No. 708,961. Patented Sept. 9, 1902.

J. C. HENRY, Dec'd.

S. A. HENRY, Executrix.

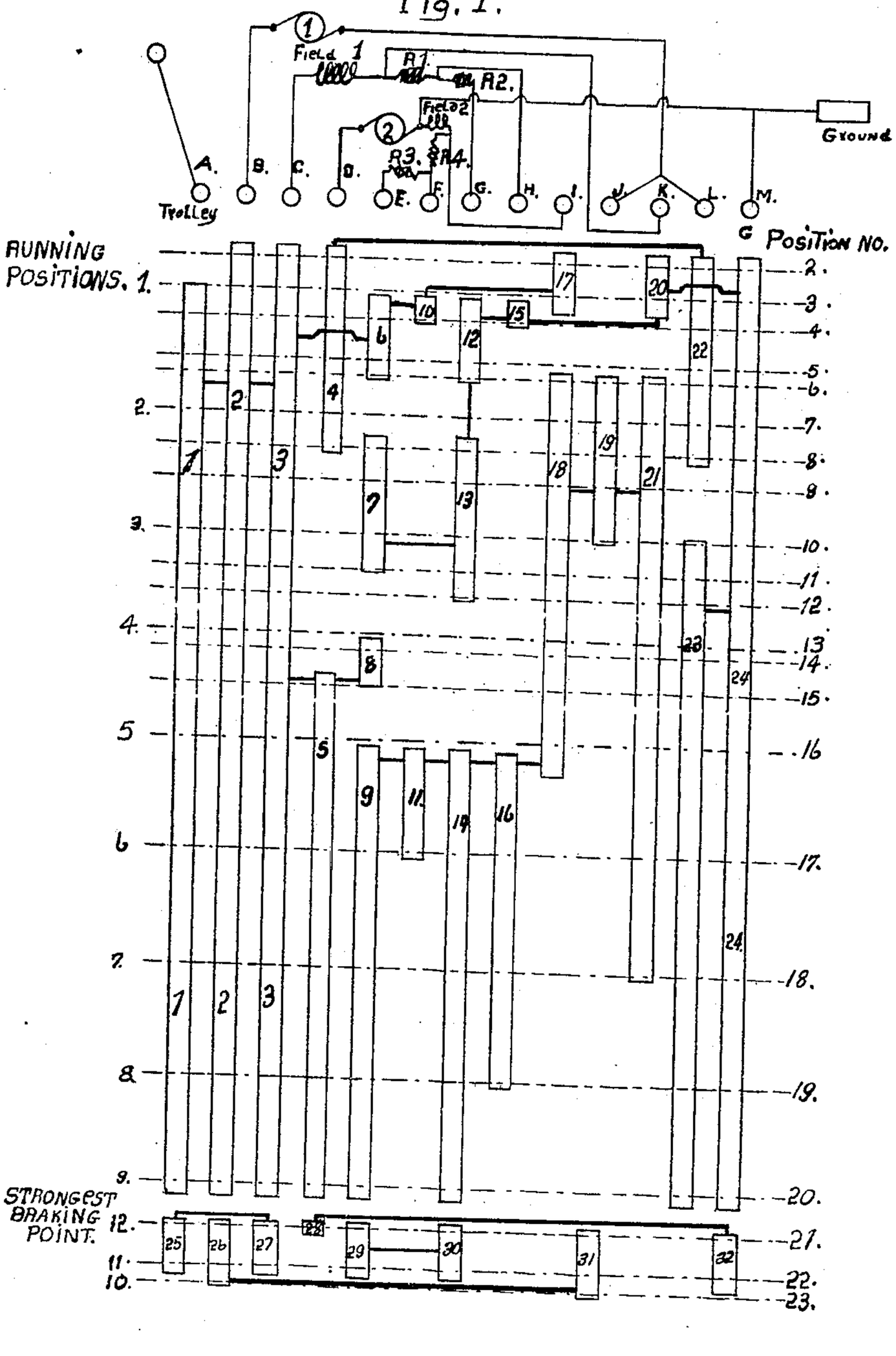
METHOD OF CONTROLLING ELECTRIC MOTORS.

(Application filed Apr. 1, 1901.)

(No Model.)

2 Sheets—Sheet 1.

Fig. 1.



WITNESSES:

Paul Henry

Carle H. Whitehead

INVENTOR.

John C. Henry

No. 708,961. Patented Sept. 9, 1902.

J. C. HENRY, Dec'd.

S. A. HENRY, Executrix.

METHOD OF CONTROLLING ELECTRIC MOTORS.

(Application filed Apr. 1, 1901.)

(No Model.) 2 Sheets—Sheet 2.

Fig. 2.

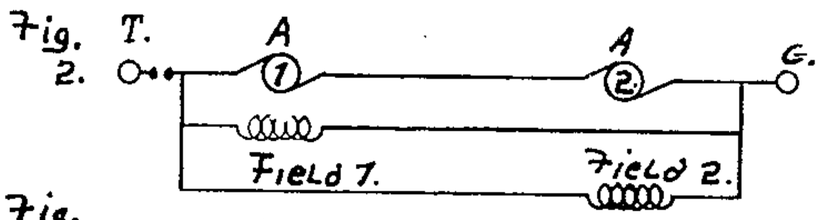


Fig. 3.

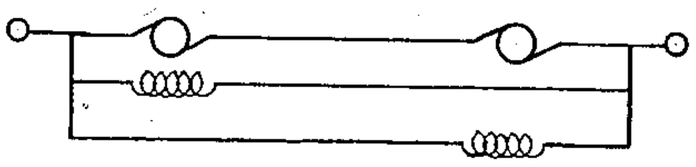


Fig. 4.

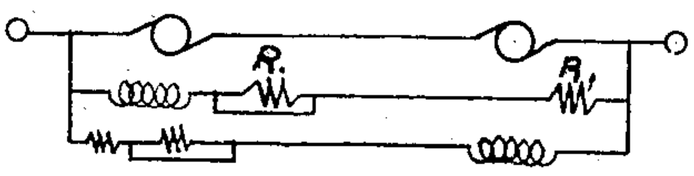


Fig. 5.

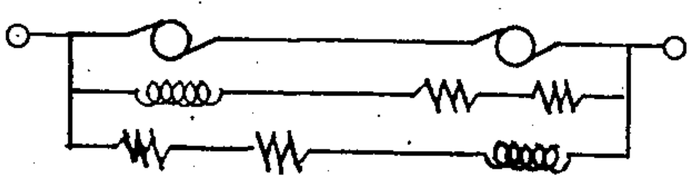


Fig. 6.

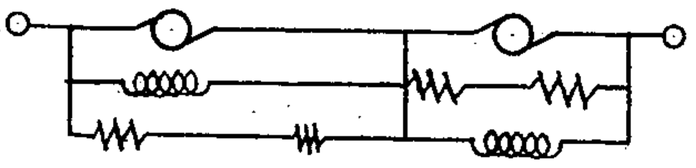


Fig. 7.

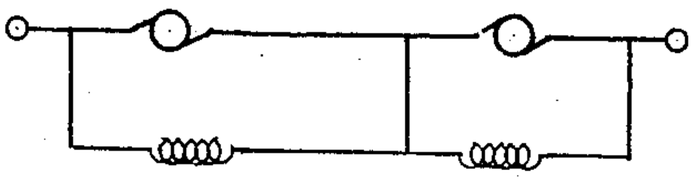


Fig. 8.

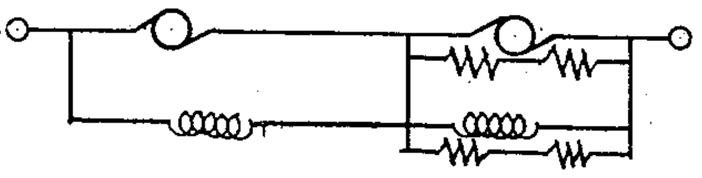


Fig. 9.

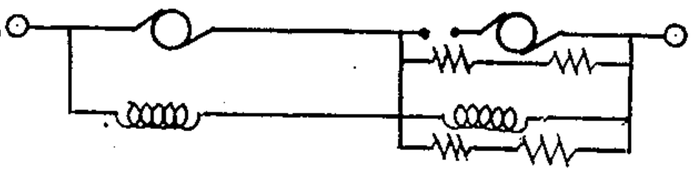


Fig. 10.

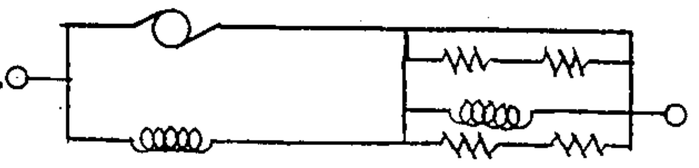


Fig. 11.

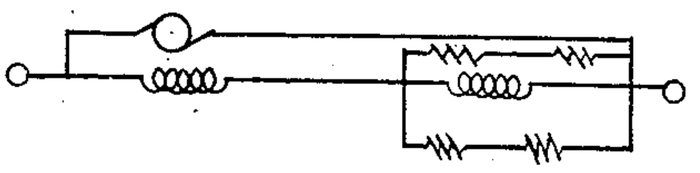


Fig. 12.

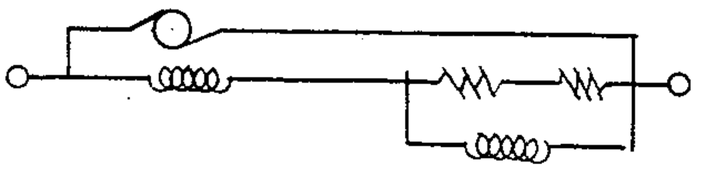


Fig. 13.

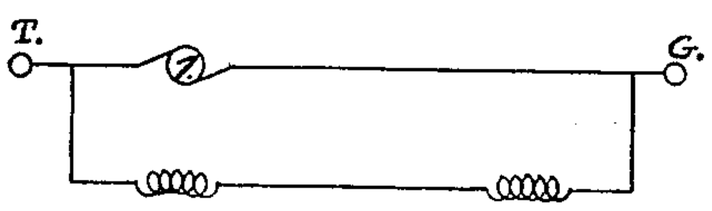


Fig. 14.

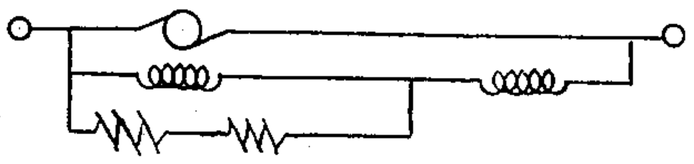


Fig. 15.

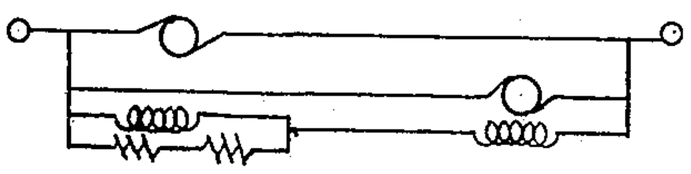


Fig. 16.

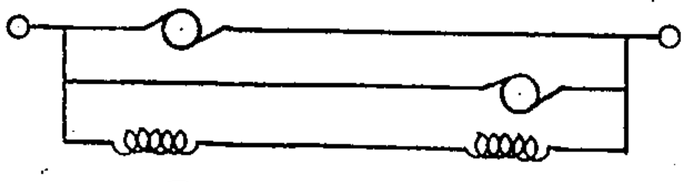


Fig. 17.

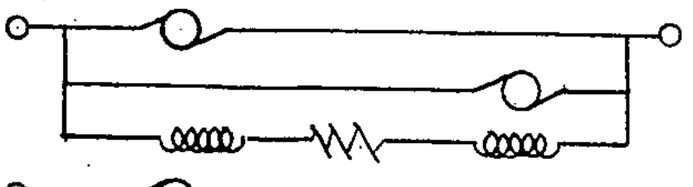


Fig. 18.

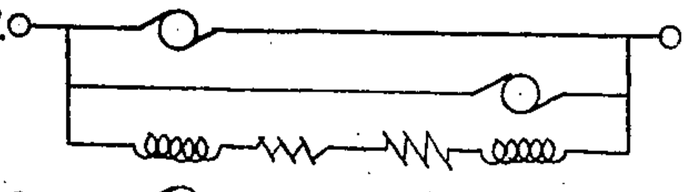


Fig. 19.

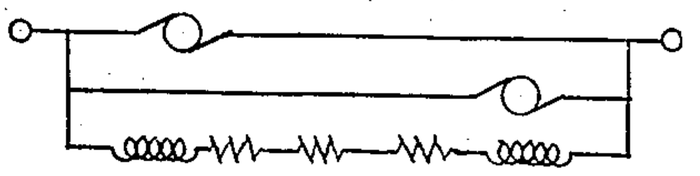


Fig. 20.

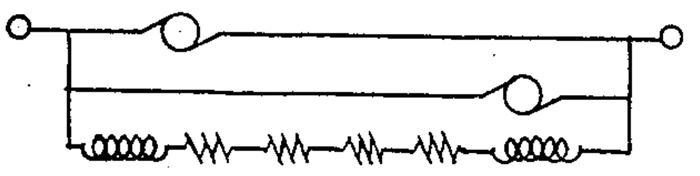


Fig. 21.

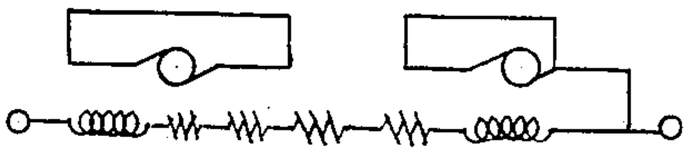


Fig. 22.

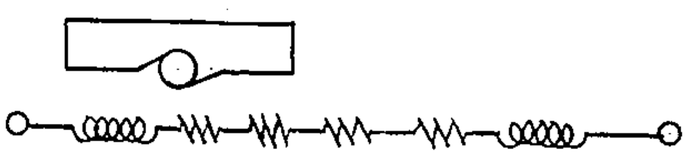


Fig. 23.

WITNESSES:

Paul Henry

Barbe Whitehead

INVENTOR.

John C. Henry.

UNITED STATES PATENT OFFICE.

JOHN C. HENRY, OF DENVER, COLORADO; SUSIE A. HENRY, EXECUTRIX OF SAID JOHN C. HENRY, DECEASED, ASSIGNOR TO STANLEY ELECTRIC MANUFACTURING COMPANY, A CORPORATION OF NEW JERSEY.

METHOD OF CONTROLLING ELECTRIC MOTORS.

SPECIFICATION forming part of Letters Patent No. 708,961, dated September 9, 1902.

Application filed April 1, 1901. Serial No. 54,001. (No model.)

To all whom it may concern:

Be it known that I, JOHN C. HENRY, a citizen of the United States, residing in the city of Denver, county of Arapahoe, State of Colorado, have invented certain new and useful Improvements in Methods of Controlling Electric Motors, of which the following is a specification.

This invention relates to improvements in means for controlling a pair of electric motors—such, for instance, as are ordinarily employed in driving an electric car. It is of the series-multiple class and may be further identified as of the regenerative species—that is, where the motors are so connected that they recoup current to the line.

This invention is an improvement on various designs which form the subject of numerous patents and pending applications filed by me.

In the drawings, Figure 1 represents a development of the controller. Figs. 2 to 23, inclusive, represent diagrams of the different arrangements of the circuits which are established in successive positions of the controller.

The main object of the invention is to insure very high voltage and great torque from the motors when they are running slow and in all cases to provide a path of low resistance around the fields, so that when the connection from the line is broken from any cause the back current generated by the self-induction of the fields is provided with a metallic circuit, so that it need not discharge through the insulation of the motors. In order to insure slow speed and great torque on starting and also to secure regeneration and consequent retarding or braking force at slow speed, I first connect the armatures in series and the fields in parallel, thus saturating the fields very strongly. I then gradually weaken the fields by changing them from parallel to series, being careful to do so without breaking the circuit. In order to change the combined motors from series to parallel, it is necessary to remove one of the motors. This I prefer to do in sections, being careful to remove the armature first, so as to prevent it from working short-circuited under fields containing residual magnetism. In the rotation of the controller the various connections hereinafter described are made by the fingers A to M coöperating with the various contact-plates 1 to 32 on the controller.

In the first running position the motors are connected in the manner shown in diagram 3. When the controller is placed in running position No. 1, diagram 2, the current enters at finger A from the trolley, thence through contacts 1 and 2, finger B, through armature No. 1, thence by finger L, contacts 22 and 4, and finger D through armature 2 to the ground, also from trolley by contacts 1, 2, and 3, finger C, through field 1, finger K, contacts 20 and 24, and finger M to ground, also from trolley through contacts 1, 2, 3, 6, 10, and 17, finger I, through field No. 2 to the ground.

In running position No. 2, diagram 7, the motors are connected as a pair of shunt-machines coupled in series. The current enters from trolley through contacts 1 and 2, passes through armature No. 1 to finger L, thence to contacts 22 and 4, finger D, through armature 2 to the ground, also from trolley through contacts 1, 2, and 3, field 1, finger K, contacts 21, 19, and 18, finger I, through field 2 to the ground. The leaving side of armature No. 1 being connected to finger J, contacts 19 and 18 to finger I and the entering side of field No. 2, a cross connection is thereby established between the armature-circuits and the field-circuits. The resistance thus inserted between one motor and the line on one side of the circuit and between the other motor and the ground on the other side of the circuit should in each case be about equal to the resistance of the fields, so that the current through the cross connection is reduced to a minimum. Consequently when the operation is reversed and this cross connection is broken there is a minimum of arcing at the contacts. In such reverse operation the two fields in series are each shunted by a resistance about equal to its own, and the fields and resistances are thus centrally cross connected, and this cross connection is then broken, leaving the fields in separate circuits.

In running position No. 3 (diagram 10) but one motor is in the circuit working with in-

tense fields. Current enters from trolley through contacts 1 and 2 to armature 1, finger L, contacts 23 and 24 to the ground, also from trolley via contacts 1, 2, and 3 through field 1, finger K, contacts 21 and 19, fingers J and L, contacts 23 and 24 to the ground.

In running position No. 4 the connections are as shown in diagram 13, but one armature being in circuit and the fields being weakened by connecting them in series. The course of the current through the motor is from contacts 1 and 2, finger B, through armature No. 1 to finger L, contacts 23 and 24 to the ground; also, by contacts 1, 2, and 3 and finger C through field 1, finger K, contacts 21, 19, and 18 through finger I and field 2 to the ground. Positions of diagrams 14 and 15 are transition positions introducing the other motor in parallel. Thus in Fig. 14 a shunt is established around the field of motor No. 1 by contact 8, (see Fig. 1,) and including resistances R^3 R^4, so as to weaken the field of motor No. 1 and strongly energize the field of motor No. 2. The armature of motor No. 2 is now connected (diagram 15) by contact 5, the current in same being at first reduced by means of the strength of the field. Then by opening the shunt, Fig. 16, the fields are equalized and the voltage of armature 2 is reduced to correspond with that of armature 1. In reversal of this operation the decrease of current in motor 2 due to its strong field is advantageous in preventing arcing when the armature 2 is open-circuited.

In running position No. 5 the connections are as shown in diagram 16. Current passes from trolley via contacts 1 and 2, through finger B, through armature 1 to finger L, contacts 23 and 24 to ground, also through contacts 1, 2, 3, and 5, finger D, through armature 2 to ground, also through contacts 1, 2, and 3, finger C, through field 1, finger-contacts 21 and 18, and finger I, through field 2 to the ground.

In running positions 6, 7, 8, and 9 the connections are the same as in position 5, except that resistance is inserted between the fields, as shown in diagrams 17, 18, 19, and 20.

In running position No. 8, Fig. 19, the current passes from field 1 through resistance R′ to finger H, by contacts 16 and 9 to finger E, through resistances R^3 R^4, and field 2 to the ground.

In running position No. 9 current passes from field 1 through resistances 1 and 2 to finger G, contacts 14 and 9 to finger E, through resistances R^3 and R^4 and field No. 2 to the ground.

In position No. 10, Fig. 23, armature No. 1 is short-circuited by contacts 26 and 31, depending for its braking action upon the residual magnetism in the field only, the trolley connections being open.

In position No. 11, Fig. 22, armature 1 is revolving short-circuited and retarded by energization of the fields by current from the lines through the fields and resistances passing from trolley through contacts 25 27, finger C, field 1, resistances R′ R^2, finger G, contacts 30 29, finger E, resistances R^3 R^4, and field 2 to ground.

In position No. 12, Fig. 21, both armatures are short-circuited by contacts 26 31 and 28 32 under weak fields which are excited by current from the line.

Having thus described my invention, the following is what I claim as new therein and desire to secure by Letters Patent:

1. The method of controlling a plurality of electric motors, whose fields are excited by a circuit independent of the armature, which consists in starting with the armatures in series and the fields in parallel and speeding up by changing the fields to series without breaking their circuit.

2. The method of changing the fields of a pair of motors from parallel to series, which consists in inserting resistances in the separate field-circuits to about equal that of the fields, establishing a cross connection so as to connect the fields and resistances together centrally, then withdrawing the resistance, leaving the fields in series.

3. The method of regulating a pair of motors, whose fields are excited by a circuit independent of the armature-circuit, which consists in weakening the field of one of the motors by shunting resistance around it to decrease the voltage of said motor, breaking the armature-circuit, allowing the current to pass through said field and resistance, in series with the other motor, and then short-circuiting said field and resistance.

4. The method of changing from series to parallel a pair of motors whose fields are excited by a circuit independent of the armature-circuit, which consists in cutting out one of the armatures, increasing the current in the corresponding field, by establishing an additional path through resistance around the first field, and subsequently connecting the second armature to the circuit in parallel.

5. The method of connecting in parallel motors whose fields are excited by connections independent of their armatures, which consists in connecting the armature of one of the motors to the circuit, and strongly magnetizing the field of the other motor, subsequently connecting the armature of the second motor to the circuit and then weakening the fields of the second motor until its voltage corresponds with that of the first motor.

6. The method of retarding a motor whose field is excited by connection independent of its armature, which consists in first short-circuiting the armature, so that it may generate current under the residual magnetism of the field and subsequently increasing the magnetism of the field with current from the line.

7. The method of regulating a pair of motors which are connected in series, consisting in weakening the strength of the fields of one of the motors by establishing a shunt around

it and thus decreasing the resistance and increasing the current in the field of the other motor, and then open-circuiting the armature of the first motor.

8. The method of changing the fields of a pair of motors from parallel to series, which consists in inserting resistance between one field and one side of the circuit and between the other field and the other side of the circuit, then cross-connecting them by a connection from the leaving-terminal of one field to the entering-terminal of the other field and then removing the resistance.

In testimony whereof I have hereunto set my hand and seal, this 7th day of March, A. D. 1901, in the presence of two witnesses.

JOHN C. HENRY. [L. S.]

Witnesses:

D. CARL HENRY,

CARLE WHITEHEAD.