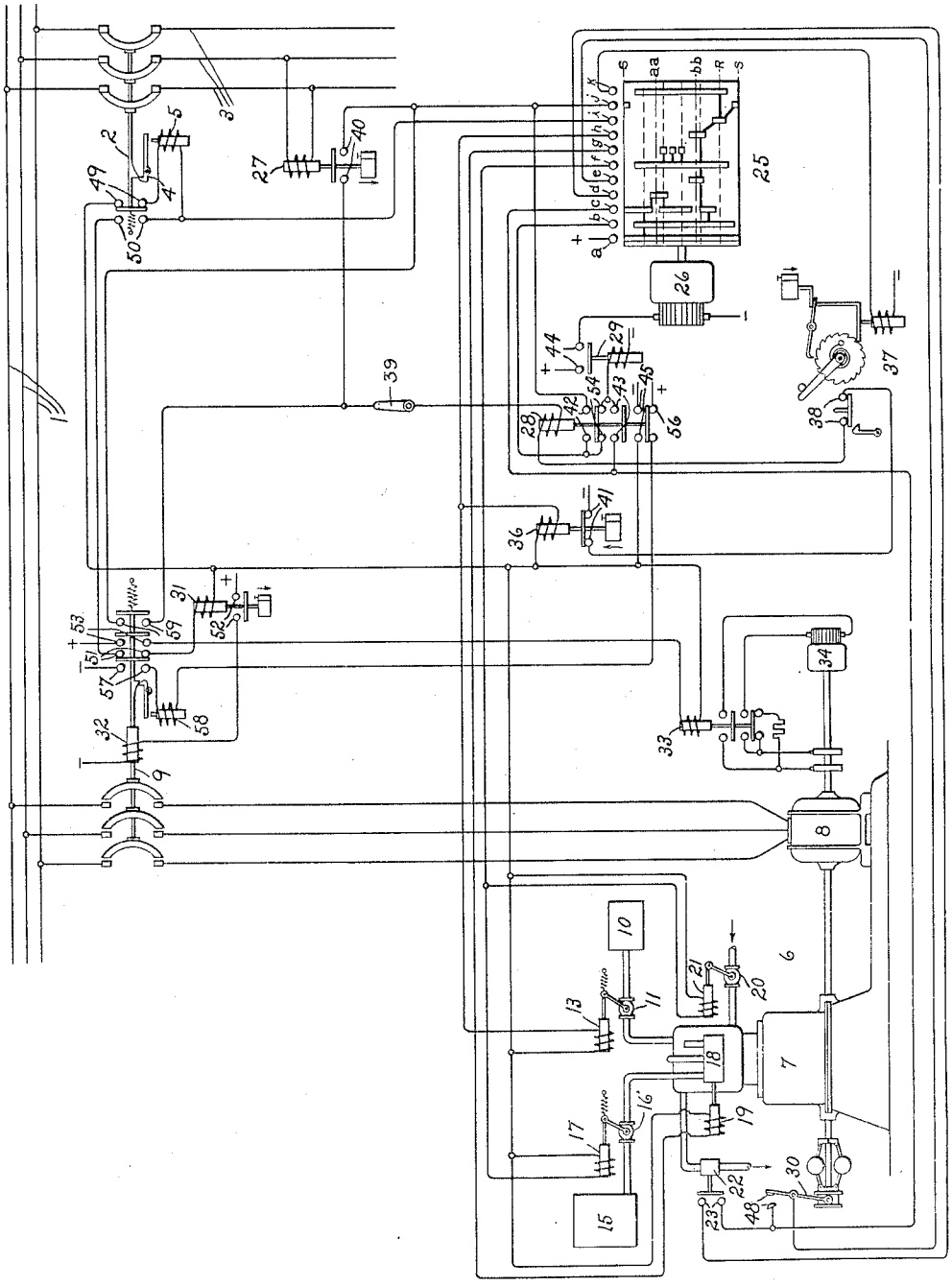
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AUTOMATIC PRIME MOVER DYNAMO ELECTRIC PLANT

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Inventor:
John M. Drabelle,
by Charles R. Mullan
His Attorney.

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AUTOMATIC PRIME MOVER DYNAMO-ELECTRIC PLANT

John M. Drabelle, Cedar Rapids, Iowa, assignor to General Electric Company, a corporation of New York

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My invention relates to automatic prime mover dynamo electric plants and its object is to provide an improved arrangement for automatically placing in operation an internal combustion engine-driven generator and particularly a Diesel engine driven generator.

Many small towns and communities receive electric power from a single power line which may be supplied with electric power by a source situated many miles away. In order to maintain continuity of service, in case the power line or the source connected thereto fails, it is desirable to have available an auxiliary source of current which may be used while the main source of supply is not available. It is essential, however, that this auxiliary source should be one which is inexpensive to install and maintain, which can be easily and quickly placed in operation when it is necessary to operate it, and whose operation can be depended upon under all conditions of weather. In accordance with the preferred embodiment of my invention, I accomplish these results by providing a Diesel engine driven generator, and means for automatically starting the Diesel engine and connecting the generator to the distribution system in response to a predetermined voltage failure of the normal supply circuit for the distribution system.

My invention will be better understood from the following description when taken in connection with the accompanying drawing, the single figure of which is a diagrammatic representation of a control system for a Diesel engine driven generator, and its scope will be pointed out in the appended claims.

Referring to the accompanying drawing, 1 represents an alternating current distribution circuit which is normally connected by means of a suitable switch 2 to an alternating current supply circuit 3. The switch 2, which may be of any suitable type, examples of which are well known in the art, is shown as a latched in circuit breaker which is held in its closed position by a latch 4 and which is arranged to be opened in response to the energization of a trip coil 5.

In order that the distribution circuit 1 may be supplied with current when the supply circuit 3 fails, I provide an internal combustion engine driven dynamo electric plant 6 which is arranged to be started and connected automatically to the distribution circuit 1 when the voltage of the supply circuit 3 remains below a predetermined value for a predetermined time. As shown, the dynamo electric plant 6 includes a Diesel engine 7 direct connected to an alternating current generator 8 which is arranged to be connected across the distribution circuit 1 by means of a suitable circuit breaker 9.

The Diesel engine 7 may be of any suitable construction, examples of which are well known in the art. Preferably, it is a multi-cylinder engine. Any suitable starting arrangement may also be provided. In the arrangement shown in the drawing, it is assumed that the engine is started by admitting compressed air from a suitable reservoir 10 to one or more cylinders of the engine. This is one of the well known arrangements for starting a Diesel engine. The supply of air pressure from the reservoir 10 to the engine 7 is controlled by means of a suitable valve 11 which is arranged to be opened by means of a magnet 13 when it is energized.

The supply of fuel from a fuel tank 15 to the engine 7 is controlled by means of a suitable control valve 16 which is arranged to be opened by means of a magnet 17 when it is energized. In order that the engine may be primed before starting, I provide a suitable primer 18 which has an operating winding 19. The engine 7 is water cooled and the supply of water to the cooling system is controlled by a suitable valve 20 which is arranged to be opened by a magnet 21 when it is energized. A suitable water flow indicator 22, examples of which are well known in the art, is provided with contacts 23 which are arranged to be closed when the cooling water is flowing through the cooling system of the engine.

With the arrangement shown, the engine is started by first opening the valves 16 and 20, then operating the primer 18 several times and then opening the valve 11 to admit compressed air to one or more of the engine cylinders. After the engine starts, the valve 11 is closed to shut off the supply of compressed air to the engine cylinders and thereby render the starting means inoperative.

In order that the various auxiliary devices associated with the engine 7 may be operated automatically in the proper sequence to start the engine, I provide a motor operated controller 25 which includes a driving motor 26 and a plurality of spaced movable contacts which are respectively arranged to engage stationary contacts so as to complete the various control circuits in the proper sequence.

As shown in the drawing, the automatic starting of the dynamo electric plant 6 is effected in response to the operation of a time delay voltage relay 27 which is responsive to the voltage of the supply circuit 3. When the voltage of the supply

circuit 3 decreases below a predetermined value and remains below this predetermined value for a predetermined length of time, the relay 27 effects the energization of a master relay 28 which, in turn, effects the energization of a control relay 29 to complete an energizing circuit for the controller motor 26. The controller 25 is then operated to effect the operation of the fuel valve 16 and the water valve 20 associated with the engine 7 after which the original energizing circuit for the control relay 29 is opened. As soon as the cooling water for the engine 7 begins to flow through the cooling system of the engine 7, the water flow indicator 22 completes an energizing circuit for the control relay 29 to restart the controller 25. The controller 25 then effects successively the operation of the primer 18 a plurality of times and then the opening of the air valve 11 after which the energizing circuit of the control relay 29 is opened to stop the controller until the engine speed reaches a predetermined value. As soon as the engine starts and its speed increases above a predetermined value, a suitable speed responsive device 30 completes an energizing circuit for the control relay 29 to restart the controller which then effects the energization of the trip coil 5 of the circuit breaker 2 to disconnect the deenergized supply circuit 3 from the distribution circuit 1 and then effects the energization of the control relay 31 which, in turn, completes an energizing circuit for the closing coil 32 of the circuit breaker 9 so that the unexcited generator 8 is connected across the distribution circuit 1. The closing of the circuit breaker 9 completes a circuit for a field contactor 33 which, when closed, connects the field winding of the generator 8 across a suitable source of direct current such as a direct connected exciter 34 so that the load circuit 1 is again energized.

In case the engine fails to start within a predetermined time, I provide an arrangement whereby the controller 25 is moved to its normal shutdown positions if the engine speed does not build up to a value to effect the operation of the speed responsive means 30 within a predetermined time after the air valve 11 is opened to start the engine. This arrangement includes a time relay 36 which is energized when the operating magnet 13 of the air valve 11 is energized and which, when energized for a predetermined length of time, effects the deenergization of the master relay 28. The master relay 28, when deenergized, effects the completion of a circuit for the motor 26 to return the controller 25 to its normal shutdown positions. If the voltage of the normal supply circuit 3 is still below a predetermined value when the controller 25 reaches its normal shutdown positions, the original energizing circuit of the master relay 28 again is completed to effect the operation of the controller 25 to attempt another starting of the engine. In order to limit the number of times the controller 25 can be operated within a predetermined time to effect the starting of the engine, I provide a notching relay 37 which is so connected to the controller 25 that it is energized once during each revolution of the controller. If the controller 25 makes a predetermined number of revolutions within a predetermined time, the relay 37 is arranged to open permanently its contacts 38 which are in the circuit of the master relay 28 so that the relay 28 remains deenergized independently of the voltage of the supply circuit 3 when the controller 25 subsequently reaches its normal shutdown positions.

39 represents a manually controlled switch which is so connected that when it is open it effects the shutting down of the prime mover plant 6 if it is in operation and prevents the plant from being started in response to the voltage of the supply circuit when the plant is shut down.

The operation of the system shown in the drawing is as follows: When the supply circuit 3 is energized and is connected to the load circuit 1 by the circuit breaker 2 and the prime mover plant 6 is shut down, the various control devices are in the positions shown in the drawing.

Let it now be assumed that the voltage of the supply circuit 3 decreases below a predetermined value so that the voltage relay 27 becomes deenergized. If the supply circuit voltage remains below this predetermined value for a predetermined length of time, relay 27 closes its contacts 40 and completes an energizing circuit for the master relay 28. This circuit is from one side of a suitable control circuit through the stationary contacts *a* and *j* and cooperating movable contacts of the controller 25, contacts 40 of the voltage relay 27, control switch 39, winding of relay 28, contacts 38 of notching relay 37, contacts 41 of relay 36 to the other side of the control circuit. Relay 28 by closing its contacts 43 completes, through the contacts *a* and *c* of the controller 25, an energizing circuit for the control relay 29. The control relay 29 by closing its contacts 44 completes an energizing circuit for the controller motor 26 so that the controller 25 is moved out of its normal shut down positions.

Shortly after the controller leaves its normal shut down position, its movable contacts effect the disconnection of the stationary contact *j* from the stationary contact *a* and the connection of the stationary contacts *b*, *f* and *k* to the stationary contact *a*. The connection of the stationary contact *b* to the stationary contact *a* of the controller 25 completes a locking circuit for the winding of the relay 28 so that this relay remains energized after the stationary contact *j* of the controller 25 is disconnected from the stationary contact *a*. This locking circuit is from one side of the control circuit through the contacts *a* and *b* of the controller 25, contacts 42 of the relay 28, contacts 40 of the voltage relay 27, control switch 39, winding of relay 28, contacts 38 of notching relay 37, contacts 41 of relay 36 to the other side of the control circuit.

The connection of the contact *f* to the contact *a* of the controller 25, completes the circuits for the operating magnets 17 and 21 of the fuel valve 16 and the water valve 20 respectively. The circuits of these magnets also include the contacts 45 of the master relay 28. As soon as the cooling water starts to flow through the cooling system of the engine 7, the water flow indicator 22 closes its contacts 23 so that when the controller 25 reaches its position *aa* an energizing circuit is completed for the control relay 29.

The connection of the contact *k* to the contact *a* of the controller 25 completes an energizing circuit for the notching relay 37 so that its movable arm is moved forward a predetermined distance but not far enough to effect the opening of the relay contacts 38.

When the controller 25 reaches its position *aa*, the above traced circuit for the control relay 29 through the contacts *a* and *c* of the controller 25 is opened. If, however, the cooling

water is flowing through the cooling system of the engine 7, the contacts 23 of the water flow indicator 22 completes through the contacts *a* and *d* of the controller 25 and the contacts 43 of the master relay 28 an energizing circuit for the control relay 29 to effect the movement of the controller from its position *aa* to its position *bb*. Shortly after the controller moves out of its position *aa*, the above traced circuit of the control relay 29 through the contacts *a* and *c* of the controller 25 is completed to effect the movement of the controller to position *bb* after the contact *d* is disconnected from the contact *a* of the controller 25. While the controller 25 is effecting this movement from its position *aa* to its position *bb*, the contact *g* of the controller is connected to the contact *a* a plurality of times so that the operating magnet 19 of the primer 18 is energized to prime the engine 7 a plurality of times. The circuit of the magnet also includes the contacts 45 of the relay 28.

When the controller 25 reaches position *bb*, the contact *c* is disconnected from the contact *a* of the controller so that the control relay 29 becomes deenergized and, in turn, deenergizes the operating motor 26. In position *bb* of the controller 25, the contact *h* is connected to the contact *a* of the controller so that the magnet 13 and the time relay 36, which are connected in parallel, are simultaneously energized. The energization of the magnet 13 opens the air valve 11 so that compressed air is admitted to one or more cylinders of the engine 7 to effect the starting thereof. If the engine starts immediately, its speed increases to a value sufficient to cause the speed responsive device 30 to close its contacts 48 and thereby complete a circuit for the control relay 29 through the contacts *a* and *e* of the controller 25 and the contacts 45 of the master relay 28 to effect the movement of the controller 25 from its position *bb* to its running position R.

Shortly after the controller 25 leaves its position *bb*, the contact *h* is disconnected from the contact *a* so that the magnet 13 is deenergized and the air valve 11 is closed. When the controller 25 reaches its running position R, the control relay 29 is deenergized by the disconnection of the contact *c* from the contact *a* of the controller 25. In the running position R of the controller 25 the contact *i* is connected to the contact *a* so that an energizing circuit is completed for the trip coil 5 of the circuit breaker 2 to effect the disconnection of the deenergized supply circuit 3 from the distribution circuit 1. The energizing circuit of the trip coil 5 also includes the auxiliary contacts 49 on the circuit breaker 2 and the contacts 45 of the master relay 28. As soon as the circuit breaker 2 opens, a circuit is completed for the control relay 31 to effect the energization of the closing coil 32 of the circuit breaker 9. The circuit of the control relay 31 is from one side of the control circuit through the contacts *a* and *i* of the controller 25, contacts 50 on the circuit breaker 2, contacts 51 on the circuit breaker 9, winding of relay 31, contacts 45 of the master relay 28 to the other side of the control circuit. Relay 31 by closing its contacts 52 completes the energizing circuit for the closing coil 32 so that the armature winding of the unexcited generator 8 is connected to the distribution circuit 1. As soon as the circuit breaker 9 closes its auxiliary contacts 53 complete an energizing circuit for the field contact 33 so that the field winding of the generator 8 is connected across the exciter 34. This energizing circuit for the field contactor 33 also includes the contacts 45 of the master relay 28.

As soon as the field contactor 33 is closed the voltage is restored to normal across the distribution circuit 1.

The plant may be shut down by opening the control switch 39 which deenergizes the master relay 28. The closing of the contacts 54 of the master relay 28 completes through the contacts *a* and *b* of the controller 25 an energizing circuit for the control relay 29 to effect the movement of the controller from the running position R to the shut down positions. The closing of the contacts 56 of the master relay 29 completes through the auxiliary contacts 57 on the circuit breaker 9 an energizing circuit for the trip coil 58 of the circuit breaker 9 so that the generator 8 is disconnected from the distribution circuit 1.

If the engine 7 fails to start when the controller 25 is in position *bb*, the above traced circuit for the control relay 29 through the contacts 48 of the speed responsive device 30 is not completed and, therefore, the time relay 36 which is connected in parallel with the magnet 13 of the air valve 11, is energized for a sufficient length of time to effect the opening of its contacts 41 which are in the energizing circuit of the master relay 28. Relay 28, by closing its contacts 54, completes through the contacts *a* and *b* of the controller 25 an energizing circuit for the control relay 29 to effect the movement of the controller 25 from its position *bb* through its running position R to its shut down positions. If the contacts 40 of the voltage relay 27 are still closed when the controller reaches its shut down positions, the master relay 28 is again energized to effect another operation of the controller 25. If the controller 25 makes a predetermined number of revolutions within a predetermined time so that the notching relay 37 is not restored to its normal position between successive operations of the controller 25, the relay 37 permanently opens its contacts 38 in series with the winding of the master relay 28 so that when the controller subsequently reaches its shut down positions, the master relay 28 is not again energized to effect another operation of the controller 25 although the contacts 40 of the voltage relay 27 may be closed.

While I have, in accordance with the patent statutes, shown and described my invention as applied to a particular system and as embodying various devices diagrammatically indicated, changes and modifications will be obvious to those skilled in the art and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, a distribution circuit, a supply circuit connected to said distribution circuit, an internal combustion engine driven dynamo plant, and means responsive to a predetermined condition of the voltage of said supply circuit for effecting the starting of the said plant, and means responsive to said starting for effecting the disconnection of said supply circuit from said distribution circuit and the subsequent connection of said plant to said distribution circuit.

2. In combination, a distribution circuit, a supply circuit connected to said distribution circuit, an internal combustion engine driven dynamo plant, means responsive to a predetermined condition of said supply circuit for effecting the start-

ing of the engine of said plant, and speed responsive means for effecting the disconnection of said supply circuit from said distribution circuit and the subsequent connection of said plant to said distribution circuit when the speed of the engine of said plant is above a predetermined value.

3. In combination, a distribution circuit, a supply circuit connected to said distribution circuit a Diesel engine driven generator, starting means for the engine driving said generator, means for effecting the operation of said starting means, and means responsive to a predetermined condition of said generator for effecting in succession the disconnection of said supply circuit from said distribution circuit and the connection of said generator to said distribution circuit.

4. In combination, a distribution circuit, a supply circuit connected to said distribution circuit an internal combustion engine driven generator having a field winding, means for starting the engine driving said generator, means responsive to a predetermined speed condition of said engine for effecting in succession the disconnection of said supply circuit from said distribution circuit and the connection of said generator to said distribution circuit with the field winding of the generator unexcited, and means responsive to the connection of said generator to said distribution circuit for effecting the energization of the field winding of said generator.

5. In combination, an electric circuit, an internal combustion engine driven generator, a cooling system for said engine means for supplying cooling water to said cooling system, a valve controlling the supply of cooling water, a primer, starting means, means for effecting the operation of said valve to admit cooling water to the cooling system of said engine, means responsive to the flow of water through the cooling system of said engine for effecting the operation of said primer and the subsequent operation of said starting means, and means responsive to the starting of said engine for rendering said starting means inoperative and for effecting the connection of said generator to said circuit.

JOHN M. DRABELLE.