in exactly the selected relative positions. In this embodiment of the invention for indicating the accurate setting of the rolls, a lamp 93 is provided which may be connected in a circuit extending from line conductor A through interlocks 55*c* and 56*c* on the direction-selecting relays 55 and 56, to the negative line conductor Y. Therefore, the lamp 93 will be lighted only when the two direction selecting relays 55 and 56 are deenergized.

It will be understood that this system of lighting must be duplicated for each screw-down motor utilized, and their operation will be similar. Therefore, only one lamp is illustrated in order not to excessively complicate the drawing. It will be readily appreciated that, by providing a different colored light for each pass, the operator will be enabled to ascertain the operating conditions of the mill. The lamps for one screw-down motor are lighted independently of the others, so that, as each screw-down motor comes to rest after moving the rolls of the particular mill to which is is coupled, an associated lamp will indicate that condition regardless of the operating conditions of the other screw-down motors. It will also be appreciated that, as the sliding contact members 35 on the limit switches move back and forth across the dead spots, in setting the screws, the indicating lamps will intermittently flash to indicate that the screw-down motors are overtravelling and that the setting of the rolls is not complete. The mills rolls, accordingly, should not be started until the lights have stopped flashing, thus indicating that the rolls are in their proper relative positions.

In order to increase production, it may be

advisable not to require that the screw-down motors stop the rolls at exactly the preselected position for each pass. Accordingly, means may be provided for stopping the screw-down motors after they have once overtravelled. Under such operating conditions, the screw-down motor will be stopped even though the sliding contact member 35 of the limit switch is not on the dead spot or contact segment 41, as has been hereinbefore described. The stopping of the motors when they overtravel may be accomplished by utilizing a plurality of toggle switches 92*a* to 92*c*, inclusive, one being provided for each pass.

Assuming that a slow setting speed is desired for the first pass, then the toggle switch 92*a* may be closed, permitting current to flow from line conductor O through the actuating coil of the resistor-connecting relay 21, through the toggle switch 92*a* and the interlock 78*g* on the first pass-selecting contactor 78, to the negative line conductor Y. As will be observed in Fig. 2, when the resistor relay 21 closes, the entire shunt resistor 19 is connected across the armature 14 of the screw-down motor 6. When relay 21 closes, interlock 21*a* opens and interrupts the circuit hereinbefore described, and the resistor 27 is connected in series circuit relation with the armature of the motor, causing the motor to operate at a low speed. It should be noted that the speed obtained by employing relay 21 will not be as low as that obtained when the relay 22 is employed, as the relay 22 effects the connection of only a portion of the resistor 19 across the armature. The relay 22 is used only when the rolls are very close to the desired position and it is desired to secure accurate settings thereof.

It will be readily understood, by referring to Figs. 3, 4 and 5, that provision for such slow-down is provided for each pass of the mill, and it is deemed unnecessary to further describe duplicate circuits, inasmuch as they are simply parallel circuits through the various toggle switches and interlocks on the pass-selector relays.

A second set of toggle switches 90*a* to 90*c*, inclusive, are provided for accomplishing what will be termed "return elimination". The purpose of "return elimination" is to cause the motors to stop the rolls after one return from over travel in the down direction, which adapts this control system particularly to roughing mills. For instance, assuming that it is not essential that the motor stop on the exact selected position for pass 1, by closing the toggle switch 90*a*, a circuit is provided leading from line conductor O through interlock 18*c* on reversing relay 18 and relay 80, the actuating coil of relay 94, toggle switch 90*a*, and the interlock 78*f* on the pass-selecting contactor 78. In such manner, an energizing circuit for the relay 94 is established and the latter is closed. A holding circuit for the relay is connected which extends from conductor O through interlock 94*a*, actuating coil of the relay 94, toggle switch 90*a* and interlock 78*f* to conductor Y.

The actuating circuit for the relay 94 cannot be completed except when the screw-down motor is running in the "up" direction, unless the reversing contactor 18 is closed. Relay 80 closes when the screw-down motor is operating in the down direction, inasmuch as its actuating coil is connected in a circuit extending from conductor A through the coil, interlock 17*c* on the motor-reversing contactor 17, and interlock 78*d* to conductor Y. Upon the closing of interlocks 17*c* and 78*d*, a circuit is also established through the actuating coil of relay 89, inasmuch as it is connected as is illustrated, in parallel relation with the actuating coil of relay 80. Therefore, when relay 89 closes, a holding circuit is established through interlock 89*b* to maintain the actuating coil of relay 80, energized after the reversing contactor 17 opens.

When the relay 94 closes, interlock 94*a* closes to establish a circuit for the actuating coil of the normally closed relay 83, which, when actuated, prevents the establishment of an energizing circuit for the reversing contactors 15 and 17. Assuming relay 94 to be closed and the screw-down motor to be raising the rolls after a down overtravel movement, in which case the reversing contactors 15 and 17 are open and reversing contactors 16 and 18 are closed, then a circuit extending from conductor M through interlock 94*b*, the interlock 17*d* and the actuating coil of relay 83 to conductor Y is established, opening the normally closed relay 83, thereby interrupting the actuating circuit of contactors 15 and 17 and preventing these contactors from closing to restart the screw-down motors to operate in the down direction and preventing hunting on the part of the screw-down motors.

In order to control the screw-down motors manually so that the rolls of each mill may be adjusted to any desired position when the schedule of operation is being selected or for any other purpose, the control means shown in Figs. 3, 4 and 5 is provided.

A hand master switch of well-known type, as is illustrated in Figs. 4 and 11, is employed for effecting the control of various circuits. These circuits are shown in Figs. 3, 4 and 5.

As has been hereinbefore described, the selector master switch must be placed in its "off" position to permit manual operation of the screw-down motor in response to the

hand master switch. When the hand master switch is in the "down" operating position, a circuit is established from conductor M, through the master switch, the actuating coil of relay 97 to the protective contact members 95 on the limit switch 33, which, in turn, are connected to conductor Y, the purpose of which circuit will be described more fully hereinafter.

Also, when the master switch is moved to its "down" operating position, a circuit is closed through the master switch, the actuating coils of the reversing contactors 15 and 17, and the normally closed contact members of relay 97 to conductor Y. With the master switch placed in the "up" operating position for raising the rolls, a circuit is closed for the actuating coils of reversing contactors 16 and 18 which extends from conductor M, through the master switch and the actuating coils of contactors 16 and 18, to conductor Y. These circuits, when completed, will effect the running of the screw-down motor in the same manner as is accomplished under automatic control.

It will also be observed that, when the master switch is placed in either the "up" or "down" operating position, a circuit is connected from conductor M, through the master switch and the actuating coil of the motor line contactor 28, to the line conductor Y, the purpose of which has been hereinbefore described.

When the screw-down motor is being operated by manual means, in accordance with this embodiment of the invention, the limit switch 33, which is mechanically coupled to the screw-down motor, as shown in Fig. 1, will be actuated by the motor, and, in order to prevent the rolls from jamming, when the screw-down motor is being operated manually, means for overtravel protection is provided. This means, as shown in Figs. 3, 4 and 5, only provides for protection against excessive overtravel in the down direction, but similar provision may be made for preventing overtravel in the up direction.

It will be observed, in Figs. 3 and 4, that a pair of contact segments 95 is disposed on the limit switch at the end of contact segments 38 and 42 and next to gear wheels 36. In Fig. 3, the circuit through the contact segments 95 is shown as extending from conductor M, through the hand master switch, when moved to its "down" operating position, to energize the coil of relay 97, and contact segments 95, to line conductor Y.

When the screw-down motor is propelling the rolls, and traveling contact member 35 in the down direction, and the contact member 35 passes out of engagement with the contact segments 38 and 42, the feed connection to the limit switch leading from conductor Y, through contact segment 38 and the movable contact 35, is interrupted. This isolates the traveling contact member 35 from the part of the limit switch used in automatic control. When the movable contact member 35 is moved to bridge the contact members 95, a circuit is established from the contact member 96 on the hand-master switch, through the actuating coil of the down overtravel relay 97, to the negative line conductor Y and the down overtravel relay 97 is closed. A holding circuit for the relay 97 is established through the interlock 97*a*. When the relay 97 closes, the interlock 97*b* opens and interrupts the circuit traced hereinbefore through the actuating coils of the reversing contactors 15 and 17. The interruption of the reversing contactors, accordingly, will cause the motor to stop, even though the operator has not removed the hand master switch from the down-operating position.

In order to move the rolls, when the down-overtravel relay 97 is closed, the hand master switch must be placed in the "up" operating position to cause the screw-down motor to reverse and open the overtravel contact members 95. When the hand master switch is actuated to deenergize contact member 96, the actuating coil of the down-overtravel relay 97 will be deenergized and, as soon as the movable contact member 35 is moved out of engagement with the contact members 95, it is possible to actuate the hand-control master switch in either direction or actuate the selector master switch for automatic control.

In this description, reference has been made to the control of but a single screw-down motor, but, manifestly, a plurality of such motors may be employed if the limit switch for each is connected in a manner similar to the one described. As illustrated in Fig. 3, the control circuits for each motor are connected across conductors O and Y in a parallel-circuit relation with the one described.

Referring to the "setting up" operation of this control system, inasmuch as the system is provided for operating a rolling mill in accordance with a predetermined schedule of operation, a definite schedule of roll positions and main-motor speeds must be worked out before any attempt at "setting up" the mill circuits may be made. In working out the schedule, for setting the limit switch, all calculations should be made on the assumption that the limit switches are in their zero positions.

In preparing the control apparatus for operation, the selector master switch is moved to the "off" position and the pass master switch to the "first" or "special-pass point" 58; and the nut 98 at the top of the movable contact member 35, which holds that sliding contact in connection with the

threaded shaft 30 is removed. Next a piece of gauge metal of the finished thickness of the stock to be rolled is placed between the rolls of each set, and the rolls are moved down upon these gauges by manipulation of the hand-master switches supplied for each screw-down motor. After the rolls have been so adjusted, nut 98 is replaced to secure the movable contact member 35 in the zero position.

The next step is to insert, in the plug sockets 43, the proper cable plug for giving the desired schedule of operation. The proper three-point or five-point plugs should be inserted to obtain the proper operation of the screw-down motors in accordance with the function of the plugs selected.

In order to regulate the speed of the driving motor for mill number 2, the arm 57 of the pass-master switch is actuated to the points 58 or the special-pass point, and the movable contact point 59 is moved along the variable field resistor 11 until the desired speed for each particular pass is determined and then the contact members 61, 62 and 63 are connected to the selected points on the resistor 11 to give the proper roll speed for the different passes.

While a provision of this character is shown for only one mill, any number of mills may be regulated in the same manner.

In the system set forth, the scheme of automatic operation provides for the return of the screw-down motors to certain definite positions for each pass, regardless of how much overtravel may have occurred when approaching these particular positions. A return stroke may be prevented, if desired, by setting of the toggle switches 90*a* to 90*c*, inclusive, in the manner hereinbefore described, and the same may be desirable to control intermediate passes of the metal, to increase production.

While the system described above has been confined to progressive operation of the screw-down motors 6 and 6*a*, it is to be understood that a combination of progressive and retrogressive operations may be obtained, depending upon the particular sockets into which the cable pass plugs are inserted. If, for example, the pass plugs 44*a* and 44*e* be interchanged, that is, if the plug 44*a* is inserted into socket 43*e*, and the plug 44*e* is inserted into socket 43*a*, the first "dead" point in the group of "contact" segments, comprising segments 39*a* to 39*i*, will occur between segments 39*e* and 39*f* when the "pass master" controller is actuated to the first pass position. In the first "pass position", contact arm 57 engages contact finger 58, and a circuit is completed whereby the contactor 78 is actuated into its pass-controlling position, whereby segments 39*e* and 39*f* are disconnected to establish a dead point in the limit switch.

When the contactor 78 is closed, the screw-down motor will operate until the moving contact member 35 has been actuated to the contact segment 41*e* located at the "dead point". At this point, the screw-down motor is deenergized to stop the rolls in the first pass position.

When the first pass has been completed, the contact arm 57 may be actuated to the second pass position. In this position, contact members 57 and 77 are closed, whereby the contactor 79 is actuated to its "pass"-controlling position. For the second "pass" operation, the contactor 78 is returned to the position shown in Fig. 5.

The contactor 78 being closed, the "dead point" controlled thereby is established between contact segments 39*a* and 39*b*. The screw-down motor will, therefore, be so energized that the rolls will be raised or separated until the moving contact member 35 has been returned to the "dead point" located at the contact segment 41*a* disposed between contact segments 39*a* and 39*b*. The operation of the screw-down motor for the second "pass" is, therefore, retrogressive with reference to the first "pass".

The second "pass" having been completed, the contact arm 57 may be actuated into engagement with the contact finger 99, or the third "pass" position of the "pass master" controller. The "pass master" controller having been actuated into the third-pass position, contactor 81 will close, and contactor 79 will open. The "dead point" of the limit switch is, therefore, shifted to a position located between contact segments 39*h* and 39*i*. The screw-down motor will then be re-energized to actuate the rolls towards each other, and the contact member 35 towards the segment 41*h* located at the "dead point" which controls the adjustment of the rolls for the third pass.

It is to be observed that the movable contact member 35 is actuated always towards the "dead point" of the limit switch, wherever it may be. Therefore, if the contact member be disposed to the right of the "dead point", it will be actuated to the left toward the "dead point", and, if disposed to the left of the "dead point", the movable contact member 35 will be actuated to the right.

The operation of the screw-down motors in connection with the third pass is progressive with reference to the first pass and retrogressive in respect to the second.

It follows, therefore, that the direction of rotation of the screw-down motors will be determined by the position of the movable contact member 35 with reference to the "dead point" created by any one of the "pass selector", contactors 78, 79 or 81.

The operation of the system is substantially as follows: When automatic screw-down

operation is desired, all of the hand-master switches are thrown to their "off" positions and the selector master switch moved to the "automatic" operating position, thereby placing the control of the system entirely under the control of the automatic switch. The next step is to move the pass master switch and contact member 57 into engagement with the contact 77, which corresponds to the first pass. In response to the circuit thereby established, all of the screw-down motors will start to rotate in such direction as to bring the rolls to the proper position selected for the first pass, provided they are not already in that position by reason of previous hand manipulation. The operator can tell when the rolls are in the proper relative positions by observing the indicator lamps.

When the rolls have been set in their preselected positions and the screw-down motors have come to rest, the table rolls of the mill may be actuated to feed metal into the mills, and the main drive motors of the mill started. The control of the tables and main-motor power circuits are not illustrated in this application, since they are so well known in the art.

After the metal has once passed through the entire set-up of mills, the pass master switch will be moved to its next position 99, corresponding to the second pass of metal through the mill, and, as soon as the indicating lamps indicate that the rolls are in the proper relative positions for this pass, the mills may be again set in operation and the metal once more moved through the mills. The above sequence of selecting the screw-down settings on the pass master switch and controlling the passage of the metal through the mill will be repeated for all of the passes until the metal has been completely worked and the last pass reached. After the last pass has been completed, the pass master switch will again be returned to its first-pass position 77, and effect the return of the rolls to the first-pass position.

While the invention has been described in accordance with a preferred embodiment, it is to be understood that various changes in circuits and apparatus may be made without departing from the scope of the invention, as set forth in the appended claims.

I claim as my invention:

1. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for adjusting the rolls, a limit switch, means for effecting the operation of said limit switch in accordance with the operation of the screw-down motor, means cooperative with the limit switch to effect the stopping of the screw-down motor in a plurality of predetermined positions and means for variably controlling the distances between the respective positions.

2. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for adjusting the rolls, a limit switch for effecting the operation of the screw-down motor, means for starting the screw-down motor, means responsive to the limit switch for automatically stopping the screw-down motor when the rolls are in different predetermined positions and means for decelerating the motor as the rolls approach said predetermined positions.

3. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for shifting the rolls, manual means for starting the screw-down motor, means for automatically stopping the screw-down motor and rolls when the rolls are in different predetermined positions, and means for regulating the distance between the respective roll positions to different values.

4. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for shifting the rolls, manual means for effecting the starting of the screw-down motor, means for automatically stopping the screw-down motor when the rolls have reached a predetermined position, and means for presetting the automatic stopping means to function at a plurality of different predetermined positions.

5. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for shifting the rolls, a manually operable switch for effecting the starting of the screw-down motor, a limit switch operable in accordance with the movement of the screw-down motor, and means for variably presetting the automatic stopping means to function at a plurality of different predetermined positions.

6. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for positioning the rolls, a manually operable switch for effecting the starting of the screw-down motor, means for automatically stopping the screw-down motor when the rolls are in a preselected position, and means for adjusting the preselecting means.

7. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for moving the rolls from one position to another as metal is passed through the mill, means for actuating the screw-down motor, means for controlling the motor to actuate the roll into a predetermined selected position said control means being adapted to automatically stop the screw-down motor when the rolls have been actuated to the selected relative position, and means governed by said con-

trol means to effect deceleration of the screw-down motor before the rolls have reached the selected position.

8. In a control system comprising an electric motor, a source of current for the system, a mechanism actuated by the motor, an automatic switch actuated in accordance with the motor, means for presetting the switch to effect stopping of the motor when the actuated mechanism is in one of a plurality of predetermined positions, said means comprising means for automatically decelerating the motor before it is stopped, a dynamic-braking circuit for the motor and means for automatically connecting said dynamic-braking circuit to the motor when the motor is disconnected from the source of current.

9. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for shifting the rolls, an automatic switch actuated by the screw-down motor, said switch being disposed to control said motor, means for presetting the automatic switch to effect the stopping of the screw-down motor when the rolls are in any one of a plurality of different predetermined positions, said presetting means comprising means for automatically effecting a reduction in the speed of the screw-down motor as the rolls approach one of the different selected positions.

10. In a control system for a rolling mill provided with a plurality of rolls, in combination, a screw-down motor for shifting the rolls, a source of current for the screw-down motor, a dynamic-braking circuit for said motor, an automatic switch actuated by the screw-down motor, means for presetting the automatic switch to effect stopping of the screw-down motor when the rolls are in one of a plurality of different predetermined positions, and means for automatically connecting the dynamic-braking circuit to the screw-down motor, when said motor is disconnected from the source of current.

11. In combination, a rolling mill provided with a plurality of rolls, a screw-down motor for shifting the rolls, means for controlling the operation of the screw-down motor and adapted to be preset to automatically deenergize the screw-down motor when the rolls are in one of a plurality of preselected positions, and means for effecting the return of the rolls to the preselected position in case the screw-down motor actuates the rolls past the selected position.

12. In combination, a rolling mill provided with a plurality of rolls, a screw-down motor for moving the rolls, means for controlling the operation of the screw-down motor and adapted to be preset to automatically effect the deenergization of the screw-down motor when the rolls are in one of a plurality of different predetermined positions, said means comprising means for effecting the return of the rolls to the preselected position in case the screw-down motor actuates the rolls past the selected position, and means for rendering the return means ineffective.

13. In a control system comprising a rolling mill having a plurality of rolls, a screw down motor for moving the rolls, means for automatically effecting the deenergization of the screw-down motor when the rolls are in a predetermined position, presetting mechanisms for preselecting one of a plurality of predetermined positions of the rolls at which automatic stopping means shall be effective, and means for indicating when the screw-down motor has arrived at a preselected position.

14. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for moving the rolls, means for starting the screw-down motor to adjust the rolls prior to each operation of the mill, means for automatically stopping the screw-down motor when the rolls are in one of a plurality of predetermined positions, means for preselecting one of a plurality of positions to which the screw-down motor will automatically adjust the rolls, and means for selecting which one of the preselected positions at which the screw-down motor will stop for each operation of said motor.

15. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for moving the rolls, means for providing automatic selection of any one of a plurality of roll positions, and means for rendering the automatic means ineffective and making the screw-down motor responsive to manual control.

16. In a control system, in combination, a plurality of rolling mills each provided with a plurality of rolls, a screw-down motor for each mill for moving the rolls, means for starting the screw-down motors to move the rolls prior to the operation of the rolling mills, means for automatically stopping each of the screw-down motors individually when the rolls which they respectively adjust are in a predetermined position, and means for preselecting one of a plurality of positions to which each of the screw-down motors will automatically move the rolls of the rolling mill.

17. In a control system, in combination, a plurality of rolling mills each provided with a plurality of rolls, a screw-down motor for each mill for shifting the rolls, means for starting the screw-down motors to adjust the rolls prior to the operation of the rolling mills, means for automatically stopping each of the screw-down motors indi-

vidually when the rolls which they adjust are in a predetermined position, means for preselecting one of a plurality of positions to which each of the screw-down motors will automatically move the rolls of each mill, and means for selecting any of the pre-selected roll positions for each successive operation of the mills.

18. In a control system, in combination, a plurality of rolling mills disposed for operating in sequence upon a piece of material, a plurality of rolls for each mill, a plurality of screw-down motors for positioning the rolls, a plurality of main driving motors for actuating the mills, means for preselecting one of a plurality of positions to which the screw-down motors may automatically move the rolls, means for preselecting the speed of the main driving mill motors for each different position of the rolls so that the linear speed of the material rolled will, at all times, be substantially equal to the peripheral speed of the rolls, and means for effecting the change of speed of the motors simultaneously with the positioning of the rolls.

19. In a control system for rolling mills provided with a plurality of rolls, in combination, a motor for raising or lowering said rolls, means for causing the motor to be deenergized to stop the rolls at any one of a plurality of pre-selected positions, and means controlled by the over-travel of said rolls past any one of said pre-selected positions for causing the motor to be reversed and thereby return the rolls to the pre-selected position.

20. In a control system for rolling mills provided with a plurality of rolls, in combination, a motor for raising or lowering said rolls, means for causing the motor to be deenergized to stop the rolls at any one of a plurality of pre-selected positions, means controlled by the over-travel of said rolls past any one of said pre-selected positions for causing the motor to be reversed and thereby return the rolls to a pre-selected position, and means for decelerating the motor before a pre-selected position is reached.

21. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for actuating the rolls from one limiting position to another, means for controlling said screw-down motor whereby the rolls may be adjusted to a selected position intermediate said limiting positions, and means responsive to movement of said rolls past said pre-selected intermediate position for causing the screw-down motor to return the rolls to said pre-selected intermediate position.

22. In a control system for rolling mills provided with a plurality of rolls, in combination, a screw-down motor for actuating the rolls from one limiting position to another, means for controlling said screw-down motor whereby the rolls may be adjusted to a selected position intermediate said limiting positions, means responsive to movement of said rolls past said pre-selected intermediate position for causing the screw-down motor to return the rolls to said pre-selected intermediate position, and means for causing the screw-down motor to actuate the rolls towards one or the other of said limiting positions step-by-step.

23. In a control system for rolling mills provided with a plurality of rolls, in combination, a motor for adjusting said rolls, means for controlling the operation of said motor whereby the rolls may be adjusted towards a pre-selected position, and means for further controlling the operation of said motor for effecting either progressive or retrogressive movement of said rolls with reference to said pre-selected position.

24. In a control system for rolling mills provided with rolls, in combination, a motor for adjusting the rolls, means for reversing the motor, means for starting the motor and then stopping it when the rolls have been adjusted to a predetermined position with reference to one another, and means for initiating deceleration of the motor at a pre-selected point before the rolls have arrived at said predetermined position.

25. In combination, a motor, means for reversing said motor, means for controlling said reversing means comprising a plurality of stationary contact segments and a movable contact member disposed for operation in accordance with the speed and direction of operation of said motor, means for segregating said stationary contact segments into groups, each of said groups comprising a plurality of said stationary contact segments connected in series-circuit relation, and means for connecting said groups of contact segments to the reversing means whereby operation of the motor in one direction is effected when the movable contact member is disposed into circuit-making relation with one of said groups and in the opposite direction when in circuit-making relation with the other of said groups.

26. In combination, a motor, means for reversing said motor, means for controlling said reversing means comprising a plurality of stationary contact segments and a movable contact member disposed for operation in accordance with the speed and direction of operation of said motor, means for segregating said stationary contact segments into groups, each of said groups comprising a plurality of said stationary contact segments connected in series-circuit relation, means for connecting said groups of contact segments to the reversing means

whereby operation of the motor in one direction is effected when the movable contact member is disposed into circuit-making relation with contact segments in one of said groups and in the opposite direction when in circuit-making relation with the contact segments in the other of said groups, and means for utilizing certain of said stationary contact segments to effect deceleration of the motor as the movable contact member approaches said point of segregation.

27. In combination, a motor, means for reversing said motor, means for controlling said reversing means comprising a plurality of stationary contact segments and a movable contact member disposed for operation in accordance with the speed and direction of operation of said motor, means for segregating said stationary contact segments into groups, each of said groups comprising a plurality of said stationary contact members connected in series-circuit relation, means for connecting said groups of contact segments to the reversing means whereby operation of the motor in one direction is effected when the movable contact segment is disposed into circuit-making relation with one of said groups and in the opposite direction when in circuit-making relation with contact segments in the other of said groups, means for progressively segregating said stationary contact members into groups, each group comprising certain of said stationary contact members connected in series-circuit relation, and means for connecting said groups of contact members to said motor-reversing means, whereby the circuit to said motor may be interrupted at the points of segregation.

28. In combination, a motor, means for reversing said motor, means for controlling said reversing means comprising a plurality of stationary contact segments and a movable contact member disposed for operation in accordance with the speed and direction of operation of said motor, means for segregating said stationary contact segments into groups, each of said groups comprising a plurality of said stationary contact segments connected in series-circuit relation, means for connecting said groups of contact segments to the reversing means whereby operation of the motor in one direction is effected when the movable contact member is disposed into circuit-making relation with one of said groups and in the opposite direction when in circuit-making relation with the other of said groups, and means for utilizing certain of said contact segments to effect deceleration of the motor when the movable contact member is at a predetermined distance from, and moving toward, the respective points of segregation.

In testimony whereof, I have hereunto subscribed my name this 9th day of December, 1927.

HAROLD C. JENKS.

DISCLAIMER

1,764,312.—*Harold C. Jenks*, Wilkinsburg, Pa. CONTROL SYSTEM FOR ROLLING MILLS. Patent dated June 17, 1930. Disclaimer filed December 1, 1937, by the assignee, *Westinghouse Electric & Manufacturing Company*.

Hereby enters this disclaimer to claims 1, 3, 4, 5, and 6 of the patent specification.

[*Official Gazette December 28, 1937.*]