R. E. HELLMUND.

SYSTEM OF CONTROL.

APPLICATION FILED SEPT. 9, 1915.

1,287,688.

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Fig. 1.

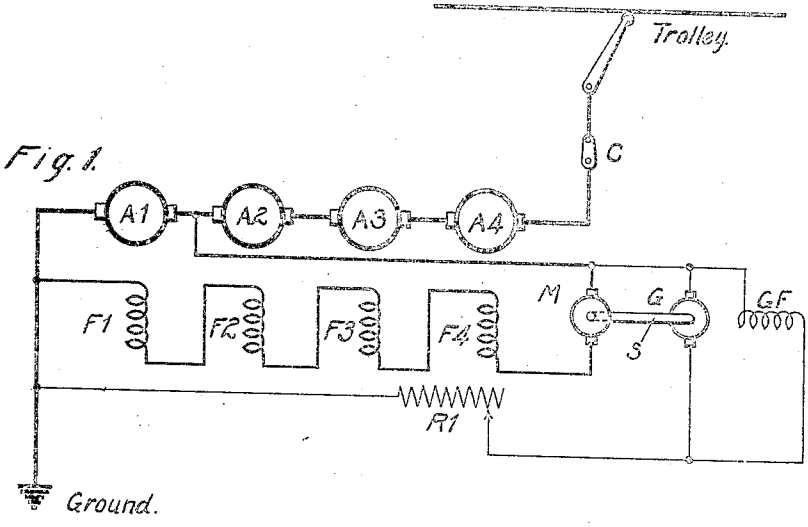


Fig 2.

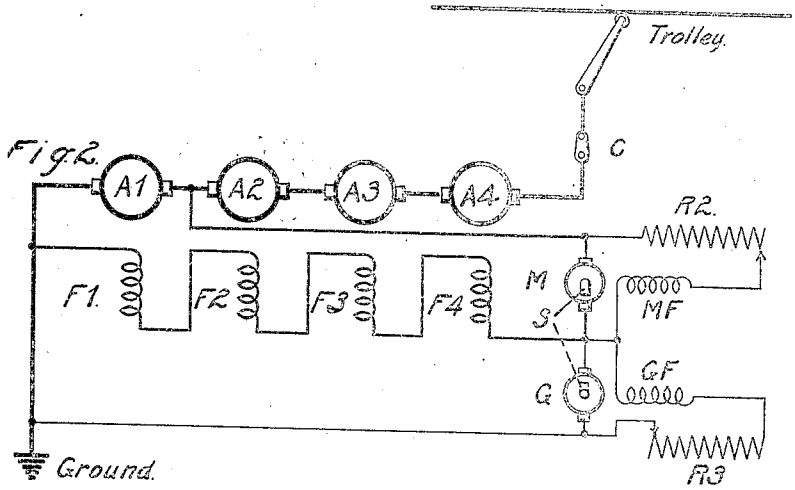
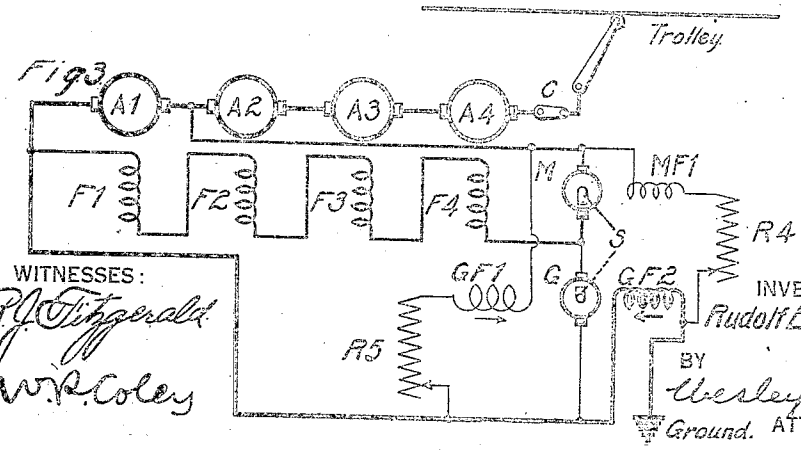


Fig 3



WITNESSES:

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SYSTEM OF CONTROL.

1,287,688. Specification of Letters Patent. Patented Dec. 17, 1918.

Application filed September 9, 1915. Serial No. 49,750.

To all whom it may concern:

Be it known that I, RUDOLF E. HELLMUND, a subject of the Emperor of Germany, and a resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Systems of Control, of which the following is a specification.

My invention relates to systems of control, and it has special reference to the regenerative control of dynamo-electric machines that are adapted for use in systems of relatively high voltage.

The object of my invention is to provide a reliable and effective system of the above-indicated character which shall be relatively economical in operation and which shall preclude the use of unsuitably high voltages in certain auxiliary circuits of the regenerative system.

The customary type of dynamotor may be successfully operated from the supply circuit up to voltages of approximately 1500 volts, but above this voltage, a machine of the dynamotor type for absorbing energy from, or returning current to, the supply circuit would have to be provided with exceedingly large commutators to avoid flash-over troubles. For this reason, it was necessary to devise other means for supplying a suitably low voltage to the auxiliary devices that are disposed upon railway vehicles and to the exciting field-winding circuit of the main machines during regenerative operation.

According to my present invention, I provide a system having the above-mentioned desirable characteristics, by connecting a dynamotor or its equivalent in parallel-circuit relation to the armature of a series of dynamo-electric machines that has the lowest voltage impressed upon it, or, in other words, the main armature that is directly connected to the negative supply-circuit conductor. In this way, a suitably low voltage for the purpose mentioned may be readily attained, as hereinafter more fully set forth.

In the accompanying drawing, Figure 1 is a diagrammatic view of a system of control embodying my invention, and Figs. 2 and 3 are similar views of systems of control that embody other modifications of my invention.

Referring to Fig. 1 of the drawing, the system shown comprises a plurality of suitable supply-circuit conductors respectively marked Trolley and Ground; a plurality of main dynamo-electric machines respectively having armatures A^1, A^2, A^3 and A^4 and series-type field magnet windings F^1, F^2, F^3 and F^4; a dynamotor of a familiar type having mechanically-connected armature windings M and G and a field magnet winding GF; a suitable switching device or controller, here shown conventionally at C, for the purpose of suitably manipulating the main machines from the supply circuit, and a resistor R^1 that is disposed in circuit with the armature winding G of the dynamotor for purposes of regulation.

The armature winding M of the dynamotor and the field-magnet windings F^1 to F^4, inclusive, of the main machines are connected in series-circuit relation across the lowest-voltage main armature A^1 which is connected directly to the negative supply-circuit conductor Ground. The field winding GF of the dynamotor is connected across the armature winding G. The armature winding M is connected in the series circuit just mentioned to act as a bucker, that is, to oppose its voltage to the regenerated voltage of the main armature A^1. In this way, the surplus exciting circuit voltage which would otherwise be wasted in resistance, is, in this case, absorbed by the armature winding M without rheostatic losses, and such surplus energy is mechanically transmitted to the armature winding G, whereby excessive field-circuit energy is returned to that portion of the main regenerative circuit that includes the main armature A^1. It will be understood that, in the case of a dynamotor, the armature windings M and G are wound on the same core (not shown), which is mounted on a suitable shaft *s*, whereby energy is mechanically transmitted between the armature windings by the core directly; whereas, in the case of a motor-generator set, energy is mechanically transmitted by the shaft *s*.

In this way, the ordinary type of dynamotor may be employed, since the voltage of the armature A^1, even in case of a supply-circuit voltage as high as 5,000 volts, would not be excessive for, and would not be likely to cause any flash-over trouble in, the dynamotor. For the purpose of regulating the speed of the dynamotor and the amount of energy that is returned to the main regen-

erative circuit, the resistor R^1 may be suitably varied, in accordance with familiar practice, as the speeds of the regenerating machines gradually decrease.

It will be understood that, while I have here shown and described my invention as embodying a dynamotor in connection with the excitation of the main field windings, a suitable motor-generator set may be employed if desired, the armature windings in that case being connected as illustrated in Fig. 1 and the various field-magnet windings being disposed in accordance with any suitable practice. It will be further understood that, if desired, the armature winding G may be employed to deliver a suitably low voltage to the various auxiliary devices, such as control circuits, lights, etc., upon the associated electric railway vehicle, as is customary.

During the motoring and the regenerative operation of the main motors, current flows from the junction point between the armatures A^1 and A^2, through armature winding M, and the field windings F^1 to F^4, inclusive, to the return conductor Ground. Current also flows from the generator armature G through the armature M, field windings F^1 to F^4, inclusive, and the resistor R^1. A circuit in parallel to the circuit traced through the armature G is effected through the field winding GF. The direction of current flow through the field windings F^1 to F^4 and the dynamotor is maintained unchanged whether the main machines are operating as motors or are operating as generators. However, during regenerative operation, the direction of current flow through the armatures A^1 to A^4, inclusive, is reversed and the excitation of the field windings F^1 to F^4, inclusive, is increased.

Reference may now be had to Fig. 2, wherein the circuit connection of the armature winding M of a motor-generator that replaces the previously-described dynamotor is identical with that illustrated in Fig. 1, while the generator armature winding G is connected intermediate the negative supply-circuit conductor Ground, and the lower-voltage terminal of the armature winding M, or, in other words, is connected across the series-connected field-magnet windings of the main machines.

In this case, the field winding GF of the motor generator is connected in circuit with a suitable variable resistor R^3 across the armature winding G, and a second field magnet winding MF for the motor generator is connected through a suitable variable resistor R^2 across the armature winding M.

The operation of the system just described will be evident from the similarity to the system illustrated in Fig. 1. In this case, the surplus exciting-field energy that is derived from the armature winding M by the armature winding G is returned directly to the exciting field-winding circuit rather than to the main armature winding A^1, whereby a machine of smaller capacity than that necessary in the system shown in Fig. 1 is required.

It will be understood that, in order to vary the operation of the dynamotor or motor-generator set and the excitation of the main field windings as the speeds of the main machines decrease, the resistors R^2 and R^3 may be suitably manipulated to respectively vary the dynamotor or motor-generator set speed and the voltage delivered by the armature winding G.

In Fig. 3, the system shown comprises the main dynamo-electric machines and the armature windings M and G of a motor-generator that replaces the previously-described dynamotor, together with connections to the main machine circuits that are identical with those illustrated in Fig. 2. However, the armature winding M is provided with a shunt field winding MF^1 that is connected in series relation with a suitable variable resistor R^4 across the series-connected armature windings M and G, while the armature winding G is provided with a shunt field-magnet winding GF^1 that is connected in series relation with a suitable variable resistor R^5 across the armature windings M and G also. A second field winding GF^2 for the armature winding G is connected in the main regenerative circuit and is differentially disposed with respect to the shunt field winding GF^1.

In general operation of the system, with the exception of the effect of the differentially disposed field windings GF^1 and GF^2, is similar to those already described, while the use of these field windings tends to prevent surges of regenerative current by reason of relatively heavy fluctuations in the supply-circuit voltage, for example, and to maintain a substantially constant regenerated current. For instance, assuming an increase of regenerated current traversing the main machine armatures and the field winding GF^2, the effective exciting field flux of the armature winding G is proportionately decreased by reason of the differential connection of the field windings GF^1 and GF^2, whereby the excitation of the main machine field windings is correspondingly decreased, and the regenerated current is rapidly reduced to the predetermined constant value desired. The differential relation of the field-magnet windings GF^1 and GF^2 *per se* is not of my present invention, but is shown and described in my copending application, Serial No. 855,539, filed Aug. 7, 1914, to which reference may be made for further description of the operation.

I do not wish to be restricted to the

specific circuit connections or arrangement of parts herein set forth, as various modifications may be made therein without departing from the spirit and scope of my invention. I desire, therefore, 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 plurality of main dynamo-electric machines severally having armatures and field-magnet windings, of means for connecting said armature windings in series-circuit relation, and an auxiliary armature winding connected as a bucker in circuit with said main field windings across one of said main armatures.

2. In a system of control, the combination with a supply circuit of relatively high voltage, and a plurality of main dynamo-electric machines severally having armatures and field-magnet windings, of means for connecting said armature windings in series relation across said supply circuit, a plurality of auxiliary armature windings, means for connecting one of said auxiliary windings as a bucker in circuit with said main field windings across one of said main armatures, and means for connecting a second auxiliary winding to that main armature.

3. In a system of regenerative control, the combination with a supply circuit, and a plurality of main dynamo-electric machines severally having armatures and field-magnet windings, of means for connecting said armature windings in series relation across said supply circuit, a plurality of mechanically associated auxiliary armature windings, means for connecting the first of said auxiliary armature windings in series relation with said main field windings across one of said main armatures to oppose the regenerated voltage, and means for connecting the other auxiliary winding to a portion of the machine circuits to return thereto the energy derived from said first auxiliary winding.

4. In a system of regenerative control, the combination with a supply circuit of relatively high voltage, and a plurality of main dynamo-electric machines severally having armatures and series-type field-magnet windings, of means for connecting said armature windings in series relation across said supply circuit, a plurality of mechanically associated and relatively low-voltage auxiliary armature windings, means for connecting the first of said auxiliary armature windings in series relation with said main field windings across the lowest-voltage main armature to oppose the regenerated voltage, and means for connecting the other auxiliary winding across the series-connected field-magnet windings to apply thereto the surplus energy derived from said first auxiliary winding.

5. In a system of regenerative control, the combination with a supply circuit of relatively high voltage, and a plurality of main dynamo-electric machines severally having armatures and series-type field-magnet windings, of means for connecting said armature windings in series relation across said supply circuit, a plurality of mechanically associated and relatively low-voltage auxiliary armature windings, means for connecting the first of said auxiliary armature windings in series relation with said main field windings across the lowest-voltage main armature to oppose the regenerated voltage, means for connecting the second auxiliary armature winding across the series-connected main field windings to apply thereto the surplus energy derived from said first auxiliary winding, a first field winding for the second auxiliary armature winding connected in series relation with the main armature, and a second shunt-connected field winding therefor differentially disposed with respect to said first field winding, whereby an increase of regenerated current effects a decrease of main field excitation, and vice versa, to maintain a substantially constant regenerated current.

In testimony whereof, I have hereunto subscribed my name this 31st day of Aug. 1915.

OLE E. HELLMUND.