D. L. LINDQUIST.

CONTROLLING DEVICE FOR ALTERNATING CURRENT MOTORS.

APPLICATION FILED MAY 26, 1905.

980,302. Patented Jan. 3, 1911.

2 SHEETS—SHEET 1.

Fig. 1.

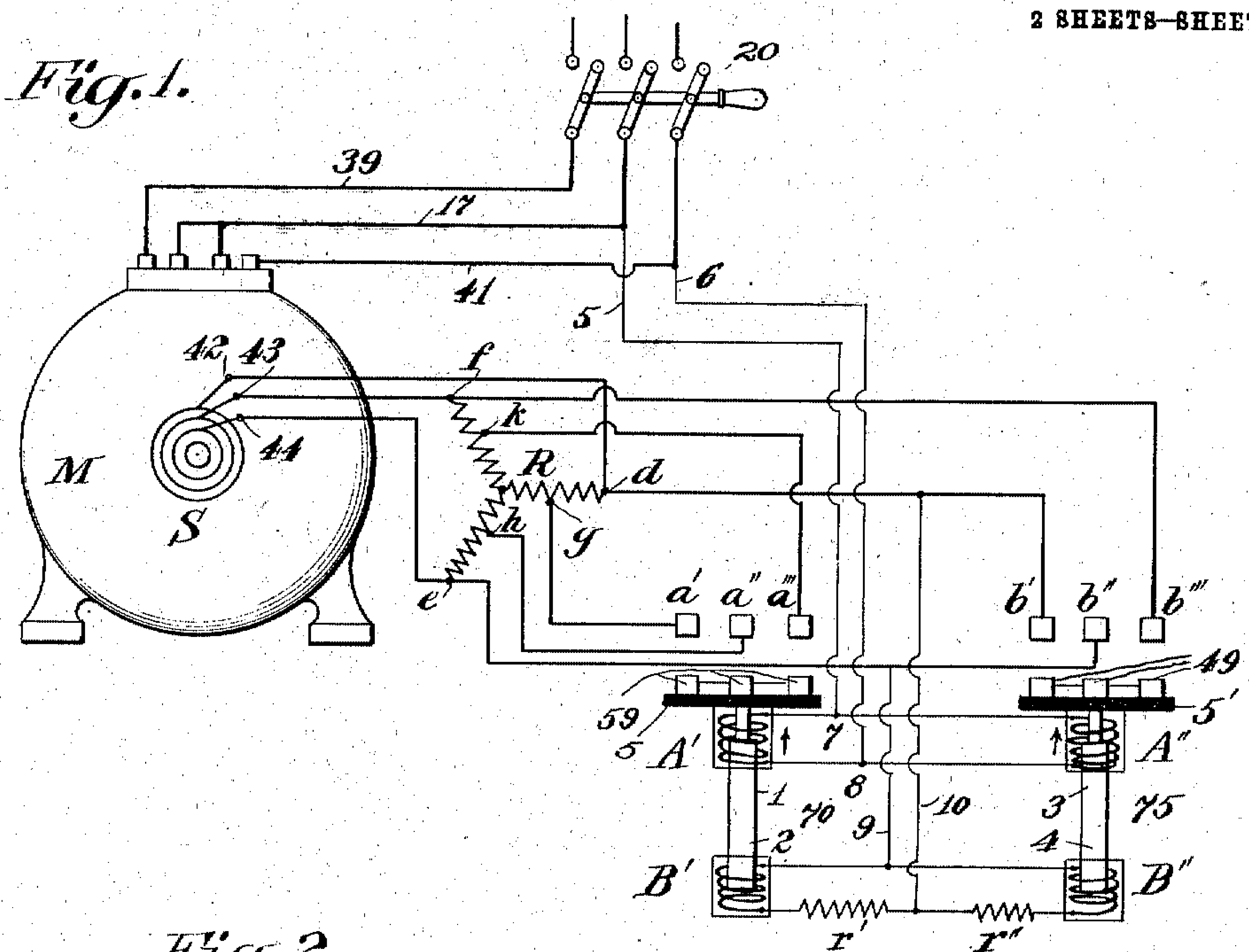
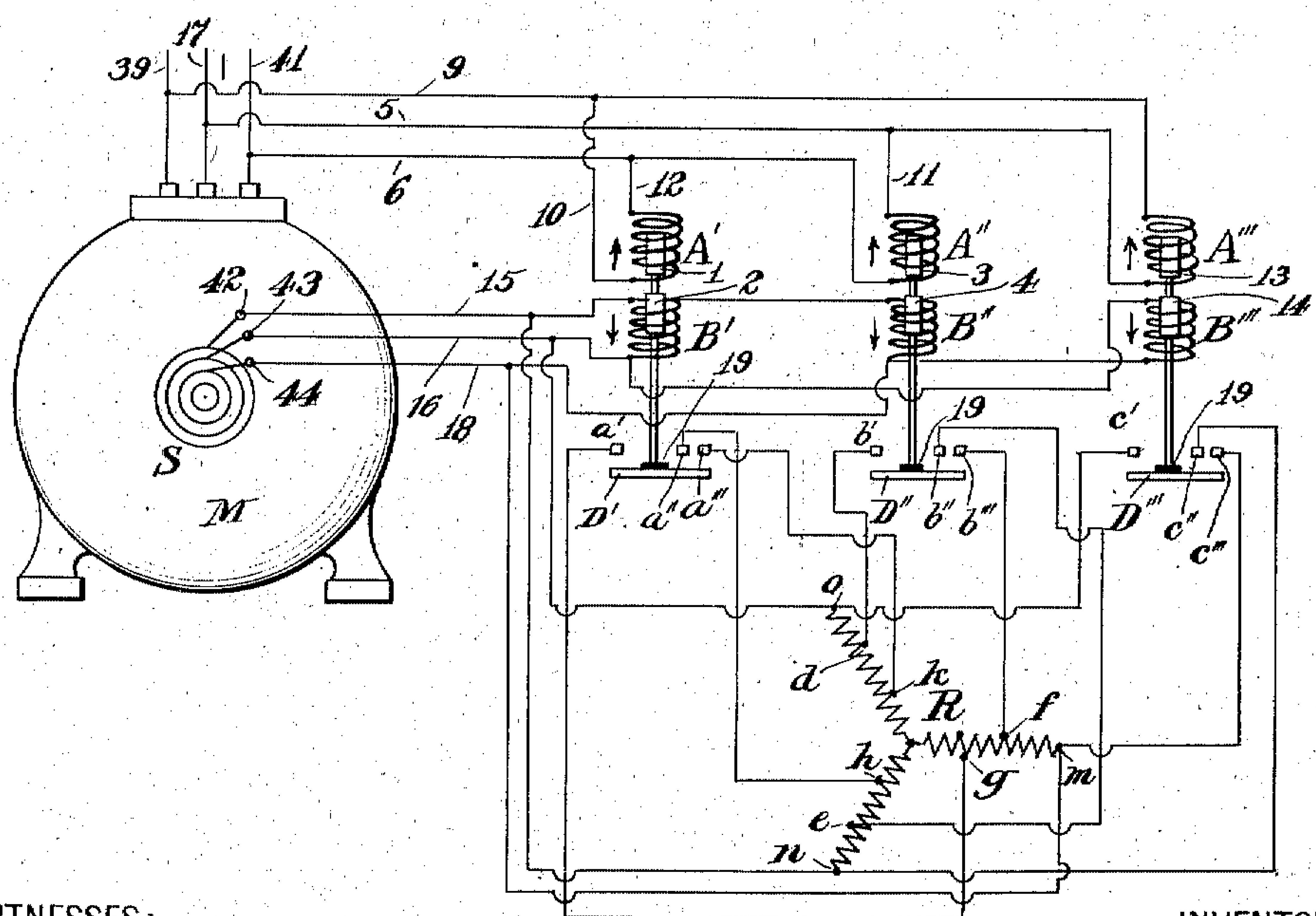


Fig. 2.



WITNESSES:

Henry E. Kirby

Walter C. Strang

INVENTOR

David L. Lindquist

BY

Brown, Darby & Hopkins

ATTORNEYS

D. L. LINDQUIST.

CONTROLLING DEVICE FOR ALTERNATING CURRENT MOTORS.

APPLICATION FILED MAY 26, 1905.

980,302. Patented Jan. 3, 1911.

2 SHEETS—SHEET 2.

Fig. 3.

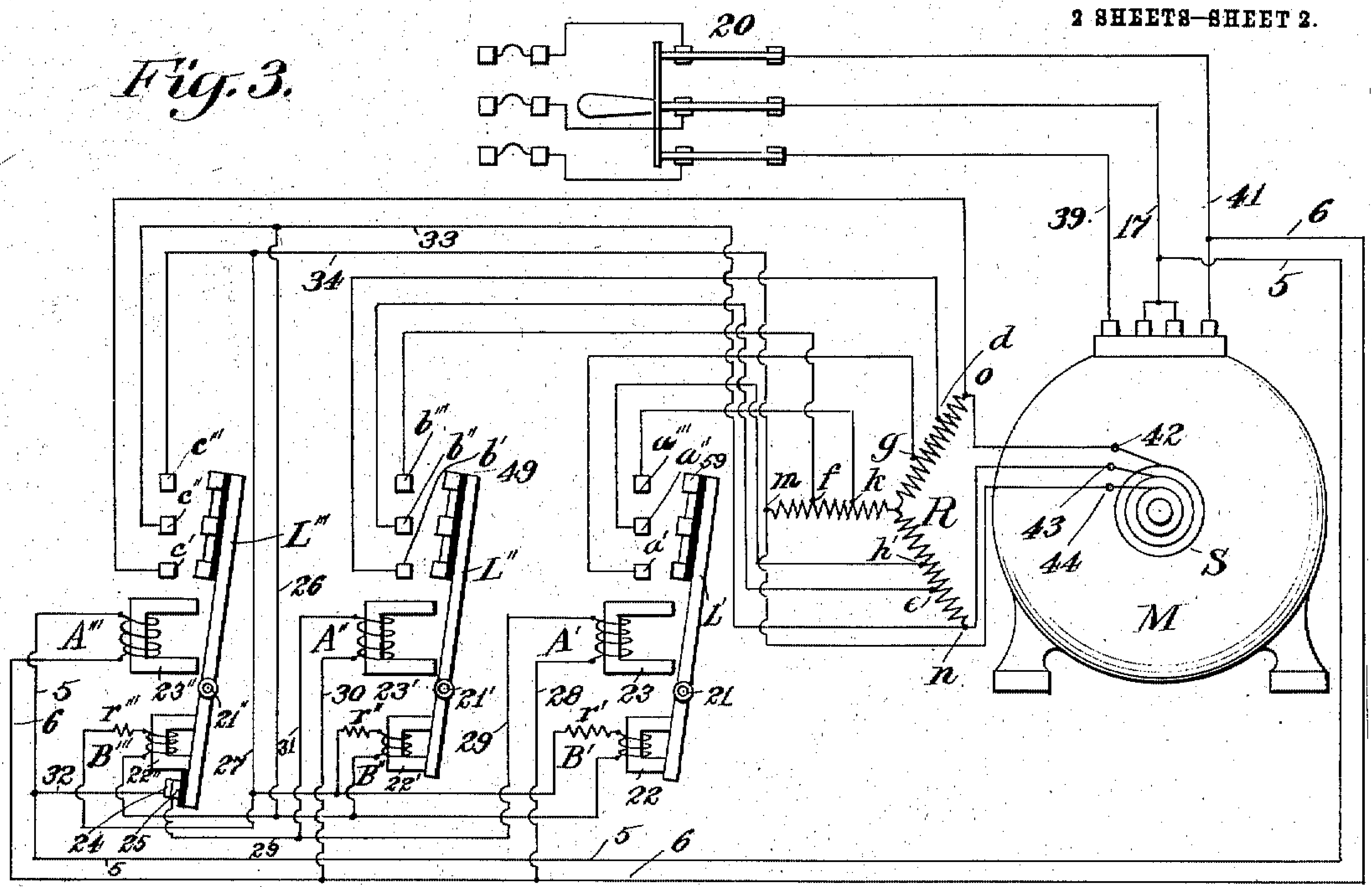
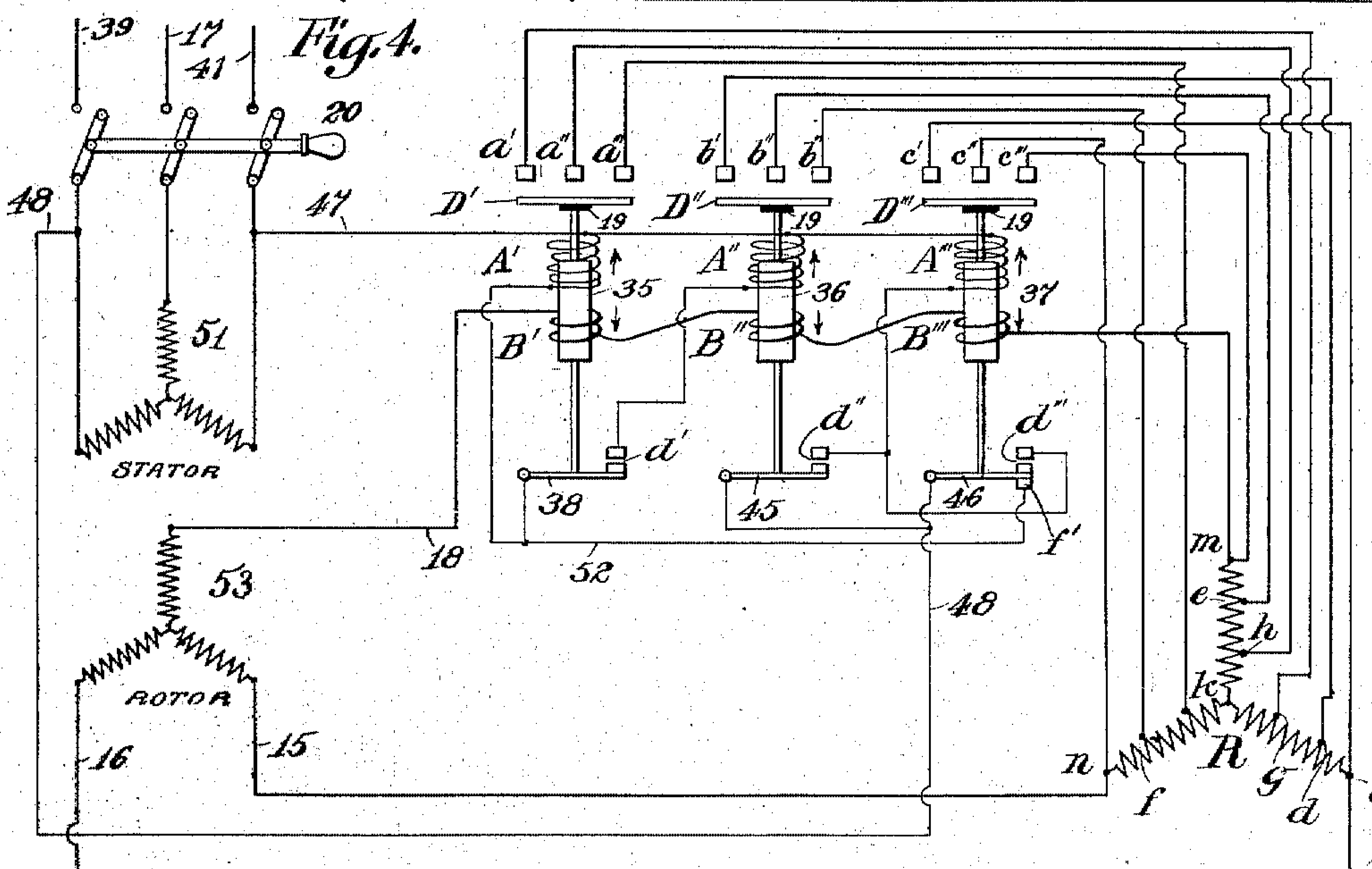


Fig. 4.



WITNESSES:

Henry E. Kirby

Walter C. Strang

INVENTOR

David L. Lindquist

BY

Brown, Darby & Hopkins

ATTORNEYS

UNITED STATES PATENT OFFICE.

DAVID LEONARD LINDQUIST, OF YONKERS, NEW YORK, ASSIGNOR TO OTIS ELEVATOR COMPANY, OF JERSEY CITY, NEW JERSEY, A CORPORATION OF NEW JERSEY.

CONTROLLING DEVICE FOR ALTERNATING-CURRENT MOTORS.

980,302. Specification of Letters Patent. **Patented Jan. 3, 1911.**

Application filed May 26, 1905. Serial No. 262,528.

To all whom it may concern:

Be it known that I, DAVID L. LINDQUIST, a subject of the King of Sweden and Norway, residing at Yonkers, in the county of Westchester and State of New York, United States of America, have invented a new and useful Improvement in Controlling Devices for Alternating-Current Motors, of which the following is a specification.

My invention relates to means for controlling electric motors of the induction type which are adapted to be operated by single-phase or polyphase currents.

The object of my invention is the provision of means for controlling alternating current motors of the induction type independently of predetermined voltages on the lines by which the motor is arranged to be supplied with current. To accomplish this I provide an electrical device adapted to be fed from the primary circuit and place it in co-acting relation with an additional electrical device fed from the secondary circuit so that upon a variation in the primary voltage the effective operation of these devices shall not be subject to change when not desired.

One embodiment of my invention is disclosed hereinafter and is an improvement in my Patent, No. 733,550, granted July 14, 1903.

I do not limit myself to the details of construction and arrangement of parts as herein disclosed, as many changes may be made without departing from the spirit and scope of my invention. I therefore desire that my claims may be construed broadly.

Referring to the accompanying drawings, Figure 1 is a diagrammatic view showing my apparatus applied to a two-phase motor which is arranged to be supplied with two- or three-phase current; Fig. 2 is a diagrammatic view showing a slight modification of Fig. 1; Fig. 3 shows an arrangement of apparatus whereby I carry out the object of my invention by means of magnets of different strengths and also shows contacts for interrupting a circuit through certain controlling electro-magnets; Fig. 4 is another modification showing the controlling coils in circuit with the secondary of the motor, in series with each other, and also showing contacts to establish and interrupt certain circuits.

Similar reference numbers and characters indicate like parts throughout the drawings.

Referring to Fig. 1, M designates a motor of the induction type. It is here shown as a two-phase motor, the main 17 being connected to the inside terminals at the top of the motor and the mains 39 and 41 to the outside terminals. The current supplied to the motor through the mains 17, 39 and 41 may be two-phase or three-phase.

To the motor secondary, by means of the slip rings S and brushes 42, 43 and 44 are connected the resistances R, here shown as star-connected. To the terminals d, e and f are connected the fixed contacts b', b'' and b''', respectively. To the intermediate points g, h and k are connected the fixed contacts a', a'' and a'''

Under the fixed contacts a', a'' and a''' are suitably mounted the movable contacts 59 electrically connected together and adapted to make contact with and electrically connect the fixed contacts a', a'', a'''. Under the contacts b', b'', b''' are similarly mounted the movable contacts 49. These movable contacts are mounted upon movable plungers or cores 1, 2, 3 and 4 of magnetizable material but insulated therefrom by the insulation 5 and 5'. The cores 1 and 2 are rigidly connected with each other as well as to the movable contents 59 and are arranged to be acted upon by the solenoids A' and B'. The relative arrangement of these cores and coils is such that when the stationary coils A' and B' are energized the coil B' tends to pull core 2 downwardly and consequently the contacts 59, while the coil A' tends to force the same upwardly. The switch 75 is similarly arranged to act in a similar manner but comes into operation to move the contacts 49 upwardly later than the switch 70 by reason of the resistance r' and r'', the resistance r' being greater than the resistance r''.

The coils A', A'' are connected in parallel across any two of the primary mains to the motor. In Fig. 1 these coils are shown connected from the points 7 and 8 by means of circuits 5 and 6, respectively, to the primary mains 17 and 41. The coils B', B'' are also connected in parallel and to any two circuits leading from the brushes connected to the rotor or secondary of the motor. Fig. 1 shows the coils B', B'' connected through the wires 9 and 10 to the terminals *e* and *d*, respectively. It is therefore obvious that though the current in the primary may be two- or three-phase and that in the secondary three-phase, the coils A′, A″, B′ and B″ are so connected that the current therein will always be single-phase. This arrangement is for the purpose not only of simplifying the wiring but to automatically control the starting of the motor and maintain the same at substantially full speed independently of the voltage in the primary. That is to say, when the circuits to the motor are closed from a source of supply of alternating current, the relation between the primary and secondary voltage is constant, and therefore the relation between the voltages applied to the coils is constant, so that if a drop of voltage should occur in the primary mains the operativeness of the switches 70 and 75 to properly start the motor will not be impaired within certain limits. This constant relation of voltages also holds true while the motor is running, so that should the main line voltage drop somewhat then the switches 70 and 75 will be held in closed position and not interfere with the running of the motor.

In starting the motor the operation is as follows: When the primary circuit is first closed from the source of supply the secondary voltage will be at its maximum and consequently the current flowing through the coils B′, B″ will be at a maximum. The coils B′, B″, having greater strength than the coils A′, A″ which are energized from two of the primary mains, will hold the switches 70 and 75 in their lower positions. So long as the voltage of the primary mains remains constant the current through the coils A′ and A″ and consequently the strength or pulling force on the cores 1 and 3 remains constant. But as the rotor speeds up the secondary voltage gradually drops causing less and less current to flow to the coils B′, B″ until finally the coil A′ overcomes the coil B′ and moves the contacts 59 into engagement with the contacts *a*′, *a*″, *a*‴ thus cutting out part of the resistances R.

The resistance *r*′ being greater than the resistance *r*″ more current will always flow in the coil B″ than in the coil B′. The coil A″ will therefore overcome the coil B″ later to cause the contacts 49 to engage the contacts *b*′, *b*″, *b*‴. That is, the motor runs to full slow speed and then a part of the resistance is cut out which causes the motor to run at a greater speed. In doing so the secondary voltage gradually drops until the motor has attained a predetermined speed when all the remainder of the resistances R are cut out by the switch 75. This causes the motor to run up to full speed.

Now since the strength of the coils A′, A″, B′, B″ varies directly as the current flow therein and the current varies directly as the voltage applied to said coils, any drop in the voltage applied will cause said coils to weaken and exert less force on their cores. With a given motor running at a given speed the relation between the primary voltage and secondary voltage is maintained constant. But should the primary voltage drop the motor would slow down proportionately and therefore the secondary voltage applied to the coils B′, B″ would be decreased and these coils would exert less force to pull down the cores 2 and 4. The strength of the coils A′, A″ is similarly decreased causing a less upward pulling force to be exerted by them, so that the resultant action of the switches 70 and 75 remains the same and the contacts are held closed.

In Fig. 2 I have shown motor controlling apparatus similar to that shown in Fig. 1 but the coils connected to the primary are connected across different phases but still remain single-phase coils; so also are the coils which are connected to the secondary connected across separate phases but remain single-phase coils. In this arrangement the current from the phases is more evenly distributed which may be an advantage in some cases in the operation of the motor. In either Fig. 1 or Fig. 2 one or more series of contacts may be added and the resistances R correspondingly increased so that the accelerating action may be as gradual as desired.

Referring to Fig. 2 the coils A′, A″, A‴ are seen to be connected to separate phases of a three-phase circuit by means of the circuits 6 and 9 for A′, 5 and 6 for A″ and 5 and 9 for A‴. The coils B′, B″, B‴ are shown similarly connected to the secondary or rotor circuit by means of the circuits 15 and 16 for B′, 15 and 18 for B″ and 16 and 18 for B‴. When energized the coils A′, A″, A‴ exert an upward pulling force on the cores 1, 3, 13, respectively, while the coils B′, B″, B‴ exert a downward pulling force on the cores 2, 4 and 14, respectively. The cores are rigidly connected together for each set of coils and also to disks D′, D″, D‴ which are adapted to electrically connect the contacts shown above them to short-circuit the resistances R and thus cause the motor to accelerate in speed up to full speed. First the coil B′ weakens after the circuit to the motor is closed until overcome by coil A′ when the disk D′ connects *a*′, *a*″, *a*‴ leading to the points *g*, *h*, *k*, short-circuiting one of the resistances R here shown as the central portion of a star-connected resistance. The disks are insulated from the solenoid cores by the insulation 19. After the disk D′ has been raised and the motor speed has been increased to a predetermined point the disk D″, and finally in a similar way the disk D‴ are raised when all of the resistances R will have been cut out and the motor is at liberty to run up to full speed.

The coils B′, B″, and B‴ may be made of different strengths so that they will release their cores successively to effect a step-by-step cutting out of the sectional resistance R.

The principle of operation of the arrangement shown in Fig. 2 is substantially the same as that already explained in reference to Fig. 1.

In Fig. 3 I have shown a different arrangement of apparatus although the principle of operation is the same as that already described in connection with Figs. 1 and 2. In place of the vertically movable cores shown in Figs. 1 and 2 I pivot levers L′, L″, L‴ at 21, 21′, 21″, respectively, in proximity to electro-magnets having poles of different lengths so that said magnets may have a maximum effect on said levers which are of magnetizable material and therefore serve as armatures. Three of these magnets, namely, A′, A″ and A‴ are connected in parallel and across two of the primary mains. Fig. 3 shows these three magnets connected to mains 17 and 41 by wires 5 and 6. The other three magnets, namely, B′, B″ and B‴ are connected in parallel and across two of the secondary circuits, as across the brushes 43 and 44 by wires 26, 33 and 27, 34.

In circuit with the magnets A′ and A″ are the contacts 24 and 25 which are normally closed but when separated break the circuit to the magnets A′ and A″, the circuit to the magnet A‴, however, always remains intact.

As in Fig. 1, resistances r', r'', r''' are shown in Fig. 3 in series with the magnets B′, B″, B‴, respectively, the value of said resistances gradually diminishing in the order named, so that the current flowing through the magnets B′, B″, B‴ for any given voltage across the circuits 26 and 27 may be least in B′ and most in B‴.

When the primary circuit is closed at the switch 20, the parts will take the positions shown and the armatures L′, L″, L‴ will be held in their normal positions by the magnets B′, B″, B‴ which are fed by current from the secondary. At the same time the magnets A′, A″, A‴ are exerting a pulling force to move the armatures in the opposite direction. Due to the rotation of the rotor the voltage in the secondary drops until magnet A′ overcomes magnet B′ and the armature L′ is moved to cause the contacts 59 to engage with the contacts a', a'', a'''. As the motor speeds up the armature L″ acts in the same manner to close its contacts and finally armature L‴ is operated after which the motor attains full speed. It should be noted, however, that when the armature L‴ is moved by the magnet A‴ the contacts 24 and 25 are separated and the circuit to the magnets A′, A″ therefore broken. The levers L′, L″ return to their normal positions but armature L‴ is held in its contact closing position by the magnet A‴ which is always in circuit with two mains of the primary. The resistance of the circuit 5, 6 being thus increased less current is necessary to be shunted away from the primary which may serve to allow the motor to run more evenly where all the magnets connected to the primary are connected across only two of the mains.

Fig. 4 shows another modification of my invention. The motor is here shown more diagrammatically, 51 designating the stator winding and 53 the rotor winding. The coils connected to the rotor are connected in series, whereas in the previous figures they were in each case connected in parallel. The coils A′, A″, A‴ oppose the coils B′, B″, B‴ in their action as before, and as indicated by the arrows. The cores 35, 36 and 37 are arranged to close contacts as already explained to cut out the resistances R and are shown supported on springs 38, 45 and 46, respectively, thus separating the contacts d', d'' and d''', and closing the contact f' with that of the spring 46.

The operation of the apparatus shown in Fig. 4 is as follows: Assuming the switch 20 closed to a source of three-phase current supply a circuit will be established through coil A′ from main 41, to and through wire 47, coil A′, wire 52, contact f' and that on spring 46, said spring, wire 48, to main 39. Until the motor has attained a predetermined speed, however, the coil B′ will exert a greater downward force than the coil A′ exerts in an upward direction on the core 35. When, however, the motor has come to a certain speed the core 35 overcomes coil B′ and the core 35 is moved upward allowing the spring 38 to close the contacts d'. The closure of these contacts closes the circuit just traced through the coil A″ also; that is, the coils A′, A″ are connected in parallel. When the core 35 was moved upward the disk D′ and contacts co-acting therewith caused a part of the resistances R to be short-circuited. The next is the cutting out of more of said resistances which is done by the disk D″ when moved upward. The contacts d'' are then closed, which places all three coils A′, A″, A‴ in parallel but when all of the resistances are finally short-circuited to allow the motor to attain full speed the contacts d''' are closed and the circuit through contact f' broken. The circuit through the coils A′ and A″ is therefore interrupted and the disks D′ and D″ with their cores allowed to come to their original positions to again separate the contacts d' and d''. The circuit through the coil A‴, however, is maintained from 47, to the contacts d''', spring 46 and wire 48. The coils B′ and B″ now hold the cores 35 and 36 down without any opposing force from the coils A′ and A″.

In the apparatus shown in Fig. 4 the resultant action on the core 35 to hold it in its upper position is substantially constant and independent of variations within certain limits of the main line voltage as any drop in the main line voltage will cause a corresponding drop in the secondary.

Having thus fully described my invention and the preferable mode of applying the principle thereof, what I claim and desire to secure by Letters Patent is:

1. The combination with an alternating current motor of the induction type, of primary mains therefor, means connected to two of said primary mains and to the secondary for controlling the speed of said motor independently of changes of voltage across the primary mains.

2. The combination with an alternating current motor of the induction type, of main lines of a source of multi-phase current supply, resistance in circuit with the secondary motor circuit, and means controlled by the voltage of said secondary circuit and comprising a circuit connected across only two of said main lines, for varying said resistance.

3. The combination with an alternating current motor of the induction type, of resistance in circuit with the secondary of said motor, opposing magnets connected respectively to the primary and secondary of the motor, and means controlled by said magnets for varying said resistance.

4. The combination with an alternating current motor of the induction type, of resistance in the secondary circuit, and means including opposing magnets for decreasing said resistance controlled by the resultant of the primary and secondary voltage of the motor.

5. The combination with an alternating current induction motor, of an electromagnetic controlling device comprising opposing magnets, said controlling device being operable by differential current in said magnets determined by the voltages in the primary and secondary of said motor from starting to full speed.

6. The combination of an alternating current motor of the induction type and electro-magnetic controlling devices therefor comprising a plurality of opposing electromagnets, half of the number of said opposing magnets being connected to the primary and the other half to the secondary of said motor, and switches successively operated by said magnets to effect an acceleration of said motor.

7. The combination with an alternating current induction motor, of resistance in the secondary motor circuit, and an electro-magnetic means comprising a plurality of oppositely actuating coils for varying said resistance in accordance with the voltage in said secondary.

8. The combination with an alternating current induction motor, of an electro-magnetic device in circuit with the secondary of said motor, motor-starting resistance, and an additional electro-magnetic device operating in opposition to said first electro-magnetic device to decrease said resistance as the motor increases in speed.

9. In a controlling device for alternating current motors, the combination with main lines of a multiphase circuit, of an alternating current motor, electro-responsive devices connected directly across two of the said main lines, a variable resistance in the secondary of the motor, electro-receptive devices connected across two terminals of the resistance, electric circuits and connections for said electro-responsive devices, and means operated by said electro-receptive devices to gradually cut out said resistance as the motor increases in speed.

10. The combination with a two phase motor of the induction type, three main lines therefor, an electro-receptive device connected directly across any two of said main lines, of variable resistance in the secondary circuit of said motor, a second electro-receptive device arranged to be connected across any two of the terminals of said secondary circuit, and means operated by said electro-receptive devices to cut out said resistance as the motor increases in speed.

11. The combination with a multiphase motor of the induction type, of supply mains therefor, electro-receptive devices connected in parallel directly across two of said mains, a variable resistance in the secondary of said motor, additional electro-receptive devices connected across any two of the terminals of said secondary, and means operated by said electro-receptive devices to gradually cut out said resistance until the motor attains full speed.

12. The combination with an alternating current electric motor, of a variable resistance in the secondary circuit of the motor, mechanism for cutting out said resistance, an electro-magnetic device for operating said mechanism, an additional electro-magnetic device energized from the secondary circuit of the motor opposing said first-named electro-magnetic device so that as the motor increases in speed one of said electro-magnetic devices will gradually overcome the other and said resistance will be gradually cut out.

13. The combination of a motor, of supply mains for supplying current to the motor, a plurality of electro-magnets connected in parallel to said supply mains, a plurality of additional electro-magnets acting in opposi-

tion to the first-mentioned electro-magnets and connected to the secondary circuit of the motor, resistances in circuit with said secondary circuit, and means operated by said electromagnets for cutting out said resistances upon the motor attaining predetermined speeds.

14. The combination of an alternating current electric motor, resistances in the secondary of the motor, a plurality of electro-magnetic devices controlling said resistances, one of said electro-magnetic devices being energized from mains of the motor and the other from the secondary circuit of the motor, and means operated by said electro-magnetic devices for cutting out said resistance, said devices being in opposition so that as the motor attains predetermined speeds the resultant action of said electro-magnetic devices effects a gradual cutting out of circuit of said resistances.

15. The combination of an alternating current motor, a controlling device therefor, comprising an electro-magnet coil energized from the primary source of current, and a coil energized from the secondary of the motor, said coils opposing each other in their action.

16. In combination, an alternating current motor, a controlling device therefor comprising an electro-magnet coil directly connected to and energized from the primary source of current and a coil energized from the secondary of the motor, the second-named coil being constructed to have a greater energizing strength than the first-named coil when the motor is first started but after the motor has attained a predetermined speed to have less strength, and a device controlled by said coils for effecting the acceleration of the motor.

17. The combination with a three-phase induction motor, supply mains therefor, an electro-magnetic device energized from any two of said mains, a variable resistance in circuit with the motor secondary, a second electro-magnetic device of different strength from said first-named electro-magnetic device and energized from said secondary, and electric circuits and connections for said devices, means controlling said resistance, and operated by said devices so that as the motor increases in speed said second named electro-magnetic device is gradually varied in strength to allow the first electro-magnetic device to effect a successive cutting out of circuit of said resistance.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses.

DAVID LEONARD LINDQUIST.

Witnesses:

CHARLES M. NISSEN,

HENRY E. KIRBY.