Aug. 2, 1932. L. C. FRANK 1,869,555

CONTROL SYSTEM FOR FARM LIGHTING PLANTS

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Fig. 1

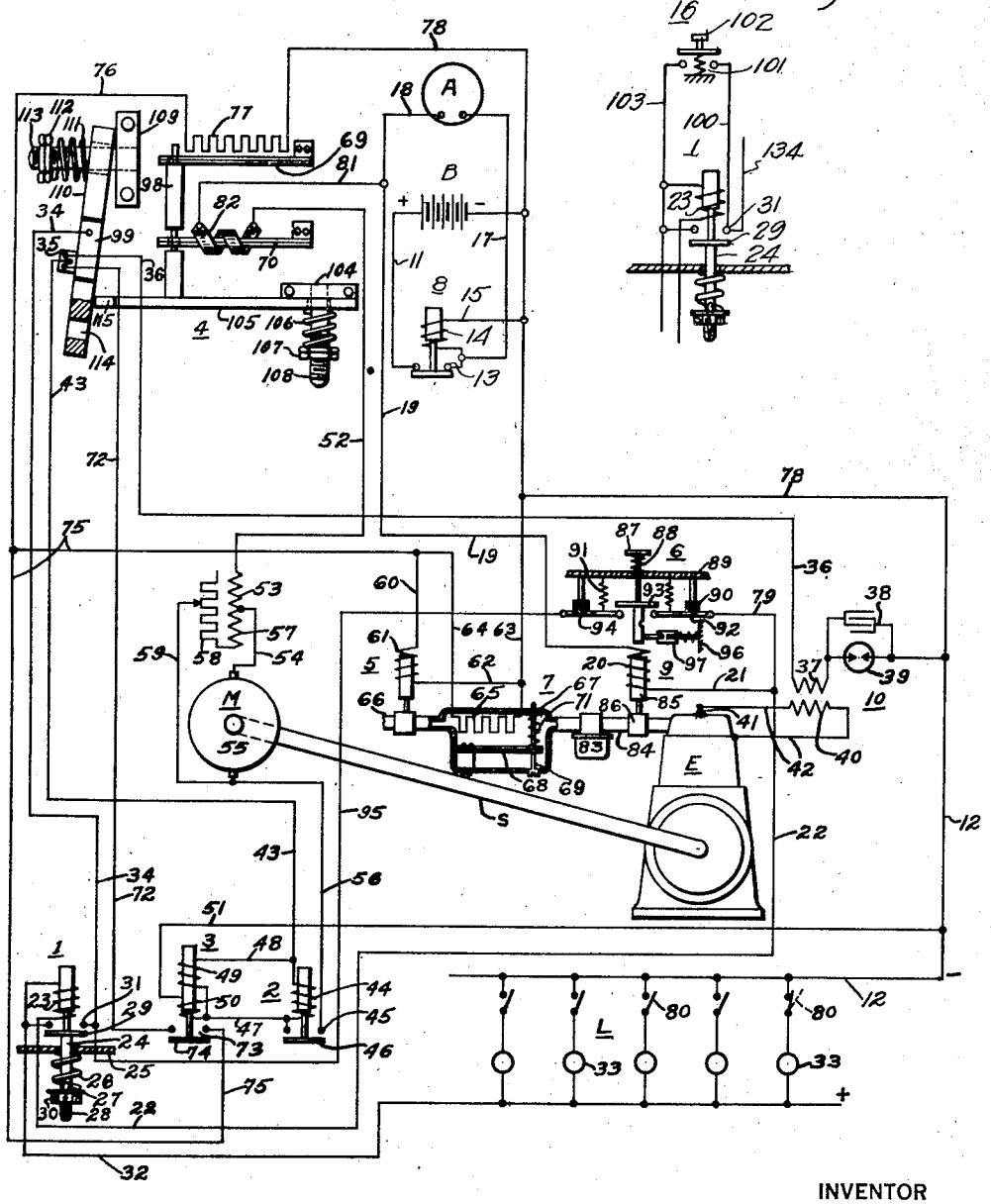

Fig. 2

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CONTROL SYSTEM FOR FARM LIGHTING PLANTS

Application filed February 8, 1930. Serial No. 427,000.

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 adapted for use on automobiles, or 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 very isolated and where the attendant, whether skilled or unskilled, merely makes periodic inspection of the plants to provide the necessary gasoline and oil.

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

A more specific object of the invention is to provide for protection against over-voltage, over-load and continued cranking when the engine fails to start.

A further object of the invention is 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 starting operations to provide for feeding an amount of fuel proportional to the current in the load-line and control circuits.

Another object of the invention is to provide for varying the choking of the engine during the starting operation and for controlling such varying choking over a predetermined range during a predetermined interval of time.

It is also an object of this invention to provide for automatic and manual starting of the generating plant and providing for expeditious cranking protection in case the engine "sticks", thus locking the armature of the dynamo-electric machine.

Other objects and advantages will be apparent from a perusal of the following specification, especially when done in conjunction with the accompanying drawing wherein Fig. 1 shows, diagrammatically, the various elements of this invention disposed in operative relation; and Fig. 2 shows, diagrammatically, a modified arrangement of the starting switch.

In the diagrammatic showing of 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 12 and 32. 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 through the dynamo-electric machine M, acting as a motor.

To protect against continuous cranking, in case the motor fails to start the engine, a thermo-electric time-limit relay 4 is provided. Associated with the engine, but more particularly with the carburetor of the engine, is an automatic-choking device 5 and an auxiliary time-limit choking device 7, and, intermediate the carburetor and the engine, is disposed a series governor 9. Reference character 8 designates another relay disposed for operation to isolate the battery B from the generating system in case the voltage decreases to a predetermined value either through excessive discharge of the battery or because of a short-circuit on the line.

The series governor 9, during operation of the engine E and machine M, controls the fuel supply, and the amount fed to the engine is proportional to the load on the line. However, during manual starting effected through the operation of the push-button switch assembly 6, disposed adjacent to the armature of the series governor 9, the governor is held open to ensure an ample fuel supply during such manual starting.

Referring more particularly to the elements in the drawing, 1 represents a series line relay and comprises an actuating coil 23, an armature 24, and a contact-bridging member 29 disposed for operation by the armature. The armature 24 may be biased towards a position in which the contact mem-

bers of the relay are open, by means of a spring 26 positioned between an upper fixed support 25 and a washer 27 secured to the lower end of the spring and held in any given position on the armature 24 by a nut 30 mounted on a screw-threaded extension 28 of the armature. The spring 26 and the armature 24 are secured against rotation.

The nut, below the washer and in threaded engagement with the extension 28 on the armature, is provided with graduations for cooperation with an index on the washer 27. By a manipulation of the nut, the biasing effect may be adjusted to any desired value and, in consequence, the current flowing through the coil necessary to hold contact members 31 closed may be predetermined. The position of the nut 30 and 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 23 at which the relay will either close or open its contact members.

For example, if the nut 30 is adjusted to a certain position, for instance, the position shown in the drawing, a current of six amperes may be required to energize the coil to close the contact members of the relay 1. When the relay is closed, a current of less 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 on the armature. If the current be reduced still further, the force exerted by the spring will become greater than the magnetic pull of the coil, and the relay will be actuated to open its contacts. The value of the coil-energizing current traversing the coil at which the relay will "drop out" or open may be as low as three amperes.

In the drawing, B designates the battery, which is of the 32-volt type. However, it is obvious that the number of individual units of the battery may be changed so that any other voltage, such, for example, as 110, may be provided.

Connected directly across the battery terminals, is a low-voltage control relay 8 having an actuating coil 14 and contact members 13 disposed to open the load-line circuit to isolate the battery from the generating system in case of 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 becomes locked during the starting operation. The circuit for the low-voltage relay may be traced from the positive terminal of the battery B, through conductor 11, contact members 13, actuating coil 14 of relay 8, conductor 15 and conductor 12, to the negative terminal of the battery. Connected in series with the load line is an ammeter A which may be mounted on a panel board in some convenient place for observation.

The actuating coil 20 of the series governor 9 is connected in the conductor 19. The function of the series governor, during normal automatic operation, is to open the valve in housing 86 in direct proportion to the load current. As shown, the actuating coil 20 acts directly on armature 85. Disposed adjacent to the series governor, is a push-button assemblage 6 comprising a supporting member 89, a push-button 87, a spring 88 disposed intermediate the push-button 87 and the supporting member 89 to bias the contact 93 of the push-button to the upper or open position. Below the supporting member 89, are pivotally mounted a pair of contact members 92 and 94 biased by springs 91 toward a given position against stops 90. Secured to the lower portion of contact member 93 is a stem provided with a notch with which a latch 97, secured to a support 96, is disposed to engage.

When the plant is to be manually started, push-button 87 is depressed against the action of spring 88 until contact 93 bridges the pivotally mounted contact members 92 and 94, thereby closing a circuit in parallel to the contact members of the series line relay above referred to. When it is desired to charge the battery, push-button 87 is depressed to permit the latch 97 to engage the notch in the projecting portion of the contact 93. When this takes place, the projecting portion also engages the armature 85 of the series governor and disposes the valve of the governor to a desired open position, thereby causing the engine to operate at a predetermined comparatively-high speed, whereby the dynamo-electric machine M generates a voltage sufficiently high to charge the battery.

Controlled by the operation of the series line relay 1, it is a time-limit thermo-electric protective cranking device 4 comprising a pair of bi-metallic strips 69 and 70 rigidly fixed, at one end, to a support. To the free end of the strips 69 and 70 is loosely secured a push rod 98 to engage a latch member 105 held in a given position against a support 104 by means of a spring 106. The tension of the spring may be adjusted by means of nuts 107 disposed on a threaded extension 108 secured to support 104 and projecting through a relatively large opening in the latch member 105. Adjacent to the upper bi-metallic strip 69 is disposed an electric heater 77 which is subject to the voltage of the generating system. Wound about the bi-metallic strip 70 is a current coil 82 connected in the system to carry either the starting current drawn by the dynamo M operating as a motor or the current generated by

the dynamo when functioning as a generator during loaded operation of the system.

Attention is called to the fact that heater 82, while wound about the bi-metallic strip 70, is nevertheless in the vicinity and in heat-transfer relation to the bi-metallic strip 69. The purpose of this arrangement is to compensate for any change in voltage that may take place in the system. For instance, if the heating effect of the heater 77 be insufficient, because of low battery voltage, to cause a deflection of the bi-metallic strip 69 through a given range in a required predetermined interval of time, the heater 82 causes sufficient heating of bi-metal strip 69 to provide for the required deflection.

When the engine is warm for instance at 70° F. and the oil in consequence not viscous, the cranking current will be small and the voltage of the battery will not be affected during cranking. The heater 77 is, therefore, subject to normal battery voltage and, since the heating effect of heater 82 under these conditions is negligible, will cause operation of the protective cranking device after a predetermined interval of time.

When the engine is cold, for instance at 32° F. and the oil correspondingly more viscous, the cranking current will be much greater and the voltage of the battery impressed on heater 77 will be somewhat lower. Under these conditions the effect of heater 82 is appreciable and by its collateral heating of strip 69 aids heater 77 sufficiently to cause deflection of this strip over a predetermined range during the same interval of time required for the higher temperature. Heater 82 thus compensates for any drop of voltage of the battery during cranking.

For a very low temperature, for instance zero, the voltage drop of the battery during cranking may be so much that heater 77 alone could not trip the protective cranking device. However, for the very low temperature the heater 82, with the slight aid of the heater 77 insures operation of the protective cranking device after a given interval of time. Tests have indicated that the protective cranking device, forming an important part of this invention, will always operate in about a minute and a half for temperature changes ranging from 0° F. to 70° F.

If, during starting operation, the engine shaft should be locked and thus the voltage applied to the motor be across a stationary armature, the current would be excessive and, in consequence, the voltage of the battery would be quite low. Under such conditions, the effect on the heater 77 might not be sufficient to cause the protective cranking device 4 to function in time to protect the armature circuit and other circuits of the system. The heater 82, therefore, ensures a rapid actuation of the protective cranking device under such conditions.

Adjacent to the bi-metal strips 69 and 70 is disposed a support 109 having a screw-threaded projecting stem 113 carrying nuts 112 and a spring 111, the tension of which may be adjusted by the nuts 112. Intermediate the spring and the support 109, is disposed a contact-carrying member 110 having a relatively large opening through which the stem 113 extends. The number 110 may thus be moved towards the right, as on a pivot, and is biased to a given position against the support 109 by spring 111.

Intermediate the ends of member 110, is positioned a contact 99 for engagement with the contact 35 when the member 110 is in the position shown in the drawing. Upon deflection of either one or both of the bi-metal strips 69 and 70, latch member 105 is moved to a lower position so that the projecting portion 115 on the latch member 105 extends into the opening 114, thereby opening the contacts 35 and 99. As soon as projection 115 enters the opening 114, latch member 105 cannot operate to close the contacts 35 and 99 and, if the protective cranking device has functioned, it is necessary for an attendant to reset the members 105 and 110 in the position shown.

Also controlled by the series-line relay are a pair of control relays 2 and 3. The control relay 2, including the actuating coil 44, contact members 45 and contact-bridging member 46, operates after the actuation of the series line relay to close a circuit for the dynamo M.

The relay 3 is provided with a pair of actuating coils 49 and 50, the actuating coil 49 being subject to the voltage of the battery and the actuating coil 50 being subject to the cranking current taken by the dynamo M when operating as a motor. During cranking operation, the magnetic effect of the coils 49 and 50 is cumulative and operates to close the contact members 73 by the contact-bridging member 74. After the engine has started and drives the dynamo M as a generator, the current in the actuating coil 50 reverses and thus its magnetizing effect is in opposition to the magnetizing effect of the voltage coil 49. The compound-wound relay 3 controls the current passing through the heater 77, the actuating coil 61 of the engine-choking device 5 and the heater 65 of the time-limit engine-choking device. If the engine starts before the protective cranking device 4 operates, contact members 73 are opened, and the circuits to actuating coil 61 and the heaters 65 and 77 are broken, as desired.

The 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 vo[illegible]-

age of the system abnormally high, energization of coil 49 alone will be sufficient to cause the closing of contacts 73, whereas, if the speed remains normal but the load becomes excessive, coil 50 alone will be sufficient to cause closing of the contacts 73. The ratio of the turns of coil 49 and 50 is so chosen that the stated functions take place. From this three-fold 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.

The operation of the device is as follows: Assuming that a number of switches 80 are closed, then, if the current flowing in the work circuit or load line 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 31 are closed, thereby establishing an engine-starting circuit through the motor. As the engine comes up to normal speed, the dynamo is driven as a generator to take up the load in the work circuit.

The circuits mentioned may be traced from the positive terminal of the battery B, through conductor 11, contacts 13 of the low-voltage relay 8, conductor 17, ammeter A, conductors 18 and 19, actuating coil 20 of the series governor 9, conductors 21 and 22, actuating coil 23 of the series line relay 1, conductor 32, load 33, switch 80 and conductor 12, to the negative terminal of the battery.

If the current in the load exceeds a predetermined value, the series-line relay closes contact 31, thereby establishing a circuit from the energized conductor 32, through contacts 31, bridged by the contact-bridging member 29 and conductor 34, to contact 99. Since, during starting operation, the elements of the protective cranking device are in the position shown in the drawing contacts 35 and 99 are in engagement, thereby establishing three parallel circuits.

The circuit for the engine ignition is established, through conductor 36, primary 37 of the transformer of the ignition system 10, condenser 38, and interrupter 39 in parallel and conductor 12, to the negative terminal of the battery. Disposed adjacent to the primary 37 is a secondary 40 having a pair of conductors 42 leading to the engine block and spark terminal 41, respectively.

The second parallel circuit established through the contacts 35 and 99 may be traced, through conductor 43, actuating coil 44 of control relay 2, conductor 47, actuating coil 50 of the compound-wound relay 3, conductor 51 and conductor 12, to the negative battery terminal.

In parallel-circuit relation to the actuating coil 44 is an actuating coil 49 by means of a conductor 48 and the conductor 47. During this stage of operation, the effect of the coils 49 and 50 is additive. However, before the actuation of the control relay 2, the combined magnetic effect of coils 49 and 50 is not sufficient to close the contacts 73 by the bridging member 74.

The control relay 2, upon energization, however, operates to close contacts 45 by the contact-bridging member 46, thereby establishing a motor circuit for the dynamo-electric machine M. This circuit may be traced from the positive battery terminal, through conductor 11, contacts 13, conductor 17, ammeter A, conductors 18 and 81, heater 82, conductor 52, series field winding 53, conductor 54, armature 55 of the dynamo M, conductor 56, contact 45—bridged by the contact bridging member 46—conductor 47, actuating coil 50, conductor 51 and conductor 12, to the negative terminal of the battery.

Disposed in parallel circuit relation to the armature 55, is a shunt field winding 57, a shunt field resistor 58 and a conductor 59.

Closure of the contacts 45 by the contact-bridging member 46 and establishing the circuits just described causes the heavy cranking current to pass through actuating coil 50, the combined magnetic effect of coils 49 and 50 thus operating to close contacts 73 by the contact-bridging member 74. Closure of contacts 73 establishes a circuit from contact 35 to contact 99, conductor 72, contact 73—bridged by the contact bridging member 74 of the compound wound relay 3—and conductor 75, through a plurality of parallel circuits and through the protective time-limit engine cranking device 4, the engine-choking device 5 and the time-limit engine choking device 7. These circuits may be traced from the energized conductor 75, through conductor 76, heater 77, conductor 78 and conductor 12, to the negative battery terminal and, through conductor 60, actuating coil 61 of the engine-choking device 5, conductor 62, conductor 63, conductor 78 and conductor 12, to the negative terminal of the battery and also from conductor 75, through conductor 64, heater 65 of the time-limit engine-choking device 7, conductor 63 and conductors 78 and 12, to the negative terminal of the battery.

If the engine fails to start within a predetermined interval of time, the combined action of the current heater 82 and the voltage heater 77 operates to break the contacts 35 and 99, thus directly interrupting the ignition circuit of the engine and the circuit for the control relays 2 and 3. Deenergization of the control relays 2 and 3 causes an interruption of the electrical-energy supply to heaters 77 and 65 and the actuating coil 61.

Since the actuation of the protective cranking device causes a movement of the latch

member 105 to a lower position for engagement with the opening 114, no further automatic cranking is possible, and an attendant must reset the protective cranking device in the position shown in the drawing, before further automatic cranking can take place.

If the engine starts within a given time after the operation of the series line relay 1, the current in the actuating coil 50 reverses, opposing the effect of the coil 49 and thus causing the separation of the contacts 73. This operation of contacts 73 prevents the protective cranking device from functioning. When the load again decreases to some predetermined low value, for instance, to 3 amperes, the series line relay drops into the position shown in the drawing, the engine stops and the battery assumes the load.

During cranking, heater 65 is energized, as above pointed out, and actuating coil 61 operates to completely close the valve in the tube 66. Energization of heater 65 causes a downward deflection of the bi-metal strip 68 and thus varies the biasing effect of the spring 71 interposed between the free end of the bi-metal strip and a valve disc 67 seated in an auxiliary opening of the housing 69 of the time-limit choking device. It will be apparent that the seating pressure of valve disc 67 varies from a maximum, during the initial stages of starting, to a minimum after a predetermined interval of time. To ensure that the bi-metal strip 68 shall be deflected over a given range in a given time, it is designed to be relatively insensitive to ambient temperature and is mounted within the housing of the time-limit choking device upon a heat-insulating block, thus preventing the dissipation of the heat transmitted from the heater 65 to the bi-metal strip 68. The subject matter of this time-limit choking device is covered in a separate application of L. C. Frank J. D. Conant, filed January 30, 1930, Serial No. 424,616 and assigned to Westinghouse Electric & Manufacturing Company.

The manual starting means above discussed need not necessarily be connected in the circuits as shown but may be disposed as shown in Fig. 2. In Fig. 2, the conductor 100, the contacts 101, the push-button 102 and the conductor 103 correspond to the conductor 79, the contacts 92 and 94, the push-button 87 and the conductor 95.

I do not limit myself to the specific structural details, arrangement of parts or circuit connections herein set forth, as various other modifications thereof may be made without departing from the spirit and scope of this invention, as defined in the appended claims.

I claim as my invention:

1. In an electric-generating system, in combination, an internal-combustion engine, a dynamo-electric machine, a battery, a load line and a system of control comprising a series line relay for closing a motor circuit for said dynamo-electric machine to crank said engine when the load in the line exceeds a predetermined amount, an electrically controlled time-limit protective cranking device for interrupting the motor circuit should the engine fail to start within the time limit of the protective cranking device, and an electrically controlled time-limit engine choking device for varying the choking of the engine during the cranking operation over a predetermined range during a predetermined interval of time.

2. In an electric-generating system, in combination, an internal-combustion engine, a dynamo-electric machine, a battery, a load line and a system of control includig a series line relay for closing a motor circuit for said dynamo-electric machine to crank the engine when the load in the line exceeds a predetermined amount, and an electrically controlled time-limit engine-choking device for varying the choking of the engine during the cranking operation over a predetermined range during a predetermined interval of time.

3. In an electric-generating system, in combination, an internal-combustion engine having a carburetor, a dynamo-electric machine, a battery, a load line, and a system of control for the dynamo-electric machine to crank the engine including a thermo-electric protective engine-cranking device, an engine-choking device, a preheater for the air passing to the carburetor, a control relay for closing the motor circuit, a compound-wound relay having a current coil and a voltage coil controlled by the control relay for closing the circuit to the preheater, the engine-choking device and the protective cranking device and a series line relay responsive to the load on the line for controlling the operation of the control relay and the compound-wound relay.

4. In an automatic electric-generating system of the demand-starter type having a battery, a dynamo, load-line circuits, an internal-combustion engine and control circuits for the system, said control circuits including a time-limit protective cranking device having a pair of bi-metal strips, an electric heater energized by the voltage of the system adjacent to one of the strips, a second electric heater energized by the cranking current adjacent to the second strip and being also in heat-transfer relation to the first strip, thereby keeping the effect on the strips substantially constant, regardless of voltage changes of the system resulting from variations in starting current, a latch actuated by the strips, and contacts opened by the operation of the latch to cause a cessation of the cranking operation.

5. In an automatic electric-generating system, in combination, a battery, load line circuits an internal-combustion engine, a dynamo-electric machine for operation as a motor to crank the engine and for operation as

a generator by said engine to supply the load on the line, a series line relay for automatically starting the engine when the load on the line exceeds a predetermined value and for causing the stopping of the engine when the load decreases below a predetermined value, a series-line governor for the engine, means for starting the engine manually, regardless of the load on the line, and means associated with the manual starting for locking the governor to open position a predetermined extent, whereby the engine maintains a relatively high speed, thus causing the dynamo to generate a voltage sufficiently high to charge the battery and also to supply the load.

6. In an automatic electric-generating system, in combination, a battery, load-line circuits, an engine, a dynamo-electric machine for operation as a motor to crank the engine and for operation as a generator by the engine to charge the battery or supply the load or both, as desired, a relay for isolating the battery from the system upon a decrease of the voltage of the battery to a predetermined minimum, and automatic-starting means for the engine, and control relays controlled by either of said starting means for establishing a motor circuit for the dynamo to crank the engine and for causing a varying choking of the engine over a predetermined range during a predetermined interval of the cranking period.

7. In an automatic electric-generating system, a battery, load-line circuits, an engine having an ignition circuit, a dynamo-electric machine for operation as a motor to crank the engine and for operation as a generator by the engine to supply energy to the system, an electromagnetic engine choker, an auxiliary thermo-electric engine choker, a thermo-electric protective engine-cranking device responsive to the cranking current and to the voltage of the system and designed to operate a predetermined time interval after being energized to interrupt the circuits of the choking devices, the ignition circuit, the motor circuit of the dynamo-electric machine and the voltage-responsive portion of the protective cranking device, thereby causing a cessation of the cranking operation.

8. In an automatic electric-generating system of the demand-starter type having a battery, a dynamo, load-line circuits, an engine and control circuits for the system, said control circuits including a thermo-electric time-limit device for limiting the cranking period of the engine to a predetermined value, and a compound-wound relay having a current coil disposed to be connected in series with the dynamo and a voltage coil disposed to be connected across the battery terminals, the ampere turns of the series coil relative the voltage coil being so chosen that the series coil acts additively to the voltage coil during the cranking operation to connect the time-limit devices in circuit relation with the battery and acts differentially to neutralize the effect of the voltage coil when the dynamo operates as a generator and at normal speed, thereby disconnecting the time-limit devices from the battery and acts to again connect the time-limit protective devices in circuit with the battery when the generator voltage is abnormally high.

In testimony whereof, I have hereunto subscribed my name this 21st day of January 1930.

LEO C. FRANK.