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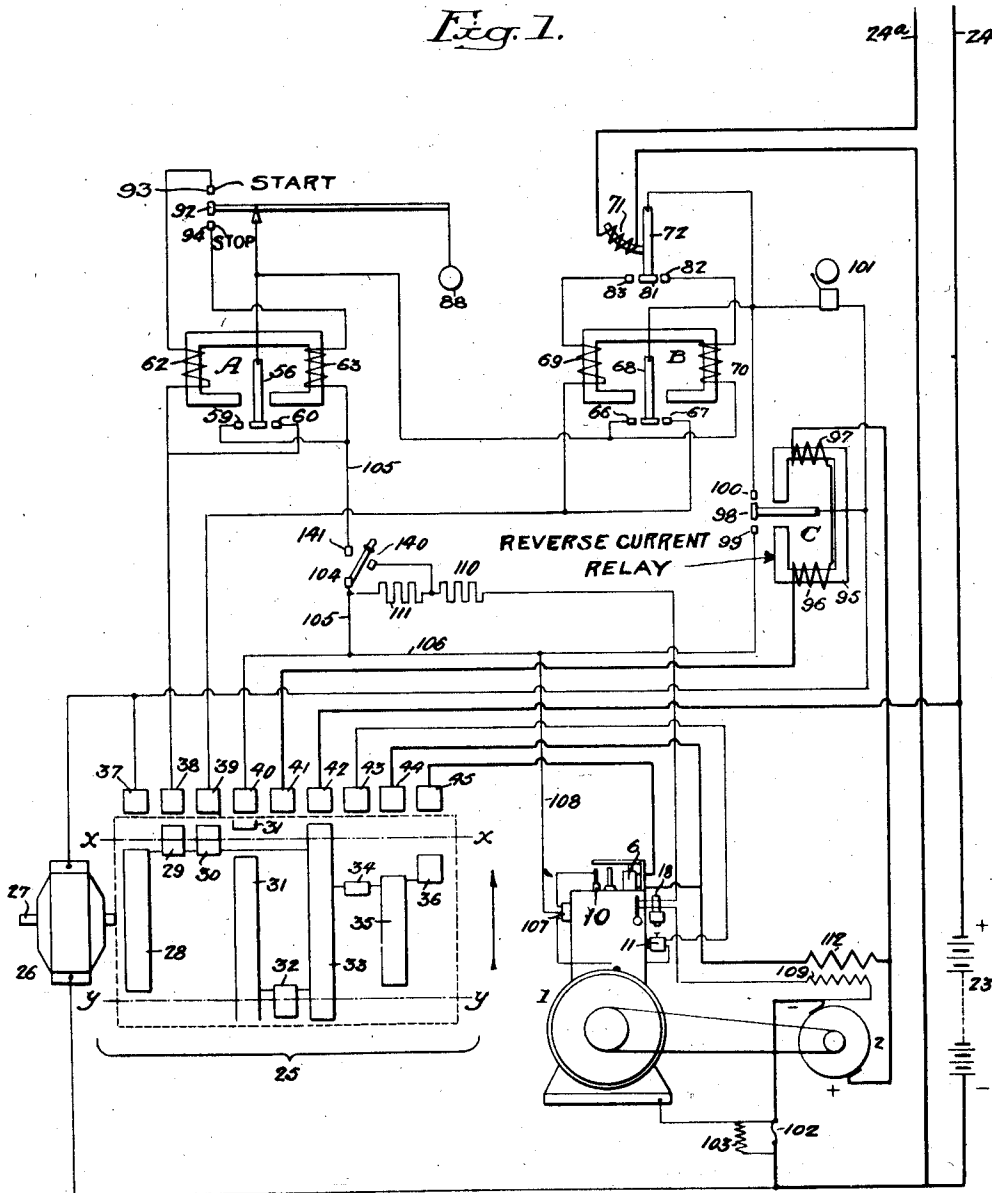
A. R. VAN HORN

AUTOMATIC ELECTRIC GENERATING SYSTEM

Filed May 7, 1919

3 Sheets-Sheet 1

Fig. 1.



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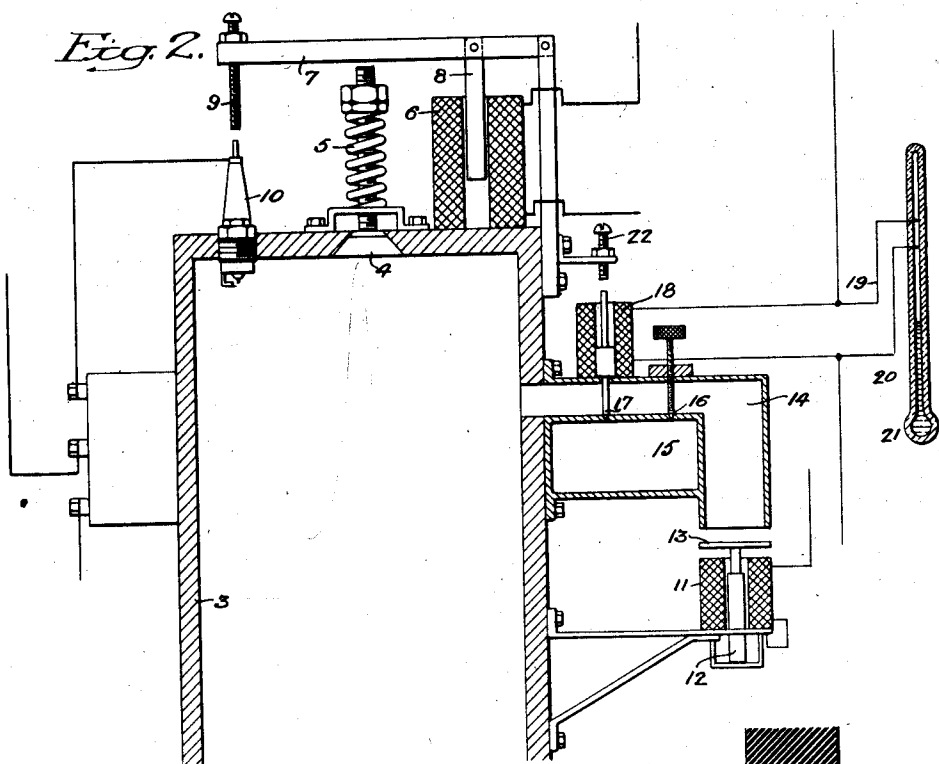
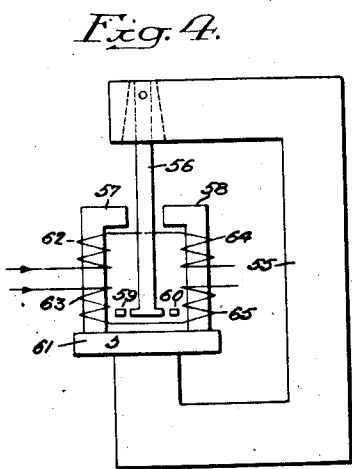
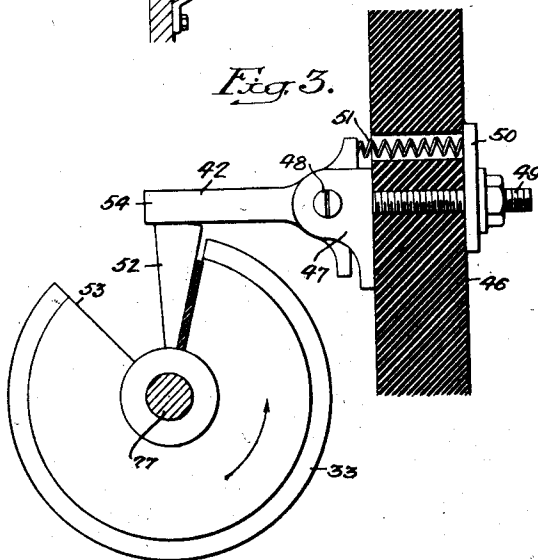
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3 Sheets-Sheet 2



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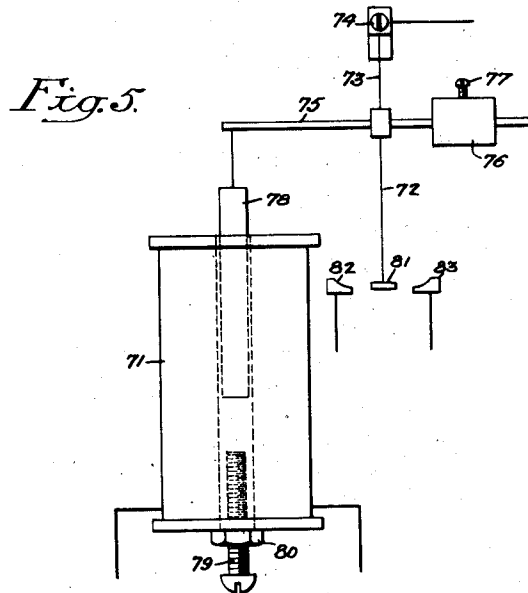
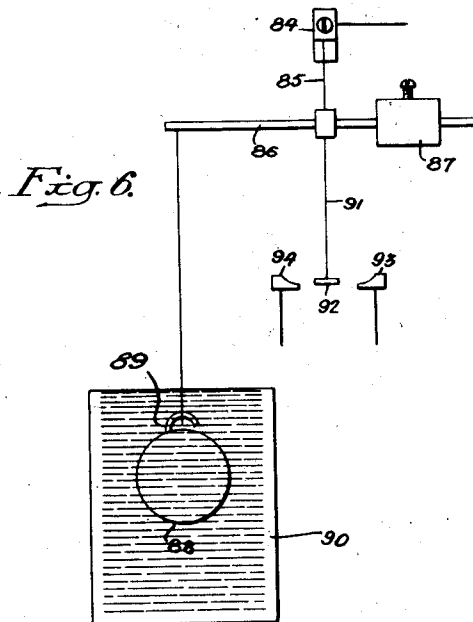
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AUTOMATIC ELECTRIC GENERATING SYSTEM

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3 Sheets-Sheet 3



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Patented Oct. 16, 1923.

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UNITED STATES PATENT OFFICE.

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AUTOMATIC ELECTRIC GENERATING SYSTEM.

Application filed May 7, 1919. Serial No. 295,361.

To all whom it may concern:

Be it known that I, ALFRED R. VAN HORN, a citizen of the United States, residing in Philadelphia, Pennsylvania, have invented Automatic Electric Generating Systems, of which the following is a specification.

One object of my invention is to provide an electric generating and distributing system including a prime mover such as an internal combustion engine, which system will be completely automatic in its operation so long as the engine is supplied with fuel and the operative conditions are normal; the arrangement and connections of the apparatus being such that an abnormal condition will cause the system, with the exception of the distributing circuit, to automatically shut down and become inoperative, at the same time putting in operation a signal device which will give an alarm indicating the existence of said abnormal condition.

A further object of my invention is to provide novel means for insuring the starting of the engine without possibility of its back firing; the invention contemplating means for automatically causing a rich fuel mixture being delivered to the engine while it is being started, together with a novel device for insuring the enriching of the fuel when and as long as the engine is at a low temperature.

It is also desired to provide an automatically controlled electric generating system in which the starting and stopping of the engine and the operation of a generator shall be dependent on and responsive to variations in the specific gravity of the storage battery electrolyte as well as upon variations in the load on the system and the invention includes a novel arrangement of apparatus and connections whereby injury to any of the contacts of said apparatus due to arcing is effectually prevented; said arrangement being such as to prevent injury to the system by accidental or malicious shifting of the movable contact members.

Another object of the invention is to provide an arrangement of circuits and apparatus whereby it shall be possible to overcharge the storage battery when this is desirable.

I also desire to provide a system of the character above noted in which the govern-

ing instruments shall be so connected that in case any of them develops either electrical or mechanical faults, the system will be automatically operated to its shut down condition; the arrangement being such as to permit such fault to be easily and quickly located.

Another object of the invention is to provide the governing controller with such a construction and arrangement of coacting contacts as will effectually prevent burning of these when they make or break the circuits of which they form part; said invention contemplating a novel form and mounting for the fingers and drum segments for attaining this end.

These objects and other advantageous ends I attain as hereinafter set forth, reference being had to the accompanying drawings, in which,

Fig. 1 is a diagrammatic view illustrating the apparatus and associated connections constituting my system;

Fig. 2 is an elevation partly in section and largely diagrammatic, illustrating an engine cylinder with certain of the apparatus associated therewith in accordance with my invention;

Fig. 3 is a transverse section of the motor-driven controller forming part of my invention, illustrating the non-arcing construction and arrangement of the coacting contact members;

Fig. 4 is a diagrammatic elevation illustrating the construction of the relays forming part of my invention;

Fig. 5 is a diagrammatic illustration of the load coil and certain of its associated apparatus; and

Fig. 6 is a diagrammatic elevation of the controlling hydrometer with its associated parts.

In the above drawings 1 represents an internal combustion engine connected in any suitable manner to a dynamo electric machine 2, so that under certain conditions it may either operate the same to generate electric current or be operated by it when it is desirable that said engine shall be cranked for starting purposes. The cylinder 3 of this engine is provided with a valve 4 which may be opened to release the compression and this valve is normally held closed by a spring 5 operative on its stem. A suitable form of electromagnet such as the solenoid

6 is so mounted, preferably on the cylinder 3, that a lever 7 connected to its core 8 will act upon the valve stem 5 to open the valve 4 when said solenoid is properly energized. 5 This same lever carries a screw 9 which may be adjusted to engage the terminal of the spark plug 10 or short circuit the spark plug gap of the engine so as to ground the spark when the solenoid 6 is energized and 10 the valve 4 is open. When said solenoid is deenergized, the spring 5 will automatically close the valve 4 and so raise the lever 7 as to move the screw 9 away from the spark plug 10. Under these conditions the engine 15 is free to operate in the ordinary manner, the short circuiting of the spark plug preventing back firing of the engine when the compression is released by opening of the valve 4.

20 In order to make possible the priming of the engine when it is being started I provide an electromagnet 11 whose core 12 carries a plate or disc 13 in such manner that when said magnet is energized said disc is 25 moved into position to close the air inlet of the mixing chamber 14 of the engine so that on the succeeding suction stroke a relatively rich mixture is drawn into said chamber from the supply chamber 15. The flow of fuel from 30 this supply chamber 15 to the mixing chamber is controlled by a running valve 16 and also by a starting valve 17, of which the former is provided with a headed and threaded stem for purposes of adjustment. 35 The valve 17 is connected to the core of an electromagnet 18 which when energized will open it and thereby admit an increased amount of fuel to the mixing chamber. In order that such increased quantity of fuel 40 shall be dependent upon or governed to a greater or less extent by the temperature of the engine, I connect said magnet 18 in a circuit including a pair of contacts 19 and 20 extending into the tube of a thermometer 21 in such manner that they will be electrically connected when the mercury has 45 risen to a predetermined point.

On starting the engine, the magnet 18 is energized as hereafter explained, so that the 50 valve 17 is opened, and after it has continued in operation long enough to be capable of running with fuel of the normal richness, as determined by its temperature, said solenoid is short circuited by the action 55 of the thermometer which is so placed as to be affected by or having the height of its mercury dependent upon; such engine temperature. Obviously any other suitable form of thermostat may be mounted on or 60 adjacent the engine so as to cause operation of the electromagnet and secure the above noted results without departing from my invention.

With the above arrangement of parts when 65 the engine is started the magnet 18 is ener-

gized and raises its core so as to open the valve 17 to an extent determined by an adjustable screw 22. Excess fuel is thus admitted from the chamber 15 by the opening 70 of the valve 17, in addition to the regular supply of fuel admitted by the valve 16, and the engine is thus supplied with a surplus of fuel sufficient to cause it to properly start even though the temperature is low as might 75 be the case in relatively cold climates.

As the engine continues to operate its temperature and that of its associated parts will gradually rise, thus heating the thermostat provided by the thermometer 21 until this short circuits the magnet 18, which is 80 thereupon deenergized and caused to release its core. The falling of the latter closes the valve 17 and thus cuts off the surplus fuel, although the engine continues to be supplied with fuel through the running valve 16. 85 When the engine stops operation and cools, the mercury in the thermometer 21 will fall sufficiently to break the connection between the contacts 19 and 20 and thus remove the short circuit of the magnet 18, thereby restoring the various parts to their original 90 relative positions ready for a repetition of the above described cycle of operations.

In addition to the engine 1 and dynamo electric machine 2, my system includes a 95 storage battery 23, which in the present instance has its negative terminal connected to the negative terminal of said machine while its positive terminal is connected to one of the line conductors 24 leading to the 100 apparatus to be supplied with current. The system further includes a governing device in the form of a drum controller 25 whose movable element is turned by a small electric motor 26. Said element which is 105 usually called the drum, consists of a shaft or spindle 27 turned by the motor 26 and having fixed upon it a series of segmental contacts 28-36, all electrically connected, and as shown in Fig. 3, designed to electrically 110 coact with a series of relatively fixed contact fingers 37-45.

The motor 26 is so connected that its armature and therefore the shaft 27 of the controller, must necessarily turn in but one 115 direction only, as indicated by the arrow in Fig. 1, and in order to prevent burning of the active surfaces of the segments and fingers I construct these as shown in detail in Fig. 3. Each of the fingers of which that 120 shown at 42 is typical, preferably has a substantially T-shaped form and is pivoted to a supporting structure 46 of insulating material so that its long arm or stem projects at right angles thereto. For so supporting 125 each finger it is movably connected to a base piece 47 by a pivot screw or pin 48 and said base piece in turn is held in place by a stud or bolt 49 extending through the insulating support 46. This stud also holds in place a 130

plate 50 whereby a spring 51 is retained in a passage extending through the insulating support and bearing upon one of the arms of the finger 42 so as to hold it in engagement with the contact segment of the controller with which it cooperates.

Each of the segments such as that shown at 33 is made of a definite angular length and may have fixed to that one of its ends which is designed to first make contact with the cooperating finger 42, a cam structure 52 rigidly held to but insulated from it in any suitable manner so that its outermost portion is further from the center of rotation or shaft 27 than is the cylindrical surface of the contact 33. The opposite end of said contact is formed with a substantially radial surface 53, as is also the outer extremity 54 of the contact finger 42. As a result, when the shaft 27 and therefore the contacts thereon, are turned in the direction of the arrow (Figs. 1 and 3) each finger equipped as above indicated is first engaged by the cam structure 52 so that it is forced outwardly to a greater distance from the shaft 27 than that of the cylindrical surface of the segment 33. As the rotation of the shaft 27 continues said finger is dropped from its elevated position on the outer end of the cam 52 upon the cylindrical surface of the segmental contact 33 and thereafter electrically engages it until the spindle 27 has so far turned as to permit said finger to drop off of its abruptly terminated end. As a consequence there is no burning of either the finger or the segment when these are first engaged and the arc formed by breaking the circuit between the finger 42 and said segment is struck between the two surfaces 53 and 54. If therefore any burning or roughening occurs from this arcing, it in no way affects the active contact surfaces formed by the under side of the contact finger or the cylindrical surface of the contact segment so that it is possible to maintain these in the highly polished unoxidized condition best suited for high conductivity and minimum interference with the current flow. Moreover by the arrangement shown the life of the contacts is indefinitely prolonged, since in the absence of the burning or cutting which customarily results from arcing, the wear occurring is practically negligible.

My system further includes two relays A and B whose preferred construction is illustrated in Fig. 4. In the case of the relay A, there is provided a permanent magnet 55 to one of whose poles is pivoted a depending iron or steel armature 56 free to move by magnetic attraction toward either of two pole pieces 57 and 58 mounted on its second pole. Two fixed contacts 59 and 60 are so placed that the first of them is engaged by the armature 56 when it is attracted to the pole piece 57, while the second is similarly

engaged when said armature is attracted to the pole piece 58.

In constructing the relay, the pole pieces 57 and 58, as well as the yoke 61, are preferably made of soft iron and upon them are mounted two pairs of coils, of which those indicated at 62 and 64 are connected differentially with respect to a similar pair of coils 63 and 65. In other words, the coil 62 is so connected to the coil 64 that when a current flows in the direction of the arrow the magnetism of one of the poles, as 57, is increased while that of the other pole 58 is decreased. The two coils 63 and 65 are likewise connected but with a resultant reversal of polarity of the two poles with a current flowing in the direction of the arrow. Obviously it is not absolutely necessary to provide two coils on each of the pole pieces 57 and 58, since the device can be made to operate with but a single coil and for convenience of description I have so illustrated the relays A and B in Fig. 1.

With the above described arrangement of parts the armature 56 is included in the circuits which include the fixed contact members 59 and 60 and said armature engages the contact 60 when the coil 62 is energized and engages contact 59 when the coil 63 is energized. The relay B is constructed similarly to the relay A, having a pair of fixed contacts 66 and 67 and a movable armature constituting a swinging contact 68 designed to engage the contact 67 when the coil 69 is energized and to engage the contact 66 when the coil 70 is energized.

In addition to these two relays, I provide a so-called load responsive device consisting of an electromagnet 71 whose movable element is connected to a movable switch member 72 in the manner illustrated in Fig. 5. For this purpose I suspend a flat metallic ribbon 73 from a suitably fixed structure 74 and on this ribbon mount a balance arm 75, on one of whose ends is carried an adjustable weight 76 retained in any desired position by a set screw 77. From the other end of the balance arm is suspended a soft iron plunger 78 constituting the core of the electromagnet 71, which has extending axially into its interior from its lower end a longitudinally adjustable element in the form of an iron screw 79 having a lock nut 80 whereby it is retained in any given position and constituting a damping or limit device for the plunger 78 to govern its downward movement. The flexible ribbon 73 is continued below the balance arm 75 and its lower end is formed to constitute or carry a contact member 81 which may engage either of two contacts 82 or 83, depending upon the energization of the magnet 71.

The winding of the magnet 71 is designed to be connected in series with the circuit

supplied by the system, and is so designed that when the load on the line increases to a predetermined extent, the core 78 is drawn down, thus causing the contact 81 to engage the contact 83 and permitting current to flow through the circuit in which these elements are included so as to cause starting of the engine as hereafter explained. On the other hand when the load decreases to a certain extent the weight 76 causes an upward movement of the core 78 sufficient to bring the contact 81 into engagement with the contact 82, thus completing another circuit and resulting in stopping of the engine.

For making the operation of the system dependent upon the specific gravity of the electrolyte in the storage battery 23, I provide a controlling hydrometer arranged as illustrated in Fig. 6, in combination with a fixed supporting structure 84 having suspended from it a flexible metallic ribbon 85. This carries a transversely extending balance arm 86 on one end of which is adjustably mounted a weight 87 while from its second end is suspended a glass bulb 88 having an open neck 89. Said bulb is at all times immersed in and filled with the electrolyte of one of the storage battery cells 90 so that it rises and falls with changes in the specific gravity of this liquid. Moreover the device possesses the well known advantage of automatically compensating for changes in the temperature of the electrolyte so that regardless of such changes, when the specific gravity of said battery has fallen to the predetermined point, depending on the amount of discharge of battery, the bulb 88 falls, so tilting the balance arm 86 that the extension 91 of the ribbon 85 is swung to one side sufficiently to bring the contact 92 carried by it into engagement with the fixed contact 93. On the other hand, when the specific gravity of the electrolyte rises to a predetermined point, as determined by the charge of the battery, the bulb 88 moves upwardly, thereby swinging the contact 92 away from the contact 93 and into engagement with a second contact 94. As in the case shown in Fig. 5, the swinging contact 92 forms part of an electric circuit which includes the suspending ribbon 85 and a suitable terminal connected thereto on the supporting structure 84.

In setting up the hydrometer when the storage battery is first installed the bulb 88 and open neck 89 are filled with electrolyte of the same specific gravity as the surrounding electrolyte. The weight 87 is then moved on balance arm 86 until the movable contact 92 is just out of contact with fixed contact 94. As shown in the drawings the neck 89 is a relatively long curved tube of very small diameter, and there is but little

force tending to cause circulation between the electrolyte within and without the bulb. Therefore, as the battery discharges, the electrolyte within the bulb maintains very approximately its original specific gravity and consequently the mass of the apparatus suspended from the left hand end (Fig. 6) of balance arm 86 remains substantially constant. However, as the specific gravity of the electrolyte outside the bulb decreases during discharge of the battery, the relative mass of the bulb and its contents increases and pulls down the left end of arm 86 until the battery is discharged to a predetermined extent at which time contact 92 will close against contact 93.

With regard to the automatic temperature compensation of the hydrometer, it is apparent that the specific gravity of the electrolyte both within and without the bulb will be affected in equal proportions by changes in temperature. Thus on an increase of temperature the liquid within the bulb will expand a very small amount and a minute quantity of electrolyte will be forced from within the bulb through neck 89 into the exterior electrolyte, thus preventing the development of any pressure within the bulb. Since the outside electrolyte also expands it is obvious that temperature changes will not produce any movement of the balance arm or contact 92, so that the hydrometer is automatically compensated for changes in temperature.

An additional element of my apparatus consists of a reverse current relay C which, like the relays A and B, includes a permanent magnet frame 95 having wound upon it coils 96 and 97 connected in series. This relay also includes a swinging contact member 98 designed to be drawn into engagement with the fixed contact 99 when the current flows in one direction through the coils 96 and 97 and to be moved into engagement with the second fixed contact 100 whenever the current flows through said coils in an opposite direction. I also employ an alarm 101 which may be either of the audible or of the visible type and so connected as hereafter described as to automatically give notice of any faulty action of my system, it being also caused to operate whenever the relay C is operated by a reversal of the current flow through its coils.

A fuse or equivalent device 102 is connected on the negative side of the system immediately adjacent the negative terminal of the dynamo electric machine 2 and has in shunt with it a resistance coil 103 so designed that when for any reason said fuse blows, sufficient current may still flow through the resistance to cause operation of the reverse current relay C without operating the dynamo electric machine 2 as a motor. As a matter of convenience the coils 62, 63, 130

69 and 70 of the relays A and B are so wound that when any one of them is supplied with current its cooperating movable element 56 or 68 is not attracted but is repelled. Under normal conditions the armature or movable contact member 98 of the relay C is always in engagement with the contact 100 and is so formed and mounted as to be conveniently moved by hand.

Without naming in detail the conductors connecting the various pieces of apparatus comprising my system, it may be noted that a normally closed switch 104, is included in a conductor 105 connected both to the contact 59 and to the coil 63 of the relay A as well as to a conductor 106 extending between the contact finger 40 of the controller 25, the ignition apparatus 107 of the engine and the contact 99 of the relay C. The ignition controlling apparatus 107 of the internal combustion engine 1 is supplied with current from this same line 106 through a conductor 108. The shunt field winding 109 of the dynamo electric machine 2 is connected in circuit with the thermostat 21 and the magnet 18 and through two bodies of resistance 110 and 111 with the conductor 105. The latter of these bodies of resistance however is designed to be short circuited when the switch 104 is engaged with contact 140, although this switch, under normal conditions, engages the contact 141. The series winding 112 of the dynamo electric machine is connected between its positive terminal and the finger 44 of the controller 25.

If it be assumed that the apparatus to be supplied with current is connected to the line conductors 24 and 24^a and that such current is being delivered from the storage battery 23 through the load coil 71, the engine 1 and dynamo electric machine 2 are idle and the drum of the controller 25 occupies such a position that it is engaged by the fingers 37—45 on the line $x-x$ so that only the segments 29, 30 and 33 are in circuit with their cooperating fingers 38, 39 and 42.

The switch 104 engages the contact 141, the armature 56 of the relay A is in engagement with the contact 59 and it is assumed that the armature 72 of the load relay occupies a position disengaged from its cooperating contacts 81 and 82, while the armature 68 of the relay B is in engagement with the contact 66. It is further assumed that the contact 92 of the hydrometer is disengaged from both of its contacts 93 and 94 and the armature 98 of the relay C engages the contact 100. All of these conditions will continue unchanged under normal operating conditions until the discharge of the storage battery has continued to such an extent that the resulting fall of the specific gravity of its electrolyte permits the bulb 88 to fall sufficiently to bring the contact 92 into en-

gagement with the contact 93. A circuit is thus established from the positive terminal of the storage battery to the contact finger 42 of the controller 25, thence through segments 33 and 29 to finger 38, coil 62 of relay A, contacts 93 and 92 of the hydrometer, contacts 66 and 68 of relay B, contacts 100 and 98 of relay C, controller motor 26 and thence to the negative terminal of the storage battery.

Although the resulting flow of current is insufficient to start said motor because the coil 62 is in series with it, the current will energize the coil 62, causing the armature 56 of the relay A to be repelled and engage the contact 60. This completes a circuit from the positive side of the storage battery to the contact finger 42, segments 33 and 29, finger 38, contact 60 of relay A, armature 56, contacts 66 and 68 of relay B, contacts 100 and 98 of relay C, motor 26 and to the negative side of the storage battery. The establishment of this latter circuit shunts the hydrometer contacts and in so doing prevents the formation of arcs in case said contacts are later separated, thereby insuring their long life. The controller motor 26 is started upon the completion of this second circuit and turns the drum in the direction of the arrow (Fig. 1) until the segment 28 engages the finger 37. A circuit is thereupon completed from the positive side of the storage battery through the drum of the controller as previously noted, to the finger 37 and thence directly through the controller motor 26 to the negative terminal of the battery. This shunts the contacts of the relay A and permits the controller motor to operate independently of them until the revolution of the controller drum brings the finger 40 into engagement with the segmental contact 31, thus completing a circuit from the positive side of the battery to said finger 40, through resistances 110 and 111, through the priming coil 18 on the engine 1 and the shunt field winding 109 of the dynamo electric machine 2, to the negative terminal of the battery 23. A second circuit is also completed by the contact finger 40 and segment 31 through the ignition apparatus 107 of the engine.

The continued rotation of the controller drum next brings the contact 36 into engagement with the finger 45 so that current flows from the positive side of the storage battery to said finger and thence through the compression releasing coil 6 of the engine, series field coil 112 of the machine 2, through the armature of the latter and to the negative side of the storage battery. Since the field coils of the dynamo electric machine are thus energized and its armature is supplied with current, it is set in operation as a motor, and being mechanically connected to the engine 1 will crank it.

Since the coil 6 is also energized, the valve

4 will be held open, thus releasing the compression of the engine and at the same time the spark plug 10 will be grounded so that back firing cannot occur. In the mean time the operation of the controller motor 26 brings the segment 35 of its drum into engagement with the finger 44, whereupon current flows from the positive side of the storage battery to said finger, directly through the series field 112 and armature of the machine 2 to the negative side of the storage battery, thus shunting the coil 6. As a consequence this latter is deenergized and the valve 4 is automatically closed by its spring 5, while in addition the ground is removed from the spark plug 10 so that the engine, being supplied with fuel, should begin to fire and at once take up its duty.

As the controller drum turns further, the contact 34 engages the finger 43, thus permitting current from the positive side of the storage battery to flow through said finger to the coil 11 and thence to the ground to which the negative side of the storage battery is connected. The core 12 of the magnet 11 is thus raised, causing the valve 13 to cut off the supply of air to the mixing chamber 14 so that a rich mixture of fuel is delivered to the engine. The rotation of the controller drum shortly causes the contact 34 to disengage the finger 43 so that this latter circuit is broken and by reason of the deenergization of the magnet 11, the valve 13 is allowed to move to its open position permitting the engine to operate on its proper fuel supply and operate the machine 2 as a generator.

Current is now supplied to the line 24—24^a and also to the storage battery, which is charged, the machine 2 now acting as a compound wound generator, until by reason of the continued rotation of the controller drum, segment 35 is disengaged from finger 44, to open the circuit between the series field and the positive side of the battery and the segment 32 is brought into engagement with the finger 41, thus completing a circuit from the positive terminal of the generator 2 through the two windings 97 and 96 of the reverse current relay C, finger 41, segments 32 and 33, finger 42, to the positive side of the storage battery and through the latter to the negative terminal of the generator. The series field winding 112 is thus shunted by coils 96 and 97 and cut out of circuit by segment 35 so that said generator operates as a shunt wound machine, its shunt field circuit being completed from the positive terminal thereof through the coils of the relay C to the finger 41, thence through segments 32 and 31, finger 40, resistances 110 and 111, electromagnet 18 and shunt field 109 to the negative terminal of the generator. The drum of the controller still continues to turn under the action

of the motor 26 until the segment 28 disengages its contact finger 37, whereupon the circuit of said motor is broken and the controller drum comes to rest with the fingers on the line $y-y$. Of said fingers those indicated at 40, 41 and 42 are engaged with their respective drum segments.

Under these conditions the engine is in operation driving the generator, which is supplying current to the line and at the same time charging the storage battery 23. As said battery gradually becomes charged, the increased specific gravity of its electrolyte will cause the bulb 88 to rise until the contact 92 engages the contact 94 of the hydrometer switch thereby establishing a circuit from the positive side of the generator 2 through the coils of the reverse current relay C, controller finger 41, segments 32 and 31, finger 40, switch 104, coil 63 of relay A, contacts 94 and 92, contacts 66 and 68 of the relay B, contacts 100 and 98 of the relay C, through the controller motor 26 to the negative side of the generator.

The resulting current flow is not sufficient to operate said motor 26 but it energizes the coil 63 sufficiently to repel the armature contact 56, causing it to electrically engage the fixed contact 59. A circuit is thus completed from the positive side of the generator through relay C, finger 41, contacts 32 and 31, finger 40, switch 104, contacts 59 and 56 of relay A, contacts 66 and 68 of relay B, contacts 100 and 98 of relay C, motor 26 and to the negative side of the generator. Said motor is thus again put in operation in the same direction as originally; causing disengagement of the controller segment 32 from its finger 41 and opening the armature circuit of the generator. The further rotation of the controller drum shortly thereafter causes disengagement of the segment 31 from the finger 40 which breaks the field circuit of the generator as well as the ignition circuit of the engine and likewise opens the circuit of the controller motor 26.

As a consequence of this operation the entire system is shut down with the contact fingers 38, 39 and 42 engaged with the drum segments 29, 30 and 33, on the line $x-x$. The storage battery is now in a charged condition and supplies current to the line 24—24^a, while all of the contacts of the several relays etc. are in their original positions, with the exception that the hydrometer contacts 92 and 94 are engaged, although they are separated as the battery discharges or until the battery is so far discharged as to cause operation of the hydrometer switch, whereupon the above cycle of operations will be repeated.

If when the system is shut down more than a predetermined current should be taken on the line 24—24^a, the resulting en-

ergization of the load coil 71 results in its contact 72 being moved into engagement with the contact 83, so that current is free to flow from the positive side of the storage battery to finger 42, segments 33 and 30, finger 39, coil 69 of relay B, contacts 83 and 72 of the load relay, contacts 100 and 98 of the relay C, through the controller motor 26 to the negative side of the storage battery. As before this primary current flow is insufficient to start said motor, but is ample to cause the movable contact 68 of the relay B to be repelled into engagement with the contact 67, with the result that said relay, as well as the contacts 81—83 of the load relay are shunted, current from the positive side of the storage battery passing from the finger 39 through contacts 67 and 68 of relay B, contacts 100 and 98 of relay C to the negative side of the storage battery through the controller motor 26. Said controller motor is thus put in operation and turns the controller drum to cause starting of the engine 1 as heretofore described. Said engine will thereafter continue to operate until by reason of the reduction of the load on the line to a predetermined amount the contact 81 of the load coil will move into engagement with the fixed contact 82, with the result that a circuit is completed from the positive side of the generator 2 through the coils of the relay C, contact finger 41, segments 32 and 31, finger 40, switch 104, contacts 59 and 56 of relay A, coil 70 of relay B, contacts 82 and 81 of the load relay, contacts 100 and 98 of relay C, controller motor 26 and to the negative side of the generator. The energization of the coil 70 repels the armature contact 68 and by shunting out of circuit said coil and the contacts 82 and 81 of the load relay, permits sufficient current to flow to the controller motor 26 to put this in operation. The resulting rotation of the controller drum thereupon causes stoppage of the engine and shutting down of the system as previously described.

The relay C is so designed that in case current flows through its coils in a direction opposite that occurring when the generator 2 is supplying current, its armature contact 98 is caused to move into engagement with the contact 99. When the engine is operating the generator and the latter is supplying current to the battery or to the line or to both, the fingers of the controller engage the drum thereof along the line $y-y$, under which conditions the fingers 40, 41 and 42 engage the segments 31, 32 and 33. If now the engine should fail to operate by reason of lack of fuel, faulty ignition, or because of any mechanical trouble, the generator 2 would be at once supplied with current from the storage battery and would tend to operate as a motor, a circuit being completed from the positive side of said battery to the

finger 42, segments 33 and 32, finger 41, coils 96 and 97 of the relay C, armature of the generator 2 and to the negative side of the battery. As above noted, such a current flow would cause the machine 2 to tend to operate the engine, but the reversal of the current through the coils of the relay C causes its armature contact 98 to disengage the contact 100 and engage the contact 99, thus establishing a circuit from the positive side of the storage battery through finger 42, segments 33 and 31, finger 40, contacts 99 and 98 of relay C and controller motor 26 to the negative side of the storage battery. Said controller motor now starts and rotates the drum of the controller into such a position as will shut down the system as heretofore described. However when said drum comes to rest under these conditions with the contact fingers engaged along the line $x-x$, one of two circuits is established, depending upon whether the engine prior to its failure had been started by the operation of the hydrometer switch or whether it had been started by the load relay.

In the former case, the armature contact 56 of the relay A is in engagement with the contact 60 and the armature contact 68 of the relay B is in engagement with the contact 66, so that a circuit is completed from the positive side of the storage battery to the contact finger 42, through segments 33 and 29, finger 38, contacts 60 and 56 of relay A, contacts 66 and 68 of relay B, alarm or signal 101, controller motor 26 and to the negative side of the storage battery. As a result the alarm will be operated until the fault causing the shut down is rectified and the armature 98 of the relay C is operated manually to cause it to engage with the contact 100, whereupon the engine will automatically start and thereafter operate as previously described.

If on the other hand the load coil 71 had operated to start the engine prior to its failure, then the armature contact 68 of the relay B is in engagement with the contact 67. Under these conditions the circuit is completed through the alarm as last described with the exception that the current flows through the segment 30 and controller finger 39.

If the engine should not be supplied with fuel or in case anything should occur which would prevent its starting when it was cranked as above described, then when the contact finger 41 was engaged by the segment 32 of the controller, the generator 2 would act or tend to act as a motor by reason of the current supplied from the storage battery. As such current flow however would pass through the coils 96 and 97 of the relay C in a direction opposite to that occurring when the generator 2 is supplying current to the storage battery and line, the

armature contact 98 of said relay will disengage the contact 100 and move into engagement with the contact 99. As a result the controller drum will continue to revolve until it is engaged by the fingers along the line $x-x$, which as before described will result in the shutting down of the system.

Should the engine be blocked or should some accident occur which would prevent the armature of the generator rotating, the fuse 102 would blow, causing current to flow through the resistance 103. The latter however would limit the amount of such current to that necessary to operate the reverse current relay C and the controller motor 26 without permitting such a current flow as would be necessary to run the generator as a motor. However, as previously described, when the contact finger 41 is engaged by the segment 32, the reverse current through the coils of the relay C will cause the drum to take the position as just described. When the drum of the controller has turned sufficiently to cause the finger 41 to engage the segment 32, the reversed current flow through the relay C will so operate the armature contact 98 as to cause it to engage the contact 99, thereby supplying current to the controller motor 26. The latter will then operate until the drum is turned to a position in which the fingers engage it on the line $x-x$ which causes the breaking of the circuit between the generator and storage battery, opens the ignition circuit of the engine, stops the controller motor 26 and completes the circuit through the alarm 101.

The function of the resistances 110 and 111 is to permit such a current flow through the shunt field of the machine 2 as will cause it to generate current at a definite voltage, and the switch 104 is connected as shown in order that it shall be possible to overcharge the storage battery 23 if this is desirable. When said switch is engaged with contact 140 and the generator 2 is charging the battery (the fingers 40, 41 and 42 being engaged with their respective segments), it at the same time prevents stopping of the engine when the specific gravity of the battery has reached its predetermined high point by opening the circuit to coil 63 of relay A. As a consequence the generator will continue to operate and will overcharge the battery until the switch 104, which is manually operated, is made to engage contact 141 when the engine is caused to shut down. The resistances 111 and 110 are arranged to be inserted in series with the shunt field of the machine 2. When the switch 104 engages the contact 140, resistance 111 is shunted, causing a larger current flow through shunt field of generator 2 and raising the voltage of said generator as is necessary to overcharge the battery.

From the above description it will be noted that my system is primarily capable of automatically dealing with any of the accidents likely to occur under conditions of use and the apparatus is so designed and connected as to prevent injury in the event of the occurrence of abnormal conditions. The existence of such conditions is indicated by an alarm and the various pieces of apparatus are automatically disconnected by the action of the controller. The latter will operate to automatically shut down the system in case the engine is overloaded, when the supply of fuel is exhausted, or when for any reason the ignition system ceases to properly function.

If the engine or generator should be blocked or in such condition as to not be free to operate properly when the controller would ordinarily start the dynamo electric machine and engine to charge the battery, then the alarm is operated and the controller moves its drum to the starting position in which the battery and generator circuits are open. If when the armature contact 98 of the reverse current circuit breaker is manually operated to move it from engagement with the contact 99 into engagement with the contact 100, the controller motor starts and turns the drum through a complete cycle of operations so that it comes to rest at its starting point (the line $x-x$) without resulting in the cranking and subsequent starting of the engine, then it is obvious that some mechanical trouble exists which has caused blowing of the fuse 102, so that the discovery and removal of the cause of such action will permit the system to be started and properly operated when such fuse is replaced. Obviously any electrical fault with the generator 2 will similarly cause blowing of the fuse, in which case the resistance 103 limits the current flow to that sufficient to permit the controller motor to operate and turn the controller drum to the position $x-x$.

Should any of the relay contacts at any time be maliciously or accidentally moved from one position to another, this would in no way injure the system but would merely start the controller motor, which as hitherto described would operate until it automatically came to rest with the fingers engaging the drum along the line $x-x$. The same operation would occur in the event of short circuiting of any of the apparatus so that in no case could the storage battery and generator be so connected as to cause injury to themselves or to the apparatus with which they are associated in my system.

One important feature of my invention resides in the provision of the load coil 71 with the fixed core portion 79, which as previously described extends for an adjust-

able distance within the same. In the absence of this fixed core, the movable core or armature 78 would oscillate when the current flowing through the coil was increased by a large amount, so that the contact 72 would be brought into engagement with the contact 83 and cause starting of the system when even though less than the predetermined load had been applied. With the arrangement shown in Fig. 5 however, a relatively large increase of the load or current flow through the coil, less than that designed to start the system, will draw in the movable core 78 for a predetermined distance but without causing it to move beyond a definite point or oscillate and as a consequence the contacts 72 and 83 are not brought into engagement until the current flow through the coil has actually been increased by the predetermined amount intended to start the generator 2.

Another important feature of the invention resides in the equipment of the hydrometer- and load- controlled switches with the two relays A and B respectively, for it will be noted from the foregoing description that the closure of either one of these primary switches immediately causes operation of its relay and a consequent starting of the controller motor 26, regardless of whether or not the particular switch which has operated, remains closed. For example, if the hydrometer balance arm should be manually depressed so that it momentarily occupied a position corresponding to a considerable fall in the specific gravity of the battery electrolyte, a momentary closure of the switch contacts 92—93 would at once cause engagement of the relay contacts 56—60, so that even though said arm were immediately released, the controller motor 26 is started and the controller drum is caused to pass through its complete cycle of operations as above described. The advantage of these relays resides in the fact that burning or other injury to the contacts of the primary switches is effectually prevented so that their life and designed method of operation are indefinitely prolonged. Similarly the relation of the relays A and B to the controller is such that after the latter has once been put in operation by the closing of the switches of either of said relays, it will continue its operation regardless of whether or not the relay armatures remain in their switch closing positions.

I claim:

1. In a system of the character described, a prime mover, a dynamo electric machine for starting the prime mover and adapted to be driven thereby to supply current to a work circuit, a storage battery, a motor-driven controller, means for starting the controller upon decrease in the charge of the battery below a given point to connect

the storage battery to the dynamo electric machine and start the prime mover, means for starting the controller when the load on the battery is greater than a certain amount, means for stopping the controller and causing the dynamo electric machine to be driven by the prime mover, means for re-starting the controller when the battery is re-charged to a predetermined point, and means operated by the controller for disconnecting the dynamo electric machine a predetermined time after failure of the prime mover to start.

2. In a system of the character described, a prime mover, a dynamo electric machine, a storage battery, a controller, two polarized relays, a reverse current relay, a switch operated by changes in the conditions in the storage battery for operating one polarized relay, another switch operated by changes in the load on the system for operating the other polarized relay, a switch operated by the latter polarized relay to affect the reverse current relay, and means for intermittently moving the said controller and sequentially bringing the dynamo electric machine and the prime mover into operative relation with the storage battery for the purpose specified.

3. In a system of the character described, a prime mover, a dynamo electric machine, a storage battery, a controller, two double-acting electro-magnets, a reverse current relay, a load relay, a hydrometer switch, connections between the switch and one of the electro-magnets for starting the controller when the specific gravity of the battery falls below a given point and for starting the controller when the specific gravity reaches a predetermined point, means of connection between the load relay and the other electro-magnet for starting the controller when the demand for current exceeds a given amount or falls below a given amount, and means of connection between the reverse current relay and the load relay and its electro-magnet and the controller and the dynamo electric machine for controlling the starting and stopping of the controller and the dynamo electric machine.

4. In a system of the character described, a storage battery, a load coil normally connected in a work circuit with the storage battery, a reverse current relay, a motor driven controller, a prime mover, a dynamo electric machine, two electro-magnets, means controlled by the condition of the charge in the storage battery for throwing the controller and the reverse current relay in circuit with one of the electro-magnets, means for shunting the said electro-magnet, means for shunting the said relay, a shunt field resistance, means for bringing the shunt field resistance into circuit, means for causing the dynamo to run as a motor and start the

prime mover, a priming coil thrown into circuit with the starting of the prime mover, means for stopping the controller, means for starting the controller and stopping the engine when the battery charge reaches a predetermined condition, and means for stopping the controller in its original position with the load coil and battery in circuit and the controller, electro-magnet and relay out of circuit.

5. A controlling apparatus for a system of the character described, comprising a motor-driven controller, a load coil, a reverse current relay, two electro-magnets, a hydrometer switch, means of connection between the load coil and one of the electro-magnets for starting the controller motor, means of connection between the hydrometer switch and the other electro-magnet for starting the controller motor, and means of connection between the reverse current relay and the controller, said apparatus being adapted to be used in connection with the dynamo electric machine, prime mover and the storage battery.

6. The combination in an electric generating system of a storage battery; a dynamo electric machine; an internal combustion engine operatively connected to said machine; a controller for governing the operation of said machine by the engine including means for causing cranking of the latter under predetermined conditions; a circuit opening device in series with the dynamo electric machine; and a body of resistance in shunt with said device for permitting sufficient flow of current to allow of operation of the controller without causing operation of or injury to said dynamo electric machine when said circuit breaking device is open.

7. The combination in an automatic elec-

tric generating system of a storage battery; a dynamo electric machine; a prime mover for operating said machine; a controller for governing the operation of the system; a motor for driving said controller; a circuit controlling device in series with said machine and with said motor; and a body of resistance in shunt with said device for limiting the current flow to an amount sufficient to operate the motor after said device has opened its circuit.

8. The combination in an automatic electric generating system of a storage battery; a dynamo electric machine; a prime mover for operating said machine; a controller for governing the operation of the system; a motor for driving said controller; a reverse current relay controlling said motor; a circuit controlling device in series with said machine and with said motor; and a body of resistance in shunt with said device for limiting the current flow to an amount sufficient to operate the relay without operating the machine after said device has opened its circuit.

9. In a system of the character described, a storage battery, a dynamo electric machine, a prime mover, a motor-driven controller, a load coil in series with the battery, an electro-magnet switch controlled by the load coil for starting the controller motor, a hydrometer switch responsive to the condition of the battery, an electro-magnetic switch operated by said latter switch for starting the controller motor, and a reverse current relay switch having contacts connected to the load coil switch, to the controller and to the dynamo electric machine for re-starting and stopping the controller motor.

In witness whereof I affix my signature.
ALFRED R. VAN HORN.