N. W. STORER.

CONTROL SYSTEM.

APPLICATION FILED SEPT. 8, 1914.

1,208,226. Patented Dec. 12, 1916.

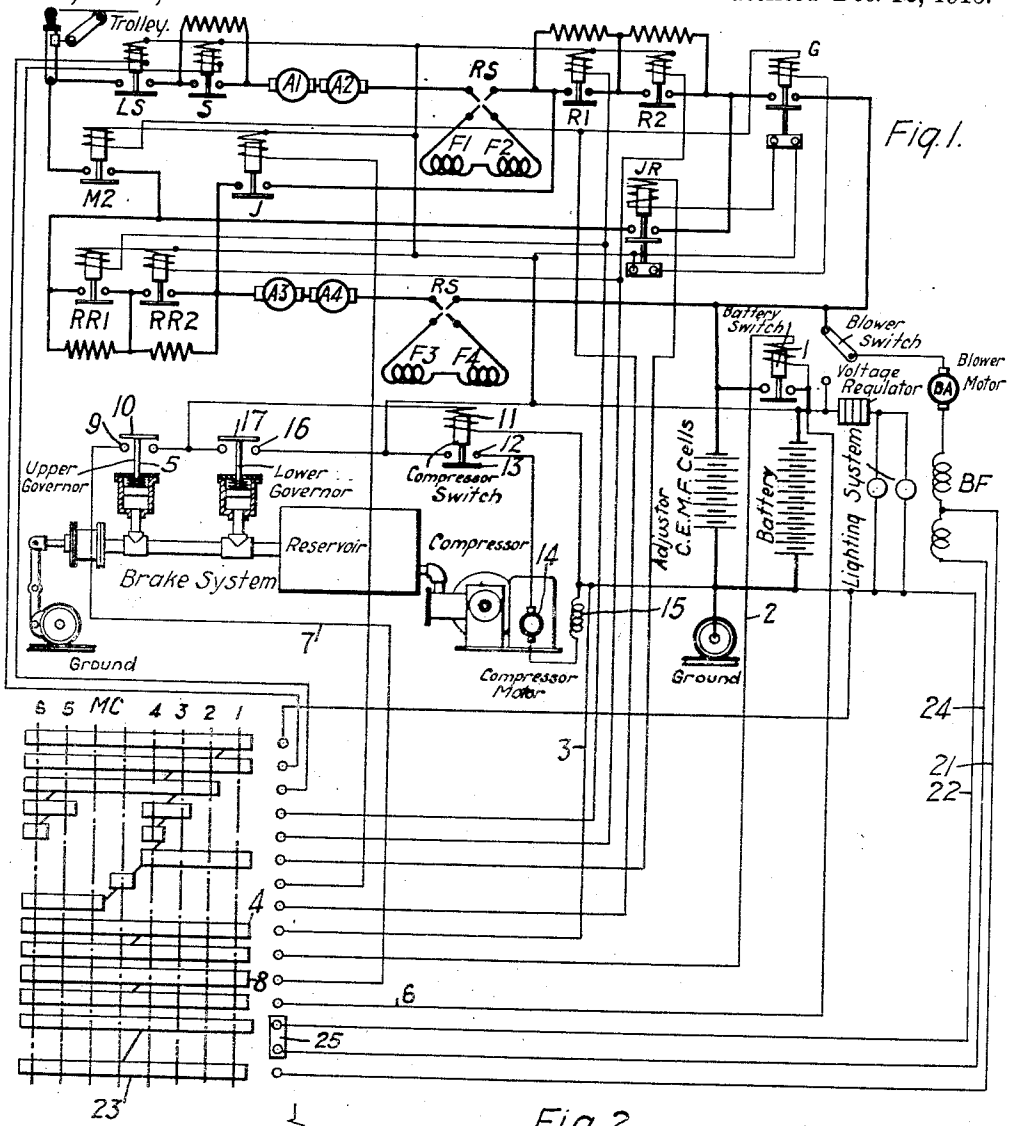


Fig. 1.

Fig. 2.

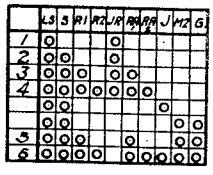
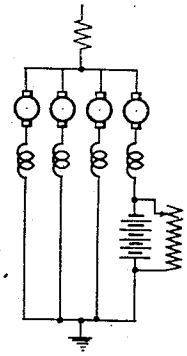


Fig. 3.



WITNESSES:

W. R. Coley

INVENTOR

Norman W. Storer.

BY

Morley & Barr

ATTORNEY

UNITED STATES PATENT OFFICE.

NORMAN W. STORER, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

CONTROL SYSTEM.

1,208,226. Specification of Letters Patent. Patented Dec. 12, 1916.

Application filed September 8, 1914. Serial No. 860,609.

To all whom it may concern:

Be it known that I, NORMAN W. STORER, a citizen of the United States, and a resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Control Systems, of which the following is a specification.

My invention relates to control systems for electric motors, and it has special reference to relatively high-voltage, direct-current control systems for railway motors.

One of the objects of my invention is to simplify and improve the arrangement of circuits and the operation of control systems of the above indicated class and to provide a high-voltage control system in which the main motor current may be utilized for operating the auxiliary apparatus, such as motor-driven compressors, lighting and control systems.

A further object of my invention is to provide a storage battery or other energy-accumulator which shall, under normal operating conditions, be connected in circuit with the driving motors and shall be charged by the motor current, except at such times as the motor current is utilized for operating the auxiliary apparatus.

A further object of my invention is to provide simple and adequate means, such as a resistor or counter electromotive force cells, which may be adjusted to suit the particular conditions of service for governing or adjusting the battery-charging current for any given interval of time to an amount which is just sufficient to maintain the battery in a charged condition.

A still further object of my invention is to provide means that shall be dependent upon predetermined pressure conditions of a pneumatic or other fluid-operated braking system, for utilizing all, or part, of the main motor current delivered from the main source of energy to operate the motor-compressor, when the driving motors are in operation; and to operate the motor compressor from the storage battery under conditions when the driving motors are not in operation and the pressure has fallen to a predetermined minimum value.

Another object of my invention is to provide a more effective and reliable means for ventilating the propelling motors.

When the usual 600 volt direct-current railway system is employed, the auxiliary apparatus is customarily operated directly from the trolley conductor.

In recent years, the development of 1200 and 1500 volt systems has been accomplished, and, in such cases, the auxiliary apparatus, such as the lighting and control circuits and the motor-compressors, have received their energy from a so-called "dynamotor" which serves to deliver a low voltage for these purposes, or from motors operated directly from the high trolley voltage. Motor-generator sets have also been proposed for supplying energy to the auxiliary apparatus. However, the use of high-voltage dynamotors and motor-generator sets is undesirable, under certain operating conditions, and results in difficulties in some classes of service and with certain types of equipments.

It is with the intention of improving operation that I have devised my present system, and also, for the purpose of meeting the demands of systems of even higher voltage, such as 2400, 3600 or 4800 volts, which are being contemplated in future railway development, particularly for high-speed interurban service and steam railroad electrifications.

According to my invention, I propose to employ a storage battery which shall normally be connected, either in series relation with all of the driving motors to be traversed by the entire motor current, or shall be connected in series circuit with a portion of the motors, in which case, it will be affected only by a proportionate part of the total motor current. The specific location of the storage battery, with respect to the main motor circuits, will depend largely upon the voltage of the system and the characteristics of the service. A blower motor is connected through a double-throw switch, whereby the motor may be connected in circuit either with the propelling motors or with the storage battery, thus permitting continuous operation of the blower, if necessary. Means are provided for increasing the active portion of the blower motor field

winding when the accelerating controller is returned to its off position, thereby decreasing the volume of cooling air that is delivered to the propelling motors, so that the cooling blast may be continued, though at a lower rate, when the propelling motors are not in operation. This action also causes a smaller discharge from the storage battery and thus reduces its necessary size. In addition, certain of the governing switches for the auxiliary apparatus are energized through the controller, thus insuring the opening of their respective circuits when the controller occupies its off position, as hereinafter described.

If a trolley voltage of 3600 volts be employed, the main motor current will be comparatively small, and, if a storage battery taking normally 100 volts is used, which is less than 3% of the line voltage, the current will be approximately the proper amount for driving the motor compressor and furnishing energy for the lighting and control circuits and other auxiliary apparatus. In case the auxiliary apparatus should require more power a higher voltage battery could be used. For example, the full-load current for the driving motors of a 50 ton car for 3600 volt service will be about 100 amperes. A 100 volt compressor motor for such an equipment will take from 50 to 60 amperes, and the average running current for the car will be approximately 60 amperes. It will, therefore, be seen that the average motor current is of substantially the proper value for operating the auxiliary apparatus and that the battery itself will only have to take care of the difference between the main motor current and the current required by the auxiliaries.

The capacity of the battery should be sufficient to operate all of the auxiliary apparatus for one or two hours, if necessary, but, in ordinary service, the battery would furnish only a small part of the current used by the auxiliary apparatus, and would intermittently be charged and discharged by small amounts, the main motor current being utilized, almost exclusively, for the auxiliary apparatus. Moreover, instead of operating the compressor to pump up the braking system when the driving motors are at a standstill, as is customarily done, the motor-compressor is arranged to be operated, as far as possible, when the driving motors are running, and to be operated when the car is at rest only when the pressure has fallen to a predetermined minimum value. In such an event, of course, the battery would supply the necessary energy for operation.

In the accompanying drawing, Figure 1 is a diagrammatic view of a system of control embodying my invention; Fig. 2 is a chart of well-known form, showing the sequence of operation of the various motor-controlling switches illustrated in Fig. 1; and Fig. 3 is a diagrammatic view of a modification of my invention.

Referring to Fig. 1 of the drawings, the apparatus shown comprises a supply circuit marked "Trolley", receiving energy from a suitable source (not shown); a plurality of driving motors having, respectively, armatures A^1, A^2, A^3 and A^4 and field magnet windings F^1, F^2, F^3 and F^4; reversing switches RS of any suitable type for reversing the electrical relations of the corresponding field windings and armatures; a plurality of accelerating resistors that are respectively adapted to be short-circuited by switches S, R^1, R^2, RR^1 and RR^2; a plurality of motor circuit switches LS, JR, JM^2 and G for arranging the motor circuits for series and parallel operation; an accumulator or storage battery marked "Battery" connected in series circuit with the aforesaid driving motors under normal operating conditions; translating devices marked, "Lighting system" connected in multiple to said "battery"; a switching device marked "Voltage regulator" for controlling the voltage of said "lighting system", a "compressor" adapted to create a predetermined fluid pressure in a system of a common type marked "Brake system"; a "compressor motor" for driving said "compressor"; a switching device marked "Compressor switch" in circuit with the "compressor motor"; an "adjuster" in multiple circuit with said "battery" for controlling the battery charging current; a switch marked "Battery switch" in series circuit with said "battery" and in multiple with said "adjuster"; a plurality of pressure governors respectively marked "Upper governor" and "Lower governor" for controlling the operation of the "compressor switch" in accordance with predetermined pressure conditions of the "brake system"; a "blower motor" that is adapted, in any well-known manner, to effect the ventilation of the propelling motors and is provided with an armature BA and a subdivided field magnet winding BF; a "blower switch", of the double-throw type, for connecting the "blower motor" to either the propelling motor circuit or to the "battery"; a master controller MC for governing the operation of the various motor-controlling switches in a well-known manner, and also associated with the auxiliary apparatus in a novel way, as hereinafter set forth; and a return circuit "ground".

For purposes of illustration, I have shown my invention in connection with a specific arrangement of motors and motor circuits and switches. However, inasmuch as my invention pertains only indirectly to this portion of the system, and, so far as its opera-

tion is concerned, is independent of it, except as it utilizes the current which traverses the driving motors, no detailed description of its operation will be given. The system shown is of a familiar series-parallel type, the "bridging" method of transition being employed. The motor armatures are permanently connected in series-related pairs, by reason of the relatively high voltage of the supply circuit that is utilized in my invention.

It is believed that this brief outline, taken in conjunction with the sequence chart of Fig. 2, is sufficient to enable those skilled in the art to clearly understand my invention, especially as it will be understood that the invention is not in any way restricted to the particular type of control shown and is applicable to many other well known control systems.

The "battery" is connected in series circuit with the driving motors and may be traversed by substantially the total motor current, although, if desired, by reason of the service conditions and line voltage, the "battery" may be connected in circuit with one of the pairs of driving motors and thus be traversed by substantially one half the motor current during parallel operation, or in circuit with one of the motors, as indicated in Fig. 3.

The "adjuster" shown comprises a plurality of counter-electromotive force (C. E. M. F.) cells, the regulating operation of which is hereinafter described.

The advantages of C. E. M. F. cells over a simple resistor, for the regulating function intended, are of considerable importance. The amount of current shunted by a resistor is substantially directly proportional to the voltage applied to the terminals. A resistor is not, therefore, inherently well adapted to protect a storage battery from overcharging. If a resistor is carefully adjusted for a given service, the battery will not become overcharged, but, if the battery is connected in series circuit with the main motors, it will be subject, at times, to excessive charging currents which will injure the battery and cause a wide fluctuation in its voltage. Such a condition is very undesirable in lighting circuits, in particular, and will necessitate a voltage regulator. On the other hand, the C. E. M. F. battery has quite different characteristics from resistors. With normal voltage on the storage battery, a very small current will pass through the C. E. M. F. battery. A relatively small increase in voltage will rapidly increase the current, and the batteries may, for example, be initially adjusted in such manner that an increase of 20% in voltage will force twenty times as much current through the C. E. M. F. battery. The counter electromotive force cells will thus automatically regulate the battery-charging current over a considerable range of service. If the storage battery is fully charged, its voltage will be high and the C. E. M. F. cells will shunt a relatively large proportion of the charging current and will, consequently, maintain a comparatively steady voltage on the storage battery and render the use of a voltage regulator unnecessary. Conversely, if the storage battery is in a low state of charge, the C. E. M. F. cells will shunt practically none of the charging current, and the storage battery will thus regain its charge.

A heavy charging current will produce a relatively high voltage on the battery terminals, unless the battery is in a low state of charge, when such a current will do no harm. Under heavy-current conditions, the relatively high storage-battery voltage will cause the C. E. M. F. cells to absorb a relatively large proportion of the charging current, as hereinbefore described, and the storage-battery voltage will thus be automatically limited to a much lower value than would be possible with a resistor. Unless a very close regulation is desired, a voltage regulator may thus be dispensed with.

Assuming that the driving motors are in operation and that the pressure of the "brake system" is at its normal value, the operation of the system is as follows: The actuating coil 1 of the "battery switch" is energized from the positive side of the "battery" and conductors 2 and 3, which are connected to a contact segment 4 of the master controller, to "ground". The "battery switch" is thus closed, thereby connecting the "battery" in multiple circuit with the "adjuster", after which the main motor current supplies the "battery", "adjuster" and auxiliary apparatus.

In order to maintain a constant voltage on the "lighting system", a "voltage regulator" of suitable form may be employed, in accordance with usual practice, and no description thereof is deemed necessary. However, the regulating effect of the C. E. M. F. cells may permit of the elimination of a regulator, as hereinbefore pointed out. If, while these conditions obtain, the pressure of the "brake system" falls to a value for which the "upper governor" is adjusted, its switch member 5 is permitted to drop and complete a circuit from the positive side of the "battery", through conductors 6 and 7, which are bridged by a contact segment 8 of the master controller, coöperating contact members 9 and 10 of the "upper governor", and energizing coil 11 of the "compressor switch" to "ground", thereby closing the switch. In so doing, a circuit is completed from the positive side of the "battery" through switch members 12 and 13 of the "compressor switch", armature 14 and field magnet winding 15 of the "compressor

motor" to the return circuit "ground". The main motor current, which serves to charge the "battery" prior to the closure of the "compressor switch", is thus shunted through the circuit just traced and is utilized, at least in part, to operate the "compressor motor" for the purpose of driving the "compressor" and pumping up the "brake system" to its normal value. During this operation, the "battery" may continue to be charged by a small amount of current or may be called upon to supply a portion of the energy for the "compressor motor", according to the amount of current taken by the driving motors at this particular time. As soon as the predetermined normal pressure is restored in the "brake system", contact members 9 and 10 of the "upper governor" are disengaged, and the "compressor switch" is opened to disconnect the "compressor motor".

The circuit through the energizing coil 11 of the "compressor switch" is interlocked through the contact members 9 and 10 of the "upper governor" and also through coöperating contact members of the master controller. It is, therefore, evident that, under normal operating conditions, the "compressor motor" can be operated only when the propelling motors are taking current.

If the driving motors are at rest, the "battery switch" cannot be closed, and, if the pressure of the "brake system" falls to a minimum safe value, for which the "lower governor" is set, its contact members 16 and 17 complete a circuit through the energizing coil 11, and the "compressor switch" is closed to deliver energy from the "battery" for operating the "compressor motor" and "compressor". In fact, the "lower governor" will act to close the "compressor switch" irrespective of the condition of the driving motors.

In the manner hereinbefore explained, the "battery" is normally charged during operation by the greater portion of the motor current, except at such time as the motor current is utilized for driving the motor-compressor set. The "battery" is employed for operating the "compressor motor" and other auxiliary apparatus when the vehicle is at rest and also for supplying a certain amount of current under conditions when the motor current is insufficient for the purpose. The "battery", therefore, is subjected to periods of charge and discharge, and the "adjuster" is set for the particular service in which the equipment is operated in order that the total charging current for a given period shall be sufficient to maintain the "battery" at substantially full-charge conditions without subjecting it to excessive charging currents or excessive over-charge. The "adjuster" preferably comprises a plurality of counter electro-motive force cells, as shown in Fig. 1; or a suitable resistor may be employed, as illustrated in Fig. 3. However, the "adjuster" is not restricted to any particular class of apparatus, as any suitable device may be employed.

When the "blower switch" occupies its upper position, as shown in Fig. 1, the "blower motor" is operated by a portion of the propelling motor current which traverses a predetermined portion of the field winding BF, conductors 21 and 22, which are connected by a contact segment 23 of the master controller in any of its "on" positions, and the return circuit "ground". If it is desired, at any time during motor operation, to energize the "blower motor" directly from the "battery", the "blower switch" is simply thrown to its lower position. As hereinbefore pointed out, it may be necessary or desirable to continue the operation of the "blower motor" at a speed below normal when the propelling motor circuit is interrupted. In this case, the "blower switch" will, of course, occupy the lower position. When the master controller is returned to its off position, the conductor 21 is open-circuited at the controller, while a conductor 24, which is connected to the outer end of the field winding BF, is connected to the conductor 22 by a contact member 25. The full field winding is thus included in circuit, with the familiar result of decreasing the "blower motor" speed and the volume of cooling air delivered.

Inasmuch as the actuating coils of the "battery switch" and of the "compressor switch", relative to the "upper governor", are energized only when the master controller occupies an operative position, these switches are always opened in the controller when current is cut off from the propelling motors, except in the case that the "compressor switch" may be energized through the "lower governor" upon closure thereof regardless of the position of the master controller. Undesirable electrical connections are thus obviated through the use of relatively simple and inexpensive apparatus.

I do not wish to be restricted to the specific circuit connections or arrangement of parts herein set forth, as many modifications may be effected within the spirit and scope of my invention. I, therefore, desire that only such limitations shall be imposed as are indicated in the appended claims.

I claim as my invention:

1. In a system of control, the combination with a supply circuit and main translating means energized therefrom, of an auxiliary source of energy, auxiliary translating means having a plurality of coöperating windings, means for connecting said auxiliary translating means in circuit either with said main translating means or with said source of energy, and means for vary-

ing the active portion of one of said windings under predetermined conditions.

2. In a system of control, the combination with a supply circuit and main translating means energized therefrom, of a source of energy in circuit with said means, a dynamo-electric machine having an armature and a field magnet winding, means for connecting said machine in circuit either with said main translating means or with said source of energy, and means for varying the active portion of said field winding under predetermined conditions.

3. In a system of control, the combination with a supply circuit, main translating means energized therefrom, and auxiliary translating means, of a dynamo-electric machine having an armature and a field magnet winding, an energy accumulator normally connected in series circuit with said main translating means and adapted to be charged, means for connecting said auxiliary translating means in parallel with said accumulator under predetermined conditions, means for connecting said machine in circuit either with said main translating means or with said accumulator, and means for varying the active portion of said field winding under other predetermined conditions.

4. A system of control comprising a supply circuit, main translating means receiving energy therefrom, auxiliary translating means, a dynamo-electric machine having an armature and a field magnet winding, an energy accumulator normally in circuit with said main translating means, means for regulating the amount of current traversing said accumulator, means for connecting said machine in circuit either with said main translating means or with said accumulator, and means for varying the active portion of said field winding under predetermined conditions.

5. A system of control comprising a supply circuit, an electric motor receiving energy therefrom, auxiliary translating means, an auxiliary dynamo-electric machine having an armature and a field magnet winding, a storage battery normally in circuit with said motor, means in parallel circuit with said battery for controlling the charging current thereof, means for connecting said machine in circuit either with said motor or with said battery, and means for varying the active portion of said field winding when the main motor current is interrupted.

6. A system of control comprising a supply circuit, a propelling motor fed therefrom an auxiliary fluid-pressure system, an auxiliary motor having an armature and a field magnet winding, a storage battery normally in circuit with the propelling motor, a translating device, means dependent upon conditions of said pressure system for connecting said translating device in parallel relation to said battery, means for connecting said auxiliary motor in circuit either with said propelling motor or with said battery, and means for varying the active portion of said field winding under predetermined conditions.

7. A control system comprising a supply circuit, a propelling motor fed therefrom, a translating device, an auxiliary fluid-pressure system, an auxiliary motor having an armature and a field magnet winding, a storage battery normally in circuit with the propelling motor, means for connecting said translating device in parallel relation to said battery under predetermined conditions of pressure in said system, means for connecting said auxiliary motor in circuit either with said propelling motor or with said battery, and means for respectively disconnecting said battery from the propelling motor circuit and for varying the active portion of said field winding when the propelling motor is not operating.

8. A control system comprising a supply circuit, a propelling motor fed therefrom, a storage battery, a fluid-pressure system, a motor-driven compressor associated therewith, a blower motor having an armature and a field magnet winding, means for connecting the battery in series with said propelling motor when the motor is running and for disconnecting said battery when the motor is not in operation, means dependent upon a predetermined condition of said pressure system for connecting the compressor motor in parallel relation to said battery during conditions of motor operation, means dependent upon a lower-pressure condition for making said connection, irrespective of the conditions of motor operation, means for connecting said blower motor in circuit either with said propelling motor or with said battery, and means for increasing the active portion of said field winding to decrease the blower motor speed when the propelling motor circuit is interrupted.

9. A system of control comprising a supply circuit, a propelling motor fed therefrom, an energy accumulator in circuit with said motor, an auxiliary motor having an armature and a field magnet winding, means for connecting said auxiliary motor in circuit either with said propelling motor or with said accumulator, and means for varying the active portion of said field winding when the propelling motor is not operating.

10. A system of control comprising a supply circuit, a propelling motor fed therefrom, a storage battery normally in circuit with the propelling motor, a blower motor having an armature and a subdivided field magnet winding, means for connecting said blower motor in circuit either with said propelling motor or with said battery, an ac-

celerating controller for said motor, and means operative in the off position of said controller to increase the active portion of said field winding.

11. A control system comprising a supply circuit, a propelling motor fed therefrom, a storage battery, a fluid-pressure system, a motor-driven compressor associated therewith, an auxiliary motor having an armature and a field magnet winding, electro-responsive means for connecting the battery in series with said propelling motor when the motor is operating, electro-responsive means dependent upon a predetermined higher-pressure system for connecting the compressor motor in parallel relation to said battery during conditions of motor operation, means dependent upon a lower pressure condition for making said connection, irrespective of the conditions of motor operation, means for connecting said auxiliary motor in circuit either with said propelling motor or with said battery, an accelerating controller for said propelling motor, and means for respectively opening the circuit of each of said electro-responsive means and for increasing the active portion of said field winding when the controller is returned to its off position.

12. In a system of control, the combination with a supply circuit and main translating means energized therefrom, of an auxiliary source of energy connected in circuit with said means, auxiliary translating means having a plurality of coöperating windings, means for connecting said auxiliary translating means in circuit either with said auxiliary source of energy directly or with said main translating means to receive a predetermined proportion of its energy therefrom during operation thereof in accordance with the value of current traversing said main translating means, and means for varying the active portion of one of said windings under predetermined conditions.

13. In a system of control, the combination with a supply circuit and a dynamo-electric machine energized therefrom, of an auxiliary source of energy connected in circuit with said machine, an auxiliary dynamo-electric machine having an armature and a field magnet winding, means for connecting said auxiliary machine in circuit either with said auxiliary source of energy directly or with said first dynamo-electric machine to receive a predetermined proportion of its energy from said auxiliary source of energy and from said first machine during operation, respectively, in accordance with the value of current traversing the first machine, and means for varying the active portion of the field winding of said auxiliary machine under predetermined conditions.

14. In a system of control, the combination with a supply circuit, and an electric motor receiving energy therefrom, of an energy accumulator connected in series circuit with said motor, an auxiliary dynamo-electric machine having an armature and a field magnet winding, means for connecting said auxiliary machine in circuit either with said energy accumulator directly or with said motor to receive a predetermined proportion of its energy from said accumulator and from said motor during operation, respectively, in accordance with the value of current traversing the motor, and means for varying the active portion of the field winding of said auxiliary machine when the motor current is interrupted.

15. In a system of control, the combination with a supply circuit, an electric motor energized therefrom, and auxiliary translating means, of an auxiliary dynamo-electric machine having an armature and a field magnet winding, an energy accumulator normally connected in series circuit with said motor and adapted to be charged, means for connecting said auxiliary translating means in parallel relation to said accumulator under predetermined conditions, means for connecting said auxiliary machine in circuit with said energy accumulator directly or with said motor, whereby said auxiliary translating means and said auxiliary machine respectively receive a predetermined proportion of their energy from said accumulator and from said motor during operation, in accordance with the value of current traversing the motor, and means for varying the active portion of the field winding of said auxiliary machine when the motor current is interrupted.

16. In a system of control, the combination with a supply circuit and main translating means energized therefrom, of an energy accumulator in circuit with said means and adapted to be charged, auxiliary translating means having a plurality of coöperating windings, means for connecting said auxiliary translating means in circuit either with said main translating means or with said source of energy, means for varying the active portion of one of said windings under predetermined conditions, and a C. E. M. F. battery adapted to automatically regulate the charging current of said energy accumulator.

17. In a system of control, the combination with a supply circuit and a dynamo-electric machine energized therefrom, of an energy accumulator connected in series circuit with said machine, an auxiliary dynamo-electric machine having an armature and a field magnet winding, means for connecting said auxiliary machine in circuit either with said accumulator directly or with said first dynamo-electric machine to receive

a predetermined proportion of its energy from said accumulator and from said first machine during operation, respectively, in accordance with the value of current traversing the first machine, means for varying the active portion of the field winding of said auxiliary machine under predetermined conditions, and a plurality of C. E. M. F. cells connected in parallel relation to said accumulator for automatically regulating the charging current thereof.

18. In a system of control, the combination with a supply circuit, an electric motor energized therefrom, an auxiliary translating means, of an auxiliary dynamo-electric machine having an armature and a field magnet-winding, an energy accumulator normally connected in series circuit with said motor and adapted to be charged, means for connecting said auxiliary translating means in parallel relation to said accumulator under predetermined conditions, means for connecting said auxiliary machine in circuit either with said energy accumulator directly or with said motor, means for varying the active portion of the field winding of said auxiliary machine when the motor current is interrupted, and a C. E. M. F. battery connected in parallel relation to said accumulator for automatically regulating the charging current and for maintaining a substantially constant voltage thereof.

19. In a system of control, the combination with a main source of energy and a main translating means energized therefrom, of an auxiliary translating means having a plurality of coöperating windings, an auxiliary source of energy, means for connecting said auxiliary translating means to the auxiliary source of energy or to the main source of energy, and means for varying the active portion of said windings in accordance with the operation of said main translating means.

20. In a system of control, the combination with a main source of energy and propelling motors energized therefrom, of an auxiliary source of energy, an auxiliary motor having a plurality of field windings, means for energizing said auxiliary motor from said main or said auxiliary source of energy, and means for controlling the operation of said propelling motors and for varying the active portions of said auxiliary motor-field windings.

21. In a system of control, the combination with a main source of energy and propelling motors in series therewith, of an auxiliary source of energy, an auxiliary motor, means for energizing said auxiliary motor in series with said propelling motors from the main source of energy or for energizing the same from the auxiliary source of energy, and means for controlling the said propelling motors and for varying the active portion of said auxiliary motor windings.

22. In a system of control, the combination with a main source of energy and a plurality of propelling motors adapted to be connected thereto, of an auxiliary motor having field windings, an auxiliary source of energy, means for energizing the auxiliary motor with the current flowing through said propelling motors or by said auxiliary source of energy, and means for varying the active portion of said auxiliary motor-field windings in accordance with the operation of said propelling motors.

In testimony whereof, I have hereunto subscribed my name this 31st day of Aug., 1914.

NORMAN W. STORER.

Witnesses:
JACOB STAIR, Jr.,
B. B. HINES.