March 17, 1931. E. X. SCHMIDT ET AL 1,796,810

ELECTRICAL GENERATING SYSTEM

Filed Nov. 2. 1929

Fig. 1

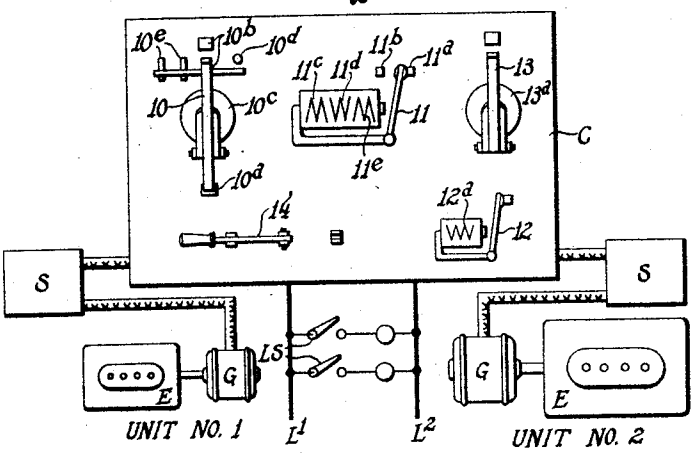



Fig. 2

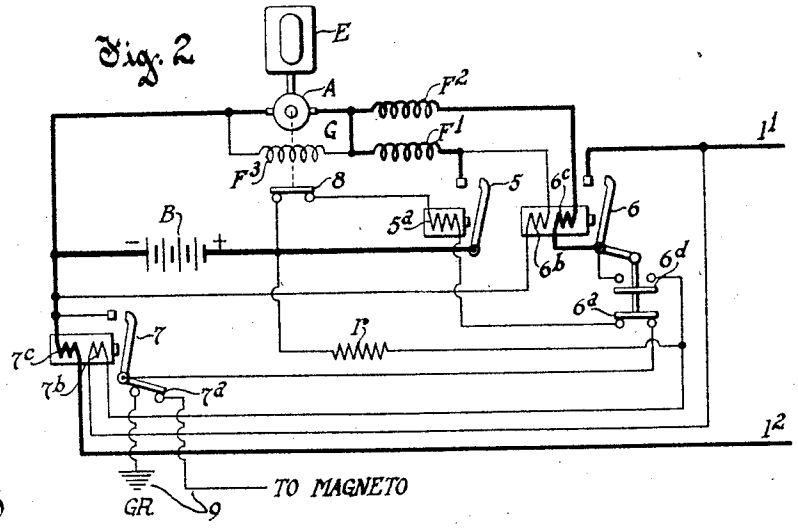
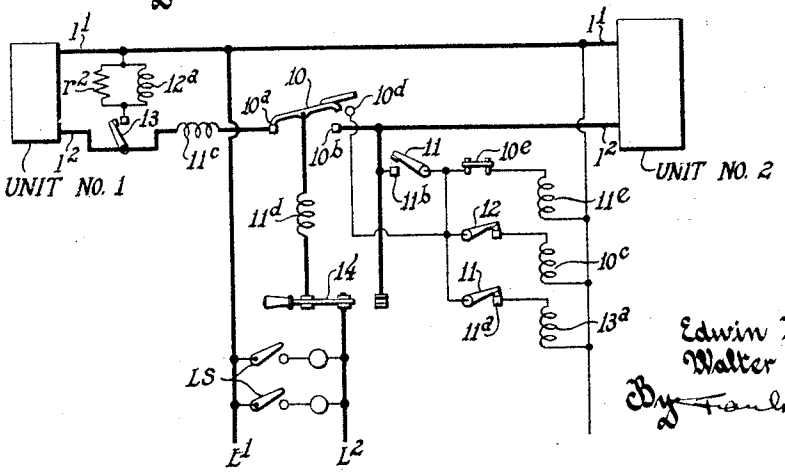



Fig. 3




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# UNITED STATES PATENT OFFICE

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## ELECTRICAL GENERATING SYSTEM

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This invention relates to electrical generating systems.

The invention relates more particularly to generating systems in which gas engine driven generating units of different capacities are employed for supplying current to a single load circuit.

The invention has among its objects to provide an automatic controller for systems of the aforesaid character which provides for automatic operation of the small generator unit under light load conditions and for operation of the large generator unit when the load exceeds the capacity of the small generator unit.

Another object is to provide a controller of the aforesaid character which provides for automatic stopping of either generator unit upon starting of the other generator unit.

Various other objects and advantages of the invention will hereinafter appear.

The accompanying drawing illustrates a generating system embodying the invention which will now be described, it being understood that the system illustrated is susceptible of modification without departing from the spirit and scope of the appended claims.

In the drawing

Figure 1 schematically illustrates an automatic control system embodying the invention.

Fig. 2 diagrammatically illustrates a preferred form of starter which is employed in connection with each of the gas engine driven units shown in Fig. 1, and

Fig. 3 is an across-the-line diagram illustrating the circuit connections of certain of the control elements shown in Fig. 1.

Referring to Fig. 1, the same illustrates a small generator unit 1 and a large generator unit 2, each of which includes a generator G and an internal combustion engine E for driving the same. Each of said units is provided with a starter S, and as hereinafter set forth a controller C cooperates with the starters S to render the small unit 1 operative to supply current to service mains $L^1$—$L^2$ under light load conditions and to render the large unit 2 operative to supply current to said service mains when the load exceeds the capacity of said former unit. Also as hereinafter set forth controller C cooperates with the starters S of units 1 and 2 to effect stopping of either generator unit upon starting of the other generator unit.

Generators G of the units 1 and 2 are of the same type, and as shown in Fig. 2 each is provided with an armature A, series field windings $F^1$ and $F^2$ and a shunt field winding $F^3$. Also as shown in Fig. 2 each of said generators is provided with a starter including a starting switch 5 and a main switch 6. Starting switch 5 provides for connection of the generator to a storage battery B for operation thereof as a motor for cranking of the engine, and as hereinafter set forth said starting switch is controlled through the medium of a normally open relay 7, a normally closed governor operated switch 8, and normally closed auxiliary contacts $6^a$ associated with main switch 6. Relay 7 is provided with normally closed auxiliary contacts $7^a$ for closing a magneto ground circuit 9 for the engine and said relay is provided with a shunt winding $7^b$ and a series winding $7^c$. Main switch 6 provides for connection of generator G to mains $l^1$ and $l^2$ and the same is provided with a shunt winding $6^b$ and a series winding $6^c$. Main switch 6 is also provided with normally open auxiliary contacts $6^d$ for establishing a charging circuit for the battery B through a resistance $r$.

The above described starter functions and operates in the following manner. An automatic start is made by connecting a load across the mains $l^1$—$l^2$. Upon connection of a load across said mains circuit is established from the negative side of battery B through the series winding $7^c$ of relay 7 to main $l^2$, thence through the load to main $l^1$ through the shunt winding $7^b$ of relay 7 and through resistance $r$ to the positive side of battery B. Winding $7^b$ effects response of relay 7 and said relay in responding removes the ground connection GR from the magneto of the engine and establishes an energizing circuit for starting switch 5 ex-

tending from the negative side of battery B through relay 7 through auxiliary contacts $6^a$ associated with main switch 6 through the winding $5^a$ of starting switch 5 and through the governor operated switch 8 to the positive side of battery B. Starting switch 5 in responding establishes a circuit extending from the left hand terminal of armature A through battery B through switch 5 and through the series field $F^1$ to the right hand terminal of said armature. The generator G then operates as a motor to crank the engine E.

It will be observed from Fig. 2 that the winding $6^b$ of main switch 6 is connected across the armature A and series field winding $F^1$ and when the engine functions to drive the generator, current is supplied to said winding to effect response of main switch 6. Main switch 6 in responding interrupts the aforedescribed energizing circuit for starting switch 5 extending through auxiliary contacts $6^a$ and establishes circuit from the right hand terminal of the armature A through series field winding $F^2$ through winding $6^c$ to main $l^1$ whereby the load connected across mains $l^1$—$l^2$ is supplied with current by generator G. Also upon response of main switch 6 the auxiliary contacts $6^d$ thereof establish a charging circuit for battery B through the medium of resistance $r$. Winding $6^c$ holds main switch 6 in closed position as long as a load is connected across mains $l^1$—$l^2$, and upon removal of such load said winding is deenergized to permit opening of main switch 6.

As aforestated starting switch 5 is energized through the medium of the governor operated switch 8. When the generator operates at a speed in excess of its cranking speed switch 8 opens to interrupt the energizing circuit for starting switch 5. Thus should the load be removed from mains $l^1$—$l^2$ and reconnected thereto before the engine speed is reduced below cranking speed the open governor switch 8 prevents closing of the motor starting circuit unnecessarily and so avoids a direct connection between the battery and the generator terminals while the generator is developing its higher voltage.

From the foregoing it will be observed that the starter illustrated in Fig. 2 provides for automatic starting of the generator unit upon connection of a load across the supply mains and for automatic stopping thereof upon removal of the load.

The controller C as shown in Fig. 1 includes an electroresponsive change-over switch 10 which is provided with normally closed contacts $10^a$ for connecting the mains of the small generator unit 1 to the service mains $L^1$—$L^2$ and normally open contacts $10^b$ for connecting the mains of the large generator unit to said load circuit. The operation of said change-over switch is controlled as hereinafter set forth through the medium of relays 11, 12 and 13. Controller C also includes a double throw knife switch 14, the purpose of which will be hereinafter set forth.

Relay 11 as shown in Fig. 1 is provided with a movable contact member normally engaging a contact $11^a$ and movable into engagement with a contact $11^b$. Said relay is provided with a pair of series operating windings $11^c$ and $11^d$ and a shunt holding winding $11^e$. Relay 12 is normally closed and is provided with a shunt operating winding $12^a$, while relay 13 is normally open and is provided with a shunt operating winding $13^a$. Also as shown in Fig. 1 the change-over switch 10 is provided with normally open auxiliary contacts $10^d$ and normally closed auxiliary contacts $10^e$, the latter contacts being adapted to open following closure of the contacts $10^b$.

The function and operation of controller C and the circuit connections therefor will now be more fully described in connection with Fig. 3. As shown in this figure the mains $l^1$ of units 1 and 2 are permanently connected to service main $L^1$ and with knife switch 14 in its left hand position main $l^2$ of unit 1 is connected to service main $L^2$ through the medium of contacts $10^a$ of transfer switch 10 and windings $11^c$ and $11^d$ of relay 11. It is thus apparent that if one of the switches LS is closed to connect a load across service mains $L^1$—$L^2$ the small unit 1 will be automatically started and connected to service main $L^2$ in the manner described in connection with Fig. 2. The small generator unit remains in operation as long as the load on service mains $L^1$—$L^2$ does not exceed the capacity of said unit.

When the load connected across service mains $L^1$—$L^2$ exceeds the capacity of the small generator unit 1, relay 11 responds under the action of its windings $11^c$ and $11^d$. Upon response of relay 11 the winding $11^c$ of said relay is connected across mains $l^1$—$l^2$ of the large generator unit through the medium of auxiliary contacts $10^c$ of transfer switch 10 and the contacts $11^b$ of said relay. Also upon response of relay 11 the operating winding $10^c$ of transfer switch 10 is connected across mains $l^1$—$l^2$ of the large generator unit through the medium of relay 12 and contacts $11^b$ of relay 11. Coil $11^c$ is of relatively low resistance and upon connection thereof across mains $l^1$—$l^2$ said coil acts as a load on the large generator unit 2 to effect starting of said unit as described in connection with Fig. 2. When the voltage across the mains $l^1$—$l^2$ of the large generator unit 2 reaches a predetermined value winding $10^c$ effects response of transfer switch 10 and the service main $L^2$ is disconnected from main $l^2$ of the small generator unit 1 by

opening of contacts $10^a$ and is connected to main $l^2$ of the large generator unit 2 by closure of contacts $10^b$. Upon disconnection of the load from the small generator unit 1 the same stops as set forth in connection with Fig. 2 and the load connected across the service mains $L^1$—$L^2$ is then supplied with current by the large generator unit 2. Upon opening of contacts $10^a$ of the transfer switch the windings $11^c$ and $11^d$ of relay 11 are deenergized but said relay is then held in its operated position by its winding $11^e$ which is energized as hereinbefore described. Upon closure of contacts $10^b$ of the transfer switch the auxiliary contacts $10^e$ of said switch open to interrupt the energizing circuit for the winding $11^e$ and relay 11 is then held in its operated position by its winding $11^d$ which now carries the entire load current. Transfer switch 10 in responding establishes a maintaining circuit for itself extending through its auxiliary contacts $10^d$ and the relay 12.

Relay 11 is held in its operated position by its winding $11^d$ as long as the current demand exceeds the capacity of the small generator unit 1. However, when the current demand decreases to a value which is less than the capacity of the small generator unit 1 relay 11 drops out and connects the operating winding $13^a$ of relay 13 across the mains of the large generator unit 2 through the medium of the auxiliary contacts $10^d$ of transfer switch 10. Relay 13 then responds to connect the operating winding $12^a$ of relay 12 across the mains $l^1$—$l^2$ of the small generator unit 1 in parallel with a resistance $r^2$. Resistance $r^2$ and coil $12^a$ of relay 12 act as a load across the mains $l^1$—$l^2$ of the small generator unit and said unit is then started as hereinbefore set forth. When the voltage across mains $l^1$—$l^2$ of the small generator unit 1 builds up to a given value winding $12^a$ of relay 12 effects response of said relay to interrupt the aforedescribed energizing circuit for transfer switch 10. Transfer switch 10 then returns to normal position to re-connect the load on the service mains $L^1$—$L^2$ to the small generator unit 1. As set forth in connection with Fig. 2 the generator units are automatically stopped under no load conditions. Thus upon return of transfer switch 10 to normal position the large generator unit 2 is stopped and the small generator unit 1 remains in operation as long as there is a current demand or until the current demand exceeds the capacity thereof.

When knife switch 14 is moved into its right hand position the small generator unit 1 is rendered inoperative since the service main $L^2$ is then connected to main $l^2$ of the large generator unit 2. However, as is apparent from the description in connection with Fig. 2 the large generator unit 2 is then operative to supply current to the service mains $L^1$—$L^2$ upon connection of a load across the same.

What we claim as new and desire to secure by Letters Patent is:

1. In a system of electrical distribution, in combination, two generator units of different capacities, separate means for starting each of said units upon current demand across the mains thereof, a load circuit normally connected to the mains of the smaller of said units, means for starting the larger of said units when the current supplied by said smaller unit to said load circuit exceeds a given value and means acting upon starting of said larger unit to connect the mains thereof to said load circuit and to disconnect the mains of said smaller unit from said load circuit.

2. In a system of electrical distribution, in combination, two generator units of different capacities, separate means for starting each of said units upon current demand across the mains thereof, a load circuit normally connected across the mains of the smaller of said units, means for starting the larger of said units when the current supplied by said smaller unit to said load circuit exceeds a given value, means acting upon starting of said larger unit to connect the mains thereof to said load circuit and disconnect the mains of said smaller unit from said load circuit, means for restarting said smaller unit when the current supplied by said larger generator unit is less than the capacity of said smaller unit and means acting upon restarting of said smaller unit to reconnect the mains thereof to said load circuit and to disconnect the mains of said larger unit from said load circuit.

3. In a system of electrical distribution, in combination, two gas-engine-operated generating units of different capacities, a common load circuit normally connected to the smaller of said units, means for starting the smaller of said generator units upon current demand in said load circuit, means for starting the larger of said generator units when the current supplied by said smaller unit to said load circuit exceeds a given value, and means responsive to a given voltage across the mains of said larger unit for disconnecting said load circuit from said smaller unit and for connecting said load circuit to the mains of said larger unit.

4. In a system of electrical distribution, in combination, two gas-engine-driven generating units of different capacities, a common load circuit to be supplied thereby, separate means for starting each of said units upon current demand across the mains thereof, an electromagnetic switch normally connecting said load circuit across the mains of the smaller of said units and responsive

to a given voltage across the mains of the larger of said units to disconnect said load circuit from said smaller unit and to connect the same to the mains of said larger unit, and means for starting the larger of said generator units when the current supplied by the smaller of said generator units to said load circuit exceeds a given value.

5. In a system of electrical distribution, in combination, two gas-engine-operated generating units of different capacities, a common work circuit to be supplied thereby, an automatic controller associated with each of said units for starting the same upon current demand across the mains thereof, a switch normally connecting said work circuit to the smaller of said generator units and responsive upon given current conditions across the mains of the larger of said units to disconnect said work circuit from said smaller unit and to connect the same to said larger unit, means for starting said larger unit when the current supplied by said smaller unit exceeds a given value, said means including a relay responsive to given current conditions in said load circuit to effect loading of said larger unit for starting thereof.

6. In a system of electrical distribution, in combination, two gas-engine-operated generating units of different capacities, a common work circuit to be supplied thereby, an automatic controller associated with each of said units for starting the same upon current demand across the mains thereof, a switch normally in a position to connect said work circuit to the smaller of said generator units and responsive upon given current conditions across the mains of the larger of said units to disconnect said work circuit from said smaller unit and to connect the same to said larger unit, means including a relay responsive to given current conditions across the mains of said smaller unit to effect starting of said larger unit, and means including a relay for starting said smaller unit when the current supplied by said larger unit to said load circuit is below a given value.

7. In a system of electrical distribution, in combination, two gas-engine-operated generating units of different capacities, a common work circuit to be supplied thereby, an automatic controller associated with each of said units for starting the same upon current demand across the mains thereof, a switch normally connecting said work circuit to the smaller of said generator units and responsive upon given current conditions across the mains of the larger of said generator units to disconnect said work circuit from said smaller unit and to connect the same to said larger unit, means responsive to given current conditions in said load circuit to effect loading of said larger unit for starting thereof, and means responsive to other current conditions in said load circuit to effect loading of said smaller unit for starting thereof.

In witness whereof, we have hereunto subscribed our names.

EDWIN X. SCHMIDT.
WALTER O. BAER.