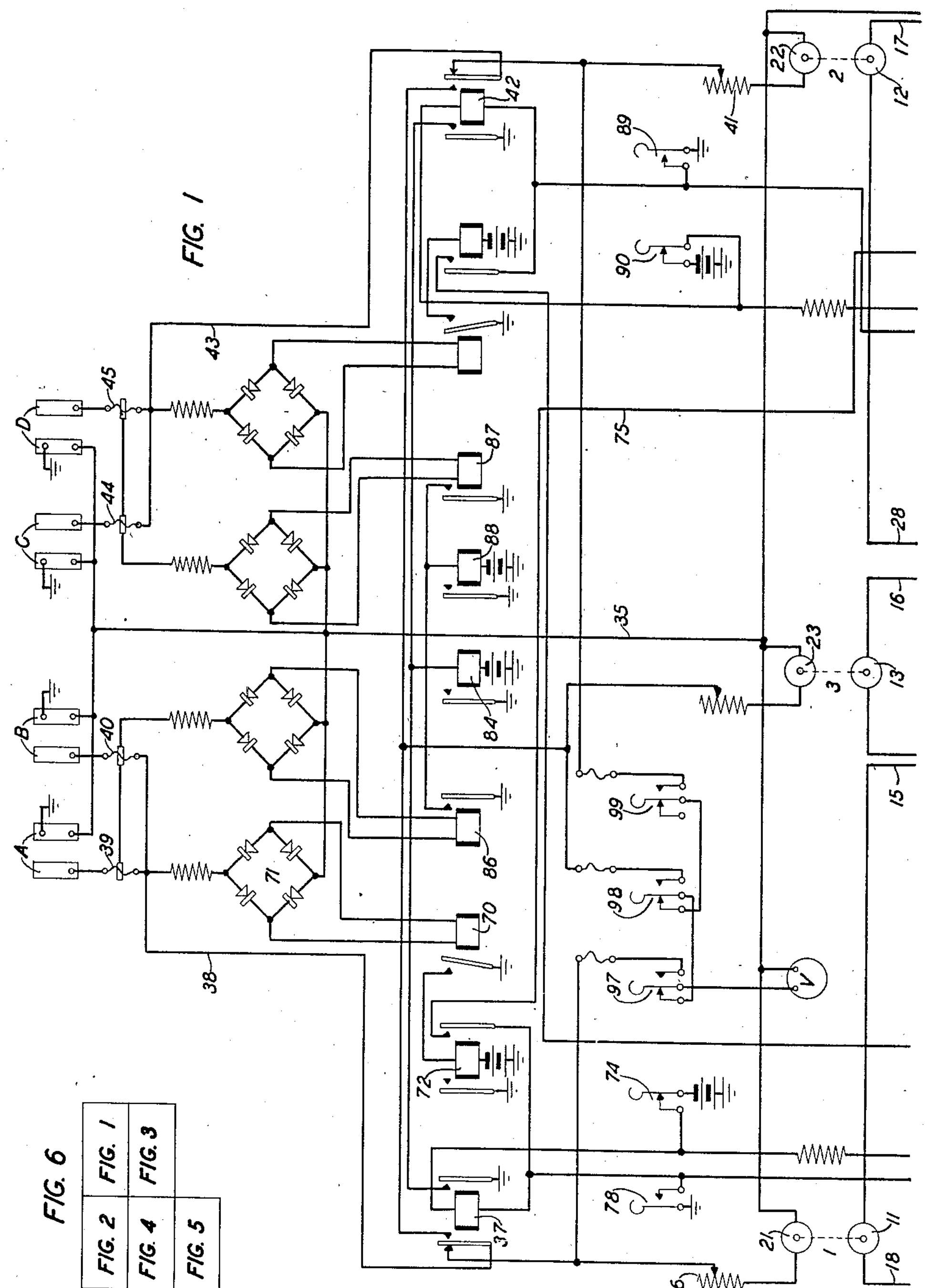
Oct. 9, 1945. H. H. SPENCER 2,386,638

POWER PLANT

Filed Feb. 9, 1944 5 Sheets-Sheet 1



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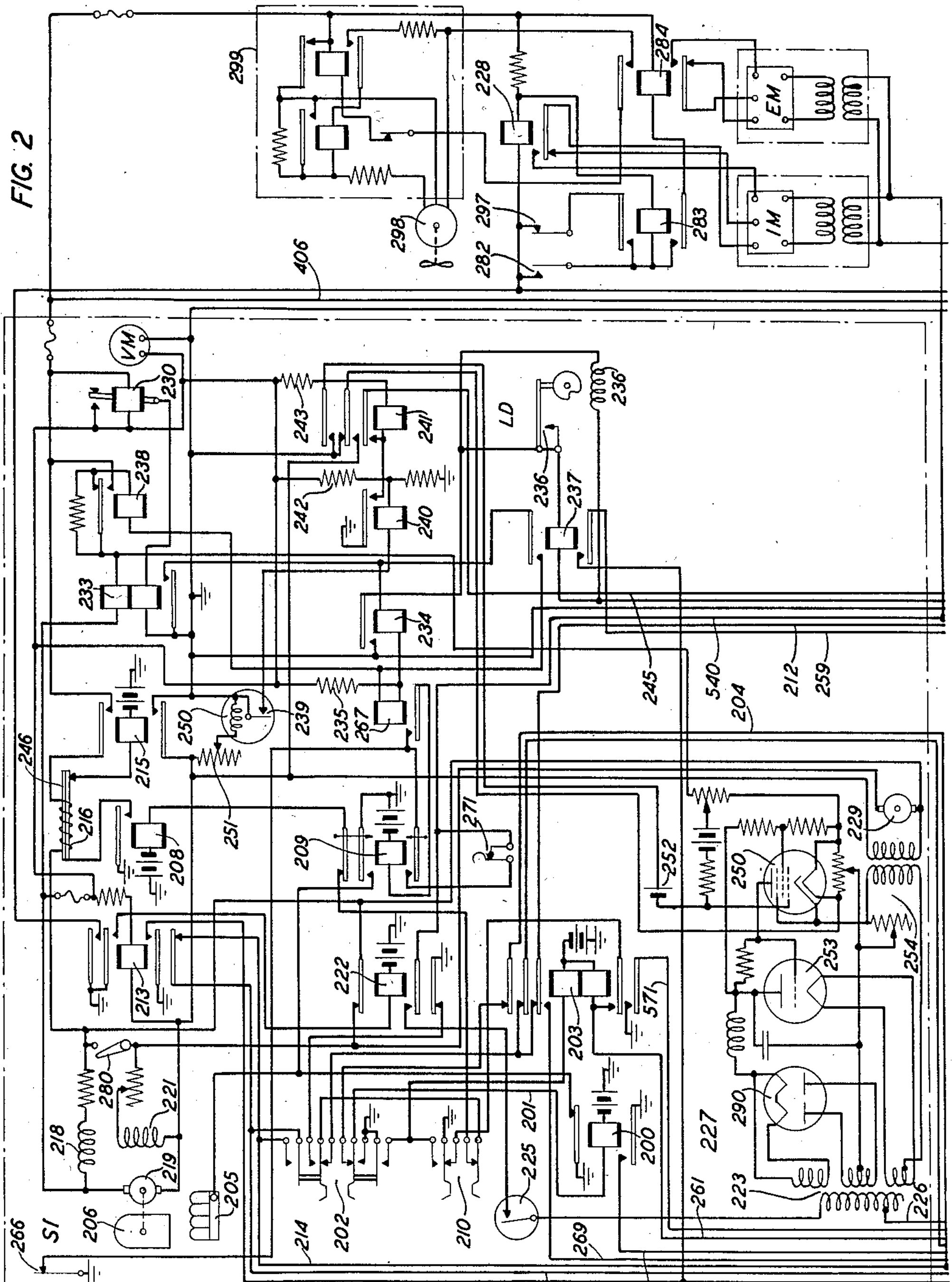
Filed Feb. 9, 1944 5 Sheets-Sheet 2

FIG. 2



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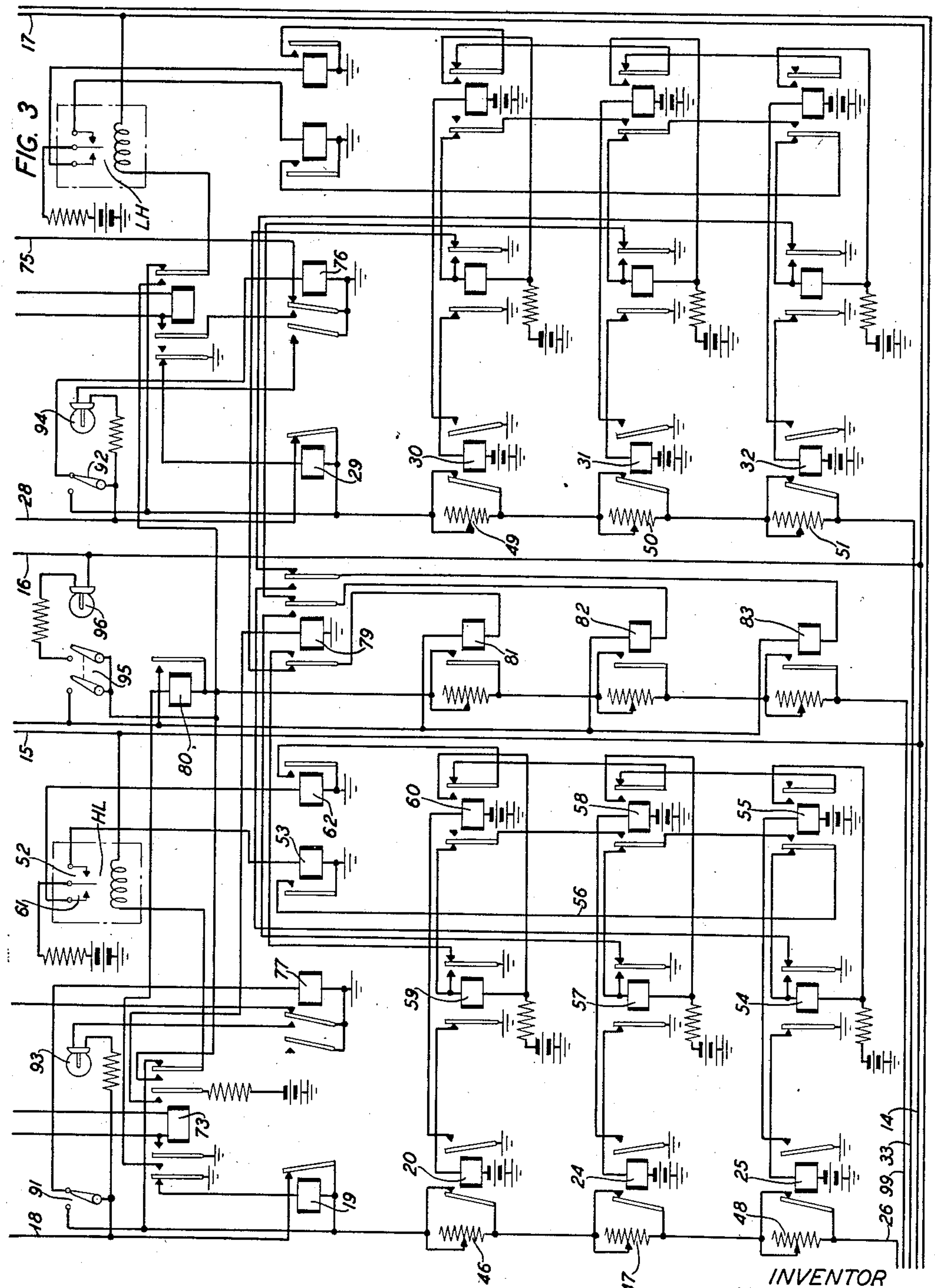
POWER PLANT

Filed Feb. 9, 1944 5 Sheets-Sheet 3

FIG. 3



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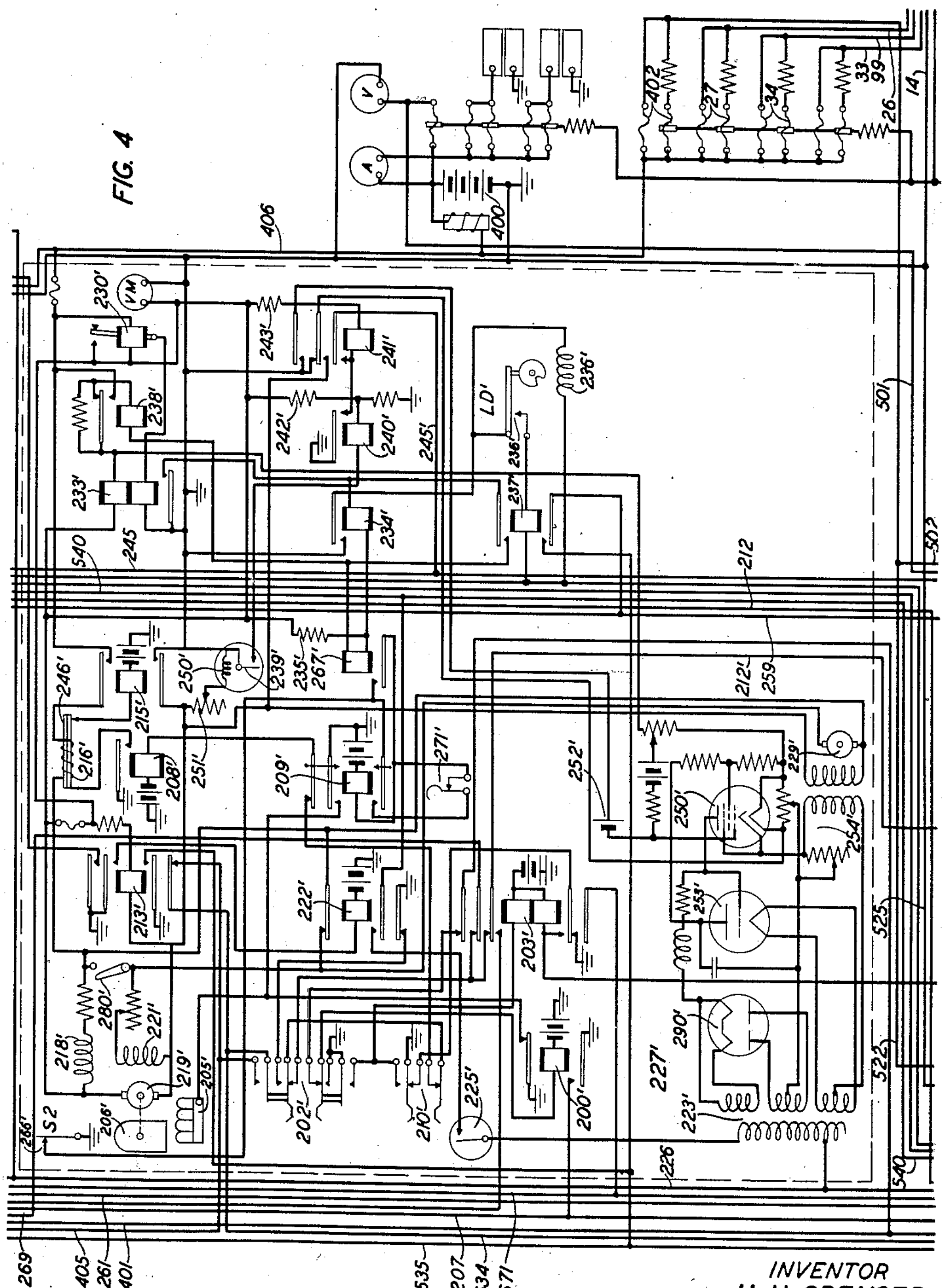
POWER PLANT

Filed Feb. 9, 1944

5 Sheets-Sheet 4

FIG. 4



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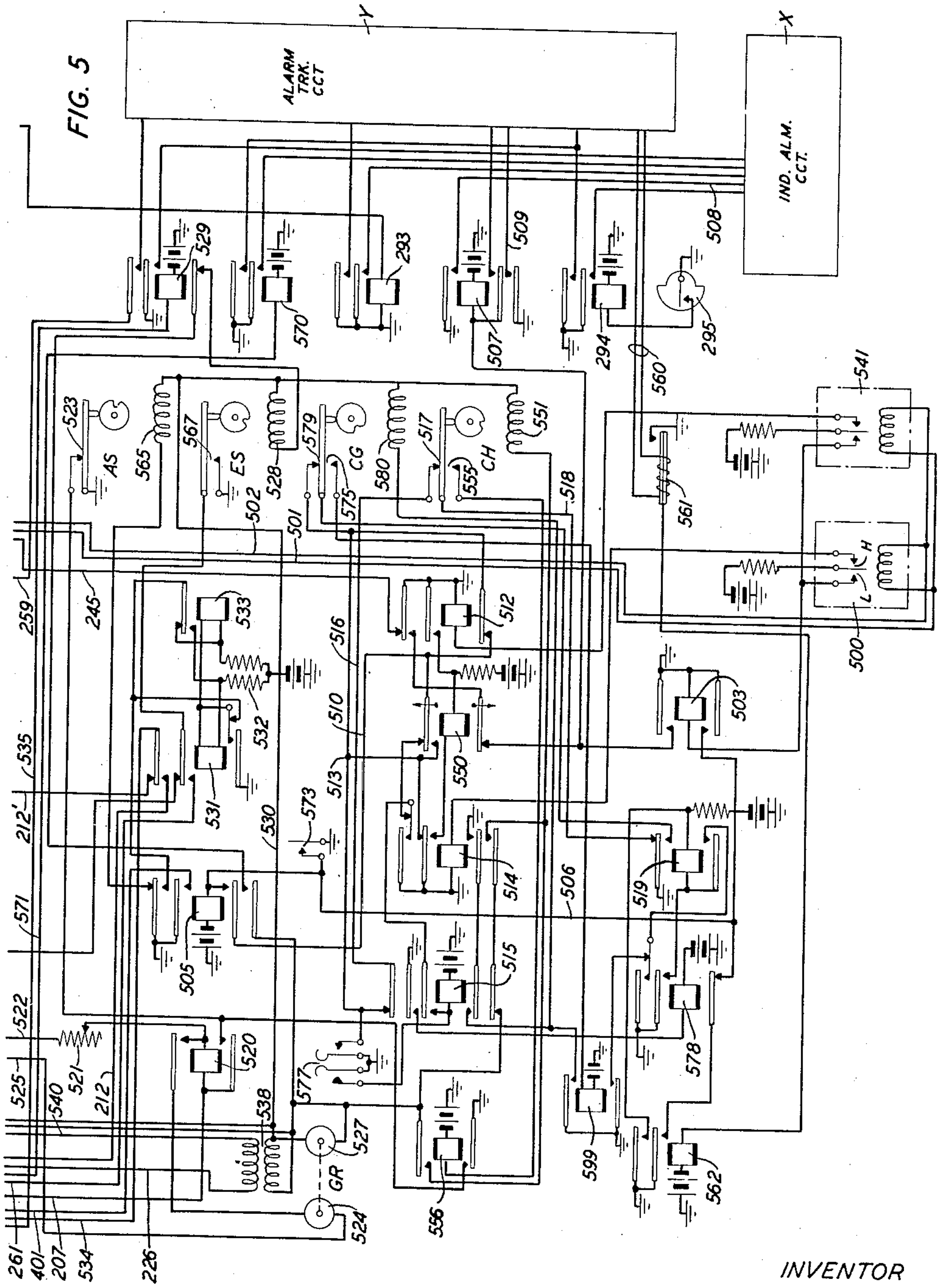
Oct. 9, 1945. **H. H. SPENCER** **2,386,638**

POWER PLANT

Filed Feb. 9, 1944 5 Sheets-Sheet 5

FIG. 5



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UNITED STATES PATENT OFFICE

2,386,638

POWER PLANT

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Application February 9, 1944, Serial No. 521,649

9 Claims. (Cl. 290—30)

This invention relates to electric power generating plants and particularly to automatically controlled power plants of the type employed in telephone communication systems.

Long distance telephone communication systems, such as transcontinental carrier telephone systems, require repeater stations at more or less regular intervals throughout their length to provide the necessary amplification of the signal carrying currents. Some of these repeater stations may be located, necessarily, in remote sparsely settled parts of the country where there is no commercial source of power available. The chief source of power for the current consuming apparatus, such as amplifiers, fans, heaters, etc., commonly used at such stations, are electric storage batteries which are maintained continuously charged, or are charged at regular intervals, as the charge is depleted by the load, by some auxiliary local source of direct current. In general, the remotely located repeater stations are unattended so that the facilities for charging the storage batteries must necessarily be controlled automatically in a manner such that an uninterrupted supply of power is insured, and should function continuously and effectively with a minimum of maintenance.

It is the object of this invention to provide an improved electric power generating plant which functions automatically to maintain an uninterrupted power supply at a station at which commercial power service and continuous maintenance are not available.

In the power supply system of this invention, the main power source comprises an electrical storage battery which supplies the various instrumentalities located at a repeater station with current, and a pair of internal combustion engine-driven generators are relied upon to maintain the battery voltage within predetermined levels as required by the load supplied thereby.

In accordance with a particular feature of the invention, suitable controls are provided which function automatically to render the two internal combustion engine-driven generators available, alternately, to charge the battery. More particularly, a pair of interacting relays are provided which function to preclude the possibility of one of the engine-driven generators being employed for successive charging operations and to thereby insure the use of the generators alternately in charging the battery.

Another feature of the invention contemplates the use of an electrically driven timing device which functions automatically to continue the charging of the battery for a period of two hours after the battery voltage has reached a predetermined high level, and to thereafter render the charging generator inoperative to further charge the battery.

A further feature resides in the use of an electrically driven timing device which serves automatically to delay the connection of the charging generator to the charging circuit for a predetermined interval of time after the voltage of the generator has built up to a predetermined level.

A still further feature of the invention provides means whereby, upon failure of the selected engine to start within a predetermined time and thereby drive its associated generator, the automatic controls are transferred to the second engine to cause it to start and to drive its associated generator for charging the battery.

Still another feature of the invention resides in the use of an alternating current generator or converter which serves to supply, among other things, the various electrically driven timers with alternating current. An auxiliary feature provides means whereby when a charging period has been completed and the controls are about to restore to normal condition, the converter is maintained operative for a predetermined interval of time to supply various ventilation controls with power.

Other features provide means for manually stopping and starting the charge from either the local unattended station or from a remotely located attended station; for manually initiating a charge of longer duration than the regular two-hours charge; for controlling the ventilation of the engine room at the unattended station; for automatically initiating a charge when the engine room temperature reaches a predetermined low temperature; and for operating alarm signals at both the local and distant stations to indicate various conditions which maintain at the local unattended station.

These and other features will be readily understood from the following detailed description when read in connection with the accompanying drawings, in which:

Figs. 1 and 3 are circuit diagrams which illustrate a particular type of load furnished by the storage battery of an unattended repeater station, and the controls therefor;

Fig. 2 is a circuit diagram showing one of the engine-driven generators, its controls and voltage regulator. This equipment is included within the space defined by the broken-line enclosure. To the right of Fig. 2 is diagrammatically illustrated the ventilation controls located in the engine room;

Fig. 4 is a circuit diagram, similar to that of Fig. 2, showing the second engine-driven generator, its controls and voltage regulator. To the right of Fig. 4 are schematically illustrated the storage battery and a plurality of individual fuse connections thereto over which various loads may be supplied with power from the battery.

Fig. 5 is a common control circuit which functions with either of the engine-driven generators of Figs. 2 and 4; and

Fig. 6 is a block diagram illustrating the manner in which the Figs. 1 to 5, inclusive, are assembled to effect a complete working system.

Each of the engine-driven generator sets designated S1 and S2 in Figs. 2 and 4, respectively, comprises an internal combustion engine and a direct current dynamo mechanically coupled together in a well-known manner. The dynamo is adapted to function as a motor to crank the engine and, when the engine starts, as a generator to supply charging current to the battery. As will appear from a later description, one or the other of the two engine-driven generator sets is selected for operation under control of a voltmeter relay **500** (Fig. 5), and the selection of either is determined by the operated or released conditions of relays **531** and **533** (Fig. 5). When one or the other set is selected, its dynamo functions as a motor to crank its associated engine, and when the engine starts, the dynamo is driven thereby as a generator to charge the battery.

A plurality of motor-driven timers LD of Fig. 2, and AS, ES, CG and CH of Fig. 5 perform various control functions. Each timer has its own separate driving motor as is schematically indicated by the coil appearing immediately below the contact-controlling disc. These motors receive power from the converter GR which comprises a direct current motor **524** and an alternating current generator **527**. The latter also furnishes current to the regulator transformers.

The condition of the power plant as illustrated in the drawings, particularly, Figs. 4 and 5, is such that the gas engine **206** and its associated generator **219** (Fig. 2) are unoperated as are also the gas engine **206'** and its associated generator **219'** (Fig. 4). In other words, the battery **400** (Fig. 4) does not yet require to be recharged. Under the condition illustrated relays **531** and **533** are unoperated.

It will now be assumed that the load on battery **400** has reduced its capacity to the point where its voltage causes relay **500** to operate its low voltage contact L. Relays **500** and **541** have their windings connected in parallel across the terminals of battery **400** by way of conductors **501** and **502** and are thus controlled in their operation by the battery voltage. Relay **500** is adjusted to operate its low voltage contact L at some value of voltage below 160 volts and approximately 141 volts, while it closes its high voltage contact H at about 157 volts. Relay **541** is adjusted to operate its low voltage contact L at about 139 volts and its high voltage contact at about 162 volts.

When relay 500 closes its low voltage contact L in response to a drop in battery voltage, relay **503** operates in an obvious circuit. At its upper armature and front contact relay **503** establishes an obvious energizing circuit for relay **507** and at its lower armature and front contact completes an operating circuit for relay **505** by way of conductor **506**.

Relay **507**, at its upper armature and front contact completes a circuit to the individual alarm circuit X by way of conductor **508** to cause the operation of a "low voltage" alarm signal at the local unattended station. By way of its outer lower armature and front contact relay **507** connects conductor **509** to the alarm trunk circuit Y to cause the appearance of a similar signal at a remote station (not shown). Relay **507**, by way of its inner lower armature and front contact, locks under control of the alarm trunk circuit.

Relay **505**, operated, locks in a circuit including grounded battery, winding, front contact and inner lower armature of relay **505**, conductor **510**, back contact and lower armature of relay **512**, to the point **513**, and thence in two parallel paths to ground, one by way of the back contact and inner upper armature of relay **514**, and the other by way of the back contact and outermost upper armature of relay **515**, conductor **516**, contact **517** of the motor-driven two hour timer CH, conductor **518**, back contact and upper armature of relay **519**. Thus, relay **505** is locked operated under control of relay **514** and also under control of the two-hour timer CH.

Relay **200** (Fig. 2) now operates in a circuit extending from grounded battery, winding of relay **200**, conductor **201** and the associated normally closed contacts of "test" key **202**, back contact and outermost upper armature of relay **203**, conductor **204**, conductor **401**, front contact and inner upper armature of relay **505** to ground. Relay **200'** (Fig. 4) will also operate at this time but, as will appear presently, performs no useful function.

At its upper armature, relay **200** removes ground from the magneto **205** of engine **206**, thereby readying the engine **206** for operation. At its lower armature relay **200** causes relay **520** to operate in a circuit extending from the positive, or ungrounded terminal of battery **400**, fuse **402**, conductor **522**, resistance **521**, winding of relay **520**, conductor **207**, front contact and lower armature of relay **200** to ground.

Relay **520**, operated, locks to ground by way of its lower armature and front contact, under the control of timer AS finding ground at contact **523** thereof. An auxiliary locking circuit for relay **520** is prepared which circuit is controlled by relay **556**. At its upper armature and front contact, relay **520** connects one terminal of the motor **524** of the converter GR to the positive terminal of battery **400** by way of conductor **522**, the other terminal of the motor being connected to the grounded terminal of battery **400** by way of conductor **525**. Thus the converter GR is started operating to furnish alternating current to various instrumentalities of the plant, such as the motors of the motor-driven timers.

At its outer lower armature and front contact, relay **505** completes a circuit to the motor winding **526** of three-minute timer ES. This circuit includes the front contact and outer lower armature of relay **505**, now connected to one terminal of the generator **527**, lower armature and back contact of relay **529**, motor winding **528** and conductor **530** which is connected to the other terminal of generator **527**. Thus the timer ES is started to operate to perform a function, at the expiration of three minutes, which will be fully described hereinafter.

At its outer upper armature and front contact relay **505** connects ground to the windings of relays **531** and **533** which relays as hereinbefore indicated, determine which of the two charging sources S1, S2, will be selected to charge the battery. Relay 531 accordingly operates in a circuit from grounded battery, resistance 532, winding of relay 531, normally closed make-before-break contacts of relay 531, to ground by way of the front contact and outer upper armature of relay 505. Relay 533 does not operate at this time since ground potential is connected to both of its winding terminals. Relay 531 locks to ground in an obvious locking circuit and opens its original operating circuit. These functions are performed by the lower armature of relay 531.

A start circuit to "start" relay 208 (Fig. 2) may now be traced from grounded battery, winding of relay 208, outer upper armature and back contact of relay 209, lower normally closed contacts of "stop" key 210, upper normally closed contacts of "test" key 202, back contact and innermost upper armature of relay 203, "start" conductor 212, front contact and outer upper armature of relay 531, conductor 534, outer lower armature and back contact of relay 213' (Fig. 4), conductor 405, outer lower armature and back contact of relay 213, conductor 214, conductor 401, front contact and inner upper armature of relay 505, to ground. It will be observed that a similar circuit to "start" relay 208' (Fig. 4) is at this time opened at the back contact and outer upper armature of relay 531 so that, though relay 200' operated, as hereinbefore described, and removed the ground connection from magneto 205' (Fig. 4) of the engine 206', this engine will not be caused to function since its corresponding start relay 208' is unoperated.

Relay 208, operated, causes relay 215 to operate in a circuit which includes the heat responsive element 246 of a thermal relay whose heater winding is indicated at 216. At its upper armature and front contact, relay 215 extends the conductor 406 from the positive terminal of battery 400 to the series field 218 of generator 219 by way of the winding 216 of the thermal relay and resistance 217, and at its lower armature and front contact connects ground to the other terminal of generator 219. Thus the generator 219 is caused to function as a motor to crank the engine 206. The ammeter 250 and its associated resistor 251 are effectively shunted during cranking by the lower armature and front contact of relay 215.

As soon as the engine 206 starts under the driving action of dynamo 219 functioning as a motor, the voltage generated by the shunt field 221 causes relay 213 to operate. At its outer lower armature, relay 213 opens the circuit to relay 208 causing this relay to restore its armature and thus to open the operating circuit for relay 215. Relay 215 accordingly, releases its armature to stop the cranking of engine 206.

At its inner lower armature, relay 213 causes relay 529 to operate in a circuit extending from grounded battery, winding of relay 529, conductor 535, front contact and inner lower armature of relay 213, to ground. At its lower armature, relay 529 opens the motor circuit to timer ES permitting the timer to reset. At its outer upper armature, relay 529 prepares the alarm trunk circuit Y for the receipt of an "engine operate" signal which is transmitted when relay 237 operates under control of three-minute timer LD as will be explained hereinafter. At its inner upper armature relay 529 connects ground direct to the individual alarm circuit to cause the immediate appearance of a signal at the local station.

Relay 213, at its inner upper armature and front contact completes an obvious operating circuit for relay 222. At its upper armature, relay 222 removes a short from the counter-electromotive force motor 229 of the regulator 227, and at its inner lower armature completes the following circuit: from the left terminal of the secondary winding of transformer 538 whose primary winding is connected directly across the generator 527 of converter GR, conductor 226, primary winding of regulator transformer 223, closed contacts of switch 225, front contact and inner lower armature of relay 222, conductor 540, to the right terminal of the secondary winding of transformer 538. In this manner alternating current from converter GR is supplied to the regulator transformer 223 and the regulator 227 is prepared for operation. The manner in which the regulator functions will be described hereinafter, it being understood that the regulator, per se, does not constitute a part of the present invention.

At its outer upper armature, relay 213 completes an operating circuit for relay 228 which causes the intake louvre in the engine room to be opened for ventilation purposes. The intake louvre motor is indicated at IM and the exhaust louvre motor is indicated at EM. With relay 228 operated the intake louvre motor functions to open the intake louvre.

As soon as the voltage of generator 219 builds up to approximately three volts above the voltage of battery 400, relay 230 operates and connects the lower winding of relay 233 across the generator output causing relay 233 to operate. Relay 234 now operates in a circuit from ground, winding of relay 234, resistance 235, to the positive terminal of generator 219. Relay 234 in operating, connects the motor winding 236 of the three-minute timer LD across the output terminals of the generator 527 of converter GR causing the timer LD to commence its cycle of operation. After three minutes have elapsed, the timer LD closes its contact 236, thereby connecting the winding of relay 237 in parallel with the motor winding 236 and causing relay 237 to operate. At its upper armature and front contact, relay 237 connects the winding of contactor relay 238 between ground and the positive terminal of generator 219 causing relay 238 to operate. Relay 28 functions to shunt relay 230 and to connect the generator 219 to the battery 400, the upper winding of relay 233 being serially included in this connection. The battery 400 is now charged by the generator 219.

When relay 237 operates, as described, it completes the connection from ground at the front contact and inner lower armature of relay 213 to the lead 259 which connects with the upper armature of relay 529. With relay 529 operated, an "engine operate" signal is transmitted over the alarm trunk circuit Y.

Thus far the system disclosed has been described under normal conditions of operation and it has been disclosed how, with relays 531 and 533 in the positions illustrated, relay 531 will operate in response to a low voltage condition of battery 400 as evidenced by the operation of voltmeter relay 500 to its low voltage contact L, and that three minutes after generator 219 builds up a voltage slightly in excess of that of the battery 400, the timer LD functions to connect the battery to the generator for charging thereby. Also have been described the transmission of "low voltage" and "engine operate" alarms and the readying of the regulator 227 for operation.

It will now be described how the charging of the battery is maintained for a period of two hours after the battery voltage has reached the high voltage contact point of relay 500, which, in practice, is 157 volts. When this voltage is reached, relay 500 closes its high voltage contact H whereupon relay 514 operates over an obvious circuit. At its inner upper armature, relay 514 completes an obvious energizing circuit for relay 550 and opens one of the locking circuits to relay 505. At its outer lower armature and front contact, relay 514 connects the motor winding 551 of the two-hour timer CH across the output terminals of the generator 527 of converter GR, this circuit including the outer lower armature and back contact of relay 515 and conductor 530. The timer CH thereupon starts its cycle of operation. Relay 505 is held operated as hereinbefore indicated under control of the timer CH, the holding circuit finding ground at a contact of relay 519 and including contact 517 of timer CH.

After the expiration of the time interval of two hours, the timer CH opens its contact 517 which interrupts the holding circuit for relay 505. Relay 505 accordingly releases its armatures. Relay 200 is thereupon deenergized causing ground to be connected again to the magneto 205 of engine 206 causing the engine to cease operating. Thus the charge to the battery is discontinued, and on current reversal from the battery, relay 233 is caused to release its armature, thereby permitting the timer LD to reset. Relay 237 thereupon releases and opens the circuit to the contactor relay 238, which relay then functions to disconnect the battery 400 from the generator. As the battery voltage falls, relays 500, 514 and 550 restore to normal.

When the timer CH opened its contact 517, it closed its contact 555 causing the operation of relay 556. Relay 556, operated, connects the motor winding 551 of timer CH to the generator 527 of converter GR, causing the timer to continue to operate until its contactor transfers to the position illustrated. In this position, contact 555 is opened to open the circuit to relay 556 whereupon this relay opens the circuit to the motor winding 551 causing the timer CH to be stopped from further operation.

When the engine 206 stops, as described above, relay 213 is restored to normal. At its inner lower armature and front contact, relay 213 opens the operating circuit to relay 529, causing this relay to release and to thereby cut off the "engine operate" alarms. At its upper inner armature and front contact, relay 213 opens the circuit to relay 222, which relay then functions to short the regulator motor 229; to open the circuit to the primary of the regulator transformer 223; and to release relay 228. Relay 228 functions to close the intake louvre in the engine room.

When relay 505 released, the three-minute timer AS started timing, its motor winding 565 being effectively connected to the generator 527 of converter GR by way of the outer upper armature and back contact of relay 505. Locking ground for relay 520 is thus maintained at contact 523 of the timer AS, holding relay 520 operated for three minutes after relay 505 releases provided relay 556 has released. This maintains the motor 524 of the converter GR connected to the battery 400 so as to provide power for operation of the louvre motors in the engine room. At the end of the timing interval, relay 520 releases and the circuit returns to normal as shown, except that both relays 531 and 533 will be operated, the latter having operated when relay 505 released and, at its outer upper armature and front contact, removed ground potential from the lower winding terminal of relay 533.

It will now be described how the engine-generator set S2 is automatically brought into service to the exclusion of set S1, when the battery voltage again reaches the low voltage contact point of relay 500. It will be understood that after the operation of set S1, relays 531 and 533 are left in operated conditions. Now when relay 500 again closes its low voltage contact L, relays 503 and 505 operate in the manner previously described. This time, however, with relays 531 and 533 operated, relay 505 connects ground to the lower terminal of relay 531 by way of the upper armature and front contact of relay 533, the lower terminal of relay 531 being already grounded by way of its locking armature and front contact. Relay 531 thereupon is deenergized and releases its armatures, and relay 533 remains operated.

When relay 503 operated, it closed an obvious operating circuit for relay 507 which relay functions, in the manner previously described, to cause the appearance of a "low voltage" alarm signal at both the local and distant stations.

Relay 505, operated, locks under control of the two-hour timer CH as in the previous description and among other functions, causes relays 200 (Fig. 2) and 200′ (Fig. 4) to operate, the former performing no useful function at this time as will appear from the following description. At its upper armature relay 200′ removes ground from the magneto 205′ of engine 206′, thereby readying the engine 206′ for operation. At its lower armature relay 200′ causes relay 520 to operate and lock under control of the timer AS, finding ground at contact 523 thereof. Relay 520, as in the earlier description, connects the motor 524 of converter GR to the battery 400 causing the converter to operate to furnish alternating current to various instrumentalities of the plant, such as the motors of the motor-driven timers.

Relay 505 at its outer lower armature and front contact completes an energizing circuit to motor winding 528 of the three-minute timer ES, causing the timer ES to operate as previously described.

With relay 531 unoperated and relay 533 operated, a start circuit to "start" relay 208′ (Fig. 4) may now be traced from grounded battery, winding of relay 208′, outer upper armature and back contact of relay 209′, lower normally closed contacts of "stop" key 210′, upper normally closed contacts of "test" key 202′, back contact and innermost upper armature of relay 203′, "start" conductor 212′, outer upper armature and back contact of relay 531, conductor 534, back contact and outer lower armature of relay 213′, conductor 405 outer lower armature and back contact of relay 213, to ground by way of conductors 214 and 401 and the inner upper armature and front contact of relay 505. It will be noted that relay 208 associated with the engine-generator set S1 cannot operate at this time since its operating circuit is opened at the outer upper armature and front contact of relay 531. Hence only the engine-generator set S2 is rendered operative at this time.

With relay 208′ operated, relay 215′ operates to complete the cranking circuit to the series field

218' of generator 219' causing the generator to function as a motor to crank the engine 206'. As previously described, the ammeter 250' and its associated resistor 251' are effectively shunted during cranking due to the engagement of the lower armature of relay 215 with its front contact.

As soon as the engine 206' starts under the driving action of dynamo 219' functioning as a motor, the voltage generated by the shunt field 221' causes relay 213' to operate. Relays 208' and 215' thereupon deenergize and the cranking of the engine 206' is stopped.

The operation of the circuit (Fig. 4) is identical with that of the circuit of Fig. 2, previously described, and it is believed unnecessary to describe it in detail further. Relay 213' performs similar functions to those performed by relay 213 and the generator 219' continues to charge the battery under control of the timer CH in a manner now apparent. At the expiration of the two-hour interval, which begins when the voltmeter relay 500 operates its high voltage contact H, the charging of the battery is discontinued and the circuit is returned to normal condition. When relay 505 restores its armatures, relay 533 releases. This condition will find relays 531 and 533 predisposed to cause the selection of the engine-generator set S1 for use to charge the battery when the battery voltage again reaches the low voltage level at which relay 500 operates its low voltage contact L. When this happens, relay 531 will reoperate which is the condition under which the earlier description was based and which resulted in the operation of the engine-generator set S1 to charge the battery.

It is apparent from the description thus far advanced that the engine-generator sets S1 and S2 are employed alternately to charge the battery 400 and that relays 531 and 533 function to insure this alternate use of the charging sources and to preclude the successive uses of either.

The above procedure applies when the engine selected for use in charging the battery 400 starts readily. If the engine 206, for example, should fail to start, cranking thereof continues until the thermal relay, comprising the heat responsive element 246 and the operating coil 216, functions to open the operating circuit for relay 215. Relay 215, released, disconnects the battery 400 from the generator 219 and cranking of the engine 206 is discontinued. The timer ES continues to operate for three minutes, when it closes its contact 567, whereupon relay 203 operates in a circuit extending from grounded battery, lower winding of relay 203, conductor 261, front contact and inner upper armature of relay 531, to ground at contact 567 of timer ES. Relay 203, operated, locks to ground at the upper normally closed contacts of "stop" key 210. A circuit may now be traced from ground, inner upper armature and front contact of relay 505, conductor 401, conductor 214, back contact and outer lower armature of relay 213, conductor 405, back contact and outer lower armature of relay 213', conductor 534, outer upper armature and front contact of relay 531, conductor 212, innermost upper armature and front contact of relay 203, conductor 269, middle upper armature and back contact of relay 203', thence through the upper normally closed contacts of key 202' lower normally closed contacts of key 210', back contact and outer upper armature of relay 209', to battery and ground through the winding of relay 208'. This last-mentioned relay then functions to start the gas engine-generator of S2 in the manner previously described. The battery 400 is then charged by the generator of S2 as previously described.

Relay 203, operated, causes relay 570 to operate in a circuit extending from grounded battery, winding of relay 570 conductor 571, outer lower armature and front contact of relay 203 to ground. Relay 570 operates and establishes obvious circuits to the individual alarm circuit X and the alarm trunk circuit Y over which "engine failure" alarms are operated.

Until the attendant manually releases relay 203 by operating key 210, each time the circuit calls for a charge the engine, which has not failed, will start first through relay 531 operated, then through relay 531 released. If both engines fail, both relays 203 and 203' would operate and lock and a "low voltage" alarm will supplement the "engine failure" alarm.

When an engine, such as engine 206 of Fig. 2, for example, is running, its output is regulated by the automatic regulator designated 227 in Fig. 2. This regulator, per se, which does not constitute a part of the present invention, comprises a full wave rectifier tube 290, a regulating tube 253, an amplifier tube 259 and a CEMF motor 229. The action of this regulator is such that with voltages below the desired value, the CEMF motor included in the shunt field of the generator 219 raises the generator voltage by reducing the potential drop across its armature. If under such a low voltage condition, the generator output should exceed the setting of the ammeter relay 250 (about 32 amperes), relay 240 would operate in a circuit extending from the positive side of the charging circuit, resistance 242, winding of relay 240, contact 239 of ammeter relay 220 to ground. Relay 240 operated, completes an operating circuit for relay 241 extending from ground, armature and front contact of relay 240, winding of relay 241, resistance 243, to the positive side of the charging circuit. Relay 241 functions to transfer the regulator to current regulation. Relay 241, operated, locks up in a circuit extending from the positive side of the charging circuit, resistance 243, winding, front contact and innermost armature of relay 241, conductor 245, back contact and outer upper armature of relay 512 to ground. Relay 512 is under the control of the high voltage contact H of voltmeter relay 541.

Current regulation is accomplished by applying a fixed bias direct to the grid electrode of the amplifier tube 259 of the regulator 227 such that constant output will be maintained from the generator 219. This bias is adjustable to give an output of about thirty amperes by varying the resistance 251. The bias applied to the amplifier grid is the differential between the potential drop across the resistance 251 and ammeter 250 as compared to a standard three volt grid battery 252, the connections to the amplifiers for these potentials being completed at the two upper front contacts and armatures of relay 241. A tendency of the generator output to increase will reduce the negative grid voltage applied to the amplifier tube 259 thereby increasing its plate current and applying a more negative bias to the regulator tube 253. This will reduce the current in the regulating field 254 so that it will have less bucking effect, thereby increasing the potential drop across the CEMF motor and reducing the generator output by reducing its field strength. A tendency of the generator output to fall off will, of course, have the opposite effect so that constant output is maintained until the battery voltage reaches a level such as to cause voltmeter relay 541 to operate its high voltage contact H. Relay 512 thereupon operates in an obvious circuit and at its upper armature and back contact opens the locking circuit for relay 241. Relay 241 accordingly releases its armatures, transferring the regulator control back to voltage regulation. The regulator, in this application, is adjustable to regulate the battery at 160 volts, measured at the battery terminals, which is below the point at which relay 541 operated (162 volts), so that relays 541 and 512 will release as soon as relay 241 releases.

Relays 500, 514 and 550, which operated when the voltage reached 157 volts under current regulation remain operated during change over from current to voltage regulation and ground potential at the upper armature and back contact of relay 519 is carried by way of conductor 518, contact 517 of timer CH, conductor 516, outermost upper armature and back contact of relay 515, front contact and upper armature of relay 550, conductor 510, inner lower armature and front contact of relay 505 to the winding of relay 505 and grounded battery, thereby maintaining relay 505 operated and keeping the engine 206 running.

As previously described, when relay 500 operated its high voltage contact H and relay 514 operated, the circuit to the motor winding 551 of the timer CH was completed and the timer functions to maintain the charge on the battery for a two hour period. Thus a two hour charge is maintained above 157 volts even though the voltage of 162 volts is not reached by that time.

Arrangements are also made to start the engine manually either at the local unattended station or at the remote station over the alarm system. The engine is started from the distant or attended station by the operation of an engine start key which by way of the alarm trunk circuit Y causes the energization of the operating coil of thermal relay 561 over conditions 560. When the heat responsive element of this relay functions to close its contact an obvious operating circuit for relay 562 is completed. At its lower armature and front contact, relay 562 places ground on the conductor 506 causing relay 505 to operate. Thus the engine is started in the same manner as described above when starting from the low voltage contact L of relay 541. This means of starting is provided as a maintenance feature to permit remote starting control. Operation of the engine will be indicated by the "engine operate" alarm signal and failure to start will be indicated, after three minutes, by the "engine failure" alarm in the manner previously described. Once started, the engine will run until the battery is charged to the regulated value when the engine will be cut off as described above.

The engine may be manually started at the local station by operating the "test" key 202 to the test position. With key 202 operated, relay 200 operates direct to ground at the contact of key 202 associated with conductor 201. Relay 203 operates over an obvious circuit and relay 208 operates in a circuit extending from grounded battery, winding of relay 208, outer upper armature and back contact of relay 209, lower normal contact of "stop" key 210, first upper alternate contact of "test" key 202, back contact and outer lower armature of relay 222 to ground. Relays 200, 203 and 208 perform the same functions ascribed to them in a previous description and the engine starts. The engine will run until the "stop" key 210 is operated causing relays 200, 203 and 208 to restore their armatures. Both keys 210 and 202 are then restored to their normal positions.

Manual operation may be employed at infrequent intervals for overcharging to return the batteries to a full charged gravity condition. Both engine sets S1 and S2 may be run at once under manual control at the local station but only one can be operated at a time automatically.

Each engine is provided, among other safeguards, with a low oil pressure contact, such as 266, which furnishes ground to the contact of relay 267 so that should this occur when relay 267 is operated, an obvious operating circuit is completed to relay 209. Relay 209 operates to ground the magneto 205 and thus stops the engine 206. Relay 209, operated, also opens the circuit to relay 208 to prevent cranking, and by way of its lower armature and front contact and the contacts of key 271 locks to ground at 266 and thereby maintains the engine 206 out of service until an attendant operates key 271. Low oil pressure when the engine is not running, and when starting, will have no effect as relay 267 will be released until relay 237 operates to cause contactor 238 to connect the generator to the battery, as previously described. On release of relay 237 when the engine shuts off under its normal control, relay 267 releases before relay 209 can operate from reduced oil pressure. Under this condition of low oil pressure an "engine failure" alarm is given after timer ES operates as a result of the engine's failure to start.

In addition to the automatic two hour charge at approximately 2.3 volts per cell each time the engine operates as previously described, provision is made for a monthly twelve hour check charge under automatic control by manually operating the "auto charge" key 577. This key, while operated, holds ground on relay 505 to maintain this relay locked to keep the engine running and also causes relay 515 to operate. Relay 515, operated, locks to ground at key 577 if the battery voltage is below the high contact value of relay 500, otherwise it locks to ground by way of the outer upper armature and front contact of relay 514. Relay 515, operated, causes relay 578 to operate which, in turn, operates and locks relay 519.

Relay 519 at its upper armature and front contact connects ground to contact 579 of the timer CG to hold relay 505 operated after key 577 is released. Relay 515, at its inner lower armature and front contact, prepares an operating circuit for motor winding 580 of timer CG which circuit is completed when relays 500 and 514 operate incident to the battery reaching the voltage at which relay 500 closes its contact H. Thus when the battery reaches this voltage the timer CG starts to function. The charge will continue for twelve hours when the timer CG breaks its contact 579. The generator regulator will hold current regulation as previously described until relay 541 operates its high voltage control H and will then transfer to voltage regulation at approximately 160 volts.

When the timer CG removes locking ground from the winding of relay 505, relay 505 releases, stopping the engine and causing the generator to be disconnected from the battery. On fall of voltage due to battery discharge relays **500**, **514** and **550** release opening the locking circuit to relay **515**. Relay **515** releases causing relay **578** to release. Relay **599**, however, is held operated to ground at contact **575** of the timer CG, thereby maintaining relay **519** operated. Thus the circuit to the motor winding **580** of timer CG is maintained closed and the timer is continued operating until it opens the contact **575** and restores to the position shown. Breaking this circuit releases relay **599** which in turn releases relay **519** returning the circuit to normal.

Provision is made for stopping this charge from the attended or remote station, if it is desired to do so, and if the battery voltage is 157 volts or more, by operating the "engine start" control at the remote station (not shown) which causes thermal relay **561** to operate. Relay **561**, in turn, causes relay **562** to operate which, at its outer armature and front contact shunts down relay **519** causing it to open the holding ground on relay **505**. Relay **505** thus is deenergized and in releasing its armatures stops the engine in the manner previously described. Relays **500**, **514**, **550**, **515** and **578** restore to normal. On manual release of the start control at the remote station relay **562** releases returning the circuit to normal.

Automatic means for maintaining the engine room above a predetermined temperature (15 degrees F.) are provided by running the engine to charge the batteries any time room temperature is below this value. At the predetermined temperature, thermostat **573** closes its contact to operate relay **505** which then functions to start the engine. The engine runs on the usual charge cycle before stopping.

Arrangements are made for manual operating and regulating the engine set. Key **210** ("stop") provides means for locking the set S1 so it cannot start and for transferring the automatic control so the other set S2 will take its place, by operating relay **203**. Key **202** ("test") provides means for running under test conditions locking out the automatic control and transferring it to the other set. Manual regulation of the generators may be accomplished by actuating switch **280** to its alternate position and adjusting the field rheostat.

In an earlier description, it was pointed out that when the engine, such as engine **206** of set S1 is operating, relay **213** operates to cause the operation of relay **228** which functions to control the opening of the intake louvre of the operating engine. That portion of Fig. 2 to the right of the large broken line enclosure and which includes relay **228** also provides control for ventilating the engine room. Thermostat **282** which is set at 90 degrees F. operates relay **283** and in turn **284** when the engine room reaches this temperature. Relay **284**, operated, closes contactor **299** to start the fan **298** and opens the exhaust louvre. The fan runs until the engine stops or until the room cools to the point where thermostat **297** opens the holding contact of relay **283**, the contact of thermostat **282** having already opened. When relay **283** releases, relay **284** releases stopping the fan and closing the exhaust louvre.

A liquidometer gauge **295** closes its contact in the event of low gasoline supply. Relay **294** operates to furnish alarms indicating low fuel supply. Relay **293** operates on discharge fuse failures to furnish alarm signals.

As hereinbefore indicated Figs. 1 and 3 are representative of a load circuit supplied from the battery **400**, and the controls therefor. Particularly, the loads are indicated schematically by the terminals A, B, C and D which are intended to connect with the filaments of the repeater amplifiers located at the unattended station.

At the lower section of Fig. 1 there are illustrated schematically three converters **1**, **2** and **3**. Converters **1** and **2** function to supply 60 volts alternating current to their respective loads whose terminals are indicated at A, B and C, D respectively. Under emergency conditions, causing loss of voltage from either converter **1** or **2**, its load will be transferred to the standby converter **3**.

Each converter consists of a direct current motor **11**, **12** or **13** and an alternating current generator **21**, **22** or **23**. It will be observed that the right-hand terminal of motors **11**, **12** and **13** are connected directly to conductor **14** by way of conductors **15**, **16** and **17**, respectively, conductor **14**, in turn being connected to the grounded terminal of battery **400**. The left-hand terminal of motor **11** is connected by way of conductor **18**, front contact and armature of relay **19**, front contacts and left armatures of relays **20**, **24** and **25**, conductor **26**, fuses **27** to the ungrounded terminal of battery **400**. The left-hand terminal of motor **12** is connected to the ungrounded terminal of battery **400** by way of conductor **28**, front contact and armature of relay **29**, front contacts and left armatures of relays **30**, **31** and **32**, conductor **33**, and fuses **34**. The left-hand terminal of converter **13** is normally open circuited. Thus the motors **11** and **12** are normally operating to drive their respective generators **21** and **22**. The right-hand terminals of generators **21** and **22**, and also of generator **23**, are connected to the grounded load terminals of sets A, B, C and D by way of common conductor **35**. The left-hand terminal of generator **21** is connected to the ungrounded terminals of sets A and B by way of variable resistance **36**, back contact and left armature of relay **37**, conductor **38**, and fuses **39** and **40** respectively. The left-hand terminal of generator **22** is connected to the ungrounded load terminals of sets C and D by way of variable resistance **41**, back contact and right armature of relay **42**, conductor **43** and fuses **44** and **45**, respectively. The left-hand terminal of the generator **23** is normally open circuited at the back contacts and left and right armatures respectively of relays **37** and **42**. The loads indicated by the terminals A and B are thus supplied with alternating current from generator **21** while the loads indicated by the terminals C and D are supplied with alternating current from the generator **22**. Standby generator **23** is normally non-operating.

It will be noted that the relays **20**, **24** and **25** associated with converter **21** are normally operated and at their left armatures short circuit the resistors **46**, **47** and **48** respectively. Similarly relays **30**, **31** and **32**, associated with converter **22**, are normally operated and at their left armatures short circuit resistors **49**, **50** and **51**. Thus the full battery voltage of 152 volts is normally supplied to the converter motors **11** and **12**.

Voltmeter relay HL has its operating winding normally connected across the input to converter **1** while voltmeter relay LH has its operating winding normally connected across the input to converter **2**. These relays function to maintain the input voltages within 137–144 volts as the battery voltage varies from 141–160 volts on its charge-discharge cycle of operation.

With the relays in the control circuits (Fig. 2) in the conditions illustrated and the battery 400 charged to the point where relay HL makes its high contact 52, relay 53 operates in an obvious circuit causing relay 54 to operate in a circuit extending from grounded battery, winding of relay 54, back contact and left armature of relay 55, conductor 56, front contact and armature of relay 53, to ground. Relay 54, operated, locks in an obvious circuit and at its left armature, opens the energizing circuit for relay 25. Relay 25 releases and at its left armature removes the short from resistor 48 thereby reducing the input voltage to converter 1 by the drop in this resistor. With the reduced input voltage relay HL restores to normal, releasing relay 53. At its right armature and back contact relay 25 causes relay 55 to operate in an obvious circuit.

When the battery 400 charges to a point where relay HL again closes its contact 52, relay 53 reoperates to cause relay 57 to operate in a circuit extending from grounded battery, winding of relay 57, back contact and left armature of relay 58, front contact and left armature of relay 55, conductor 56, to ground by way of the front contact and armature of relay 53. Relay 57 locks operated in an obvious circuit. At its left armature and back contact relay 57 causes the release of relay 24, which relay at its left armature inserts resistor 47 in the input circuit to converter 1 to lower the input voltage in the same manner as relay 25, as previously described.

When the battery 400 charges to the point where relay HL again operates its contact 52, it being understood that contact 52 and, in turn, relay 53 are released on the reduced voltage, relay 53 is reoperated causing relay 59 to operate in a circuit extending from grounded battery, winding of relay 59, back contact and left armature of relay 60, front contact and left armature of relay 58 (operated when relay 24 restored its right armature), front contact and left armature of relay 55, conductor 56, armature and front contact of relay 53 to ground. Relay 20 inserts resistors 46 in the input circuit to converter 1 and at its right armature causes relay 60 to operate in an obvious circuit. Thus the input voltage to converter 1 is reduced a third time.

The circuit remains in this condition until the battery voltage falls on cessation of charge to the low voltage contact point of relay HL. At this time relay HL closes its contact 61 to complete an obvious operating circuit to relay 62. At its armature and front contact relay 62 connects ground to the lower terminal of relay 59 by way of the front contact and right armature of relay 60 causing relay 59 to be shorted down. Relay 59 in restoring its left armature causes relay 20 to reoperate. At its left armature and front contact relay 20 shorts resistor 46 thereby raising the input voltage to converter 1 by the drop in resistance 46. At its right armature and front contact relay 20 causes relay 60 to be deenergized. As the input voltage drops, relay HL opens its contact 61 causing relay 62 to restore its armature.

When the battery voltage falls to the point where relay HL again makes its low voltage contact 61, relay 62 reoperates to connect ground to the lower terminal of relay 57 by way of the right armature and back contact of relay 60 and the right armature and front contact of relay 58. Thus relay 57 is caused to release its armatures. Relay 57, at its left armature and back contact reestablishes the operating circuit for relay 24 which functions to remove resistor 47 from the input circuit to converter 1 and thereby increase the input voltage in the same manner as described in connection with the operation of relay 20. Relay 58 releases when relay 24 operates its right armature and relays HL and 62 release on the increase in voltage.

When the low voltage contact 61 of relay HL is closed for the third time due to a drop in battery voltage, relay 62 is reoperated causing the connection of ground to the lower terminal of relay 54 by way of the right armature and back contact of relay 60, right armature and back contact of relay 58, and the right armature and front contact of relay 55. Thus relay 54 is deenergized and releases its armatures. At its left armature and back contact relay 54 reestablishes the operating circuit for relay 25 causing relay 25 to operate. At its left armature and front contact relay 25 shorts resistor 48 causing an increase in the input voltage to converter 1 and at its right armature it causes the release of relay 55. Thus the circuit is returned to the condition illustrated.

Operation of the voltage relay control for converter 2 is identical with that just described and it is deemed unnecessary to include herein any description thereof. It is apparent that the unidentified relays appearing in Fig. 2 to the right of relays 29, 30, 31 and 32 are identical in operation and purpose to relays 59, 60, 57, 58, 54 and 55 which appear to the right of relays 20, 24 and 25.

Under emergency conditions causing loss of voltage from either converter 1 or 2, its load will be transferred to the standby converter 3. This is accomplished on converter 1, for example, when relay 70, which is normally held operated by the output of converter 1 through rectifier 71, releases on loss of voltage and causes relay 72 to operate in an obvious circuit. Relay 72 functions to provide "no voltage" alarm (not shown) and at its right armature completes an operating circuit for relays 37 and 73 (Fig. 2). This circuit extends from grounded battery at "converter transfer" key 74, windings of relays 37 and 73 in parallel, right armature and front contact of relay 72, conductor 75, front contact and inner armature of relay 76, to ground. Relay 76 is normally operated being included in the input circuit to converter 2. Relay 37, at its left armature, transfers the load conductor 38 from the left terminal of generator 21 to the left terminal of standby generator 23, it being understood that the right terminal of generator 23 is connected to the ground as previously described.

Relay 73, operated, opens its left normally closed armature contact causing relay 19 to release. Relay 19 thus functions to disconnect battery from motor 11 of converter 1, and from the winding of relay 77 causing the latter to restore its armatures. At its inner armature and front contact relay 73 locks operated until the key 74 is operated manually. At its outer right armature, relay 73 transfers the winding of voltage relay HL to the battery input for converter 3. At its inner right armature, relay 73 completes an obvious operating circuit for relay 79. At its outer left armature and front contact, relay 73 connects the winding of relay 80 to the input circuit to converter 3 causing relay 80 to operate. Relay 80, operated, completes the connection of battery to the converter motor 13 causing the converter 3 to start, and connects battery to the windings of relays 81, 82 and 83. With relay 79 operated, relays 81, 82 and 83 are now controlled from the voltage relay HL in the same manner as previously described in connection with relays **20, 24** and **25.**

Relay **79** at its three armatures and front contacts, connects one terminal of each relay **81, 82** and **83** to ground at the right armatures and back contacts of relays **59, 57** and **54** respectively, the other terminals of relays **81, 82** and **83** being connected to the battery lead to converter **3** by way of the front contact and armature of relay **80.** Under this condition relays **54, 57** and **59** will respond to closures of the high voltage contact **52** of relay HL to cause relays **20, 24** and **25,** and **81, 82** and **83** to restore their armatures but only the last three relays will function to control the input voltage to converter **3.**

As soon as converter **3** builds up its voltage relay **70** will operate through rectifier **71** cutting off the "no voltage" alarm (not shown). When relay **37** operated, it connected ground at its right armature and front contact to the winding of relay **84** which at its armature and front contact completed a circuit (not shown) in which a "transfer" signal is operated. The "transfer" alarm remains operated since relay **37,** like relay **73** is locked operated.

Trouble on converter **2** causing loss of output voltage will transfer its load to the standby converter **3** in a manner similar to that described for converter **1** except that relay **79** is unoperated causing relays **81, 82** and **83** to operate with relays **30, 31** and **32** instead of with relays **20, 24** and **25** as just described.

Safeguards are provided to prevent transfer of both converters **1** and **2** to the standby **3.** If both converters **1** and **2** should fail, the first to fail will transfer to the standby as described and the other will be kept from transferring by the release of either relay **77** or **76** which removes ground from the transfer relay.

Failure of a discharge fuse, **39, 40, 44** or **45** will cause either relay **86** or relay **87** to operate which causes relay **88** to operate to transmit a "no voltage" alarm (not shown).

In the event of maintenance on the regular converters **1** and **2,** the load is transferred to the standby converter **3** by operation of the "converter transfer" keys **78** or **89.** The load will then be carried by converter **3** until the "converter transfer" return key **74** or **90** is operated. Either regular converter **1** or **2** may be operated for maintenance purpose by actuating its respective key **91** or **92.** While in this position the lamp **93** or **94** is operated to assure the attendants returning the key to normal before leaving the station or returning the load to its regular converter. A switch **95** and guard lamp **96** serve similar purposes in connection with converter **3.**

Keys **97, 98** and **99** are provided to permit the voltage of each converter **1, 2** and **3** to be read on the meter V.

What is claimed is:

1. In a power supply system in which a storage battery is charged at recurring intervals the occurrences of which intervals are determined by the voltage condition of the battery, duplicate means for charging the battery, control means for automatically rendering each of said duplicate charging means operative to charge said battery only during different alternate intervals whereby neither of said duplicate charging means operates to charge said battery during successive intervals, and means responsive to the battery voltage for controlling said control means.

2. In a power supply system, a storage battery supplying current to a load circuit, a first source of power for charging said battery, a second source of power for charging said battery, and control means responsive to a predetermined low voltage condition of said battery for causing the connection of said first source of power to said battery for a predetermined period of time to charge said battery, said means functioning automatically when said battery again reaches the said predetermined low voltage condition after the expiration of the said predetermined period of time for causing the connection of said second source of power to said battery to charge said battery.

3. In a power supply system, a storage battery supplying current to a load circuit, a first internal combustion engine-driven generator, a second internal combustion engine-driven generator, means responsive to a predetermined low voltage condition of said battery for rendering only said first engine-driven generator operative to charge said battery, and means for maintaining said first engine-driven generator operative to charge said battery for a predetermined interval of time after the voltage of said battery reaches a predetermined high level and for thereafter rendering said first engine-driven generator inoperative to charge said battery, said first means operating automatically in response to a subsequent occurrence of the said predetermined low voltage condition of said battery for rendering only said second engine-driven generator operative to charge said battery.

4. In a power supply system, an electrical storage battery supplying current to a load circuit, a pair of charging generators, an internal combustion engine for each of said generators each having an ignition circuit, means responsive to a predetermined low voltage condition of said battery for completing the ignition circuit of one of said engines and for causing its corresponding generator to operate as a motor and to crank said engine, means operating upon failure of said engine to start within a predetermined period of time for discontinuing the cranking of said engine by said generator, a motor-driven timer operating during the cranking of said engine, and means controlled by said timer when said engine fails to start for causing the other of said generators to be driven by its corresponding engine to charge said battery.

5. A power supply system comprising an electrical storage battery supplying current to a load circuit, a pair of charging generators, an internal combustion engine for each of said generators and each having an ignition circuit, means responsive to a predetermined low voltage condition of said battery for completing the ignition circuit to one of said engines and for causing its corresponding generator to operate as a motor to crank said engine, means operating should said engine fail to start and drive said generator within a predetermined interval of time for stopping the cranking of said engine, a motor-driven timer, means controlled by said motor-driven timer for causing the other of said generators to function as a motor to crank its corresponding engine, and means responsive to the voltage built up by said other generator when its corresponding engine starts for stopping the cranking of said other engine and for subsequently connecting said other generator to said battery to charge it.

6. A power supply system comprising an electrical storage battery supplying current to a load circuit, a charging generator, an internal combus-

tion engine having an ignition circuit, for driving said generator, control means automatically responsive to a given low voltage condition of said battery to complete the ignition circuit of said engine and to continuously crank said engine, means responsive to the building up of a predetermined output voltage by said generator driven by said engine when it starts, to prevent further cranking of said engine, a motor-driven timer, means responsive to generator voltage of predetermined level for operating said motor-driven timer to cause it to initiate a timing cycle of predetermined length, and means controlled by said motor-driven timer when it completes its timing cycle for completing the charging circuit from said generator to said battery.

7. In combination in a power supply system, a storage battery supplying current to a load circuit, a pair of charging sources for said battery, means responsive to a predetermined low voltage condition of said battery for connecting one of said charging sources to said battery, a timing device, means responsive to a predetermined high voltage condition of said battery for placing the connection of said one of said charging sources to said battery under the control of said timing device and for initiating the operation of said timing device, means controlled by said timing device at the expiration of a predetermined time interval following the initiation of its operation for disconnecting said one of said charging sources from said battery, whereby the charging of said battery is discontinued, means responsive to the discontinuance of the charging of said battery from said first charging source for preparing said second charging source for connection to said battery, and means responsive to the said predetermined low voltage condition of said battery for completing the connection of said second charging source to said battery.

8. In combination, an electrical storage battery, a charging generator, an internal combustion engine having an ignition circuit, for driving said generator, a normally stationary motor-driven timer, a converter for supplying the timer motor with operating current, control means responsive to a given low voltage condition of said battery for completing the ignition circuit to said engine and for cranking said engine whereby said engine starts and drives said generator to charge said battery, means responsive to a predetermined high voltage condition of said battery for connecting said motor-driven timer to said converter whereby said timer starts a timing cycle, and means controlled by said timer when it completes its timing cycle for interrupting the ignition circuit to said engine whereby said engine discontinues the driving of said generator and the charge to said battery is stopped a predetermined interval of time after said battery reaches the said predetermined high voltage condition.

9. In combination, an electrical storage battery, a charging generator, an internal combustion engine having an ignition circuit, for driving said generator, a normally stationary motor-driven timer, a second motor-driven timer, a converter for supplying said motor-driven timers with operating current, control means including a relay responsive to a given low voltage condition of said battery for completing the ignition circuit to said engine, for connecting said generator and the input terminals of said converter to said battery whereby said engine functions after starting to drive said generator to charge said battery and said converter is rendered operative to supply operating current to said motor-driven timers, means responsive to a predetermined high voltage condition of said battery for connecting said first motor-driven timer to the output terminals of said converter whereby said timer starts a timing cycle, means controlled by said timer when it completes its timing cycle for disabling said ignition circuit and for releasing said relay whereby the charge to said battery is discontinued a predetermined interval of time after said battery reaches the said predetermined high voltage condition, means controlled by said relay when released for operating said second motor-driven timer, and means controlled by said second timer when it completes its cycle of operation for disconnecting the input terminals of said converter from said battery.

HARRY H. SPENCER.