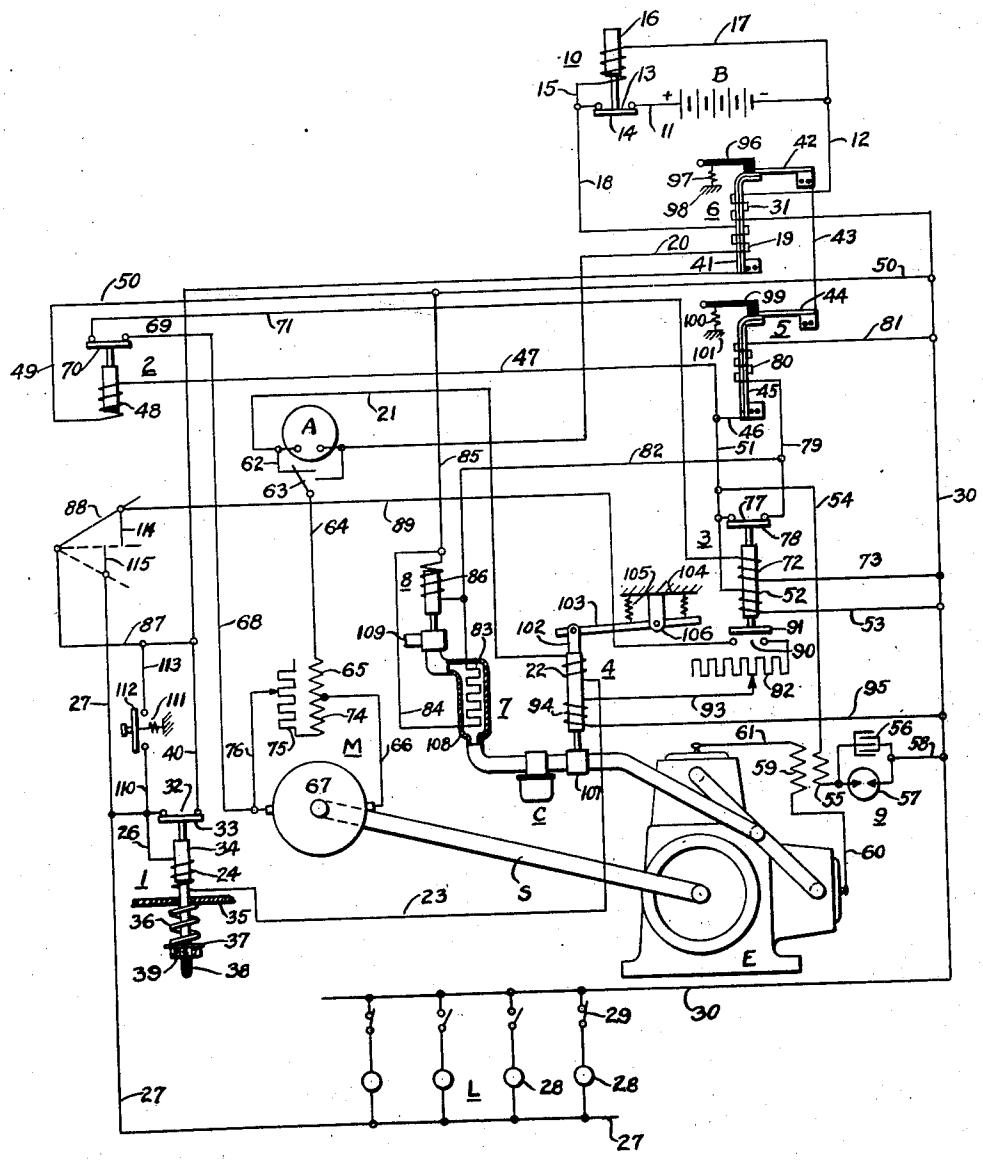
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CONTROL SYSTEM FOR FARM LIGHTING PLANTS

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CONTROL SYSTEM FOR FARM LIGHTING PLANTS

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This invention relates generally to control systems for electric power plants such as are used for farm lighting, the operation of airplane beacons or similar service.

More particularly this invention relates to automatic-electric generating systems including among other elements a battery, an engine, a dynamo electric machine and load-line circuits, and suitable for use in isolated places, such as country residences, farm homes, places where the attendant is partially or totally unskilled in the art of managing such plants, or generating plants for airplane beacons, which are often in very isolated places and where the attendant, whether skilled or unskilled, merely makes periodic inspection of the plants to provide the necessary oil and gasoline.

An object of this invention is the provision of an electric power plant, which shall be simple in construction, automatic and efficient in operation and which may be readily installed.

Another object of the invention is to provide in a simple manner for protection against over-voltage, over-load, and continued cranking when the engine fails to start.

Other objects of the invention are to provide for automatic starting of the engine when the load on the line exceeds a predetermined value, and for automatic stopping of the engine when the load on the line decreases to a predetermined value, and for controlling the fuel supply to the engine during the starting operation, to limit the fuel to an amount proportional to the current in the load line and control circuits.

Another object of the invention is to provide for selectively charging the battery of the generating unit, either slowly or rapidly, as desired.

It is also an object of the invention to control the fuel supply to the engine during normal automatic operation, whereby it is proportional to the difference between the magnetic effect of a current flowing in a circuit subject to the voltage of the system and the magnetic effect of a current flowing in the load line of the system.

Other objects and advantages will be apparent from a perusal of the following specification especially when taken in conjunction with the accompanying drawing, wherein the single figure shows diagrammatically the various elements of this invention in operative relation.

In the drawing representing the automatic electric generating system, 1 designates a series line relay for automatically controlling the starting and stopping of the engine E in response to load conditions in the load lines 27 and 30. Associated with the control system, and particularly with the series line relay 1, are a pair of control relays 2 and 3 which control the starting operation of the engine E by the dynamo electric machine M.

In order to protect against continuous cranking of the engine in case it fails to start, a thermo-electric time-limit relay 5 is provided. Associated with the engine, but more particularly with the carburetor of the engine, is an automatic choking device 8, an electric air heater 7 and intermediate the carburetor and the engine is disposed a compound governor 4. Reference character 10 designates a further control relay for isolating the battery B from the generating system in case the voltage of the battery drops very low either because of excessive discharge of the battery or because of a short-circuit in the load lines or some other portion of the system.

The differential-compound governor 4 is provided with a current coil 22 in series with one of the load lines and operates to supply fuel to the engine E, during normal automatic operation of the engine E and machine M, proportional to the line current, and a voltage coil 94 operating in opposition to the current coil 22. During either manual or automatic starting or during charging of the battery, the connections of governor are changed, converting it into a series governor, thus insuring an ample fuel supply during starting or battery charging, as will be pointed out more in detail hereinafter.

Referring more particularly to the elements in the drawing, 1 designates a series line-relay and comprises an actuating coil 24, an

armature 34, and a contact bridging member 33 disposed for operation by the armature. The armature 34 may be biased towards a position in which the contact members of the relay 1 are open, by means of a spring 36 positioned between an upper fixed support 35 and a washer 37 secured to the lower end of the spring and held in any given position by a nut 39 on a screw-threaded extension 38 of the armature. The spring 36 and armature 34 are secured against rotation. The nut below the washer in threaded engagement with the extension 38 on the armature is provided with graduations for cooperation with an index on the washer 37. By a manipulation of the nut the biasing effect may be adjusted to any desired value and in consequence the current value flowing through the coil necessary to hold contacts 32 closed may be predetermined. The position of the nut 39, hence the degree of compression initially applied to the spring when the relay is in the open position, will determine both the "pull in" and the "drop out" values of current flowing in the coil 24 at which the relay will either close or open its contact members.

For example, if the nut 39 is adjusted to a predetermined position, for instance, the position shown in the figure of the drawing, a current flow of six amperes through the coil 24 may be required to close the contact members of the relay 1. The relay having been closed, a smaller value of current than six amperes will maintain it closed; therefore, if the current be reduced to a value below six amperes, a balancing point will be reached at which the magnetic pull of the coil on the armature will balance the pull of the spring 36 on the armature. If the current be reduced still further, the spring will overcome the magnetic pull of the coil and the relay will be actuated to open its contacts. The value of current traversing the coil 24 at which the relay will "drop out" or open may be as low as three amperes.

If the current flowing in the work circuit or load lines is below a predetermined value, as for example below six amperes, the storage battery will supply the current. If the current demand exceeds six amperes, the contact members 32 close thereby establishing an engine starting circuit through the motor. The engine is thus started and as it comes up to normal speed, the motor is driven as a generator and takes up the load in the work circuit.

In the figure, B represents the battery which is of the 32-volt type. However, it is obvious that the number of individual units of the battery may be increased so that any other voltage, such as a 110-volt battery, may be provided.

Connected directly across the battery terminals is a low-voltage control relay 10 having an actuating coil 16 and contacts 13 disposed to open the load line circuits to isolate the battery from the generating system in case of an excessive discharge of the battery or because of the heavy current that may be drawn by the dynamo-electric machine M in case the rotor is held in locked position by the engine E during starting. The circuit for the low-voltage relay may be traced from the positive terminal of the battery through conductor 11, contacts 13 bridged by the contact 14 carried by the armature of relay 10, conductor 15, actuating coil 16 and conductor 17 to the negative battery terminal.

To prevent over-loading of the generating system beyond the capacity for which it is designed, a thermo-electric over-load relay 6 is provided. This thermo-electric relay consists of a bimetal strip 41 fixed at one end and free to move at the other end. Encircling the bimetal strip are a pair of electric heaters 19 and 31 each in series with one of the load lines. Adjacent the free end of the bimetal strip is disposed a pivoted latch member 96 of dielectric material and spring biased to move in a clockwise direction. The bimetal strip 41 and the fixed conductor porton 42 are placed in series with a portion of the control circuit. If the load exceeds a predetermined value, the bimetal strip 41 deflects towards the left and the pivoted member 96 moves intermediate the bimetal strip 41 and the conductor 42, thus interrupting the control circuit and stopping the engine. It will be noted once pivot member 96 has moved to a lower position, it will permanently separate the bimetal strip 41 and the conductor 42, thus making it necessary for an attendant to reset the thermo electric over-load relay in case it is desired to start the engine.

The engine E, forming a part of the generating system, is of the two-cylinder ignition type, however, it is obvious that an engine having any number of cylinders or one having no electric ignition system may be used. The ignition circuit associated with the engine is designated generally by reference character 9.

To insure rapid and automatic starting of the engine, an electromagnetic choker 8 having an actuating coil 86 is provided. During the starting operation this choker is energized and operates to close a valve located in the air intake tube 109, thereby insuring that a proper proportion of fuel and air is supplied to the engine during starting.

Intermediate the carburetor and the choker is disposed a heater 7 consisting of a housing 108 and the heating coil 83. This electric heating coil 83 is connected in parallel circuit relation to the choker 8 and operates during the same interval of time that the choker operates. The purpose of heater 7 is

to pre-heat the air passing to the carburetor during starting, thereby aiding in the vaporization of the fuel and thus insuring more rapid starting.

A thermo-electric time-limit protective cranking device 5 is disposed in series with the control circuits and the thermo-electric over-load relay above mentioned. This protective cranking device consists of a bimetal strip 45 fixed at one end and free to move at the other. Encircling the bimetal strip 45 is an electric heating coil 80 which is subject to the control of a compound relay hereinafter described. Adjacent the upper and free end of the bimetal strip 45 is disposed a pivoted member 99 of dielectric material which engages with the end portion of a conductor 44, contacting with the bimetal strip 45. The pivoted member 99 is spring biased to move in a clockwise direction. If during the starting operation the engine fails to start within a predetermined interval of time for which this protective crank device has been adjusted, the bimetal strip 45 deflects towards the left and the pivoted member 99 moves intermediate the bimetal strip 45 and the conductor 44, thereby interrupting the control circuit and thus stopping the cranking operation. It will be noted, once bimetal strip 45 has moved towards the left a predetermined distance permitting member 99 to move intermediate conductor 44 and the bimetal strip 45, no further cranking can take place unless pivoted member 99 is reset by an attendant.

Also controlled by the series line relay are a pair of control relays 2 and 3. The control relay 2, including the actuating coil 48, contacts 69 and contact bridging member 70, operates after the actuation of the series line relay to close the motor circuit for the dynamo M above mentioned.

The relay 3 is provided with a pair of actuating coils 52 and 72, the actuating coil 52 being subject to the voltage of the battery and the actuating coil 72 being subject to the cranking current taken from the battery by the dynamo M when acting as a motor. During the cranking operation, the magnetic effect of the actuating coils 52 and 72 is cumulative and operates to close the contacts 77 by the bridging member 78. After the engine has started and drives the dynamo M as a generator, the current in the actuating coil 72 reverses and thus its magnetizing effect is in opposition to the magnetizing effect of voltage coil 52. The compound-wound relay 3 controls the current passing through the heater 80 of the thermo-electric time-limit protective engine cranking device 5, the actuating coil of the engine choker 8, and the heater 7 for the air passing to the carburetor. If the engine starts before the protective cranking device 5 operates, contacts 77 are opened and the circuits of the actuating coil 86 of choker 8 and the heaters 80 and 83 are broken, as desired.

This compound-wound relay, since it controls the operation of the protective cranking device provides for starting protection thus preventing depletion of the battery because of continuous cranking. If during operation the speed of the engine E for some reason becomes excessive, thus raising the voltage of the system abnormally high, energization of coil 52 alone will be sufficient to cause closing of contacts 77, whereas if the speed remains normal but the load becomes excessive, coil 72 alone will be sufficient to cause closing of the contacts 77. The ratio of the turns of coils 52 and 72 is so chosen that the stated functions take place. From this threefold function of the compound-wound relay it is apparent that this relay provides in a very simple manner for cranking protection, over-load protection, and over-voltage protection of the generating system.

Intermediate the carburetor and the engine is disposed a governor housing 107 within which is disposed a fuel valve controlled by the compound governor 4. The compound governor 4 is of the electric type and is provided with a current coil 22 so connected in the circuit to be subject to the combined currents in the load lines and the control circuits. This governor is also provided with a voltage coil 94 which may be connected either directly across the load line or in such a manner as to be subject to the control of the series line relay above described. The governor is provided with an armature 102 secured at its upper end to a bar 103 pivoted at 106. The supporting pivot 106 is suitably secured to a support 104. The bar 103 is subject to the action of a pair of springs 105, which springs when not subject to tension tend to hold the bar 103 and thus the valve in the housing 107 in a given position.

The magnetic effect of the current coil 22 of the governor 4 is always in such direction that the valve in housing 107 is moved to open position in proportion to the load on the line. The magnetic effect of the coil 94, however, is always in such direction as to tend to close the valve in housing 107. Obviously, the amount of fuel admitted to the engine will thus be a function of the difference of the magnetic effects of coils 22 and 94 and will also be somewhat influenced by the springs 105. To insure an ample supply of fuel during the starting operation, the voltage coil 94 is connected in series with back contacts 90 and 91 of the compound relay 3. During the starting operation, compound relay 3 will be moved into the position shown in the drawing, closing contacts 77 by the bridging member 78 and interrupting the contacts 90. The differential effect of the voltage coil is thus removed during starting and since the starting current is normally quite large, the fuel

valve will be in wide open position and the engine will be supplied with the desired amount of fuel during the starting operation.

In series with the voltage coil is also disposed a resistor 92 provided with an adjustable contact member 93. During normal operation of the plant, the voltage of the generating system may be adjusted within a wide range by merely shifting contact member 93. The voltage coil 94 is connected to the load line 27 through a switch 88 and a conductor 89.

The switch 88 is designed to take any one of four positions. In the drawing it is shown in the "automatic" position. In this position, the switch connects the voltage coil to a point in the circuit beyond the contacts 32, controlled by the series line relay 1. If the switch 88 be in the position shown by the horizontal dotted line, contacts 114 and 115 are bridged by the switch 88. The voltage coil 94, therefore, produces the desired effect on the governor 4 and yet the control circuit being closed keeps the engine and the dynamo in operation. The engine will thus operate at a comparatively slow speed and the voltage will be comparatively low, thus supplying only a "trickle" charge to the battery B.

If the switch 88 is in the position shown by the inclined dotted line, the voltage coil 94 does not function and the control circuit for the engine and dynamo are connected in the circuits of the system and the engine is caused to operate regardless of the position of the contacts of the series line relay 1. The engine will, therefore, operate at a comparatively high speed and the machine M will generate a high voltage, thus providing a heavy charge to the battery B. Since for this position of the switch the effect of the voltage coil is not effective, the fuel supply to the engine will be proportional to the load on the line. If the load increases, the speed of the engine increases and as a consequence the voltage of the machine M. The load, therefore, cannot operate to dissipate the charge of the battery B.

The operation of the electric generating system is as follows:

Assuming that the load drawn by the load units 28 exceeds a predetermined value for which the series line relay 1 has been adjusted, this relay having been energized sufficiently operates to close contacts 32 by the bridging member 33, thereby establishing a circuit from the positive terminal of the battery B through conductor 11, contacts 13 bridged by the contact member 14 of the low voltage relay 10, conductor 18, series heater 19 of the thermo-electric over-load relay 6, conductor 20, ammeter A, conductor 21, current coil 22 of the compound governor 4, conductor 23, actuating coil 24 of the series line relay 1, conductor 26, contacts 32 bridged by the contact bridging member 33, conductor 40, bimetal strip 41 of the thermo-electric over-load relay 6, conductors 42, 43 and 44, bimetal strip 45 of the protective cranking device 5, conductors 46 and 47, actuating coil 48 of control relay 2, conductors 49, 50 and 30, heater 31 of the thermo-electric over-load relay 6 and conductor 12 to the negative terminal of the battery.

In parallel circuit relation with the actuating coil 48 of the control relay 2 is disposed a conductor 51, actuating coil 52 of compound relay 3, conductors 53 and 30, heater 31 and conductor 12 to the negative terminal of the battery. Energization of actuating coil 52 during this stage of the operation is not sufficient to cause the closure of contacts 77 by the bridging member 78, but the energization of this coil does operate to reduce the time constant of the compound relay when the other actuating coil 72 is energized.

Energization of actuating coil 48, as above explained, closes the contacts 69 by the bridging member 70, thereby establishing an armature circuit for the dynamo electric machine M. This circuit may be traced from the energized conductor 62 of the ammeter A, switch 63, conductor 64, series field winding 65 of the dynamo M, conductor 68, contacts 69 bridged by the contact member 70, conductor 71, actuating coil 72 of the compound relay 3, conductors 73 and 30, heater 31 and conductor 12 to the negative terminal of the battery. In parallel circuit relation to the armature 67 is also disposed the shunt field winding 74, the rheostat 75 and the conductor 76.

Attention is called to the fact that during this starting operation the magnetic effect of the current passing through the current coil 72 is cumulative to the magnetic effect of the voltage coil 52. Relay 3 will thus be operated and contacts 77 are closed, thereby establishing a plurality of parallel control circuits hereinafter discussed. Closure of contacts 32 by the bridging member 33 also established an ignition circuit for the engine which may be traced from the energized conductor 51 through conductor 54, primary winding 55 of the transformer associated with the ignition system 9, condenser 56 and interrupter 57, conductors 58 and 30, heater 31 and conductor 12 to the negative terminal of the battery.

The parallel control circuits above referred to may be traced from the energized conductor 79 which was energized by the closure of contacts 77 through conductors 82, heating coil 83 of the preheater 7, conductors 84, 85 and 50, heater 31 and conductor 12 to the negative terminal of the battery. In parallel circuit relation to the heating coil 83 is disposed the actuating coil 86 of the engine choking device and also the heating coil 80 of the protective cranking device 5. It is

thus obvious that the heater 7, the choker 8 and the protective cranking device are energized at the same time and since the protective cranking device 5 controls the circuits to the control relays above discussed, the time of energization of the control relays, as well as the air heater, choker and the protective cranking device are controlled directly by the protective cranking device.

If the engine starts, as it usually will, before the protective cranking device interrupts the control circuits, the current in the armature of the machine M reverses, thus producing a magnetic effect in the coil 72 in opposition to the magnetic effect of the coil 52 and the compound relay 3 operates to open contacts 77 and close contacts 90 by the bridging member 91. The engine will thus come up to speed as desired and operate to take up the load on the line.

Applicant does not desire to be restricted to the specific structural details, arrangement of parts or circuit connections herein set forth, as various modifications thereof may be effected without departing from the spirit and scope of this invention and only such limitations are to be imposed on this invention as are indicated in the appended claims.

I claim as my invention:

1. In an electric generating system including, a battery, a load line, an internal combustion engine having an ignition circuit, a dynamo having dynamo circuits for cranking the engine and for supplying the line load when driven as a generator by the engine, in combination, a control system including a control relay for closing the dynamo circuit, a second relay for controlling the starting operation, circuits for said relays and ignition circuit, a thermo-electric time-limit protective cranking device for interrupting the circuits to the control relays and the ignition circuit, a differentially compound-wound governor, having a voltage coil and a current coil and circuits therefor, for the engine and a switch in the circuit of the voltage coil for connecting the voltage coil either directly across the load line or across the load line subject to the control of one of the control relays or for disconnecting the voltage coil from the load line.

2. In an electric generating system including a battery, a load line, an internal combustion engine having an ignition circuit, a dynamo having circuit connections for cranking the engine and for supplying the line load when driven as a generator by the engine, in combination, a control system including means for limiting the cranking period of the engine to a predetermined time interval, a differentially compound governor for the engine, circuit connections for said governor, and a control relay for controlling the means for limiting the cranking period and for changing the connections of the governor to cause it to function as a series governor during the engine starting operation.

3. In an electric generating system including a battery, a load line, an internal combustion engine having an ignition circuit, a dynamo for cranking the engine and for supplying the load when driven as a generator by the engine in combination, a control circuit including a compound-wound relay connected to protect the system against over-voltage, over-load, and continued cranking should the engine fail to start after a predetermined interval of the starting period and a series line relay controlling the starting and stopping of the engine in response to load conditions of the line.

4. In an electric generating system including a battery, a load line, an internal combustion engine, a dynamo for cranking the engine and for supplying the load in the line when driven as a generator by the engine in combination, a control system including a time-limit protective cranking device to prevent depletion of the battery as a result of continued cranking should the engine fail to start, and an adjustable governor whereby the voltage of the dynamo when acting as a generator may be varied, and a control relay controlling the operation of the governor during the starting operation and causing the energization of the time-limit protective cranking device.

5. In an automatic electric generating system including a battery, a load line, an internal combustion engine having an ignition circuit, a dynamo having a dynamo circuit for cranking the engine and for supplying the load when driven as a generator by the engine, in combination, a control system comprising a low voltage protective relay for isolating the battery from the generating system if the voltage of the battery decreases below a predetermined value, an electromagnetic engine choker and circuit connections therefor, an electric heater for heating the air passing to the carburetor, thermo-electric time-limit protective engine cranking device, a control relay for closing the circuit of the dynamo, a compound-wound control relay having an actuating coil subject to the voltage of the battery and a second actuating coil subject to the current passing through the dynamo, said compound-wound relay controlling the circuit connections of the engine choker, the air heater, and the protective cranking device and the protective cranking device in turn controlling the energization of the actuating coils of the control relays and the ignition circuit of the engine, a series line relay responsive to the current in the line and the control relays for controlling the connection to the control relays, the air heater, the protective cranking device, the engine choker, and the ignition circuit, an electrically operated governor for the en-

gine having a current coil and a voltage coil acting differentially, a switch for connecting the voltage coil of the governor either directly across the line or across the line subject to the control of the series line relay, said voltage coil of the governor being also subject to the control of the compound-wound relay and a thermo-electric over-load relay also controlling the energization of the actuating coils of the control relays and the ignition circuit of the engine.

6. In an electric system for controlling the operation of an internal-combustion engine, a governor for the engine having a current coil operating to increase the fuel supply to the engine proportional to the current in the current coil and a voltage coil operating to decrease the fuel supply to the engine proportional to the current in the voltage coil, circuits for said coils, and a relay for interrupting the circuit of the voltage coil during starting of the engine thereby increasing the fuel supply to the engine during the starting operation.

7. In an electric system for controlling the operation of an internal-combustion engine driving a generator, a governor for the engine having a current coil operating to increase the fuel supply to the engine proportional to the current in the current coil and a voltage coil operating to decrease the fuel supply to the engine proportional to the current in the voltage coil, circuits for said coils, a relay for interrupting the circuit of the voltage coil during starting of the engine thereby increasing the fuel supply to the engine during the starting operation and a switch for interrupting the circuit of the voltage coil thereby increasing the speed of the engine to cause the generator driven by the engine to supply energy to the system in excess to the load demand in the system.

8. In an electric system for controlling the operation of an internal-combustion engine driving a generator supplying energy to the system, a battery associated with the system, a governor for the engine having a current coil operating to increase the fuel supply to the engine proportional to the current in the current coil and a voltage coil operating to decrease the fuel supply to the engine proportional to the current in the voltage coil, circuits for said coils, a relay for interrupting the circuit of the voltage coil during starting operation thereby increasing the fuel supply to the engine during starting and a switch associated with the governor to change the governor characteristics of the governor to provide either for slow or rapid charging of the battery.

9. In an electric system for controlling the operation of an internal-combustion engine driving a generator supplying energy to the system, a battery associated with the system, a differentially compounded governor for the engine having a voltage coil and a current coil, an adjustable resistor in series with the voltage coil for adjusting the voltage of the generator, a plurality of control means for controlling the starting, stopping and normal operation of the engine, a circuit eliminating the effects of the voltage coil of the governor and some of the control means from the system for causing rapid charging of the battery, a second circuit eliminating the effect of some of the control means for causing slow charging of the battery, a third circuit to provide for automatic operation of the system at a voltage substantially equal to the voltage of the battery and a switch for selectively establishing the three circuits.

10. In an electric system for controlling the operation of an internal-combustion engine driving a generator supplying energy to the system, a battery associated with the system, a differentially compound governor for the engine having a voltage coil and a current coil, an adjustable resistor in series with the voltage coil for adjusting the voltage of the generator, a plurality of control means for controlling the starting, stopping and normal operation of the engine, a circuit eliminating the effects of some of the control means and the voltage coil for causing rapid charging of the battery, a second circuit eliminating the effect of some of the control means for causing slow charging of the battery and a switch for selectively establishing the circuits.

In testimony whereof, I have hereunto subscribed my name this 5th day of March, 1930.

LEO C. FRANK.