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POWER GENERATING SYSTEM

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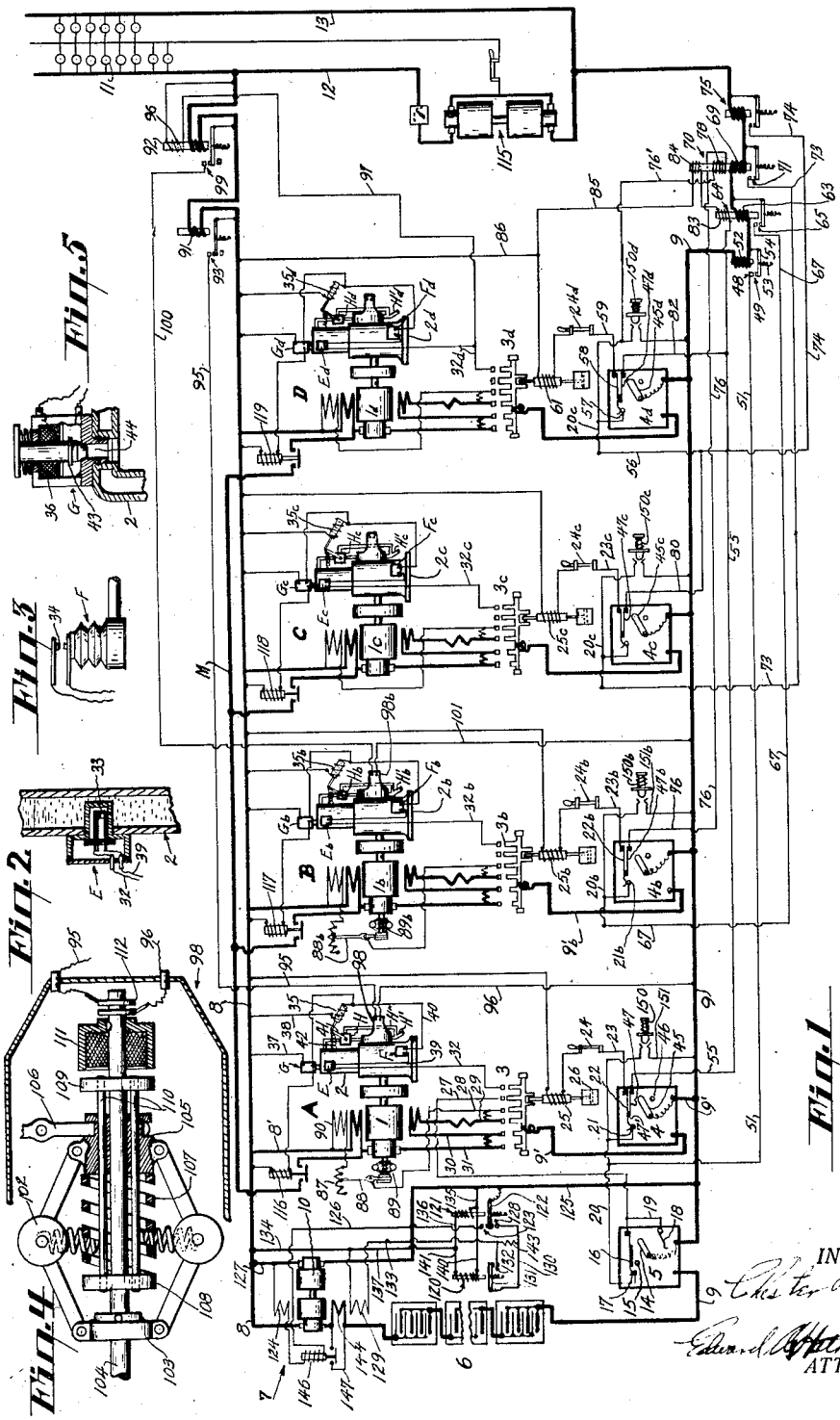


Fig. 1

Fig. 4

Fig. 2

Fig. 3

Fig. 5

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POWER-GENERATING SYSTEM

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This invention relates to power generating systems and more particularly to one adapted to have automatic parallel operation and control of internal combustion motors driving electric generators.

It is an object of my invention to provide an improved arrangement of a plurality of generating units driven by prime movers such as internal combustion engines, preferably of the Diesel type, whereby the same may be so automatically controlled as to provide a flexible source of power adapted to be readily varied in accordance with a wide range of power demand while at the same time maintaining substantially constant voltage. Due to the flexibility of my improved system it is possible to generate power at a minimum cost because fuel consumption and wear and tear is reduced to a minimum.

A further object is to provide an improved automatic multiple unit system preferably in a bank of say three or more units and to have them so controlled that they are successively operated as the load comes on or increases. Still another object is to provide improved means whereby if the first unit which would usually be used for small loads becomes inoperative or fails to start, preferably the last unit in this emergency will be automatically operated instead, as the last unit of the bank will more likely be in the best operating condition of all the units due to being operated last and therefore the least during normal successive operation of the units. It will be understood that some unit other than the last one might be used for the emergency operation. A further object is to operate the remaining units automatically and preferably in a predetermined order either after the first unit is running or after the emergency operation of the last unit or whichever unit may be chosen for the emergency operation.

Another object is to provide a multiple unit system so arranged that it is particularly adapted to permit effective and efficient voltage control to be maintained by a battery booster during automatic starting and stopping of any of the units and irrespective of whether or not the units are operating successively in their normal order or certain of the units are operating in their emergency order.

A further object is to provide an improved arrangement to control automatically the fuel supply of a Diesel engine so that the fuel supply control is properly coordinated with the various automatic features of my improved system.

Other objects have to do with further automatic controls and arrangements which will be more fully described and understood from the following description of the accompanying drawings, in which:

Fig. 1 is a combined wiring diagram and schematic view of certain elements of my improved system,

Fig. 2 is a section of a thermostat control adapted to be used in places where overheating might endanger or damage the equipment, to be placed for instance in the cooling water of the cylinder as shown or in a bearing oil sump to be responsive to bearing temperatures,

Fig. 3 is a diagrammatic view of pressure operated bellows controlled contacts to be used with the lubricating system,

Fig. 4 is an enlarged view of one of the speed governors with the variable speed control attached, and

Fig. 5 is a diagrammatic sectional view of an electrically closed compression relief valve.

In the illustrative embodiment of my invention as shown in the accompanying drawing A, B, C and D, each represent a power unit having electric generators driven by internal combustion motors with switching mechanism for each unit, the motors specifically disclosed herein being of the Diesel engine type.

In unit A, an electric generator 1, driven by a direct connected internal combustion motor 2, is controlled by a solenoid operated starting switch 3 and a reverse current time relay 4 in addition to other elements which are more fully described hereinafter.

A supplemental source of current supply such as a storage battery 6 or other suitable source is connected to current mains 8 and

9 through a booster unit 7 and ampere hour meter 5 respectively. Booster 7 is driven by an electric motor 10 and is so arranged that when battery 6 is being charged booster 7 raises the voltage across the battery terminals above the potential across mains 8 and 9, and on discharge reverses its potential and raises the battery voltage so as to maintain a substantially constant potential across mains 8 and 9.

Translating devices 11 are connected to mains 8 and 9 through conductors 12 and 13 each of which has various relay coils inserted in series with these conductors, for purposes to be described later.

Starting operation when battery discharges.—Let it be assumed that battery 6 is charged and that no current is being consumed by translating devices 11. In such a case an operating hand 14 of ampere meter 5 would be against a stop 15 and at the same time hold a spring contact 16 away from a fixed contact 17. If now a small amount of current is used by the translating devices 11, the hand 14 on ampere hour meter 5 will travel toward a spring contact 18 and if this current demand continues long enough hand 14 would make contact with spring 18 thus indicating that a predetermined amount of current had been withdrawn from the battery. The amount of battery discharge to be permitted is represented by the ampere hours necessary to cause hand 14 to travel from stop 15 to spring contact 18. The amount of this battery discharge is of course less than full discharge.

When hand 14 makes contact with spring 18 current flows from main 9 through a wire 19, spring contact 16, contact 17, wire 20, contact 21, spring contact 22, wire 23, switch 24, and to a coil 25 of solenoid operated starting switch 3. Rapid closing of contacts of switch 3 is prevented by a dash pot 26. Action of solenoid 25 closes the contacts of the starting switch to wires 27—32 in such manner as to secure proper starting of generating unit A, the generator 1 acting as a motor to rotate engine 2 and receiving current from mains 8 and 9 through the reverse time element 4 and wires 8′ and 9′.

Compression relief; thermostatic and fuel controls.—During this period when generator 1 is actuated as a motor by the current supplied from battery 6, contact is made by starting switch 3 with conductor 32. Current flows through this conductor from main 9 through wire 9′, switch 3 and conductor 32 to the normally closed contacts 33 of a thermostat device E, thence through a conductor 39 and normally closed contacts 34 of an oil pressure operated expansible device F, thence through a wire 40 to a solenoid 35 of a fuel oil by-pass valve H and also to a solenoid 36 Figs. 1 and 5 of a compression relief valve G, thence through conductors 37 and 38 to main 8. The oil pressure device F is simply connected by a pipe to the usual lubricating system thereby being responsive to the functioning of the usual oil pump. When fuel control solenoid 35 is energized a lever 41 of by-pass valve H is moved against the action of a spring 42 so that fuel oil, pumped by any usual fuel oil system, including a fuel supply pipe H′ is made available for consumption in the engine cylinder or cylinders. Normally when coil 35 is not energized spring 42 pulls lever 41 into such position that all fuel oil is by-passed back to the fuel supply through pipe H″ with none going to the cylinder. The coil 36 of compression relief valve G, which is diagrammaticaly shown in Fig. 5, causes a plunger 43 to seat in an opening 44 and permit full compression within the engine cylinder or cylinders. When the engine starts firing, generator 1 then stops receiving current as a motor, and instead supplies current to mains 8 and 9 in its generator capacity. Once the unit starts generating it continues to do so until the battery is fully charged even though the line load has dropped or ceased. As the battery charges, hand 14 moves upwardly until when the battery becomes fully charged hand 14 is in its upper position and opens contacts 16 and 17 to stop the unit.

Reverse current relay.—Should the generating unit for any reason get out of order and the engine 2 fail to drive generator 1 then the generator would operate as a motor taking current from mains 8 and 9. Under such circumstances it is desirable not to permit the generator to act as motor for any longer period of time than is necessary to start the engine and at the end of that time to then shut off the current for this motor action. To accomplish this automatically the reverse current relay 4 is so adjusted that when generator 1 is drawing current to act as a motor, a hand 45 will be actuated and caused to leave a stop 46 and travel toward a spring contact 47. This relay is adjusted so as to allow the usual interval necessary for allowing generator 1 to act as motor to start the engine without hand 45 making contact with spring 47. However, should hand 45 press against spring 47 it in turn presses against spring contact 22 through a separating insulating block 47′. Pressure on spring contact 22 raises it from contact 21 and opens the circuit to solenoid 25 of starting switch 3, thus causing this switch to open and causing the generating unit to be stopped as circuits to the generator are interrupted as well as circuit 32. The opening of circuit 32 causes by-pass valve H to by-pass all fuel and at the same time solenoid 33 of compression relief valve G is deenergized thereby eliminating engine compression.

From the foregoing it is seen that the ampere hour meter 5 is adapted automatically

to start the generating unit upon a predetermined battery discharge while the reverse current time relay comprises means for automatically eliminating the unit if the engine fails to start. Should the generating unit A run short of cooling water or become overheated thermostat contacts 33, enclosed in the cylinder water cooling space, will open automatically thus stopping the generating unit by opening the circuits to solenoids 35 and 36 or should the lubricating oil pressure fail, contacts 34 would be opened thereby similarly de-energizing solenoids 35 and 36. As the engine could not drive the generator in this case the generator would act as a motor for a short interval until reverse current relay 4 would cause solenoid switch 3 to open. It is of course to be understood that the thermostatic control may be applied to any portions of the engine which might become overheated, such for instance as the bearings. Here the thermostat device could be positioned in the usual oil chamber for the bearings and be actuated by the hot oil from the bearing, the oil temperature being an indication of the bearing temperature.

Line load control (of first unit).—In the event that no current is used by translating devices 11 and the battery 6 is fully charged then hand 14 will be in its upper full charge position and hold open contacts 16 and 17 of the ampere hour meter so that generating unit A will not operate. Assuming, however, that a considerable current demand or line load would be caused by translating devices 11 being thrown on the line 12, 13 so as to cause a current demand above that which it is desired to have the battery carry alone as previously described, then a relay 48 is energized by a coil 52 which is in series with circuit 13 to the translating devices. The amount of current necessary to operate solenoid 48 and accordingly close contacts 49 and 50 is controlled by a spring 53, acting on an armature 54. When contacts 49 are closed a circuit is established from conductor 9 through wire 51 to wire 20, then through contact 21, spring 22, and wire 23 to solenoid 25 to actuate the starting switch 3, and thus start generating unit A. Closing of contacts on relay 48 will cause generating unit A to remain in operation regardless of ampere hour meter 5 but any failure in operation by engine 2 will cause reverse current relay 4 to stop unit A as previously described.

Operation of units successively or in emergency.—Failure of engine 2 to start causes hand 45 of reverse current relay 4 to contact with spring 47 whereby current passes from main 9 through hand 45, spring contact 47, wires 55 and 56 to contact 57 or reverse current relay 4*d* (unit D), to spring contact 58 through wire 59 and to solenoid coil 61 of solenoid starting switch 5*d* of generating unit D. Unit D thereupon starts to operate and thus takes the place of generating unit A which is out of order. Operation of reverse current time element 4*d*, starting switch 3*d* and elements E*d*, F*d*, G*d* and H*d* is similar to the operation of these elements described for generating unit A, it being understood that each of the generating units and controls are duplicates and that when convenient or clear, similar reference characters or numbers provided with a sub-letter "*b*," "*c*" or "*d*" refer to corresponding elements in the respective units B, C, and D and the corresponding elements in unit A are designated by a similar number but without any sub-letter *a*.

Assume generating unit A to be operating and contacts 49 of relay 48 to be closed. Further increase in load to near full capacity of unit A will cause coil 63 to sufficiently energize relay 64 so as to close contacts 65 causing current to flow from conductor 9 through wires 67, 20*b*, contact 21*b*, spring 22*b* and wire 23*b* to solenoid 25*b* thereby closing starting switch 3*b*, and causing unit B to operate and divide the load with unit A. A further increase in load near to full capacity of units A and B will cause coil 69 to sufficiently energize relay 70 so that contacts 71 will be closed allowing current to pass from conductor 9 through wire 73 to wires 20*c* and 23*c* and coil 25*c* thereby starting generating unit C. A load equal or beyond the capacity of units A, B and C will in similar manner cause relay 75 to start generating unit D by allowing current to pass from main 9, through wires 74, 20*c*, and 59, to coil 61 thereby starting unit D.

Should generating unit A be out or get out of order and unit D be started to take the load then units B and C will come in successively on increases in load due to the action of relays 64 and 69 in the same manner as if generating unit A were operating, relay 64 closing with the aid of shunt coil 83 on same line current normally required to close relay 48, and relay 69 closing on same line current normally required to close relay 64. The result is that unit B starts due to closure of contacts 65. These two units, D and B, are thus adapted for operation to supply a line load which is sufficient to justify, normally, operation of only one unit. However, it is desirable that both units be operating due to the existence of emergency conditions, it being advantageous under such conditions to have an excess immediate potential supply of current to maintain operation well within the factor of safety. It will be noted also that when unit D is once started under emergency operation, it continues to operate irrespective of the line load for there is no normal manner by which the circuit for solenoid 61 can be broken except by manually resetting reverse current element 4 thereby breaking con-

tact between elements 45 and 47, the manual resetting of a reverse current relay being a well known characteristic of such an instrument. Of course if unit D fails to start it is automatically cut out but this operation does not occur while normal conditions exist. With unit D continuously operating, under emergency conditions, and unit B coming into operation on a line load normally intended to be taken care of by only one unit, it is seen that the system amply insures continuity of service even under adverse conditions.

In case generating units A and B were operating and unit B should become out of order then current will pass from spring 47*b* through wire 76 to coil 78 of relay 70, wire 76′ and on to contact 57 through spring 58, wire 59 to solenoid 61 of generating unit D thus starting this unit and causing it to operate in place of unit B. Also action of current in passing through coil 78 of relay 70 causes the adjustment to be changed such that contacts 71 will be closed by less current than under normal conditions with all units in operating condition. This is for the purpose of maintaining ample power available to meet sudden loads and causes unit C to operate on similar load which would normally require operation of unit B.

In event unit C becomes out of order and is cut out due to generator 1*c* acting as a motor for too long a period, spring 47*c* of its reverse current time relay 4*c* will be engaged by arm 45*c* to complete a circuit established through spring 47*c*, wires 80 and 56 and thus starting, as before described, generating unit D to operate in its place.

Should generating unit A fail to operate and unit D be started and operated in its place it is possible that unit D might likewise become or already be out of order. If hand 45*d* of reverse current time element 4*d* makes contact with spring 47*d*, spring 58 would be lifted from contact 57 thus stopping unit D. However current would flow from contact 47*d* through wire 82 to coil 83 and thence on to coil 84 and through wires 85 and 86 to the other line 8. Energizing of coils 83 and 84 causes relay 64 to close on same amount of current normally required to close contacts on relay 48 and similarly relay 70 will now be in condition to close its contacts on the same amount of current normally required to close the contacts of relay 64. It is thus seen that if the units are out of order the action of the relay mechanisms 48, 64 and 70 is advanced in accordance with the number of units that are out of order.

Variable speed control.—Generating units A and B are shown as adaptable to a variable speed control as it is desirable to operate a prime-mover such as an internal combustion engine motor at a reduced speed, preferably about five-eighths, during part load as the maintenance of such an engine varies as some function of its speed. Hence it is better to operate two engines at reduced speed and part load each than to operate one engine at full speed and full load. In describing the line load relay controls 48, 64 and 70, reference was made to the units operating at or near full capacity which meant the fullest capacity for which they were then permitted to operate by a restrained governor and which, as to the restrained units, effected this part speed and load just referred to. To permit full speed and load, generator 1 of unit A has a resistance 87 in series with a shunt field 90 and which can be varied by action of an arm 88 which is controlled by a usual centrifugal speed governor 89. Relays 91 and 92 are in series with the line leading from the generating units to the translating devices. Relay 91 is so adjusted that when very little current is being used by translating devices 11, contact 93 is open. In this event generating unit A is operating at its lower speed and little if any of resistance 87 is in series with shunt field 90. As the load increases, relay 91 closes contacts 93 to actuate, by current passing from mains 8 and 9 through wires 95 and 96, an electrically controlled speed governor mechanism 98 which changes the governor adjustment on the engine to make it operate at an increased speed. As the engine speeds up from the lower to the higher speed, arm 88 is operated by governor 89 in such manner that resistance 87 is inserted in shunt field 90 so as to keep the generator terminal voltage constant with the increase of speed.

Relay 92 operates to control generating unit B in a manner similar to that of unit A except that relay 92 does not need necessarily to act until relay 91 has caused unit A to be operating at maximum speed. Should generating unit A be out of order, coil 96 of relay 92 is energized and relay 92 now acts to close its contacts 99 on the same strength of current as is normally required to close the contacts on relay 91. The circuit for energizing relay 92 is made through switch 3*d*, wire 97 and coil 96 whereby contacts 99 are closed to actuate on unit B governor restraining mechanism 98*b* by current through wires 100 and 101. Units C and D are not shown with their governor restraining mechanisms connected for variable control but set only for full speed. However, to connect the remaining units for variable speed so that they would be successively operated at full speed it would only be necessary to continue the relay system 91 and 92 in the same manner as the relays 48, 64, etc. are continued for all the units. As shown also units C and D being for full speed only do not need a governor controlled rheostat as in units A and B.

The governor control mechanism 98 comprises usual fly-balls 102, linked to a collar 103 fixed to the engine shaft 104 and to a movable collar 105. The usual fuel control lever

106 is moved toward a fuel closing position as the fly-balls move outwardly as the engine speed increases. A relatively short and heavy compression spring 107 is in the expanded position, as shown, for part speed whereby the fly-balls may move outwardly relatively easily although when desired to increase the speed it is necessary to restrain outward movement of the fly-balls. This is done by increasing the compression on spring 107 through collars 108 and 109 connected to rods 110. An electro-magnet 111 fixed to the engine shaft attracts collar 109 when energized by current supplied from wires 95, 96 through slip rings 112, thereby pulling on rods 110 to compress spring 107 and causing a greater engine speed to result.

There may also be used a conventional balancer unit 115 for giving three wire direct current distribution where two wire generators are used.

Equalizer bus switches 116—119, connected to a bus bar M, are closed whenever generating units A, B, C or D are in operation and may be energized by the same circuit as energizes the coils for compression relief valves G, G*b*, etc. These switches are normally open on the respective units when they are not in operation. Hand switches 150, 150*b*, etc. may be inserted in lines 151, 151*b*, etc. thereby permitting any unit to be operated for test purposes independently of the automatic controls whereas switches 24 when open will prevent any operation whatsoever of the units.

Coordinated booster and multiple unit control.—From the foregoing disclosure it is seen that from automatic starting and stopping of the units, the use of a battery for carrying small or momentary line loads, engine starting loads, etc. fluctuating line voltage would ordinarily result but even with a large or small number of units it is possible in my improved multiple unit arrangement herein shown to use a single battery booster adapted to cooperate with any of the units during starting or stopping thereof, to maintain constant line voltage or to recharge the battery if the line voltage is normal.

To accomplish this booster 7 is controlled by relays 120 and 121. Relay 121 is normally adjusted so that with normal line voltage on its coil, energized by current through wires 125, 135, 136, 137 and 134, armature 122 closes upper contacts 123 thus energizing booster shunt field 124 by current supplied from mains 8 and 9 through wire 125, armature 122, wire 126, relay 146, field 124 and wire 127 causing the booster to reverse its normal polarity and maintain a voltage across the battery which will permit the battery to be charged if it is in a condition to require charging. During this same period of normal line voltage, relay 120 is energized by current through wires 135, 140, 141, 137 and 134, thereby raising armature 131 and opening contacts 132. Shunt field 129 when energized is of opposite polarity to the other shunt field 124. A resistance 143 is connected across wires 130 and 133. A slight drop in line voltage, due to a generating unit starting or a sudden heavy load being thrown on the line beyond the capacity of any generators which might be operating at that moment, causes relay coils 120 and 121 to release their armatures whereby both armatures drop or are pulled down by their springs to close contacts 128 and 132 and open contacts 123. Shunt field 124 is thus de-energized and shunt field 129 is energized to restore normal polarity by current passing from main 9, thence through wire 125, armature 122, wire 130, armature 131, contacts 132, wire 133, field 129 and wire 134 to main 8. Field 129 is wound so that it causes the booster 7 to raise the voltage of the battery to approximate the fixed voltage desired on the line when the field current is controlled by vibrating relay 120. Series field 144 is wound so that when the battery is discharging this field assists shunt field 129 and assists in compensating for voltage drop of the battery when heavy discharges are necessary. In order to prevent the series field 144 assisting the field 124 when the battery is being charged a relay 146 is energized by the same current as energizes field 124 thereby closing a short circuit or shunt 147 around the series field but when field 124 is de-energized, relay 146 is de-energized likewise whereby shunt or short circuit 147 is disconnected to permit the series field to be energized.

Summary of certain features.—From the foregoing disclosure it is seen that certain of the specific features of the system are:

I. When line load is small, battery carries it alone until the battery discharges a predetermined amount, when

1. Ampere hour meter connection 14, 18 is made and starts power generating unit A,

a. By causing generator to act as motor

b. During which time compressor relief valve is closed and fuel by-pass valve is positioned for admission of fuel to cylinders, whereupon

c. Engine starts and continues operating if lubricating pressure and thermostatic controls permit, the generator now supplying current to the battery and mains.

2. If power unit A fails to start or fails during operation, last unit D is automatically substituted and started, in that

a. Generator on unit A acts as a motor for a period of time sufficient to start the engine and upon failure to start, reverse current relay 4 causes

1. Motor action of generator to be stopped,

2. By-pass of fuel oil from cylinder, and makes

3. Starting connections for last unit D,

which is started and controlled in same manner as unit A.

3. If generating unit A starts, it remains in operation until battery is fully charged when hand 14 is up and opens contacts 16, 17 to prevent operation of a unit.

II. If line load is too great for constant supply by battery alone, units are successively added to line, as the load requires,

1. If any unit fails to start or operate in its turn

a. The last unit is automatically substituted and started

b. And the other units are added in their regular order.

2. If the last unit fails to operate, units B and C are added successively.

III. The units may be successively added

1. First at part speed and capacity

2. Then at full speed and capacity.

a. Speed governor is set for initial operation at part speed while

b. Successive increases in line load, operates electrical controls for resetting speed governors for full speed on successive units.

IV. Generator voltage maintained constant, during speed change, by independent rheostat governor.

V. Battery booster control of voltage is had, when

1. Battery is supplying line alone.

2. Any one of the series of generating units is starting or the load is being shifted or divided between units.

3. A sudden load is added to the line.

4. The relay system operates to reverse the normal polarity of the booster to charge the battery when normal line voltage exists and to restore normal polarity when line voltage drops thereby to maintain normal line voltage.

It is thus seen that many automatic features are had and which in addition permits use of a battery having a smaller capacity than would be necessary to carry normal line loads although the battery is able momentarily to carry loads in excess of its capacity until an additional unit may be started to carry the excess load. While my improved system has been shown in connection with four units it is readily seen and to be understood that many features are applicable in a system employing two or three units or even more than four units although a three unit system will probably be preferred.

Other changes and variations may be had from the arrangement specifically disclosed without departing from the spirit of the invention as set forth in the appended claims.

I claim:

1. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, and means whereby upon failure of a unit another unit is automatically substituted therefor.

2. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system for supplying motor starting current, and control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, said internal combustion motors being of the Diesel engine type and provided with a fuel supply, and said control means including mechanism adapted to by-pass engine fuel automatically when the engines fail to operate or are inoperative.

3. The combination set forth in claim 1 further characterized in that said units are three or more in number and have provision whereby they are adapted to operate successively as set forth in claim 1.

4. An automatic electric generating system adapted to supply current to a main line comprising, in combination, three or more generating units each having a generator driven by an internal combustion motor, a storage battery in said system for supplying motor starting current, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, and means whereby if a certain unit stops or fails to start another of the units is automatically operated out of its regular successive order.

5. An automatic electric generating system adapted to supply current to a main line comprising, in combination, three or more units each having a generator and an internal combustion motor for driving the same, means whereby the units are adapted to be started up in a predetermined order and brought onto the line automatically in accordance with the line load, and means whereby if one of said units fails another of said units which is operated the least will automatically be started to substitute for the unit which failed.

6. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system, control means adapted automatically to start said units successively as the load demand requires, and means whereby if a generating unit becomes out of order it is automatically stopped and another unit automatically started.

7. An automatic electric generating system comprising, in combination, a plurality of

generating units each having a generator driven by an internal combustion motor, a storage battery in said system, control means adapted automatically to start said units successively as the load demand requires, and means whereby if a generating unit becomes out of order it is automatically stopped and the load distributed among other units if all are operating or if a remaining unit is idle and ready for operation it will be automatically started to carry the load of the unit which is stopped.

8. The combination set forth in claim 6 further characterized by having means whereby any unit is stopped automatically in accordance with a rise in temperature, of an engine part, above a predetermined value, while the remainder of the generating system continues to function in the automatic manner set forth in claim 6.

9. The combination set forth in claim 6 further characterized by having means whereby any unit is stopped automatically in accordance with a failure of the lubricating oil supply, while the remainder of the generating system continues to function in the automatic manner set forth in claim 6.

10. The combination set forth in claim 1 further characterized by having said control means include for each unit a relay operated by line current, the relay for each unit having provision whereby it is adapted to close on substantially the same line current that closes the relay for the preceding unit.

11. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system for supplying motor starting current, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, and means whereby the units upon being successively started are initially operated at part speed and when the line load increases the units are operated at full speed.

12. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system for supplying motor starting current, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, and means whereby the units upon being successively started are initially operated at part speed and when the line load increases the units are successively operated at full speed.

13. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system for supplying motor starting current, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, a battery booster, and means whereby the battery booster acts to maintain a substantially constant voltage on the line when the load is temporarily in excess of the capacity of the generating unit or units which are operating.

14. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system, means whereby the units are started by current supplied from the battery to the generators thereby causing the latter to act as electric motors for starting the combustion motors, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, a battery booster, and means whereby substantially constant voltage on the line is maintained by said booster while a unit is being started.

15. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system for supplying motor starting current, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, a battery booster, and control means whereby when the units are supplying all the line load, the battery booster acts to raise the line voltage to such a value across the battery terminals that the battery may absorb its full charge.

16. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system for supplying motor starting current, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, said control means including electrical mechanism responsive to successive increases in line load to start and add units automatically in accordance with said increases, a battery booster, and means whereby substantially constant voltage on the line is maintained by said booster while a unit is being started.

17. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator

driven by an internal combustion motor, a storage battery in said system for supplying motor starting current, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, said control means including relay mechanism operated in steps automatically in accordance with increases in line load to automatically start the units in operation, and means whereby substantially constant voltage is maintained on the line while a unit is being started.

18. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by a Diesel engine provided with a fuel supply which is open during starting and running of the engine, a supplemental source of current connected to said system, control means adapted to start said units successively and bring the same into parallel operation automatically as the load demand requires, said control means having provision for effecting the starting of the first unit by current supplied from said supplemental source, and means for automatically diminishing the engine fuel supply when an engine fails to operate.

19. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by a Diesel engine, provided with a compression relief a supplemental source of current connected to said system, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, said control means having provision for effecting the starting of the first unit by current supplied from said supplemental source, and means for stopping an engine by relieving the compression thereof, automatically in accordance with predetermined operating conditions.

20. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by a Diesel engine, provided with a fuel supply, a supplemental source of current connected to said system, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, said control means having provision for effecting the starting of the first unit by current supplied from said supplemental source, and means for stopping an engine by controlling the fuel supply therefor automatically in accordance with predetermined operating conditions.

21. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by a Diesel engine, provided with a fuel supply and a compression relief, a supplemental source of current connected to said system, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, said control means having provision for effecting the starting of the first unit by current supplied from said supplemental source, and means for stopping an engine by diminishing the fuel supply therefor and relieving the compression thereof automatically in accordance with predetermined operating conditions.

22. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by a Diesel engine, provided with a fuel supply and compression relief, a supplemental source of current connected to said system, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, said control means having provision for effecting the starting of the first unit by current supplied from said supplemental source, and means for stopping an engine by diminishing the fuel supply therefor and relieving the compression thereof automatically in accordance with predetermined operating conditions, said latter means including solenoids, one for the fuel supply and another for the compression relief, with a common circuit therefor.

23. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by a Diesel engine, a supplemental source of current connected to said system, control means adapted to start said units successively and bring the same into parallel operation, automatically as the load demand requires, and means whereby if any unit stops or fails to start, another of the units which is operative and available is automatically started and operated.

24. An automatic electric generating system, comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a storage battery in said system, control means adapted automatically to start said units successively as the load demand requires, means whereby if a generating unit becomes out of order it is automatically stopped and another unit automatically started, and means whereby if the latter unit fails to function then another unit is started.

25. An automatic electric generating system, comprising, in combination, three or more units each having a generator and an

internal combustion motor for driving the same, means whereby the units are adapted to be started up in a predetermined order and brought onto the line automatically in accordance with the line load, and means whereby if one of said units fails another of said units is automatically started to substitute for the unit which failed.

26. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a supplemental source of current connected to said system for supplying the small loads thereof, without operation of a generating unit, control means adapted to start said units in a predetermined order automatically in accordance with the load demand, said control means having provision for starting the first unit by current from said supplemental source and for starting subsequent units by current from the unit which is initially operated, a voltage booster for said supplemental supply, and means for controlling said booster whereby substantially constant voltage is maintained on the line when any unit is being started or the line load is in excess of the capacity of the generating unit or units which are operating.

27. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a supplemental source of current connected to said system for supplying the small loads thereof, without operation of a generating unit, and control means adapted to start said units in a predetermined order automatically in accordance with the load demand, said control means having provision for starting the first unit by current from said supplemental source and for starting subsequent units by current from the unit which is initially operated, and means whereby if a generating unit fails to function it is automatically stopped and another unit automatically started.

28. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, a supplemental source of current connected to said system for supplying the small loads thereof, without operation of a generating unit, and control means adapted to start said units in a predetermined order automatically in accordance with the load demand, said control means having provision for starting the first unit by current from said supplemental source and for starting subsequent units by current from the unit which is initially operated, and means whereby if a unit fails to function another unit is automatically started and continued in operation irrespective of any decrease in line load.

29. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, control means adapted automatically to start said units successively as the load demand requires, and means whereby if one of the units fails to function another unit is automatically started and continued in operation even though there subsequently exists a load demand below that required to start the unit which failed.

30. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, control means adapted automatically to start said units successively as the load demand requires, means whereby if one of the units fails to function another unit is automatically started and continued in operation even though there subsequently exists a load demand below that required to start the unit which failed, and means whereby upon starting of the continued operating unit an additional unit is rendered available thereby providing an excess immediate potential supply of power.

31. An automatic electric generating system adapted to supply current to a main line comprising, in combination, a plurality of generating units each having a generator driven by an internal combustion motor, control means adapted automatically to start said units successively as the load demand requires, means whereby if one of the units fails to function another unit is automatically started and continues in operation even though there subsequently exists a load demand below that required to start the unit which failed, means whereby upon starting of the continued operating unit an additional unit is rendered available thereby providing an excess immediate potential supply of power, and means for discontinuing the additional unit when the load demand drops below a predetermined value but permitting the continued operation of the other unit.

CHESTER F. STRONG.