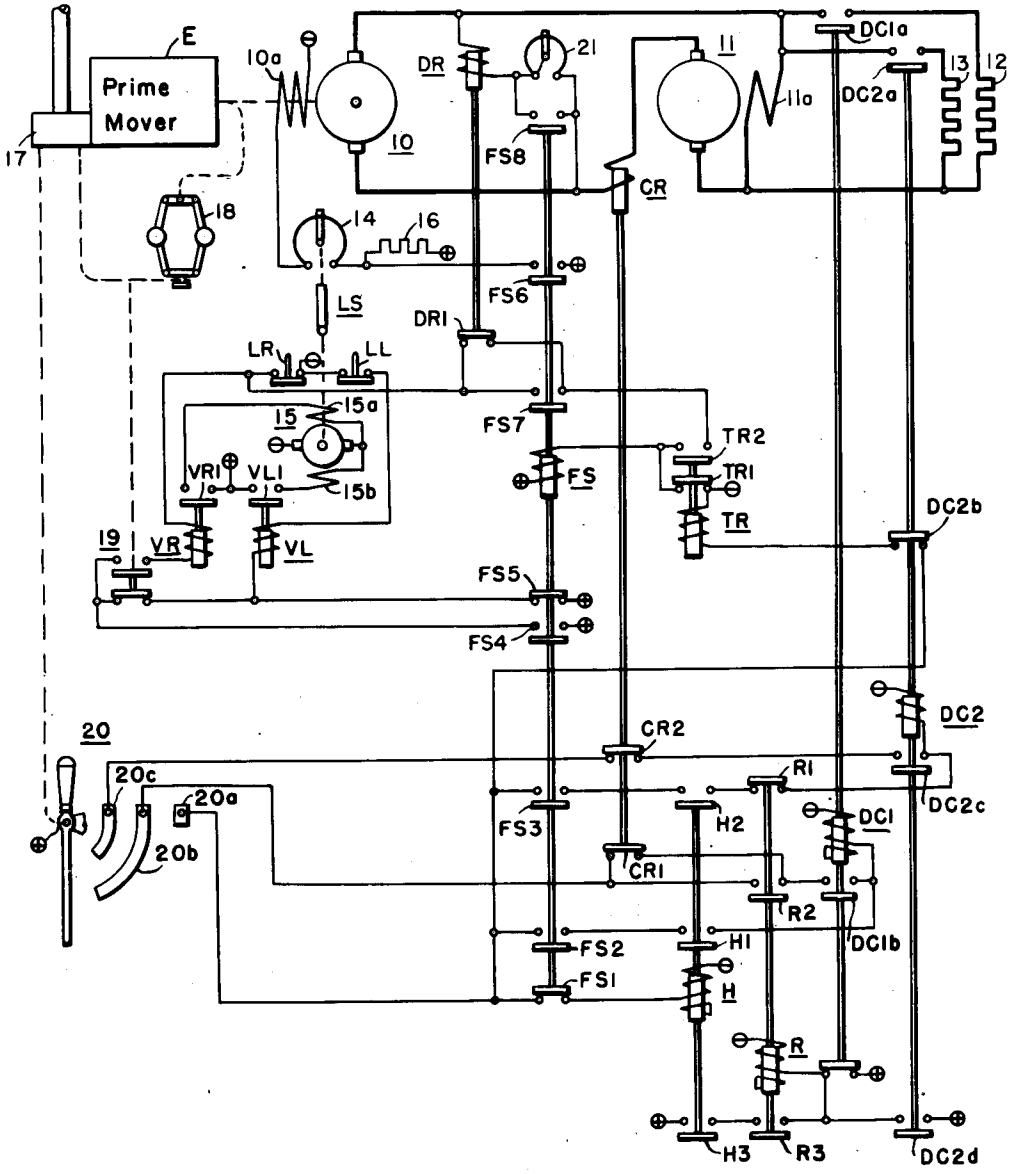
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ENGINE-DRIVEN ELECTRIC GENERATING PLANT

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ENGINE-DRIVEN ELECTRIC GENERATING PLANT

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My invention relates, generally, to engine-driven electric generating plants and, more particularly, to plants of this kind which are utilized to supply power to the traction motors of locomotives.

An object of my invention, generally stated, is to provide a control system for diesel-electric locomotives which shall be simple and efficient in operation and which may be economically manufactured and installed.

A more specific object of my invention is to provide for weakening the excitation of the traction motors of a diesel-electric locomotive under predetermined conditions, whereby higher running speeds may be obtained.

A further object of my invention is to provide for automatically initiating field weakening of the traction motors when the engine fuel regulator is at its maximum setting and the generator at maximum excitation.

Another object of my invention is to provide for weakening the excitation of the traction motors in successive steps.

A still further object of my invention is to provide for adjusting the engine load when field weakening is initiated.

Other objects of my invention will be explained fully hereinafter or will be apparent to those skilled in the art.

In accordance with one embodiment of my invention, the field weakening or shunting of the traction motors supplied by the engine-driven generator of a locomotive is initiated by control means responsive to the condition at which the engine fuel regulator is at its maximum setting and the generator is at maximum excitation. Two successive stages of field weakening are provided and the engine load is adjusted when field weakening is initiated.

For a better understanding of the nature and objects of my invention, reference may be had to the following detailed description, taken in conjunction with the accompanying drawing, in which the single figure is a diagrammatic view of a control system embodying the principal features of the invention.

Referring to the drawing, a main generator 10, which is driven by an engine E, is connected to supply current to a traction motor 11 having a series field winding 11*a* across which two field weakening resistors 12 and 13 may be connected by means of contact members DC1*a* and DC2*a* of contactors DC1 and DC2, respectively. A field winding 10*a* of the generator 10 is connected through a rheostat 14, which is operated by a reversible motor 15, and a series resistance 16 across a direct-current source of supply. The resistance 16 is normally short-circuited by contact members FS6 of a contactor FS.

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The reversible motor 15 is controlled by an engine governor 18 which controls a throttle mechanism 17 and is also utilized to provide torque control. The governor 18 is disposed to operate, either directly or through a servo-mechanism, a switch 19 which controls the energization of relays VR and VL. Contact members VR1 and VL1 of the relays VR and VL, respectively, are connected in series-circuit relation with two opposed field windings 15*a* and 15*b*, respectively, on the motor 15. If the engine speed decreases, the rheostat 14 is automatically actuated in a direction to reduce the excitation of the generator. Conversely, if the engine speed rises, the rheostat 14 is automatically actuated in a direction to increase the excitation of the generator.

Field weakening of the traction motor 11 is automatically effected in two successive stages when a driver's controller 20 is in the position for supplying maximum fuel to the engine and the field rheostat 14 is actuated to the position corresponding to maximum excitation of the generator. A predetermined maximum current in the traction motor causes a current relay CR to operate whereby the motor field is returned to full excitation by successive stages.

When the driver's controller 20 is in the maximum position, a circuit is completed from positive through a segment 20*a* on the controller and normally closed contact members DC2*b* of the contactor DC2 to a relay TR. This relay accordingly operates to open its contact members TR1 and close its contact members TR2, thereby bringing the field contactor FS under the control of a limit switch LS having contact members LR disposed to open when the field rheostat 14 attains the position corresponding to maximum generator excitation. The contact members TR1 and TR2 of the relay TR are disposed to so overlap that the operation of the relay TR does not open the contactor FS, the energizing circuit for its coil being maintained through the contact members TR2 and FS1.

Deenergization of the contactor FS by the opening of the limit switch LR results in the energization through interlock contact members FS1 of a delayed opening relay H which operates to close its three sets of contact members H1, H2 and H3. Deenergization of the contactor FS also results in the opening of the contact members FS6 whereby resistor 16 is connected into the cir-

cuit of the generator field winding 10a. When this resistance is inserted in the circuit the generator field collapses rapidly. Also the relay VL is energized by contact members FS5 closing so that the rheostat 14 is actuated backwardly, thereby immediately reclosing the limit switch LR. The backward movement of the rheostat 14 is limited by the limit switch LL. When the generator voltage has dropped to a predetermined value, a relay DR which is connected across the generator armature drops out. The resulting closure of contact members DR1 of the relay DR completes a circuit through contact members TR2 and limit switch LR to reenergize the field contactor FS.

The insertion of resistance 16 in the main generator field circuit and the increase of resistance of the rheostat 14 reduce the load on the diesel engine with a consequent increase of speed. The servo-mechanism of the engine governor would, therefore, remain in the voltage raise position. Accordingly, during transition into the intermediate and weak fields, while the field contactor is deenergized, this servo-mechanism is isolated by contact members FS4 which are open during the transition period.

Reenergization of the contactor FS results in again short-circuiting the field-resistor 16 at the contact members FS6. It also results in a circuit being completed through contact members FS2 and H1 to the contactor DC1 which closes its contact members DC1a to connect the resistance 12 in parallel-circuit relation with the traction motor field winding 11a, thereby completing the first stage of field weakening.

It will be noted that while the energization of the contactor FS results in the deenergization of the relay H by the opening of contact members FS1, the opening of contact members H1 will be delayed by the short-circuited winding on the relay H. By the time the contact members H1 open contactor DC1 will have closed and completed a maintaining circuit for itself through contact members DC1b, the relay contact members CR1 and a segment 20b on the controller 20. It will also be noted that there is no circuit completed to the contactor DC2 since the contact members R1 of a delayed opening relay R do not close until the relay is deenergized. This relay is not deenergized until the relay H has opened its contact members H3.

The next stage of field weakening is obtained when, with the driver's controller in the maximum position, the rheostat 14 again reaches the position corresponding to maximum generator excitation. When this occurs the limit switch LR is again opened and, contact members TR2 being closed, the contactor FS is again deenergized and the resistance 16 again inserted in the circuit for the field winding 10a of the generator. The generator voltage accordingly drops rapidly until the relay DR operates to reestablish a circuit through its contact members DR1, the limit switch LR (now closed) and contact members TR2 to the field contactor FS.

Energization of the contactor FS now results in the completion of a circuit through contact members FS3, H2 and R1 to the field contactor DC2 which operates to close its contacts DC2a, thereby connecting the resistance 13 in parallel-circuit relation with the motor field winding 11a to complete the second stage of field weakening. Closure of the contactor DC2 also results in the completion of a maintaining circuit for itself through contacts DC2c, CR2 and segment 20c on the driver's controller 20.

It will be noted that since the contactors DC1 and DC2 have their maintaining circuits completed through sectors on the driver's controller any stage of field weakening, once it has occurred, can be maintained although the driver moves the control handle back from the maximum position.

Assuming that two stages of field weakening have been initiated and that contactors DC1 and DC2 are energized, a certain predetermined load on the traction motor 11 will cause the relay CR to open its two normally closed contact members CR1 and CR2. The opening of contact members CR2 interrupts the maintaining circuit for the contactor DC2 which accordingly opens to remove the resistor 13 from the motor field circuit, thereby returning the equipment to the first stage of field weakening.

However, the maintaining circuit for contactor DC1 is not interrupted by the opening of contact members CR1 because these contact members are bridged by contact members R2 of the delayed opening relay R. This relay, which was energized through contact members DC2d while contactor DC2 was closed, maintains its contact members closed for a few seconds after its coil is deenergized. By the time the contact members R2 open the traction motor current will have dropped to a value at which the contact members CR1 and CR2 of the current relay CR are again closed. Unless the traction motor current again exceeds the predetermined value the equipment remains with one stage of field weakening in action.

The next time the contact members CR1 and CR2 open on account of heavy currents in the traction motor the contactor DC1 is immediately opened because the normally open contact member R2 in its maintaining circuit is now open. The opening of this contactor returns the equipment to full motor excitation.

It will be noted that the function of changing back from weak field to full field obtains equally with the driver's controller 20 in the maximum position as well as with the handle moved backward slightly.

When changing from full field into weak field the contactor FS is opened, thereby inserting the resistor 16 into the generator field circuit and causing a rapid decrease in the excitation of the generator field. At the same time the opening of the contactor FS causes the field rheostat 14 to move in the direction providing less excitation for the generator field. Changing to the weak field of the traction motor occurs as soon as the generator voltage has dropped to a predetermined amount, and a control rheostat 21 has been provided in the circuit for the coil of the relay DR in order that the voltage at which the relay DR drops out can be preset.

As long as the contactor FS is energized, the rheostat 21 is short-circuited by contact members FS8 but as soon as the contactor FS opens the rheostat 21 it connected into the circuit for the coil of the relay DR. The resistance of this rheostat can be set to cause the relay DR to open immediately when the contactor FS opens, in which case the engine load would be at a maximum. On the other hand, the engine load control rheostat can be so set that when the contactor FS opens, the field rheostat 14 will have to lower excitation of the generator to such an extent before the relay DR drops out that there will be no engine load whatsoever at the moment

of changing to the weak field connections. Therefore, the engine load control rheostat provides a means for readily adjusting the allowable engine load during the period of transition to the weak field connections for the traction motors.

As already mentioned, the field weakening cannot be initiated unless the driver's controller 20 is in the maximum position. However, once one or two stages of the field weakening has occurred the moving back of the driver's control handle maintains such stages of field weakening as have been obtained while the control handle was in the maximum position.

It will be noted that each stage has its own maintaining sectors associated with the driver's controller and by making these sectors of unequal length the control can be inherently so made that two stages of field weakening are dropped successively, as the control handle is moved away further and further from the maximum position. However, both stages of field weakening are at all times subject to the automatic control of the current relay CR, as previously explained.

It will be noted that when the driver's controller handle is in the maximum position, the first stage of the field weakening is obtained by the closing of the contactor DC1, as previously explained, and that after the closure of this contactor the driver's handle can be moved slightly backward, thereby preventing the obtaining of the second stage of field weakening. If the driver's control handle is moved again to the maximum position the equipment is capable of obtaining the second stage of field weakening under correct conditions.

It will also be noted that when the driver's control handle is held in the maximum position, one or both stages of field weakening can automatically come in and go out and come in again according to the operating conditions prevailing. Thus, the field weakening is automatically controlled in accordance with the operating conditions.

From the foregoing description, it is apparent that I have provided a system for automatically obtaining field weakening of the traction motors of a diesel-electric locomotive, or similar vehicle, in a plurality of stages. The field weakening is initiated when the generator which supplies the traction motors is at its maximum excitation and the engine fuel regulator is at its maximum setting.

Since numerous changes may be made in the above described construction and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In a control system, in combination, a motor having a field winding, a generator for supplying current to the motor, an engine for driving the generator, shunting means for the motor field winding, control means for controlling the generator excitation, switching means controlled by said control means for controlling the operation of said field shunting means, and relay means repsonsive to the motor current for also controlling the operation of said field shunting means.

2. In a control system, in combination, a motor having a field winding, a generator for supplying current to the motor, an engine for driving the generator, an engine fuel controller, shunting means for the motor field winding, control means for controlling the generator excitation, switching means for controlling the operation of said field shunting means, said fuel controller and said control means cooperating to control the operation of said switching means, and relay means responsive to the motor current for also controlling the operation of said field shunting means.

3. A power-plant comprising an electric motor having a series main-field winding, a variable-voltage generator supplying substantially all of its output-current to the motor, said generator having a controllable main-field winding, a controllable engine supplying substantially all of its output-power for driving the generator, an engine-controller under the control of an engineman, a variable-adjustment controlling-means for controlling the excitation of the generator main-field winding, shunting-means including at least one field-shunt adapted for connection in parallel-circuit relation across the series main-field winding of the motor, and field-shunting relay-means, responsive to a maximum-excitation position of said generator-field controlling-means, and responsive also to a maximum-power setting of the engine-controller, for connecting an effective field-shunt across said series main-field winding of the motor.

4. A power-plant comprising an electric motor having a series main-field winding, a variable-voltage generator supplying substantially all of its output-current to the motor, said generator having a controllable main-field winding, a controllable engine supplying substantially all of its output-power for driving the generator, an engine-controller under the control of an engineman, a variable-adjustment controlling-means for controlling the excitation of the generator main-field winding, shunting-means including at least one field-shunt adapted for connection in parallel-circuit relation across the series main-field winding of the motor, and field-shunting relay-means, responsive to a maximum-excitation position of said generator-field controlling-means, and responsive also to a maximum-power setting of the engine-controller, for connecting an effective field-shunt across said series main-field winding of the motor and reducing the generator-excitation.

5. The invention as defined in claim 4, in combination with means, responsive to a predetermined operating-condition, for cutting out an effective field-shunt from its shunting connection across said series main-field winding of the motor in time to prevent sustained overloading during a shunted-field operating-condition of the motor.

6. A power-plant comprising an electric motor having a series main-field winding, a variable-voltage generator supplying substantially all of its output-current to the motor, said generator having a controllable main-field winding, a controllable engine supplying substantially all of its output-power for driving the generator, an engine-controller under the control of an engineman, an excitation-means responsive to the engine-speed, for controlling the excitation of the generator main-field winding, shunting-means including at least one field-shunt adapted for connection in parallel-circuit relation across the series main-field winding of the motor, and field-shunting relay-means, responsive to an operating-condition accompanied by a substantially maxi-

mum generator-voltage, for first reducing the generator-excitation and immediately afterwards connecting an effective field-shunt across said series main-field winding of the motor.

7. The invention as defined in claim 6, in combination with means, responsive to a predetermined operating-condition, for cutting out an effective field-shunt from its shunting connection across said series main-field winding of the motor in time to prevent sustained overloading during a shunted-field operating-condition of the motor.

8. A power-plant comprising an electric motor having a series main-field winding, a variable-voltage generator supplying substantially all of its output-current to the motor, said generator having a controllable main-field winding, a controllable engine supplying substantially all of its output-power for driving the generator, an engine-controller under the control of an engineman, a controlling-means for controlling the excitation of the generator main-field winding, shunting-means including at least one field-shunt adapted for connection in parallel-circuit relation across the series main-field winding of the motor, and field-shunting relay-means, responsive to an operating-condition accompanied by a substantially maximum generator-excitation and a maximum-power setting of the engine-controller, for first reducing the generator-excitation and immediately afterwards connecting an effective field-shunt across said series main-field winding of the motor.

9. The invention as defined in claim 8, in combination with means, responsive to a predetermined operating-condition, for cutting out an effective field-shunt from its shunting connection across said series main-field winding of the motor in time to prevent sustained overloading during a shunted-field operating-condition of the motor.

10. A power-plant comprising an electric motor having a series main-field winding, a variable-voltage generator supplying substantially all of its output-current to the motor, said generator having a controllable main-field winding, a controllable engine supplying substantially all of its output-power for driving the generator, an engine-controller under the control of an engineman, an excitation-means, responsive to the engine-speed, for controlling the excitation of the generator main-field winding, a multi-step adjustable field-shunting means, adapted for connection in parallel-circuit relation across the series main-field winding of the motor, field-shunt increasing-means, responsive to successive attainments of one predetermined operating-condition accompanied by a maximum excitation-condition of the generator-field excitation-means and a maximum-power setting of said engine-controller, for connecting said field-shunting means in successive steps, at least one such step in response to each such attainment, across said series main-field winding of the motor, and field-shunt decreasing-means, responsive to successive attainments of another predetermined operating-condition, for disconnecting said field-shunting means in successive steps, at least one such step in response to each such attainment, from its shunting connection across said series main-field winding of the motor, in time to prevent sustained overloading during a shunted-field operating-condition of the motor.

11. The invention as defined in claim 10, characterized by said field-shunt increasing-means including voltage-responsive resetting-means, responsive to a predetermined drop in the voltage of the generator after a shunt-increasing operation, for resetting said field-shunt increasing-means in readiness for another shunt-increasing operation.

12. A power-plant comprising an electric motor having a series main-field winding, a variable-voltage generator supplying substantially all of its output-current to the motor, said generator having a controllable main-field winding, a controllable engine supplying substantially all of its output-power for driving the generator, an engine-controller under the control of an engineman, a variable-adjustment controlling-means for controlling the excitation of the generator main-field winding, a multi-step adjustable field-shunting means, adapted for connection in parallel-circuit relation across the series main-field winding of the motor, field-shunt increasing-means, responsive to successive attainments of a maximum excitation position of said generator-field controlling-means, and responsive also to a maximum-power setting of the engine-controller, for connecting said field-shunting means in successive steps, at least one such step in response to each such attainment, across said series main-field winding of the motor, and field-shunt decreasing-means, responsive to successive attainments of another predetermined operating-condition, for disconnecting said field-shunting means in successive steps, at least one such step in response to each such attainment, from its shunting connection across said series main-field winding of the motor, in time to prevent sustained overloading during a shunted-field operating-condition of the motor.

13. A power-plant comprising an electric motor having a series main-field winding, a variable-voltage generator supplying substantially all of its output-current to the motor, said generator having a controllable main-field winding, a controllable engine supplying substantially all of its output-power for driving the generator, an engine-controller under the control of an engineman, an excitation-means, responsive to the engine-speed, for controlling the excitation of the generator main-field winding, a multi-step adjustable field-shunting means, adapted for connection in parallel-circuit relation across the series main-field winding of the motor, field-shunt increasing-means, responsive to successive attainments of one predetermined operating-condition accompanied by a maximum excitation-condition of the excitation-means and a maximum-power setting of said engine-controller, for connecting said field-shunting means in successive steps, at least one such step in response to each such attainment, across said series main-field winding of the motor, each time also causing a reduction in the excitation produced by the excitation-means, and field-shunt decreasing-means, responsive to successive attainments of another predetermined operating-condition, for disconnecting said field-shunting means in successive steps, at least one such step in response to each such attainment, from its shunting connection across said series main-field winding of the motor, in time to prevent sustained overloading during a shunted-field operating-condition of the motor.

14. The invention as defined in claim 13, characterized by said field-shunt increasing-means including voltage-responsive resetting-means, responsive to a predetermined drop in the voltage of the generator after a shunt-increasing opera-

tion, for resetting said field-shunt increasing-means in readiness for another shunt-increasing operation.

15. A power-plant comprising an electric motor having a series main-field winding, a variable-voltage generator supplying substantially all of its output-current to the motor, said generator having a controllable main-field winding, a controllable engine supplying substantially all of its output-power for driving the generator, an engine-controller under the control of an engineman, a variable-adjustment controlling-means for controlling the excitation of the generator main-field winding, a multi-step adjustable field-shunting means, adapted for connection in parallel-circuit relation across the series main-field winding of the motor, field-shunt increasing-means, responsive to successive attainments of a maximum-excitation position of said generator-field controlling-means, and responsive also to a maximum-power setting of the engine-controller, for connecting said field-shunting means in successive steps, at least one such step in response to each such attainment, across said series main-field winding of the motor, each

time also causing a reduction in the setting of the generator-field controlling-means, and field-shunt decreasing-means, responsive to successive attainments of another predetermined operating-condition, for disconnecting said field-shunting means in successive steps, at least one such step in response to each such attainment, from its shunting connection across said series main-field winding of the motor, in time to prevent sustained overloading during a shunted-field operating-condition of the motor.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,657,239	Clymer	Jan. 24, 1928
1,833,017	Cutler	Nov. 24, 1931
2,245,083	Webb et al.	June 10, 1941
2,290,867	Curry	July 28, 1942
2,292,203	Cowin	Aug. 4, 1942
2,433,628	Schlapfer	Dec. 30, 1947