Sept. 4, 1945. G. A. SCHERRY 2,384,135

AUTOMATIC STOPPING AND STARTING GENERATOR SET

Filed May 22, 1944 3 Sheets-Sheet 1

Fig. 1

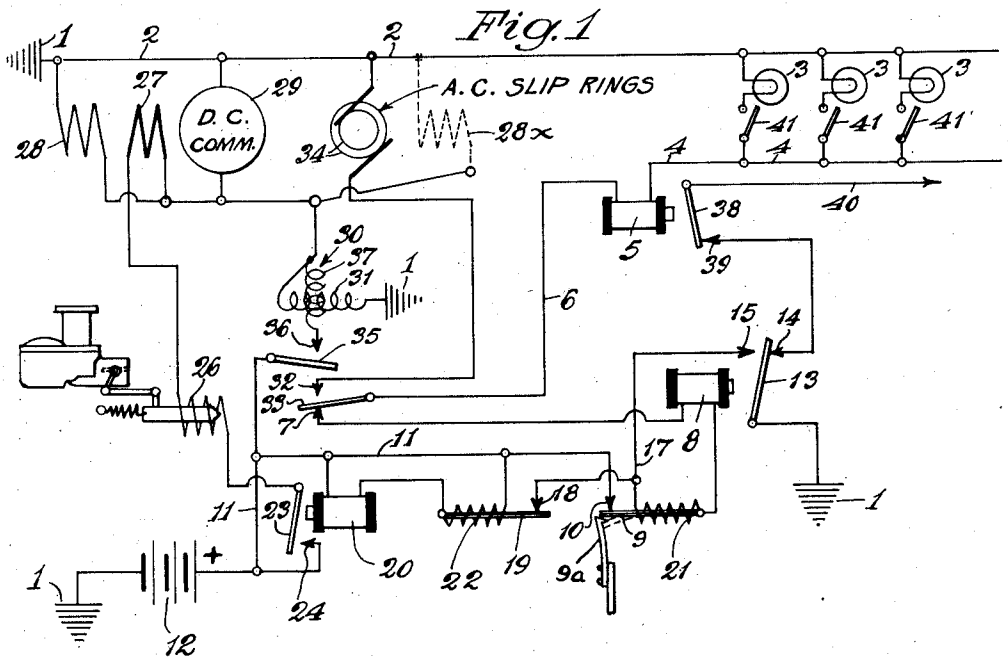
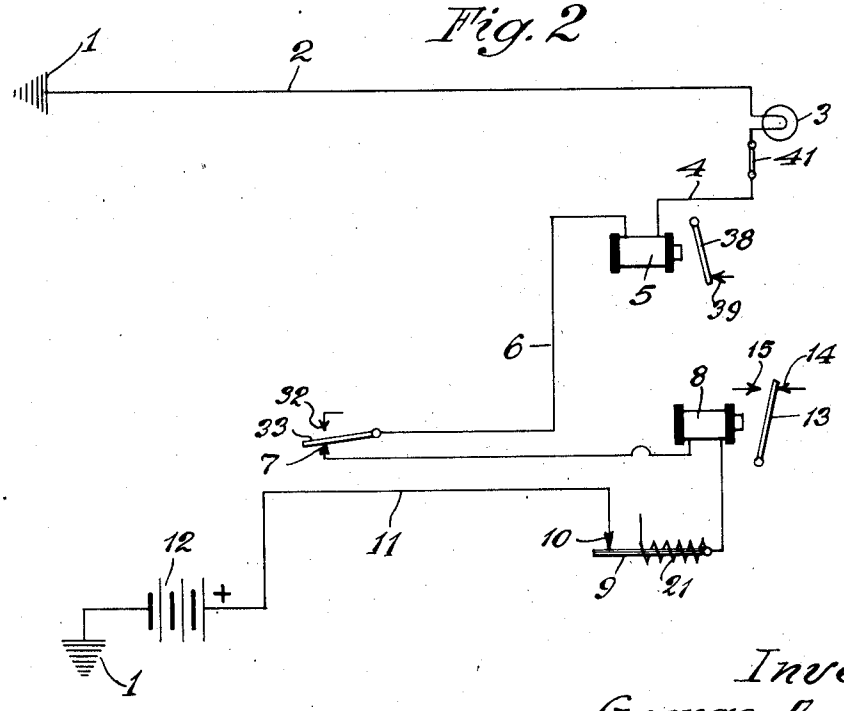


Fig. 2



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Fig. 3

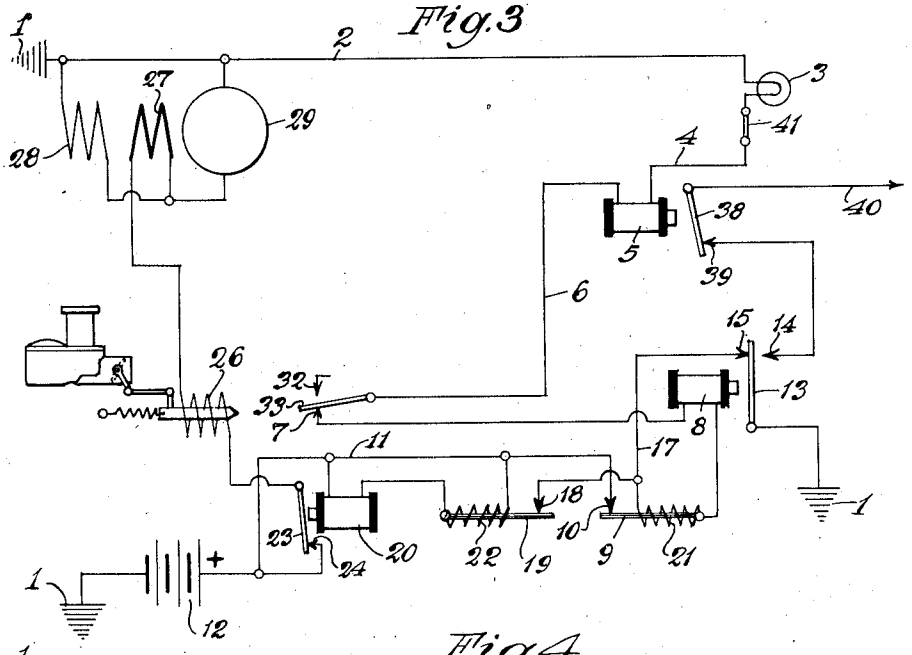


Fig. 4

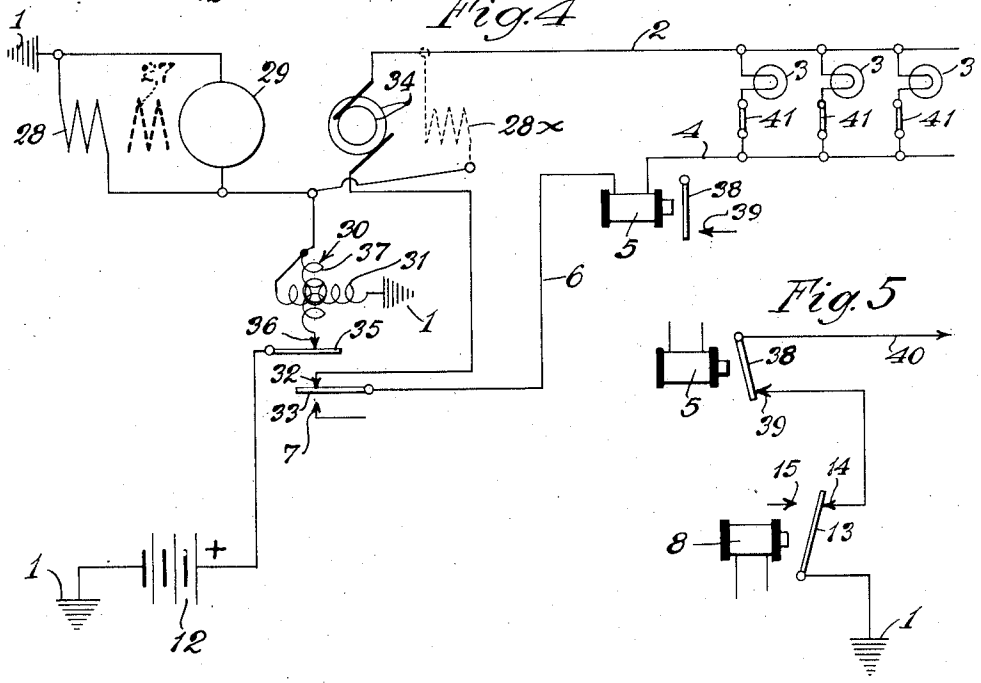


Fig. 5

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AUTOMATIC STOPPING AND STARTING GENERATOR SET

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Fig. 6

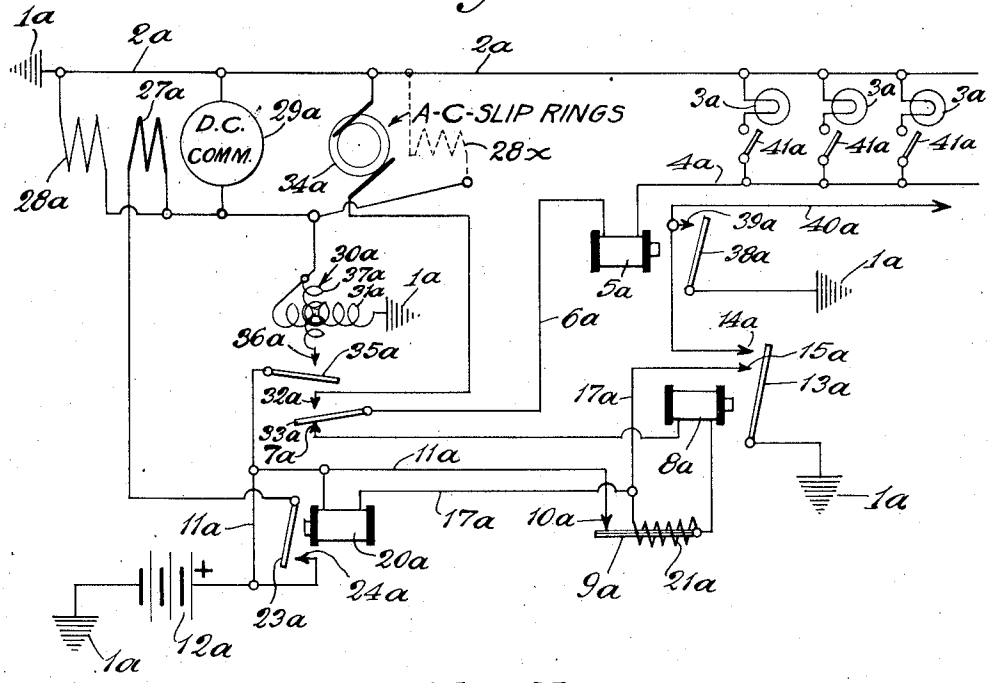
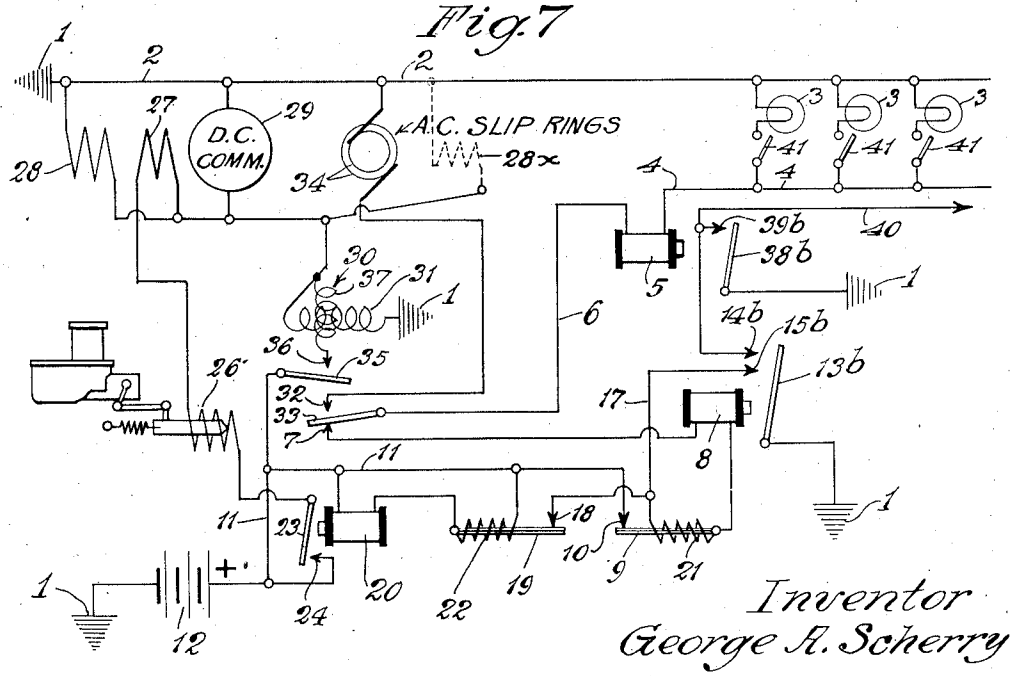


Fig. 7



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UNITED STATES PATENT OFFICE

2,384,135

AUTOMATIC STOPPING AND STARTING GENERATOR SET

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Application May 22, 1944, Serial No. 536,744

8 Claims. (Cl. 290—30)

My invention relates to an improvement in the automatic starting and stopping of engine driven generator sets and has for one purpose to provide a generator set which starts automatically in response to load.

Another purpose is to provide such a set which stops automatically when the load drops to a predetermined minimum.

Another purpose is to provide a generator set of the automatic stopping and starting type which employs a circuit of relative simplicity and a minimum of operating parts.

Another purpose is to provide such a set which will start in response to the closure of a very low load.

Another purpose is to provide such a set in which a battery is employed to provide the energy for cranking or starting an internal combustion engine, and in which means are provided for limiting the drain on the battery.

Another purpose is to provide a set in which a battery is employed to provide the energy for cranking or starting an internal combustion engine and in which the ignition circuit for the engine is battery energized.

Another purpose is to provide a set in which a battery is employed to provide the energy for cranking or starting an internal combustion engine and in which the ignition circuit for the engine is magneto energized.

Another purpose is to provide such a set in which a Diesel engine is employed.

Another purpose is to provide means in such a set for automatically choking the engine during the starting period.

Another purpose is to provide means in such a set, for providing cranking cycling.

Other purposes will appear from time to time throughout the specification and claims.

My invention is illustrated more or less diagrammatically in the accompanying drawings, wherein:

Figure 1 is a wiring diagram illustrating the complete basic control circuit in the condition it takes when the controlled unit is out of operation;

Figure 2 is a partial wiring diagram illustrating the initial control circuit in the condition which it takes when a load is closed in the generator circuit;

Figure 3 is a partial wiring diagram illustrating the starting circuit during cranking operation;

Figure 4 illustrates the running circuit during load conditions, with the battery being recharged;

Figure 5 is a partial or stopping circuit illustrating the result of removal of the load from the generator;

Figure 6 illustrates a complete variant circuit illustrating the employment of my invention with a Diesel operated set; and

Figure 7 illustrates an adaptation of the circuit for use with battery type engine ignition systems.

Like parts are indicated by like characters throughout the specification and drawings.

As a matter of convenience I list herewith some of the major elements of the circuit herein shown which will be mentioned from time to time in the course of the description of the circuits employed in my invention.

The load relay including a coil **5**, a movable contact **38** and a fixed contact **39**.

The battery relay having a coil **8**, a movable contact **13** and fixed contacts **14** and **15**.

The starter relay having the coil **20**, the fixed contact **24** and the movable contact **23**.

The reverse current relay **30** having the coils **31** and **37**, the fixed contact **36** and the movable contact **35** plus the movable contact **33** and the fixed contacts **7** and **32**.

The cranking cycling relay including the bimetal movable contact **19**, the fixed contact **18** and the resistance **22**.

The cranking limiter relay including the movable bimetal contact **9**, the fixed contact **10** and the resistance **21**.

The automatic choke solenoid **26**.

With reference to the generator rotor I illustrate, in the wiring diagram, generator slip rings **34** and a D.-C. commutator **29**. It will be understood that I may employ a single rotor or two separate rotors, the wiring diagram being equally applicable to either situation, separate fields **28** and **28**x appearing in Figure 7.

Referring to the drawings, Figure 1 illustrates a basic control circuit in which the switches are all shown in the position which they normally take when the controlled unit is out of operation. When, as shown in Figure 2, a load is connected to the generator, it closes the circuit from a ground **1** or common connection to the conductor **2**, through the load **3**, switch **41**, conductor **4**, load relay coil **5**, conductor **6**, contacts **33** and **7** of the reverse current relay, battery relay coil **8**, cranking limiter relay element **9**, contact **10**, conductor **11**, and back to the positive of the battery **12**, through which it returns to the ground or common connection **1**. Completion of this circuit is illustrated in Figure 2.

The result of the closure of this initial circuit is as follows: The current flowing through the connections illustrated in Figure 2 is not sufficient to actuate the load relay and the contacts **38**, **39** are left in the closed position. But it does actuate the battery relay, which causes a number of things to happen, with the resulting condition shown in Figure 3. Energizing the battery relay coil **8** causes the movable contact **13** to move from the contact **14** to the contact **15**. This re-

moves the ground connection or short circuit from the engine magneto ignition system and permits that system to function normally. The engine ignition system is not shown in detail since it does not of itself form part of the present invention. However, it will be understood that the conductor 40 forms part of such system, which may include either a return circuit completed through a normally grounded ignition system to a grounded control circuit, or a return circuit permanently connected to the common connection 1 of the control circuit. The closure of contacts 13 and 15 permits current to flow from the ground or common connection 1 across the contacts 13 and 15, through the conductor 17 and contact 18 through the cycling relay element 19 and starter relay coil 20 back to the positive of the battery 12, through which it returns to the ground or common connection 1.

At the same time, the closure of the contacts 13 and 15 energizes the resistance 21 of the cranking limiter relay and the resistance 22 of the cranking cycling relay. The functioning of these two relays will be described later. The completion of the circuit through the starting relay coil 20 causes sufficient current to flow to actuate this relay, thereby closing contacts 23 and 24. The closure of the contacts 23 and 24 draws current from the positive of the battery 12 through the engine choke solenoid 26, the series field 27, the shunt field 28, to the ground or common connection 1 whence it returns to the battery 12. Also the D.-C. commutator 29 forms a parallel circuit with the shunt field 28 by connecting between the series field 27 and the ground or common connection 1. The connections in use at this moment are illustrated in Figure 3. It is clear from Figure 3 that the cranking current is used directly to energize the choke solenoid 26, this current varying in value, depending upon the temperature of the equipment and general starting conditions. One can readily see, therefore, that the pull of the choke solenoid, and consequently the degree or amount of choking of the engine, will vary according to the starting conditions. The result causes a rotating action of the rotor which may be employed to crank any suitable internal combustion engine not herein shown in detail, as its details do not of themselves form part of the present invention.

Assume that such engine is started by the cranking rotation of the rotor, the engine is then effective to rotate the rotor at a substantially increased R. P. M. over the cranking speed. This causes the rotor to generate a voltage across the D.-C. commutator 29 which is greater than the normal battery voltage and therefore causes the actuation of the reverse current relay 30 by energizing the voltage coil 31. This causes a change to the conditions shown in Figure 4. When relay 30 operates it closes a circuit across the contacts 32, 33 and breaks the circuit through the contact 7. When the circuit through the contacts 33 and 7 is broken, the battery relay coil 8 is de-energized which, in turn opens contacts 13 and 15, which de-energizes the cranking limiter relay, the cranking cycling relay and the starting relay. The de-energizing of the battery relay also causes closure of the contacts 13, 14 which connects the ground or common connection with the contacts 38, 39 of the load relay and conductor 40, which in turn grounds or short circuits the engine magneto ignition system. This would cause the engine to stop, but for the action of the load relay which takes place at the same instant, as below explained. The de-energizing of the starting relay 20 opens the circuit across the contacts 23, 24, which interrupts the flow of the current which caused the cranking action and actuation of the choke solenoid.

The de-energizing of the cranking limiter relay and the cranking cycling relay removes them from the possibility of performing their normal functions, which will be explained later.

At the same instant that contacts 33 and 7 are opened, contacts 32 and 33 are closed, which forms a circuit from the A.-C. slip rings 34 through the conductor 2, across the load 3 and switch 41, back along the conductor 4 to the load relay coil 5, conductor 6, through the contacts 32, 33 and back to the slip rings. This causes a flow of current from the generator to supply the load. This current is sufficient to actuate the load relay, causing the opening of the contacts 38 and 39, which removes the ground or short circuit from the engine magneto ignition system, and thereby permits the engine to continue running.

At the same time the operation of the reverse current relay closes the contacts 35, 36 and permits the delivery of current from the D.-C. commutator 29 through the series coil 37 of the reverse current relay across the contacts 35, 36 to the positive of the battery 12, through the battery to ground or common connection 1, and back to the commutator 29, in order to recharge the battery for future starting cycles. The position of the relays and the tracing of all circuits that are now in operation are illustrated in Figure 4. The relay 5 remains operative to separate the contacts 38 and 39 regardless of load variations through a very substantial range. Thus the engine ignition system is permitted to function normally and the engine will continue to run, assuming that there is sufficient fuel and no other trouble prevents its running.

When the load is removed from the generator, the load relay 5 is no longer energized to separate the contacts 38 and 39. In that event, as shown in the stopping circuit of Figure 5 the ignition system circuit is grounded or short circuited through the conductor 40, the now closed contacts 38 and 39, and the contacts 13 and 14 to ground or common connection 1. This renders the engine magneto ignition system inoperative, and therefore the engine must stop. When the engine is stopping, a flow of current is caused through the coil 37 in reverse direction to normal, which de-energizes the relay 30 and returns the contacts to their normal position which they take when the equipment is at rest. All relay contacts have now returned to the position indicated in Figure 1, where they started from.

With reference to the employment of the battery to deliver cranking power to the D.-C. commutator 29, when the system is as shown in Figure 3, the cranking limiter relay and the cranking cycling relay are both energized, as explained above, and the period during which current can flow from the battery is limited thereby. Assume that for some reason the engine does not start. After a short period of time the heat caused by the resistance winding 22 affects the heat responsive element 19, breaking the connection at 18. This de-energizes both the starting relay 20 and the resistance element 22. Then as the element 19 cools it again closes the circuit through the contact 18. This make and break cycle is repeated several times if the engine still fails to start. As the relay 20 controls the flow of battery power used to crank the engine, the bat-

tery current is thus delivered intermittently for short periods with a time lag between each period of flow, thus producing a series of cranking cycles of the engine. This repetition continues until the limiter relay operates. Meanwhile the limiter relay heat responsive element **9** is being continuously heated by the resistance heater **21**. Eventually the element **9** is moved into circuit opening position with contact **10** and by suitable means is prevented from reclosing these contacts until the element **9** has cooled and the relay is manually reset. Any suitable means may be employed, but I illustrate diagrammatically the latch **9***a*.

As the opening of the connection between the element **9** and contact **10** interrupts the main control circuit illustrated in Figure 2, it renders the connections illustrated inoperative, and prevents all battery drain unless and until the limiter relay is manually reset.

It will be understood that if the motor still does not start, after the limiter relay has been manually reset, the same sequence will again take place, thus preventing exhaustion of the battery. It will be understood that the time necessary to operate the cranking limiter relay is substantially greater than the time necessary to operate the cranking cycling relay, and until the cranking limiter relay has moved to circuit breaking position, the cranking cycling relay will continue to go through its sequence of making and breaking. Thus in effect, the engine will be subjected to a series of cranking turns, each cranking period being separated by a time lag, and if, during the sequence of cranking operations, the motor does not start, then finally the cranking limiter relay moves the element **9** and contact **10** to circuit breaking position and there will be no further cranking and no drain on the battery unless and until the operator manually recloses the cranking limiter relay after it has been substantially cooled. Thus to recapitulate the general operation of the system, the system is initiated by putting a load across the conductors **2** and **4**. This load might be provided for example by an electric light or any other piece of electrically operated equipment. If a light connected across the conductors **2** and **4** is switched on then the sequence above discussed is initiated, the flow of battery current causes rotation of the rotor to give a series of cranking cycles to the engine, the engine then starts and drives the rotor with the double result of delivering power to the load and recharging the battery. Operation will normally continue until the load is cut off and the load relay permits grounding of the engine ignition system. The sensitivity of the battery relay is important to determine the minimum load at which the device can be started. The characteristics of the load relay are vital in determining the minimum load at which the system will continue to run, and the capacity of the load relay coil **5** will determine the maximum continuous load that can be handled by this control system. Thus the proper selection of the load relay and the battery relay will determine the range of minimum starting load and maximum continuous load that can be handled by this circuit. The system is automatic throughout, except that if the engine fails to start after a reasonable length of time, further operation is prevented unless and until the operator resets the cranking limiter relay.

In connection with the use indicated herein of series field, shunt field and D.-C. commutator, it will be understood that any suitable electrical equipment may be employed, which can be used to rotate or crank the engine, and, when driven by the engine, can be used to recharge the battery. Also, with reference to the A.-C. slip rings, any suitable electric equipment for power generation may be employed, whether A.-C. or D.-C., which is connected to or driven from the engine.

My invention may be applied to Diesel engines but in that case, the line **40** may be employed in connection with a circuit to control the fuel supply, since no ignition system is employed in the Diesel cycle. Any suitable electrically operated control valve, that is normally open, may be employed to cut off the flow of fuel to the Diesel engine, when it is desired to put the unit out of use. No change in the circuit shown is necessary, except to omit the choke and the cycling relay.

Or I may employ a variant circuit which still retains the fundamental principles of the automatic control circuit shown in Figures 1 and following, but is changed therefrom in certain respects. Such a circuit, modified for Diesel engine use, is shown in Figure 6. Many of the elements of the circuit need not be separately described as they are the same as those shown in the previous drawings. Corresponding elements are indicated in Figure 6 by using the same number followed by "*a*."

Comparing Figures 1 and 6, since no carburetor is employed in connection with Diesel engines, the coil **26** and its associated solenoid plunger are omitted from Figure 6. The cycling relay is omitted from Figure 6 since there is no necessity for successive cranking impulses in starting a Diesel engine. It will be noted that whereas contacts **38** and **39** of Figure 1 are normally closed, the contacts **38***a* and **39***a* of Figure 6 are normally open. Similarly whereas in Figure 1, contacts **13** and **14** are normally closed, in Figure 6 the corresponding contacts **13***a* and **14***a* are normally open. Whereas contacts **38**, **39**, **14** and **13** in Figure 1 are connected in series, the corresponding contacts **38***a*, **39***a*, **14***a* and **13***a* in Figure 6 are connected in parallel, to control the current flow to any suitable electrically operated normally closed valve in the fuel line of the Diesel engine. The particular valve does not form part of the present invention and is therefore not illustrated. An advantage of the modified circuit shown in Figure 6 is that the fuel valve actuating means is only energized while the engine is in operation.

It will be understood that the valve energizing circuit includes the line **40***a* extending to any suitable electric valve actuating mechanism not herein shown, the circuit being completed through a normally grounded system to a grounded control circuit, or a return circuit permanently connected to the common connection **1** of the control circuit.

In connection with both forms of the device, it will be understood that the internal combustion engine, whether of the Diesel type or the ordinary carbureting type includes any suitable drive shaft, not herein shown, and any suitable driving connection between said drive shaft and the rotor of the generator. It may be convenient to provide a unitary shaft directly driven by and forming part of the internal combustion engine, said shaft carrying the rotor of the generator. The D.-C. combination starter and battery charger and the generator supplying power

to the load may be wound all in one unit or may be two separate machines, so long as both are mechanically connected to the shaft of the engine.

Referring to Figure 7, it illustrates a circuit which is generally the same as the circuit shown in Figure 1 but is altered to render it adaptable for use with a unit in which the ignition circuit is battery energized. Whereas in Figure 1, which shows a circuit adapted for magneto ignition, the contacts **38** and **39** of the load relay are normally closed, in Figure 7, the corresponding contacts **38***b* and **39***b* are normally open. Whereas in Figure 1 the contacts **13** and **14** of the battery relay are normally closed and **13** and **15** are normally open, in the circuit of Figure 7, the corresponding movable switch member **13***b* is normally open and when bridged, closes a circuit across the fixed contacts **14***b* and **15***b*. Thus the contacts **38***b*, **39***b*, **14***b* and **13***b* are connected in parallel, like the corresponding contacts in Figure 6, but unlike the corresponding contacts of Figure 1, which are connected in series. Except for the above-mentioned elements, the rest of the circuit is identical with Figure 1 and the same indicating numerals have been applied thereto.

Our previous explanation of the operation of the circuits has assumed that the A.-C. slip rings and D.-C. commutator are both mounted on the same rotor and that the windings connected to them are under the influence of a common field, shown at **28**. It is possible, without changing the circuit, to employ windings connected to the D.-C. commutator and A.-C. slip rings which are under the influence of separate fields. To indicate this possibility, I have illustrated in dotted lines in Figures 1, 4, 6, and 7, an additional field **28***x*.

I claim:

1. In an engine driven generator set, an internal combustion engine, a generator including a rotor with a D.-C. commutator and A.-C. slip rings, a generator circuit, a battery, a battery circuit, means responsive to a load across said generator circuit for closing said battery circuit, means for starting said internal combustion engine in response to the closing of said battery circuit, a driving connection between said internal combustion engine and said rotor, and means for charging said battery in response to the actuation of said generator by said internal combustion engine, including a reverse current relay intermediate said battery and said generator, said reverse current relay being adapted also to transfer the load circuit from the battery circuit to the generator circuit, for normal running of the set.

2. For use with an engine driven generator set including a generator, and a generator circuit, and a combination starter and battery charger, a battery, a battery circuit, means responsive to a load across said generator circuit for closing said battery circuit and means for controlling said battery circuit including a cranking cycling relay and a cranking limiter relay, said cranking cycling relay and cranking limiter relay each including a warping bar and a resistance therefor, and distinct circuits for each said resistance.

3. For use with an engine driven generator set including a generator, and a generator circuit, and a combination starter and battery charger, a battery, a battery circuit, means responsive to a load across said generator circuit for closing said battery circuit, said battery circuit including a battery relay and a starter relay, and means for controlling said battery circuit including a cranking cycling relay and a cranking limiter relay, said cranking cycling relay and cranking limiter relay each including a warping bar and a resistance therefor, and distinct circuits for each said resistance.

4. For use with an engine driven generator set including a generator, and a generator circuit, and a combination starter and battery charger, a battery, a battery circuit, means responsive to a load across said generator circuit for closing said battery circuit, said battery circuit including two relays, and means for controlling said battery circuit including a cranking cycling relay and a cranking limiter relay, said cranking cycling relay and cranking limiter relay each including a warping bar and a resistance therefor, and distinct circuits for each said resistance.

5. For use with an engine driven generator set including a generator, and a generator circuit, and a combination starter and battery charger, a battery, a battery circuit, means responsive to a load across said generator circuit for closing said battery circuit, said battery circuit including two relays, and means for controlling said battery circuit including a cranking cycling relay and a cranking limiter relay, said cranking cycling relay and cranking limiter relay each including a warping bar and a resistance therefor, and distinct circuits for each said resistance, said cranking cycling relay being in circuit with one of said relays and said cranking limiter relay being in circuit with the other said relay.

6. For use with an engine driven generator set including a generator, and a generator circuit, and a combination starter and battery charger, a battery, a battery circuit, means responsive to a load across said generator circuit for closing said battery circuit, said battery circuit including a starting relay and a cranking limiter relay, and means for controlling said battery circuit including a cranking cycling relay and a cranking limiter relay, said cranking cycling relay and cranking limiter relay each including a warping bar and a resistance therefor, and distinct circuits for each said resistance, said cranking cycling relay being in circuit with said starter relay, said cranking limiter relay being in circuit with said battery relay.

7. For use with an engine driven generator set including a generator and a generator circuit, and a combination starter and battery charger, a battery, a battery circuit, means responsive to a load across said generator circuit for closing said battery circuit, said battery circuit including two relays, and means for controlling said battery circuit including a cranking cycling relay in circuit with one said battery circuit relay and a cranking limiter relay in circuit with the other said battery circuit relay.

8. For use with an engine driven generator set including a generator and a generator circuit, and a combination starter and battery charger, a battery, a battery circuit, means responsive to a load across said generator circuit for closing said battery circuit, said battery circuit including two relays, and means for controlling said battery circuit including a cranking cycling relay in series with one said battery circuit relay and a cranking limiter relay in series with the other said battery circuit relay.

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