

July 31, 1934.

J. F. SCHNABEL

1,968,174

SYSTEM OF MOTOR CONTROL FOR HOISTS

Original Filed Aug. 4, 1930

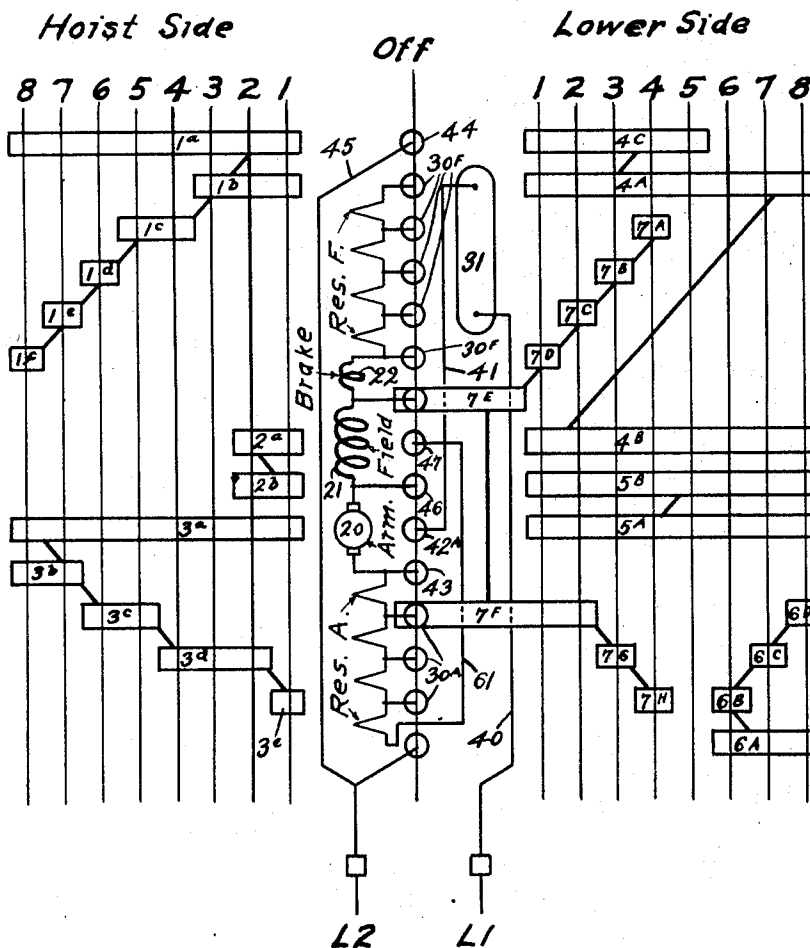
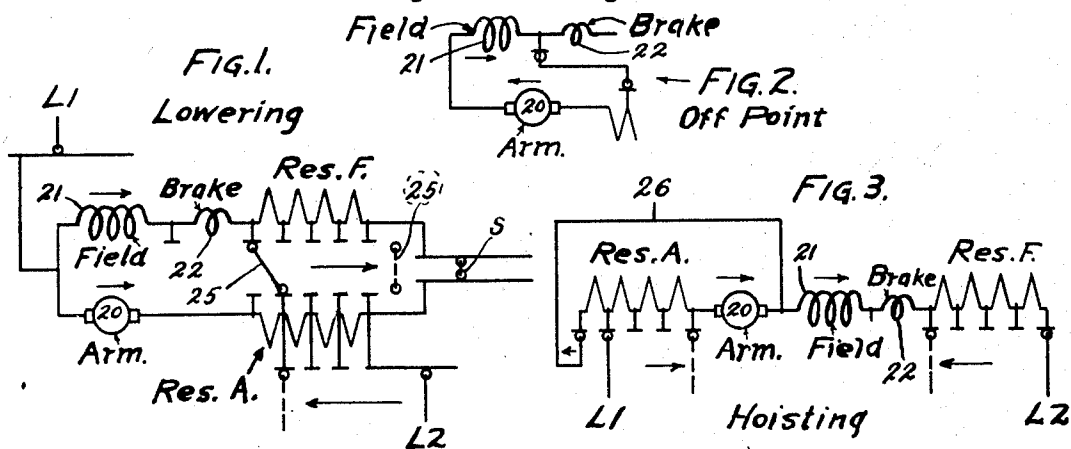


FIG. 4.

INVENTOR.
James F. Schnabel
BY
Ray Oberlin & Day
ATTORNEYS.

UNITED STATES PATENT OFFICE

1,968,174

SYSTEM OF MOTOR CONTROL FOR HOISTS

James F. Schnabel, Cleveland, Ohio

Application August 4, 1930, Serial No. 472,780

Renewed February 4, 1933

9 Claims. (Cl. 172-152)

The present invention relates to a system of control for the operation of electric motors, and more particularly where the motor is used on hoisting apparatus both for raising the load and for lowering the same, and the system is more particularly adaptable for the controlling of the lowering movement particularly to obtain a satisfactory dynamic braking control.

The object of the present invention is to provide a control system in which all of the resistors are in use in the circuit during the entire lowering movement, and also to use the resistors assembled in as few banks as possible. The importance of such an arrangement is clear, when it is understood that the object of dynamic braking control in lowering is to provide for the dissipation of the potential energy stored in the load by allowing the motor to act as a generator when driven by the descending load. This energy which is released is then radiated in the form of heat from the resistors suitably placed in the control circuit. It is possible to return a part of the energy to the power line, but the larger part must be dissipated from the resistors and it is very desirable, therefore, to make use of all the resistors during lowering movement so as to obtain the greatest amount of heat dissipating material, and thus in turn reducing the weight and cost of the control mechanism.

This arrangement is also desirable because on many hoists, the empty hook or light loads that will not overhaul, must also be lowered and although the potential energy under these conditions is not sufficient to overcome the friction of the mechanism, the resistors are required to dissipate a considerable amount of energy even under this condition. The hoisting motors are commonly made with series fields but, in lowering, the field is normally connected across the line similar to a shunt wound motor.

Most of the resistors are placed in the circuit in such a way that they will limit the current that can flow in the series field from the power line if the load that is being handled is not sufficiently heavy to furnish the energy to magnetize the field so that even under light load conditions, a very considerable amount of energy in the form of heat must be dissipated from the resistors. In such a control system for hoists, there must also be provided a considerable range in lowering speeds and to secure very low speeds on the first few controlled points, it is necessary to draw considerable energy from the line in order to produce a strong field in the motor and at the same time it is necessary to reduce the line

voltage as applied to the armature to a low value. This makes it necessary for the resistors to radiate a larger amount of energy at low lowering speeds for light loads as well as heavy loads.

Heretofore dynamic braking controllers have had a part of the resistors short-circuited or left out of the circuit on the first few points in lowering and provision has been made for inserting such resistors in the field circuit as the controller is moved to the full speed lowering position. This type of control gives a strong field for the low speeds and a weaker field for the higher speeds. In some control systems additional resistor banks have been used for reducing the voltage on both the field and armature on the first few lowering points, and these resistors have then been cut out and remain unused on the remaining points of the controller. In the present controller, the system is so arranged that all of the resistors are in the circuit during the entire lowering operation.

On other systems of dynamic braking, fixed resistances are used in the armature path in lowering and such resistances are usually of rather high value to insure the release of the magnetic brake as a too rapid increase of the resistors in the field and brake path, obtained by rapidly moving the controller before gravity can accelerate the load, will allow the most of the current to flow through the armature path and reduce the flow through the field and brake circuit so low as to prevent the brake being entirely released. A high fixed resistance in the armature path on the last few points will also reduce the voltage on the armature when lowering light loads and make its speed slower than is desired and at the same time such type of fixed resistance will increase the speeds of overhauling loads unduly. In the present system the resistance of the two parallel paths may be maintained at such relative values as will give proper operation of the brake and the necessary torque to start the motor, until the last few points of the controller, when the resistance remaining in the armature path may be reduced to a minimum. Such a system makes the controller better adapted for use with brakes of varying operating characteristics and improves the lowering speeds which can be obtained and makes it possible to obtain high speeds with the light loads and to obtain close control of the slower speeds for the heavy loads. To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims.

110

The annexed drawing and the following description set forth in detail certain mechanism embodying the invention, such disclosed means constituting, however, but one of various mechanical forms in which the principle of the invention may be used.

In said annexed drawing:

Fig. 1 is a diagrammatic wiring circuit showing the controller for the lowering direction at the first lowering point; Fig. 2 shows the safety dynamic braking circuit at the off-point; Fig. 3 is a wiring diagram showing the hoisting circuit; and Fig. 4 is a wiring diagram of a drum-like controller arranged to obtain the circuit shown in Figs. 1, 2 and 3.

In Fig. 1 there is illustrated a motor having an armature 20 and a field coil 21 and a brake coil 22 in series with the field, two resistor banks A and F and the two-line wires, L1 and L2, the line L1 being connected to the motor circuit between the armature and field, the other line L2 being connected to a point between the two resistor banks. One end of resistor bank A is connected to one end of the armature and one end of the resistor bank F is connected to the brake coil, the other ends of the two resistor banks being connected together in the lowering position by the connection S. The controller also provides a movable bridge 25, which in the position shown, is connected across between the two resistance banks. In Fig. 1 the first control point of the lowering position of the controller is shown, and in this first point as indicated, the resistor bank F is connected in series with the field and brake coils 21 and 22, while the resistor bank A is connected in series with the armature 20, the line wire L1 being connected between the field and armature to form parallel circuits, and the line wire L2 being connected to the circuit beyond the outer ends of the resistor banks A and F, this circuit with the connection S closing the paths from the other ends of the resistor banks.

As the controller is moved toward the full lowering speed position, the bridge moves toward the right as shown in the diagram until it reaches the ends of the resistor banks, and thus both banks of resistors are maintained in parallel circuit during the movement of the controller over the contacts.

The L2 side of the line is also a movable contact and this contact moves to the left as the bridge 25 moves to the right, but is maintained beyond the end of the bank A until the bridge has reached the ends of the banks of resistors. After the bridge has reached the ends of the resistor banks, the contact for L2 is moved over the contacts on resistor bank A until it reaches the last point as shown in dotted lines in Fig. 1. The bridge connection 25 during this latter movement of L2 may be maintained across the ends of the two resistor banks or may be moved clear of the bank contacts, the parallel circuit between the banks then being maintained by the connection S.

Assuming that the current flows from the power line L1, the current from the line will divide and will flow in one path through the field and the brake and also in the parallel path through the armature and out through line L2. The current which flows in the path through the field and brake will be limited by the resistor bank F and the current flowing in the armature path will, at the time of starting, be limited by the resistor bank A. If the load is not heavy

enough to overhaul the motor, the current will continue to flow in the armature circuit, but if it overhauls, the motor will then act as a generator and current will flow in the opposite direction in the armature path. The speeds of the overhauling loads will be limited by the circuit of lesser resistance formed by the bridge, but on loads that will not overhaul, the bridge has less effect. This bridge may be so connected on the various points as to maintain at all times the desired balancing of the field and the armature paths in order to insure enough current in the field path to obtain prompt brake release and also to obtain sufficient current in the armature path to provide the necessary motor torque.

The bridge 25 also provides at the first point a dynamic braking circuit, that is, the closed circuit around and including the armature, field and brake and as shown, one division of resistor bank A is included in this dynamic braking circuit. The location of the ends of the bridge on the two banks A and F will be at such points as to maintain the desired relative resistance values of these two banks to suit the conditions under which the motor and the brake are operating and to obtain the necessary speeds. The speeds of overhauling loads will increase as the controller is moved toward the full speed lowering position as more resistance is introduced into the local dynamic braking circuit which is formed by the movable bridge connection.

Speeds of loads which will not overhaul will also increase, though not as fast. This is due to the increase in the voltage applied in the armature and the increase in the resistance shunted around the armature. On the final points of the controller, the field magnetism will be weakened by the insertion of a part of or all of bank A in the field path and the voltage on the armature will be increased to nearly full line voltage since only a very small part of bank A is left in series with the armature across the line. This gives a larger increase in speeds for the light loads, but for heavy loads, the increase in speed will not be so great as the resistance of the local dynamic braking circuit is maintained at the same value as on the preceding points.

If failure of power should occur during the lowering, the motor would stop unless the load is so heavy as to overhaul sufficiently to furnish the necessary energy for keeping the brake released. Such a load would continue to lower at a somewhat reduced speed because no voltage would be applied to the armature, but the control of the motor would not be greatly affected and the load could be stopped in the usual manner by bringing the controller to the off position. The back electro-motive force of the motor is in the proper direction to maintain the field excitation.

At the off point of the controller as shown in Fig. 2, the power line is disconnected, but the dynamic braking circuit through the motor is maintained, but the brake coil 22 is now left out of the circuit so that the brake will set and hold the hoist and load in its position. It will be seen that at this off-point, the dynamic braking circuit assists the magnetic or friction brake to bring the load to rest from the slow speed at the first point and thus reduces the wear on the brake to a minimum.

In Fig. 3 the armature 20 is shunted by means of a connection 26 on the first point with one division of bank A, the remainder being in series with the armature. On the second point the connection 26 from the end of a bank A to a point

between the armature and the field remains the same, but the contacting connection for L1 is moved to the right to the second step and thus two divisions of resistor bank A are shunted around the armature with the remaining two in series. It is not desirable to use all of the resistors of banks A and F in series with the motor on the first point in hoisting as the current flow would not be enough to operate the series brake or to give sufficient torque to keep the heavier loads from going down when they should hoist. That part of the resistor bank A which is not desirable in the motor circuit, can either be left out during hoisting, or it may be used for the armature shunt as desired.

This system of control may be used or obtained from controllers of various types, but the controller indicated as shown in Fig. 4 is a drum type controller which may be as satisfactorily employed as either a face plate type of controller, or controller of the magnetic contactor type.

In Fig. 4, which is a conventional wiring diagram, stationary contact fingers or brushes 30A, 30F, etc., are mounted upon an insulating support. A magnetic blow-out device 31 for extinguishing the arc is usually provided but is not essentially a part of the system. A cylindrical drum is provided on which are located the various contact segments, this drum being arranged and rotated by means of a controller handle (not shown) in the usual manner so that the contact fingers will be connected together to give the desired circuits through the armature, field, brake and resistors on the various points of the controller. Fig. 4 shows a development of the surface of this drum and to understand the operation, it is only necessary to consider the movement of the entire plane of contacts to the right or left of the position shown, that to the right being the hoisting side which brings into engagement with the stationary contact fingers A the movable hoist contacts, while movement to the left brings into engagement with the contact fingers the movable lowering contact segments. The vertical lines marked 1 to 8 inclusive on each side represent the points of various speeds for both lowering and hoisting line 1 in each case giving the lowest speed for each direction and the lines 8 giving the highest speed for each direction with gradual increases in speeds on the intervening points. Certain of the contacts C on the cylinder are joined together in groups. The drawing shows connections by full lines between the rectangular spaces or contact segments which represent the contacts proper and the groups are numbered as will be hereinafter explained to show the operating conditions.

As illustrated, five stationary contact fingers 30A and 30F are connected to each bank of resistors to obtain four divisions in each bank, but a greater or lesser number of divisions may be used depending upon the controller and motor size and the use to which it will be put.

With the controller on the hoist side, current will flow from L1 through wire 40, blowout 31 and wire 41 to the contact finger 42A engaging one of the contacts 3A of group 3, through the connected contacts 3b—c—d—e to one of the contacts 30A; on the first point the current enters the bank at the second contact from the bottom and passes through all, except the end division of the resistors to the armature. On succeeding steps, the current enters bank A through contacts 3b—c—d, leaving additional divisions of the resistor bank A out of the circuit until on the

last point all of the resistors are out of the circuit. The current flows from armature contact finger 43 through the armature 20, field coil 21, brake coil 22 to resistor bank F, through the resistors to top contact 30F and then through contacts of group 1 to the top contact finger 44 and through connection 45 to L2. On succeeding steps the current passes from bank F to contacts 1c—d—e and f of group 1 at the adjacent points leaving the successive divisions of the resistor bank F out of the circuit until on the last point all are left out. The contacts 2A and B of group 2 make the connections contacting with fingers 46 and 47 to close the shunt circuit for the armature shunt. If this feature is not desired, these contacts are simply omitted and the number of speeds in hoisting will be reduced by two. If these contacts are used as shown, on the first point the current divides at the contacts of group 3, part flowing from the contact finger next to the bottom one, through the end division of resistor bank A, through the wire 61 to the connected contact finger 47, through the contacts 2A and B to the contact finger 46 connecting with the point between the armature and the field. On the second point the current divides at the third contact finger from the bottom, part flowing through the two division of the resistors, through wire 61, thence as before.

With the controller on the lowering side, the current will flow from L1, wire 40 through the blowout coil 31 and wire 41 and connected contact finger 42A, through the contacts 5A and 5B of group 5 to finger 46 and connection point between the armature 20 and field 21. The current here divides part flowing through the field 21 and brake 22 and all of the resistor bank F to the second contact finger from the top, through the contacts 4A and 4C of group 4, the top contact finger 44 and wire 45 to L2; the other part of the current passes through the armature and all of bank A, through wire 61 and its connected contact finger 47 to contact 4B of group 4 to the top contact finger, thence through wire 45 to L2. The movable bridge is formed by the contacts of group 7, the contacts 7A—B—C—D—E plus the contacts 7F—G—H constituting the bridge 25 indicated in Fig. 1. The connection S between the two resistor banks is constituted by the contacts 4A—4B. From the first to the fourth points the contacts of this group engage successive points of division of resistor bank A with successive points of division of bank F through contacts 7A, 7B, 7C, 7D, 7E, 7F, 7G and 7H and connecting wire 71; from the fifth point on to the last, this bridge connection is open. From the sixth point on to the last the L2 side of the line is not connected to the contacts of group 4 but instead is connected by the bottom contact finger to the contacts of group 6. On the sixth point the field current passes through resistor bank F to the second contact finger from the top, contacts of group 4, the contact finger 47 and connected wire 61, the end division of bank A, the second contact finger from the bottom, contacts of group 6 to the bottom contact finger to line L2. On each of the remaining steps an additional division of resistor bank A is added to the field path. At the same time the resistance of the armature path on each of the steps 6, 7 and 8 is reduced one division. On the sixth step the armature current flows through all of resistor bank A, except the last division, to the second contact finger from the bottom, contacts of group 6 to bottom contact finger to L2. On the eighth step only one divi-

sion of bank A is left in the armature circuit, the current passing from the fourth contact finger from the bottom to the contacts of group 6, thence to L2 as before. At the off-point, the safety dynamic braking circuit is completed by two of the contacts of group 7, connecting the field, armature and the first division of bank A is a closed circuit.

Fig. 4 shows only one arrangement of the stationary contact fingers or brushes and contacts on the drum that may be used with this system. Other groupings of contacts might be preferred to make simpler castings for the drum parts. I do not wish to limit my invention to a particular type of controller construction, but to cover the location and interconnections of the motor, brake and resistors in a system of control as shown principally in Fig. 1, so that all of the resistors are in use all of the time in lowering.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the mechanism herein disclosed, provided the means stated by any of the following claims or the equivalent of such stated means be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. In an electric control system for motors of the type comprising an armature and series field winding, a circuit including a loop comprising the field winding and a first resistor bank the armature and a second resistor bank, a bridge connection across said two resistor banks, including all of the resistance in the loop, a bridge connection movable with respect to both resistor banks substantially throughout the length thereof to vary the amount of each included in the loop, a power line connected to said loop between said field winding and armature and a second power line movably connected to said second resistor to transfer resistance from the armature path to the field winding path and vice versa between said power lines.

2. In an electric control system for motors of the type comprising an armature and series field winding, means for connecting the field winding and a resistor in one path and the armature and a second resistor in a parallel path to form a closed loop, a movable bridge connected to the two resistors and forming a loop of variable resistance containing the motor armature and field winding, a power line connected to a point between the field winding and armature in said loop and the other power line being movably connected to said second resistor, and adapted to transfer portions of said resistors from one of said paths to the other to vary the voltage on the armature and to vary the field strength.

3. In an electric control system for motors of the type comprising an armature and series field winding, means for connecting the field winding and a resistor bank in one path and the armature and a second resistor bank in a parallel path, a connection between the two resistors for including variable amounts thereof in an internal loop containing the armature and field winding, a power line connected between said field winding and said armature and another power line movably connected to said second resistor and adapted to cut out resistance from the armature path and place the same in the field winding path.

4. In an electric control system for motors of the class comprising a field winding and an armature, and requiring power or dynamic braking,

means for connecting the field winding, the armature, and resistors in a closed loop, a movable bridge connection between points on said loop resistors for varying the resistance in said closed loop, and power connections to the closed loop, one power line being connected between the armature and the field winding and the other being movably connected to the resistors, the movable connection of said power line being adjustable to shift portions of the resistors from the armature path to the field winding path and vice versa to give varying voltage on the armature and varying field strength.

5. In a system of control for hoist motors of the class comprising a field winding and an armature, and requiring power or dynamic braking, means for providing a duplex circuit, comprising connecting the field winding and a resistor, and the armature and a second resistor in a closed loop with one terminal of the field connected to one terminal of the armature and a connection between the said two resistors movable with respect to both providing a dynamic braking circuit of varying resistance, and power connections to the closed loop, one power line being connected to a point between the field winding and the armature, and the other being movably connected to the second resistor to vary respectively the resistance of the armature and field winding paths and thereby to vary the voltage on the armature and the strength of the field.

6. In a control system for hoists, motors of the type having an armature and field winding, a closed circuit including the armature and field winding of the motor and resistors, a power line connected to said closed circuit placing said armature and field winding in parallel paths, a variable connection between points on said resistors forming a dynamic braking loop including the armature and field winding and for varying the amount of said resistors in said dynamic braking loop, while maintaining all of said resistors in said closed circuit for any and all operating speeds controlled by the system and another power line variably connected to said resistors to shift the same between the armature and field winding paths to vary the armature voltage and field strength.

7. In a control system for hoists in which a series motor is driven as a generator during lowering to retard overhauling loads, means for obtaining the maximum dissipation of the energy stored in the load to be lowered with a minimum provision of resistor elements, comprising a closed circuit including the armature and field winding of the motor and resistors, means for forming a dynamic braking loop including said field winding and armature, and for varying the amount of said resistors in said loop, means for shifting resistors between the armature and field winding paths to vary the armature voltage and the field strength, a power line connected between said armature and said field winding and another power line movably connected to said resistors, all of said resistors being utilized for the dissipation of energy at any and all operating positions of said system.

8. In an electric hoist system and apparatus, a pair of power supply mains, a motor comprising an armature and series field winding, and means including circuit controlling means for selectively establishing: a hoist holding circuit comprising a first closed loop containing, in series relation, the armature, the series field winding and loop re-

5 distance; then establishing a lowering circuit comprising a second closed loop containing, in serial relation, the armature, the series field winding, and second loop resistance in two parts, one part
10 being at least a portion of the said first loop resistance, and the circuit comprising a series resistance connected at one portion to the loop at a point between the two parts of the said second
15 loop resistance, and connected at another portion to one of the power lines, the other power line being connected to the loop at a point between the series field winding and armature, thus providing
20 resistance in series respectively with the armature and field winding across the line through the series resistance; and then establishing another lowering circuit comprising a third closed loop
25 containing, in serial relation, the armature, the series field winding and third loop resistance in two parts, a first part of the resistance being the said series resistance, and a second part being at least a part of said first loop resistance, one power
30 line being connected to a point between the first and second parts of the said third loop resistance, the other power line being connected to a point between the series field winding and armature, thus providing resistance in series respectively
35 with the armature and field winding across the line, which is respectively less and greater than in the first mentioned lowering circuit.

9. The method of controlling a hoist motor comprising an armature and series field winding, in association with a pair of power mains, resistor means and controller means for establishing elec-
40 tric circuits including resistance of the resistor means and for varying the resistance thereof in the circuits, which includes connecting the arma-
45 ture and field winding and resistor means having a first ohmic value in a first closed loop to oppose lowering; then connecting the armature, series field winding and resistor means having a second
50 ohmic value in a second closed loop, and connecting resistor means in series with the second loop at an intermediate point of the resistor means
55 having the said second ohmic value, and connecting one power line to the second loop at a point between the armature and field winding and the other power line to the series resistor means, with
60 the field winding and armature respectively across the line through the series resistor means each in series with a part of the second resistor means, to effect lowering at one speed; then connect-
65 ing the armature and field winding and resistor means having a third ohmic value in a third closed loop, and connecting one power line to the third loop at a point between the field winding and armature, and the other power line to the third loop at an intermediate part of the
70 resistor means having the third ohmic value, with the field winding and armature respectively across the line each in series with a part of the third resistor means, the part in series with the field winding and armature respectively being of
75 greater and lesser ohmic value than in the second closed loop, to effect lowering at a second speed.

JAMES F. SCHNABEL.

35 110

40 115

45 120

50 125

55 130

60 135

65 140

70 145

75 150