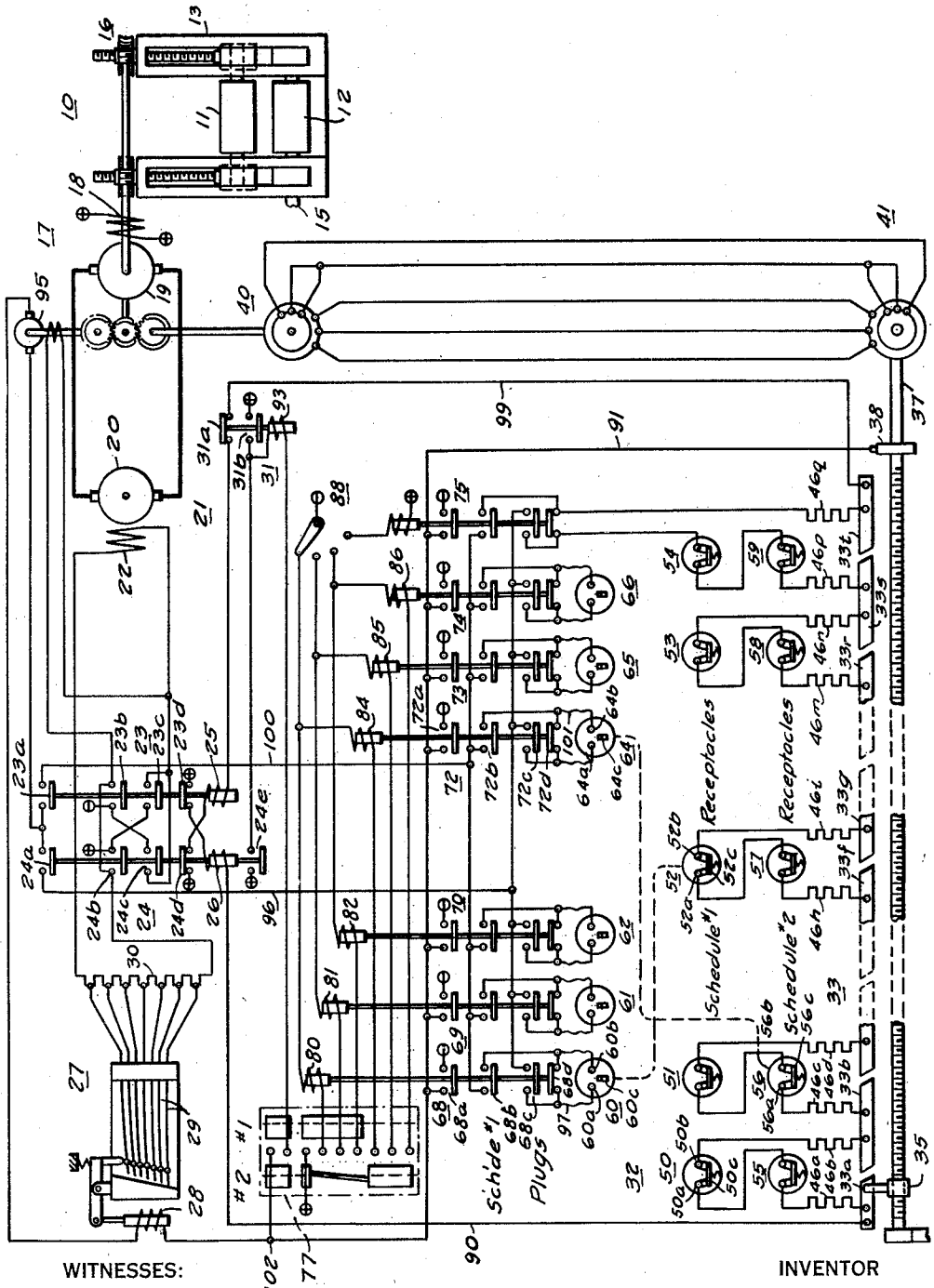
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CONTROL SYSTEM

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WITNESSES:

E. A. McCloskey.

F. V. Fiolma

INVENTOR

Willard G. Cook.

BY

Crawford

ATTORNEY

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CONTROL SYSTEM

Willard G. Cook, Wilkinsburg, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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My invention relates, generally, to control systems, and it has reference in particular to an automatic screwdown control system for rolling mills and the like.

Generally stated, it is an object of my invention to provide a new and improved screwdown control system which is of simple and economical construction and which is rapid and accurate in its operation.

More specifically, it is an object of my invention to provide for controlling both the direction and speed of operation of the screwdown motor of a rolling mill by means of a single limit switch having a movable contact arm and a single track of stationary contact segments for determining the control circuits for both functions.

It is also an object of my invention to provide for simplifying the design and reducing the size of the limit switch used to determine the direction and speed of operation of a screwdown motor for a pair of relatively movable rolls or devices of a similar character.

Another object of my invention is to provide for reducing the number of stationary contact segments required in a limit switch for selectively controlling the operation of a screwdown motor.

Still another object of my invention is to reduce a number of connections between the limit switch and the pass relays in a screwdown control system.

A further object of my invention is to provide for reducing the size of the connector plugs and the size of the receptacles associated with a screwdown limit switch.

Other objects will, in part, be obvious and will, in part, be explained hereinafter.

According to one embodiment of my invention, the operating circuits of the direction and speed controlling relays controlling the operation of the screwdown motor of a rolling mill are determined by a limit switch which has only a single set or track of stationary contact segments engageable by a movable contact arm actuated in accordance with the movement of one or more of the rolls. A pair of control resistors are connected between each of the stationary contact segments to provide variable resistance control circuits for the direction and speed controlling relays. The circuits are selected by pass relays which are connected intermediate different ones of the control resistors by means of receptacles for receiving pass plugs. The direction control relays for the screwdown motor are selectively energized depending on the position of the movable contact arm relative to the point of interruption of the circuit through the control resistors, as determined by which of the pass relays is operated. The screwdown speed control relay is operated in accordance with the number of control resistors in its operating circuit, which is dependent both on the position of the movable contact arm and which of the pass relays is operated.

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For a more complete understanding of the nature and objects of my invention, reference may be made to the following detailed description which may be read in connection with the accompanying drawing, in which the single figure is a diagrammatic view of a screwdown control system embodying the invention in one of its forms.

My invention comprises an improvement over and a simplification of the screwdown control systems described and claimed in Patent No. 1,764,312 which issued on June 17, 1930, to Harold C. Jenks, and my copending application Serial No. 540,237 which was filed on June 14, 1944, both of which are assigned to the assignee of the present invention.

Referring to the drawings, the reference numeral 10 may denote, generally, a roll stand such as is commonly used in steel mills wherein relatively movable rolls 11 and 12 are rotatably supported in a frame structure 13. The rolls may be driven in any suitable manner, and the driving means (not shown) may, for example, be connected to the lower roll 12 by means of a shaft extension 15 in a well known manner. Relative movement of the rolls to change the distance or spacing between them may be effected by means of a screwdown mechanism 16 which may be operatively connected to the journals of the upper roll 11 for raising and lowering it relative to the lower roll 12. Operation of the screw mechanism 16 may be effected by means of a screwdown motor 17 having a field winding 18 and an armature 19.

Control of the screwdown motor 17 may be effected by using a variable voltage system and connecting the armature 19 thereof across the armature 20 of a control generator 21. Both the direction and speed of operation of the screwdown motor 17 may then be readily controlled by controlling the excitation of the field winding 22 of the control generator. For example, "raise" and "lower" relays 23 and 24 having operating windings 25 and 26, respectively, may be utilized for reversibly connecting the field winding 22 to a suitable source of electrical energy.

A speed control relay 27 may be provided for

varying the excitation of the field winding 22 to control the speed of the screwdown motor 17. The operating winding 28 of relay 27 may be energized in varying degrees to actuate an armature operatively connected to a plurality of flexible contact members 29 for shunting different portions of a control resistor 30 connected in circuit relation with the field winding 22.

In order to provide for effecting operation of the screwdown motor so as to always lower the roll 11 to its final position and prevent raising thereof as the final operation, an interlock relay 31 may be provided for preventing operation of the "raise" relay 23 after the "lower" relay 24 has been operated, during the operation of the screwdown motor to position the roll 11 for any one given rolling operation.

In order to provide for controlling the operation of the "raise" and "lower" relays and the speed control relay 27 so as to move the roll 11 in the proper direction and at a suitable speed depending on the distance and direction of the desired position from the actual position of the roll, means such as the limit switch 32 may be provided. The limit switch may, for example, comprise a single track or set 33 of stationary contact segments 33*a*, 33*b* through 33*f*, 33*g* and 33*r*, 33*s* and 33*t* arranged in spaced end-to-end relation and having overlapping inclined end portions, and a movable contact arm 35 engaging different ones of the stationary contact segments for effecting electrical connection therewith through the medium of the driving shaft 37 and a collector ring 38. Operation of the contact arm 35 may be effected in any suitable manner as by means of a syncrotie system including motors 40 and 41 operatively connecting the shaft 37 to the screwdown motor 17.

Predetermined operation of the "raise" and "lower" relays 23 and 24 may be effected by providing for energizing the operating windings 25 and 26 thereof through different portions of the limit switch 32. For example, a plurality of control resistors, represented by resistors 46*a* through 46*q*, may be connected in paired relation between adjacent segments of the track 33.

The selection of the operating windings 25 or 26 to be energized may be effected by providing for interrupting the connections between the resistors at different predetermined points, by connecting a pass control relay between the control resistors of a particular pair. Where it is desired to preset one or more schedules at one time, provision may be made for connecting one or more pass relays of different schedules between a given pair of resistors. This may be effected by connecting one or more receptacles between the control resistors of each pair, which may be represented in part by the schedule #1 receptacles 50 through 55 and their associated schedule #2 receptacles 56 through 59, which are shown in the drawing. Only a single receptacle is necessary between the resistors of each pair where it is desired to set up only a single rolling schedule at one time.

The receptacles may be of any suitable type and may be of the general construction which is described in detail in my copending application, Serial No. 540,237 hereinbefore referred to. Instead of having three stationary contact members, as described in the copending application, the present invention requires only a single pair of contact members for each receptacle, which may be typified by the contact members 50*a* and 50*b* of receptacle 50. These contact members may be

normally connected together by short-circuiting means 50*c* similar to that described in detail in my copending application.

External connections to the track 33 may be made by means of a plurality of plugs 60 through 62 which represent a portion of the plugs which may be used for obtaining different positions of the roll 11 for the #1 schedule, and plugs 64 through 66 which represent a portion of the plugs for a #2 schedule. Each of the plugs may comprise a pair of stationary contact members typified by the contact members 60*a* and 60*b* of the plug 60, which are disposed to engage the stationary contact members *a* and *b*, respectively, of any receptacle in which the plug may be positioned. Each of the plugs may also be provided with an actuator such as the actuator 60*c* of the plug 60 for operating the short-circuiting switch means normally connecting the contact members of the receptacle in which the plug is positioned, to open said contact members.

The connections between the control resistors 46*a* through 46*q* may be interrupted at any predetermined point or points to provide for stopping the screwdown motor 17 when the movable roll 11 reaches a predetermined position. The interruption of these connections may be effected by means of a plurality of pass relays which may be connected by flexible conductors to the plugs, and may be represented by the pass relays 68, 69 and 70 of schedule # 1, and the corresponding pass relays 72, 73 and 74 of schedule #2. An additional pass relay, known as the "special pass" relay 75, may be provided for determining the minimum or zero setting of the movable roll 11.

The selection of the particular operating schedule may be made by means of a schedule selector switch 77 which provides for selectively connecting the operating windings 80, 81 and 82, or 84, 85 and 86 of the pass relays of schedule #1 or schedule #2, respectively, as the case may be, to a suitable source of electrical energy for energization. A "pass" control switch 88 may be provided for determining which of the "pass" control relays operates, hence determining the operation of the direction and speed control relays.

With the roll 11 and the contact arm 35 in the position shown, the #1 pass plug 60 may be positioned in any of the #1 schedule receptacles, depending on the desired spacing between the rolls 11 and 12, and the schedule selector switch 77 may be operated to the #1 schedule position to provide for energizing one or another of the operating windings 80, 81 or 82. If the plug 60 is, for example, positioned in the receptacle 52 with the pass selector switch in the position shown, contact members 60*a* will be open and the actuator 60*c* will operate the normally closed short-circuiting switch means 52*c* and interrupt the connection between the control resistors 46*h* and 46*i*, thus isolating the segments 33*f* and 33*g* of the limit switch track.

Accordingly, an energizing circuit will be provided for the "lower" relay 24 from the positive terminal through contact members 23*d* of the "raise" relay, operating winding 26, and conductor 90 to the left-hand end of the track 33 through segment 33*a*, contact arm 35, shaft 37, collector ring 38, conductor 91 and contact members 68*a* of the pass relay 68 to the negative terminal. The "lower" relay 24 operates, connecting the field winding 22 of the control generator 21 to the source through contact members 24*b* and 24*c* in

such a manner as to effect operation of the screwdown motor 17 to move the rolls 11 and 12 closer together.

At the same time, the operating winding 93 of the lockout relay 31 is energized through contact members 24e. The relay operates and locks up through contact members 31b, through the schedule selector switch 77 and contact members 68a of the pass control relay 68. Operation of the "raise" relay 23 is thereby prevented by contact members 31a being held open until either the pass control switch 88 or the schedule selector switch 77 is operated to interrupt the holding circuit.

Operation of the screwdown motor continues until the movable contact arm 35 leaves the segment 33f, the number of resistors 46a through 46h in the circuit having little effect on the operation of the directional relays, whereupon the energizing circuit for the operating winding 26 of the "lower" relay is interrupted. An energizing circuit for the "raise" relay 23 is set up, but the lockout relay 31 prevents its completion.

When the "lower" relay 24 operates, an energizing circuit is provided for the operating winding 28 of the speed control relay 27 extending from the movable contact arm 35 through the shaft 37, collector 38, conductor 91, operating winding 28 through the armature circuit of a pilot generator 95, contact members 24a of the "lower" relay 24, conductor 96, contact members 68c of the #1 pass relay 68, flexible conductor 97, contact member 60a of the plug 60, contact member 52a of the receptacle 52, through control resistors 46h through 46a connected between segment 33f and each of the segments to the left of segment 33f to the movable brush 35.

The operating winding 28 of the speed control relay 27 is thereby energized in accordance with the number of the control resistors 46a through 46h included in its operating circuit, and the voltage developed by the pilot exciter 95. The control resistors 30 in circuit relation with the field winding 22 of the control generator will be shunted accordingly, and as the arm 35 moves toward the segment 33g, the speed of the screwdown motor will be substantially proportional to the distance the roll 11 is from the desired final position. When the arm 35 leaves the segment 33f, the circuit for the "lower" relay 24 is opened and the energizing circuit for the speed control relay 27 is interrupted at contact members 24a. An energizing circuit for the "raise" relay 23 is set up, but is held open by the interlock relay 31.

Other roll positions may be predetermined by positioning different ones of the #1 schedule plugs in others of the #1 schedule receptacles and operating the pass selector switch 88 to operate the corresponding pass relays successively. The interlock relay 31 is deenergized upon each such operation, thus permitting raising of the roll 11 on a subsequent pass.

Since the contact members of the receptacles are all normally short-circuited by their respective short-circuiting switches, two or more roll schedules may be set up by providing two or more receptacles in series between each of the control resistors of a pair and providing one or more additional sets of pass plugs and pass control relays such as those represented by the #2 schedule pass plugs 64 to 66 and the #2 schedule pass relays 72 through 74. These plugs may be positioned in the desired receptacles of the #2 schedule without in any manner interfering with the operation of the #1 schedule.

Should a subsequent rolling operation require that the rolls be spaced further apart, one of the pass plugs, for example, plug 64 of schedule #2, may be placed in receptacle 56. The schedule selector switch 77 may be operated to the schedule #2 position, whereupon the holding circuit for the interlocking relay 31 is interrupted during the transfer and the relay returns to the deenergized position.

With the pass selector switch 88 in the #1 pass position as shown, an obvious energizing circuit is provided for the operating winding 84 of pass relay 72. The pass relay 72 operates, opening contact members 72d and interrupting the control resistor circuit between resistors 46c and 46d (the short circuiting switch means 56c was opened by the actuator 64c of the plug 64.

At the same time, an energizing circuit for the "raise" relay 23 is provided, extending from the positive terminal through contact members 24d of the "lower" relay 24, contact members 31a of the interlocking relay 31, conductor 99 to segment 33t and through the control resistors 46q, 46p, etc., connected between segments 33t and 33g, to the movable contact arm 35, shaft 37, collector 38, conductor 91 and contact members 72a of the pass relay 72 to the negative terminal. The field winding 22 of the control generator is thereupon so energized through contact members 23b and 23c that the screwdown motor 17 raises the roll 11 until the movable arm 35 leaves the segment 33g and moves onto the segment 33f.

Thereupon the "raise" relay energizing circuit is interrupted, since the contact members 72d are open, and the "lower" relay 24 is energized. The screwdown motor 17 reverses and lowers the roll 11 to its final position until the arm 35 leaves the segment 33f. Thereupon the "lower" relay circuit is interrupted and an energizing circuit is prepared for the "raise" relay. The interlocking relay 31, which was energized when the "lower" relay operated, remained energized through its 31b contact members and prevents energization of the "raise" relay.

The speed of the motor 17 in raising the roll 11 from its previous position is again determined by the speed control relay 27 and pilot exciter 95. The energizing circuit for the operating winding 28 of the speed control relay extends from the arm 35 through shaft 37, collector 38, conductor 91, operating winding 28, armature of exciter 95, contact members 23a of the "raise" relay 23, conductor 100, contact members 72b of the pass relay 72, flexible conductor 101, contact member 64b of the plug 64, contact member 56b of receptacle 56, resistor 46d, etc., through 46h and 46i to segment 33g and arm 35. As the arm moves to the left, the amount of the control resistance 46 decreases, so that the speed of the motor 17 is reduced by the speed control relay 27 inserting more of the resistance 30 in the circuit of the control generator field winding 22 until the minimum speed is reached at the final stopping point.

From the above description and the accompanying drawing, it will be apparent that I have provided a simple and effective manner for controlling the operation of a screwdown motor. Since only a single pair of contact members are required in each of the receptacles, the size of the receptacle and the size of the plugboard used with the limit switch may be greatly reduced. Likewise, the number of contacts in the pass plugs may be reduced, which enables them to be made smaller and at the same time reduces the

size of the cable connections thereto. In addition, only a single track of contact segments is required for the limit switch itself instead of the multiple track heretofore common in the art, so that the size of the limit switch itself may be greatly reduced. By providing for selectively determining the energizing circuit of the speed control relay 27 through the limit switch in accordance with the direction of operation of the screwdown motor control circuits for the "raise" and "lower" directional control relays, and the speed control means may be selectively provided through different portions of the limit switch by means of a single track and the movable contact arm without interfering with each other.

Since certain changes may be made in the above-described construction and different embodiments of the invention may be made without departing from the principles thereof, it is intended that all the matter contained in the above description and shown in the accompanying drawing be considered as illustrative and not in a limiting sense.

I claim as my invention:

1. In a control system for a motor operatively connected to move one member relative to another, means operable to control the direction of operation of the motor, means operable variably to vary the speed of the motor, means including a limit switch having a movable arm operatively connected to the motor and actuable to engage a plurality of stationary contact segments arranged in a single track with control resistors connected therebetween in circuit relation with said segments for jointly providing variable impedance operating circuits through different of the control resistors for controlling the direction control means and variably operating the speed control means, and control means for interrupting the circuit through the control resistors at different predetermined points to determine the direction and speed of operation of the motor.

2. For use with a motor operatively connected to move one member relative to another, means operable to control the direction of operation of the motor, means operable to vary the speed of the motor, means including a limit switch with a movable arm for engaging a plurality of stationary contact members arranged in a single path and having control resistors connected therebetween in circuit relation with said contact members for providing control circuits through different portions of the control resistors to jointly determine the operation of the direction and speed control means to continuously vary the speed of the motor in accordance with the position of the arm, and means for interrupting the connections between the contact members to determine the operation of the direction and speed control means.

3. For use in a screwdown system having a motor operatively connected to a movable member, a limit switch having a movable arm operatively connected to the motor for engaging a plurality of spaced contact segments, resistor means connected between and in series circuit relation with adjacent segments, circuit means including a plurality of position control relays operable to control connections between adjacent segments through said resistor means, direction means for the motor selectively energizable through predetermined ones of the resistor means dependent upon which position control relay is operated, speed control means for the motor, and means responsive to the direction of operation of the motor for providing an energizing circuit through predetermined others of the resistor means for the speed control means.

4. In a control system for a motor operating a movable member, control means comprising a movable arm operatively connected to the motor for engaging a plurality of spaced apart contact members arranged in a single track, a pair of resistors connected in series circuit relation between adjacent segments, control means having contact means selectively operable to interrupt connections between the resistors of a pair, direction means having contact means for controlling the operation of the motor connected to each end of the track for selective energization through the movable arm, means operable to vary the speed of the motor, and circuit means including contact means of an operated control means and the direction means for selectively providing an operating circuit for the speed control means.

5. A screwdown control system for a motor operatively connected to vary the spacing between a pair of relatively movable members comprising, a pair of direction relays for controlling the operation of the motor, each having one terminal connected to a source of control voltage, means including a switch device having a plurality of stationary contact members arranged in a track and connected between the other terminals of the direction relays, said switch device having a movable arm operatively connected to the motor engaging the stationary contact members and connected to the other terminal of the source, a pair of resistors connected in series circuit relation between each pair of stationary contact members, control means for controlling the circuit connections between the resistors of each pair, means for controlling the speed of the motor, and circuit means operable under the control of the direction relays and the control means for providing a predetermined operating circuit for the speed control means dependent on the position of the movable member from the desired position.

6. For use with a motor operatively connected to one of a pair of relatively movable members, means operable to control the direction of rotation of the motor, means operable under the control of said means to vary the speed of the motor, a plurality of control resistors, and means including a limit switch having a plurality of contact segments arranged in a single path and connected to the control resistors and a movable arm operatively connected to the motor for engaging different ones of the segments and providing variable control paths through different portions of the control resistors for the direction and speed control means.

7. In a control system for a motor operatively connected for moving one member relative to another, a limit switch comprising a single elongated track of spaced apart contact segments arranged in overlapping end-to-end relation for engagement by a movable contact member operatively connected to the motor for movement along the segments in accordance with the relative position of said one member, circuit means including a pair of control resistors connected between each pair of adjacent contact segments in series circuit relation therewith, means operable to control the direction of rotation of the motor, means operable under the control of the direction controlling means to control the speed of the motor, and control means selectively connecting said pairs of control resistors including a plurality of control relays selectively operable to control

the operation of the direction and speed control means by providing predetermined variable energizing circuits therefor through predetermined ones of the control resistors.

8. A control system for a motor operatively connected to position a movable member comprising, means operable to determine the direction of operation of the motor, means operable under the control of the direction means to control the speed of the motor, a limit switch having a movable contact arm operatively connected to the motor for engaging a plurality of stationary contact segments associated with resistance means to provide energizing circuits for the direction and speed control means for the motor, and contact means associated with the contact segments operable to provide predetermined connections therebetween for effecting predetermined operations of the direction and speed control means.

9. In a control system for a motor operatively connected to actuate a movable member to different positions, means operable to control the direction of operation of the motor, means operable under the control of the direction control means to control the speed of the motor, and means operable to control the direction and speed control means including a limit switch having a plurality of stationary contact segments with resistance means connected therebetween and a movable contact arm operatively connected to the motor for providing variable control circuits for the speed and direction control means.

10. The combination with a limit switch having a single track of stationary contact segments and a movable contact arm, of resistance means connected between adjacent contact segments, a plurality of receptacles each having a pair of contact members connected intermediate the resistance means between one of said pairs of contact segments and provided with normally closed switch means connecting the contact members, a plug positionable in one of said receptacles having means for actuating the switch means when the plug is inserted and having a pair of contact members to engage the receptacle contact members, and control means normally connecting the plug contact members together operable to provide external connections therethrough to the resistance means.

11. A control system for a motor operatively connected to move one member to predetermined positions relative to another member comprising, a limit switch having a plurality of stationary contact segments arranged in a single track and a movable contact arm for engaging said contact segments which is operatively connected to the motor, a pair of resistance elements connected one to each segment between each pair of adjacent contact segments, a plurality of receptacles each having a pair of contact members connected intermediate different ones of the resistance elements of each pair and normally connected together by normally closed switch means in each receptacle, a plug detachably positionable in different of the receptacles, said plug having contact means to engage the receptacle contact members and means to actuate the normally closed switch means of the receptacle to the open position after the plug contact members engage the receptacle contact members, a pair of direction relays for effecting operation of the motor in opposite directions and having operating windings with one terminal of each connected to opposite ends of the contact segments of the limit switch for connection to one terminal of a source of control potential through the movable contact arm and the other terminal of each connected to the other terminal of the source, means operable to control the speed of the motor, and control means associated with each of the plugs having normally closed contact members connecting the plug contact members operable to interrupt the connections between different pairs of resistance elements and to provide control circuits through different ones of the said resistance elements for the speed control means.

WILLARD G. COOK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,092,051	Cook	Sept. 7, 1937
Re. 20,658	Knight	Feb. 22, 1938
1,764,312	Jenks	June 17, 1930