No. 845,856. PATENTED MAR. 5, 1907.

G. H. CONDICT.

METHOD OF AND APPARATUS FOR BRAKING VEHICLES.

APPLICATION FILED MAY 9, 1906.

4 SHEETS—SHEET 1.

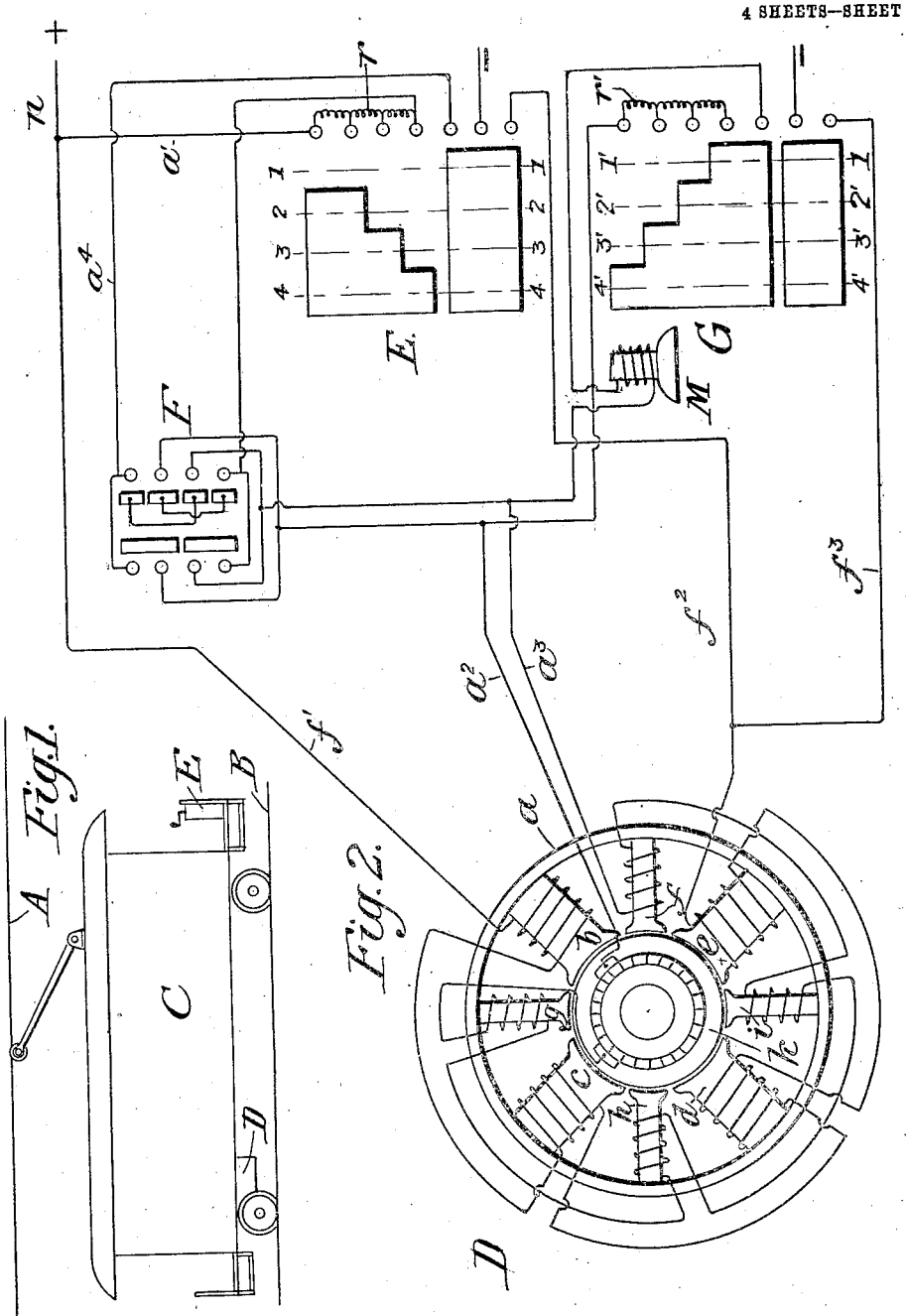

Fig. 1.

Fig. 2.

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by Munn & Goldsborough,
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4 SHEETS—SHEET 2.

Fig. 3.

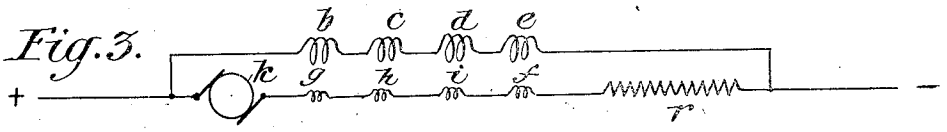


Fig. 4.

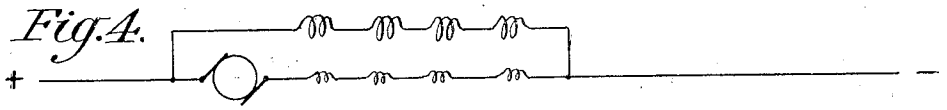


Fig. 5.

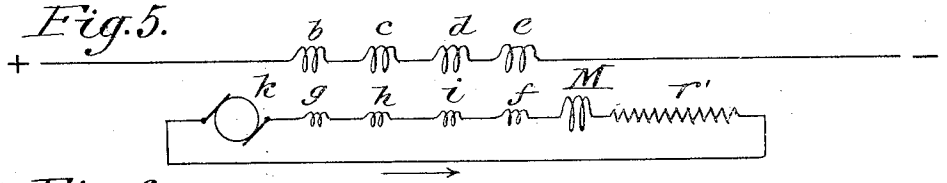


Fig. 6.

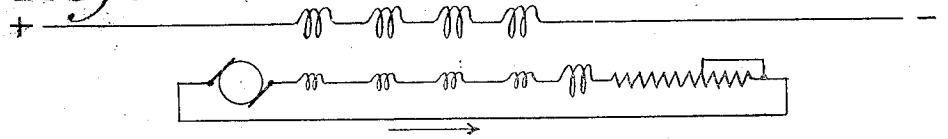


Fig. 7.

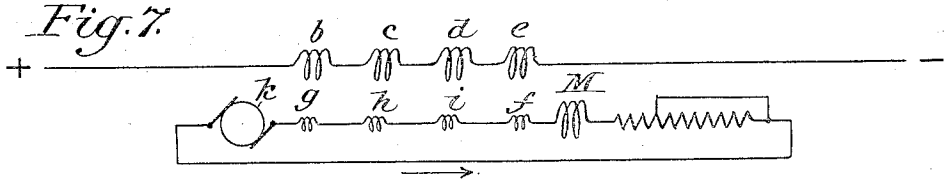


Fig. 8.

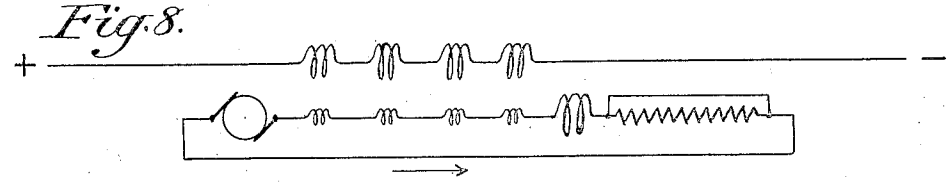


Fig. 10.

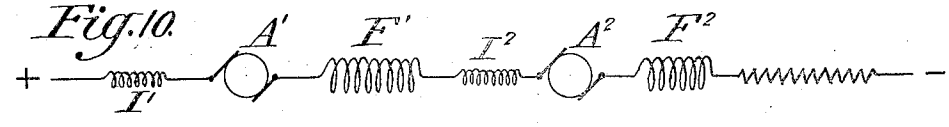


Fig. 11.

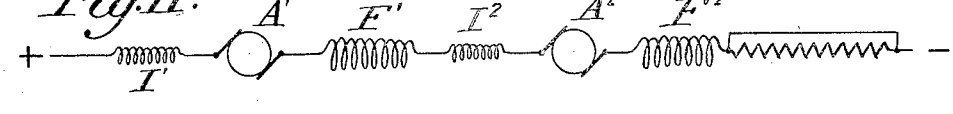
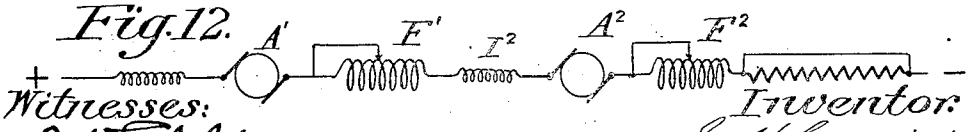


Fig. 12.



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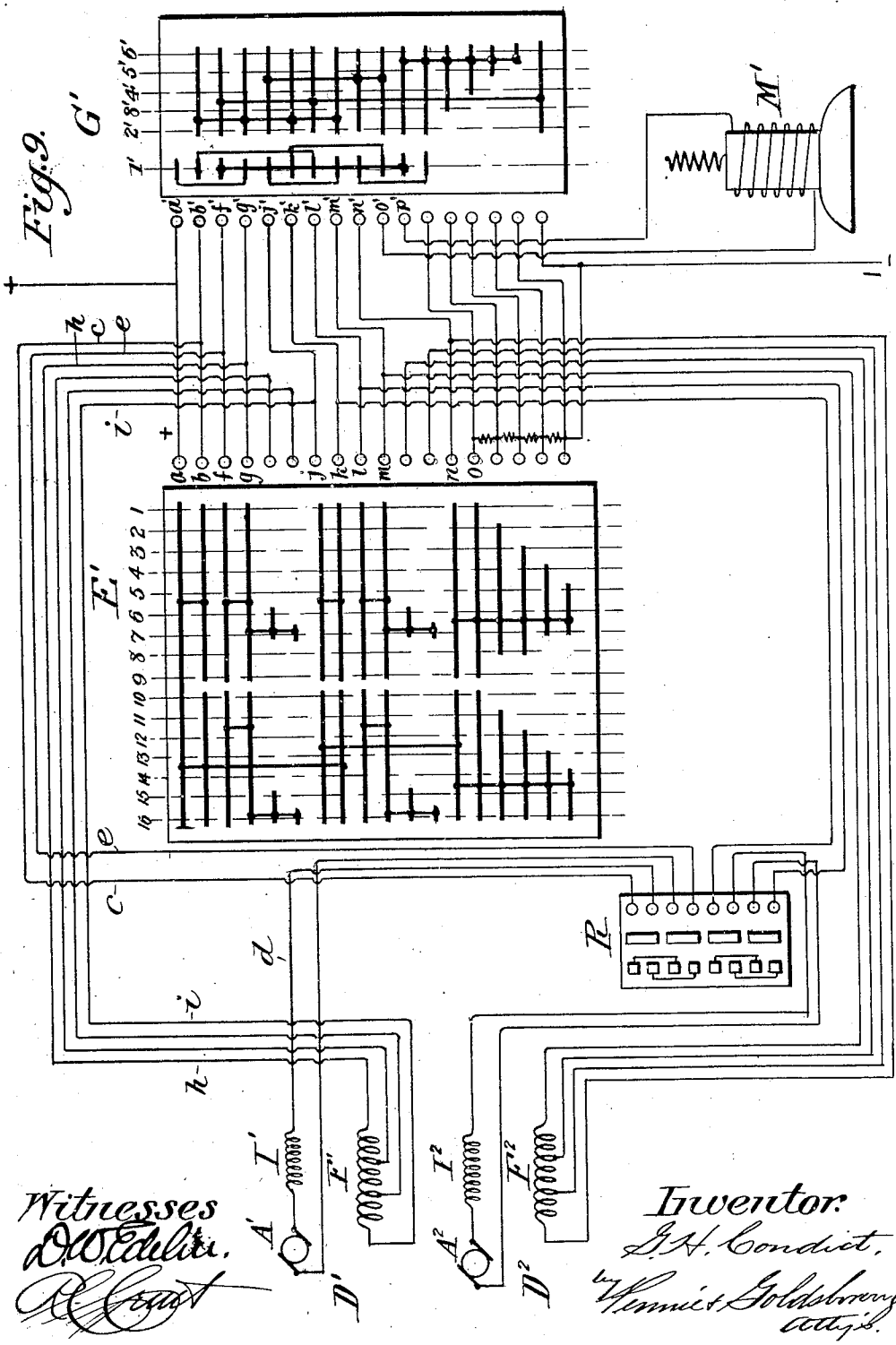
4 SHEETS—SHEET 3.

Fig. 9.



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4 SHEETS—SHEET 4.

Fig. 13.

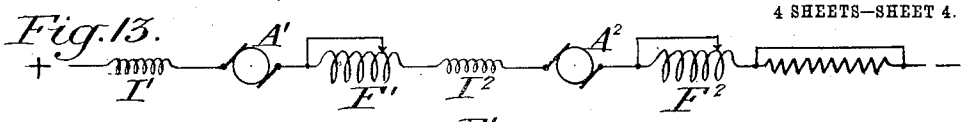


Fig. 14.

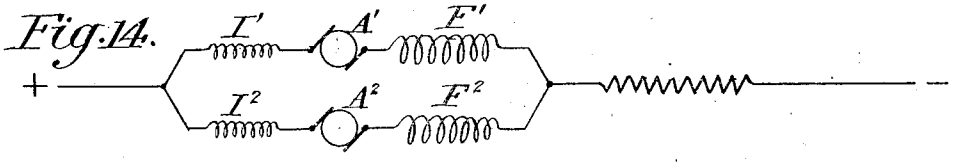


Fig. 15.

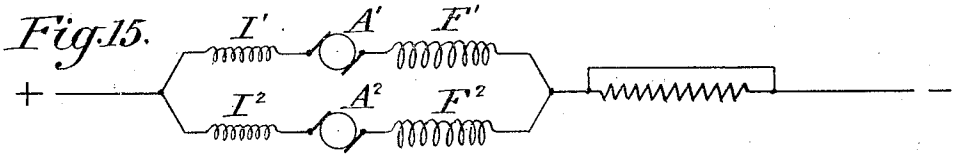


Fig. 16.

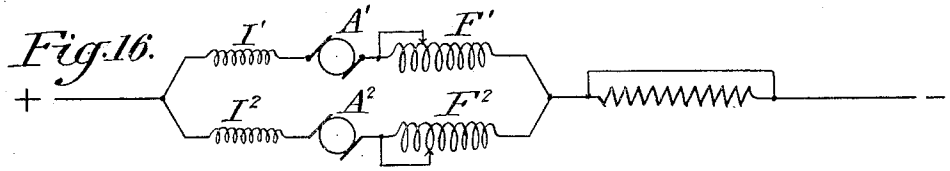


Fig. 17.

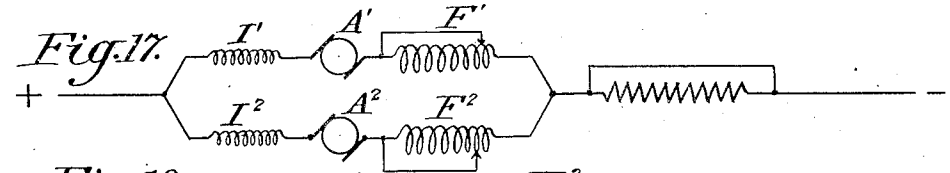


Fig. 18.

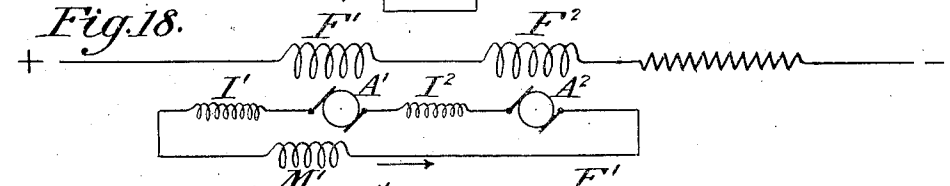


Fig. 19.

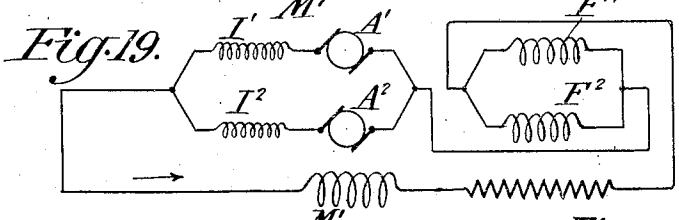
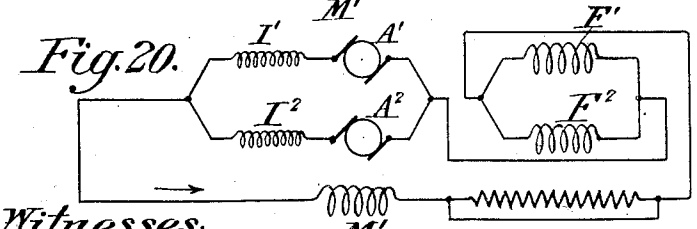


Fig. 20.



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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR BRAKING VEHICLES.

No. 845,856. Specification of Letters Patent. Patented March 5, 1907.

Application filed May 9, 1906. Serial No. 315,973.

To all whom it may concern:

Be it known that I, GEORGE HERBERT CONDICT, a citizen of the United States, residing at Plainfield, county of Union, State of New Jersey, have invented certain new and useful Improvements in Method of and Apparatus for Braking Vehicles; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to means for braking vehicles driven by an electric motor or motors, and contemplates the employment of the driving-motors as generators of a braking current, when those motors are driven by the momentum of the vehicle.

It has heretofore been proposed to employ electric motors upon vehicles as braking-generators; but their use, so far as I am aware, has been hardly more than experimental. The chief reason why the generator system of braking has not found favor in the past is that the enormous variations in the load of the generator corresponding to different degrees of braking has caused the braking-generator to spark in a destructive manner, in many cases actually flashing over the commutator between the brushes.

According to the present invention the sparking referred to, and with it the chief objection to the use of motors as braking-generators, is removed and a practical working system produced. This is accomplished by the use of auxiliary poles, acting upon the armature-coils when they are undergoing commutation, and generating in those armature-coils a current in the same direction and of substantially the same strength as the current flowing in the armature-circuit with which the coil undergoing commutation is about to be connected.

It has been customary to locate in each interpolar space in such dynamo-electric machines an auxiliary pole to act upon the armature-coils when they are passing through the interpolar space and undergoing commutation. It is not essential, however, that these auxiliary poles should be so located, provided that they are located in proximity to any proportion of the armature-coil in such a manner as to generate in each coil the necessary compensating electromotive force when that coil is undergoing commutation.

It will be recognized by those skilled in the art that there exist many systems for controlling motors on driven vehicles when these motors are acting to drive the vehicles, and my invention does not contemplate any improvements in such systems; but I may use any desired number of motors and may regulate those motors by any desirable system of control when they are being used to drive the vehicle.

In the accompanying drawings I have illustrated one extremely simple system of control, in which a single shunt-motor is used and which is well adapted to use on comparatively light vehicles, such as automobiles, and a second more complicated system which is better adapted to the driving of heavy vehicles, such as railway-cars, and in which two motors are used, together with a series multiple system of control.

Figure 1 is a diagrammatic illustration of a street-railway car, track, and trolley-wire. Fig. 2 is a diagram showing the construction of the dynamo-electric machine, which is to be used both as a motor and as a braking-generator, together with controllers for regulating the machine as a motor and as a braking-generator. Figs. 3 to 8, inclusive, are simplified diagrams of the connections of the various parts in different positions of the controllers. Fig. 9 is a diagram of a more complicated system of control, in which two motors are employed, it being understood that the mechanical construction of the motors is the same as in Fig. 2, though in Fig. 9 the motors are represented by a diagram of their windings only. Figs. 10 to 20, inclusive, are simplified diagrams of the connections of the parts shown in Fig. 9 at different positions of the controllers.

Referring particularly to Fig. 1, the system comprises a conductor A for conducting the current to the car C, provided with a motor D and a controller E and means for taking the current from the conductor A. B represents the track, which also constitutes the return-conductor for the current. It will be understood that in the case of an automobile the driving-current may be supplied from a battery carried by the vehicle.

In Fig. 2 the motor D is seen to comprise a frame *a*, which supports the main poles *b c d e* and the commutating-poles *f g h i*, the commutating-poles being located in the spaces between the main poles, so that each coil of the armature as it undergoes commutation is under the influence of the field of the com-

mutating-poles, which field is independent of the main poles and is maintained at the proper strength to produce sparkless commutation regardless of changes in load or in direction of rotation of the armature. The simplest way of thus maintaining the proper strength of the field of the commutating-poles is to connect the coils of said poles in circuit with the armature of the dynamo-electric machine, so that the current in the coils of the commutating-poles always corresponds in strength and direction to the current in the armature-circuit. The main poles alternate in polarity in the usual manner, and the commutating-poles also alternate in polarity, each commutating-pole being of the same polarity as the following main pole in the direction of rotation of the armature when the machine is used as a braking-generator and of the same polarity as he preceding main pole in the direction of rotation of the armature when the machine is used as a motor. It will be understood that though this is a preferred construction it is not an essential one, the essential thing being that the commutating-poles shall be so connected and located that they shall generate in the armature-coils undergoing commutation a current flowing in the same direction and of substantially the same strength as the current which that coil will be called upon to carry as soon as the commutation is completed and the coil is again included in the active circuits of the armature.

The controller E here shown is of the simple resistance type and serves to regulate the machine when it is acting as a motor. The reversing-switch F is of the usual type and needs no further description. The controller G is for the purpose of regulating the machine when it is used as a braking-generator and will be further described hereafter. M is a magnetic brake, which is here shown diagrammatically as a track-brake, though it will be understood that any desired form of magnetic brake may be employed.

The controllers E and G and the reversing-switch F are illustrated in the conventional manner, the small circles representing contact-fingers and the contact-bars on the controller-drum being shown in development.

If it be assumed that the reversing-switch is thrown to the right, which we assume is the position to drive the car forward, then if the drum of the controller E is rotated right-handedly under the contact-fingers lying along the dotted line 1 1 the circuits will be as follows: The current entering from the positive main divides at the point n and flows through the conductor f'', the main field-coils of the motor, the conductor f^2, back through the contact-plate on the controller E to the negative main. The other branch from the point n flows through the conductor a', the resistance r, the reversing-switch, the conductor a^2, the armature k of the motor, the windings of the auxiliary poles, the conductor a^3, the reversing-switch, the conductor a^4 to the contact-plate on the drum of the controller E and to the negative main. It will be seen that in such position the circuit connections are as shown in Fig. 3, with the armature of the motor, the auxiliary field-windings, and the resistance r in series across the line and the main field-coils in shunt to this circuit—that is, the motor is being used as a shunt-motor.

A rotation of the controller E to the positions 2, 3, and 4 cuts out the resistance r step by step to the full-speed position of the motor, which is attained at position 4 and is illustrated in Fig. 4 of the drawings, in which it will be seen that the armature and auxiliary field-coils are connected across the line and the main field-coils are in shunt to this circuit.

If it is desired to use the motor as a braking-generator, the controller E is returned to the off position, the reversing-switch F is not moved, and the controller G is rotated right-handedly to bring the contact-fingers on the line 1′ 1′. In this position the current enters from the positive main, passes through the conductor f', the main field-coils of the motor in the same direction as before, the conductor f^3, the controller G, and back to the negative main. The main field-coils are thus connected directly across the line with the current flowing through them in the same direction as when the machine was used as a motor. The armature-circuit may be traced from the left-hand brush of the motor through the auxiliary field-coils in a direction opposite to the direction of current-flow through these coils when the machine was being used as a motor, through the conductor a^3, the magnetic brake M to the controller G, through the resistance r', and back through conductor a^2 to the right-hand brush of the generator. In this position the circuits are then as shown in Fig. 5, in which the main field-coils are connected across the line, and the auxiliary field-coils, the resistance r', and the armature of the generator and the magnetic brake are connected in a closed circuit. The subsequent move of the controller G to the positions 2, 3, and 4 gradually cuts out the resistance r', as shown in Figs. 6, 7, and 8, and thus increases the braking effect. It would be possible to substitute for the magnetic brake a heavy resistance, in which the current generated by the dynamo-electric machine as it is driven by the momentum of the vehicle would be absorbed, and in such case the controller should of course be arranged to gradually decrease the resistance to increase the braking effect, as will be readily understood by those skilled in the art. I prefer, however, to use a positive magnetic brake.

Referring now to Fig. 9, there are shown diagrammatically two motors D′ and D², and it will be understood that these motors are provided with interpoles, the windings of which are represented diagrammatically at I′ and I², and these interpoles may be arranged as shown in Fig. 2 or in any other suitable manner. In the system of control here shown the motors are series-motors as distinguished from Fig. 2, in which the motor is illustrated as a shunt-motor. A′ represents the armature of motor No. 1, and A² represents the armature of motor No. 2. F′ represents the main field-windings of motor No. 1, and F² the main field-windings of motor No. 2. It will be seen that these main field-windings are divided into three sections for a purpose which will appear hereafter. R represents a reversing-switch of ordinary construction, which needs no further description. E′ represents a controller for regulating the power of the dynamo-electric machines when they are used as motors, and G′ a controller for regulating them when they are used as braking-generators. As before, the contact-fingers are represented by circles, and the controller-drums are shown in development. M′ is a magnetic brake of any preferred construction.

If we assume that the reversing-switch is thrown to the right and that this is the position to drive the motors forward and then the drum of the controller E′ is rotated to the right into the position 1, the following circuit connections are established: The current enters from the positive main to the finger *a*, the contact on the controller, the finger *b*, conductor *c*, through the reversing-switch, conductor *d*, auxiliary field I′, armature A′, reversing-switch, conductor *e*, finger *f*, contacts on the controller-drum, finger *g*, conductor *h*, field F′, conductor *i*, finger *j*, contacts on the controller-drum, finger *k*, reversing-switch, auxiliary field I², armature A², reversing-switch, finger *l*, contacts on the controller-drum finger *m*, field F², finger *n*, contacts on the controller-drum, finger *o*, and through the four resistance-sections in series to the negative main or ground. In this position the parts are connected as shown in Fig. 10, in which it will be seen that the auxiliary fields, the armature, and the main field of the two motors are connected in series with each other and with the regulating resistance across the line. This is the slow-speed position of the controller. The subsequent movement of the controller to the positions 2, 3, 4, and 5 cuts out the regulating resistance step by step and results in the connection shown in Fig. 11, in which all the parts are connected in series without any resistance in circuit. A further movement of the controller to the position 6 cuts out one section of the main field-windings, as shown in Fig. 12. A further movement of the controller to position 7 cuts out another section of the main field-windings, as shown in Fig. 13, thus giving the full series speed of the motors. At positions 8 and 9 the field-coils which were cut out at positions 6 and 7 are reinserted, and the resistance is also reinserted in two steps, all preparatory to connecting the motors in multiple. Position 9 is the last series step, and the next following position is position 10, in which the motors are connected in multiple. In this position the circuit is as follows: from the positive main through the finger *a* to the contacts on the controller-drum, where the circuits divide, one path being through finger *b*, conductor *c*, reversing-switch, conductor *d*, auxiliary field I′, armature A′, reversing-switch, conductor *e*, finger *f*, contacts on the controller-drum, finger *g*, conductor *h*, main field F′, conductor *i*, finger *j*, to contacts on the controller-drum, where the branch circuits reunite. The other branch is from finger *a*, contacts on the controller-drum finger *k*, reversing-switch, auxiliary field I², armature A², reversing-switch, finger *l*, contacts on the controller-drum, finger *m*, field F², finger *n*, and to the contacts on the controller-drum, where the circuits reunite. From here the current passes by the finger *o* through the resistance-sections in series to the negative main or ground. This arrangement of the circuit is shown in Fig. 14, in which it will be seen that the motors are in parallel and in series with the regulating resistance. In positions 11, 12, 13, and 14 the regulating resistance is cut out step by step, giving the arrangement shown in Fig. 15, and in positions 15 and 16 the sections of the main field are cut out, giving the arrangement shown in Figs. 16 and 17, which latter is the full-speed position of the motors. If now it is desired to brake the vehicle, the controller E′ is returned to the off position and the controller G′ is rotated to the left to bring the contact-fingers onto the position *l′*. In this position the circuit connections are as follows: from the positive main to finger *a′*, cross connections on the controller-drum, finger *g′*, conductor *h*, field F′, conductor *i*, finger *j′*, cross connections on the controller-drum, finger *m′*, field F², finger *n′*, cross connections on the controller-drum and through the four resistance sections in series to the negative main. The armature-circuit is from the right-hand brush of armature A′, through auxiliary field I′, conductor *d*, reversing-switch, conductor *c*, finger *b′*, cross connections on the controller-drum, finger *l′*, reversing-switch, armature A², auxiliary field I², reversing-switch, finger *k′*, cross connections on the controller-drum, finger *o′*, magnetic brake M′, finger *p′*, cross connections on the controller-drum to finger *f′*, and through conductor *e* and the reversing-switch back to the left-hand brush of the ar-

mature A′. In this position the circuit connections are as shown in Fig. 18, in which the field F′ and F² are connected directly across the line in series with each other and with the resistance. The two armatures are in a closed circuit in which is included the auxiliary fields I′ and I² and the magnetic brake M′. A further rotation of the controller G′ to position 2′ establishes the following circuit connection after cutting off all connection with the external circuit. Starting from the right-hand brushes of armature A′ and A² in two parallel circuits through the auxiliary fields I′ and I² and the reversing-switch to the fingers *b′* and *k′* by cross connections on the controller-drum to fingers *m′* and *g′*, and from thence in two parallel paths through fields F′ and F² to fingers *j′* and *n′*, and thence by a cross connection on the controller-cylinder to finger *o′* through the magnetic brake M′ to finger *p′* by cross connections on the controller-drum through the four sections of the resistance in series and back by cross connections on the controller-drum to fingers *l′* and *f′*, and thence in parallel paths back to the left-hand brushes of the armatures A′ and A². In this position the circuit connections are as shown in Fig. 19, in which it will be seen that the armature A′ and the auxiliary field I′ are in parallel with the armature A² and the auxiliary field I², and these parallel circuits are in series with the fields F′ and F² in parallel with the resistance and with the magnetic brake M′. A further rotation of the controller G′ to positions 3′, 4′, 5′, and 6′ gradually cuts out the regulating resistance, increasing the braking effect until the position shown in Fig. 20 is reached. It will be seen that by this arrangement the current through the main field-windings is always in the same direction and provision is made for maintaining the magnetization of the fields by connecting them directly across the line at the first position of the braking-controller. After this the current from the armatures of the motors, which are now acting as generators, may be relied upon to energize the field-magnets.

While I have illustrated and described two systems for controlling the dynamo-electric machines when they are acting as braking-generators, it will be obvious that various modifications of the systems might be made without departing from the spirit of my invention. Just as many modifications of the system for controlling the dynamo-electric machines when they are acting as motors may be made.

It will be seen, therefore, that my invention may have a wide application and that it is not limited to the particular structures or the particular applications illustrated and described.

What I claim is—

1. The method of braking a vehicle driven by an electric motor, which consists in using the motor as a braking-generator driven by the momentum of the vehicle, and maintaining in the motor during the braking operation a commutating-field independent of the main field.

2. The method of braking a vehicle driven by an electric motor, which consists in using the motor as a braking-generator driven by the momentum of the vehicle and creating by the current so generated a commutating-field independent of the main field.

3. The method of braking a vehicle driven by an electric motor which consists in using the current generated in the motor when it is driven by the momentum of the vehicle to create a compensating current in the armature-coils undergoing commutation, and to energize a magnetic brake on the vehicle.

4. The combination with a vehicle, of a motor having a main field, means for converting said motor into a braking-generator, and means for maintaining in the motor during the braking operation a commutating-field independent of the main field.

5. The combination with a vehicle, of a motor having a main field, a magnetic brake having an energizing-coil, and means for connecting the energizing-coil of the brake in circuit with the armature of the motor, and for maintaining in the motor a commutating-field independent of the main field, when the motor is driven by the momentum of the vehicle.

6. The combination with a vehicle, of a motor having a main field, a commutating-field independent of the main field, and energizing-coils for said fields, and a controller adapted to close the armature-circuit of the motor through the said energizing-coils.

7. The combination with a vehicle, of a motor having a main field, a commutating-field independent of the main field, and energizing-coils for said fields, a magnetic brake having energizing-coils, and a controller adapted to close the armature-circuit of the motor through all of said energizing-coils.

8. The combination with a vehicle, of a motor having a main field, a commutating-field independent of the main field, and energizing-coils for said fields, and a controller adapted to connect the main-field energizing-coils with a source of current-supply and to close the armature-circuit of the motor through the energizing-coils of the commutating-field.

9. The combination with a vehicle, of a motor having a main field, a commutating-field independent of the main field, and energizing-coils for said fields, and a controller adapted to connect the main-field energizing-coils with a source of current-supply and to close the armature-circuit of the motor through the energizing-coils of the commutating-field, and by a further movement to

disconnect the main-field energizing-coils from the supply-circuit and to include them in the armature-circuit.

10. The combination with a vehicle of a motor having a main field, a commutating-field independent of the main field, and energizing-coils for said fields, a magnetic brake having energizing-coils, and a controller adapted to connect the main-field energizing-coils with a source of current-supply and to close the armature-circuit of the motor through the energizing-coils of the commutating-field and of the magnetic brake, and by a further movement to disconnect the main-field energizing-coils from the supply-circuit and include them in the armature-circuit.

11. The combination with a vehicle, of a plurality of motors having main fields, commutating-fields independent of the main fields, and energizing-coils for said fields, a magnetic brake having energizing-coils, a suitable resistance, and a controller adapted to connect the main-field energizing-coils of the motors in series with one another and with the resistance across supply-mains leading from a source of current-supply, to close the armature-circuit through the energizing-coils of the commutating-fields and of the magnetic brake, and by a further movement to disconnect the main-field energizing-coils and the resistance from the supply mains and include them in the armature-circuit, and by further movements to gradually remove the resistance from the armature-circuit, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

GEORGE HERBERT CONDICT.

Witnesses:

WILLIAM H. DAVIS,

LAURA B. PENFIELD.