Dec. 27, 1955 W. T. J. DAY ET AL 2,728,865

AUTOMATIC POWER CONTROL SYSTEM

Filed Nov. 5, 1951

3 Sheets-Sheet 1

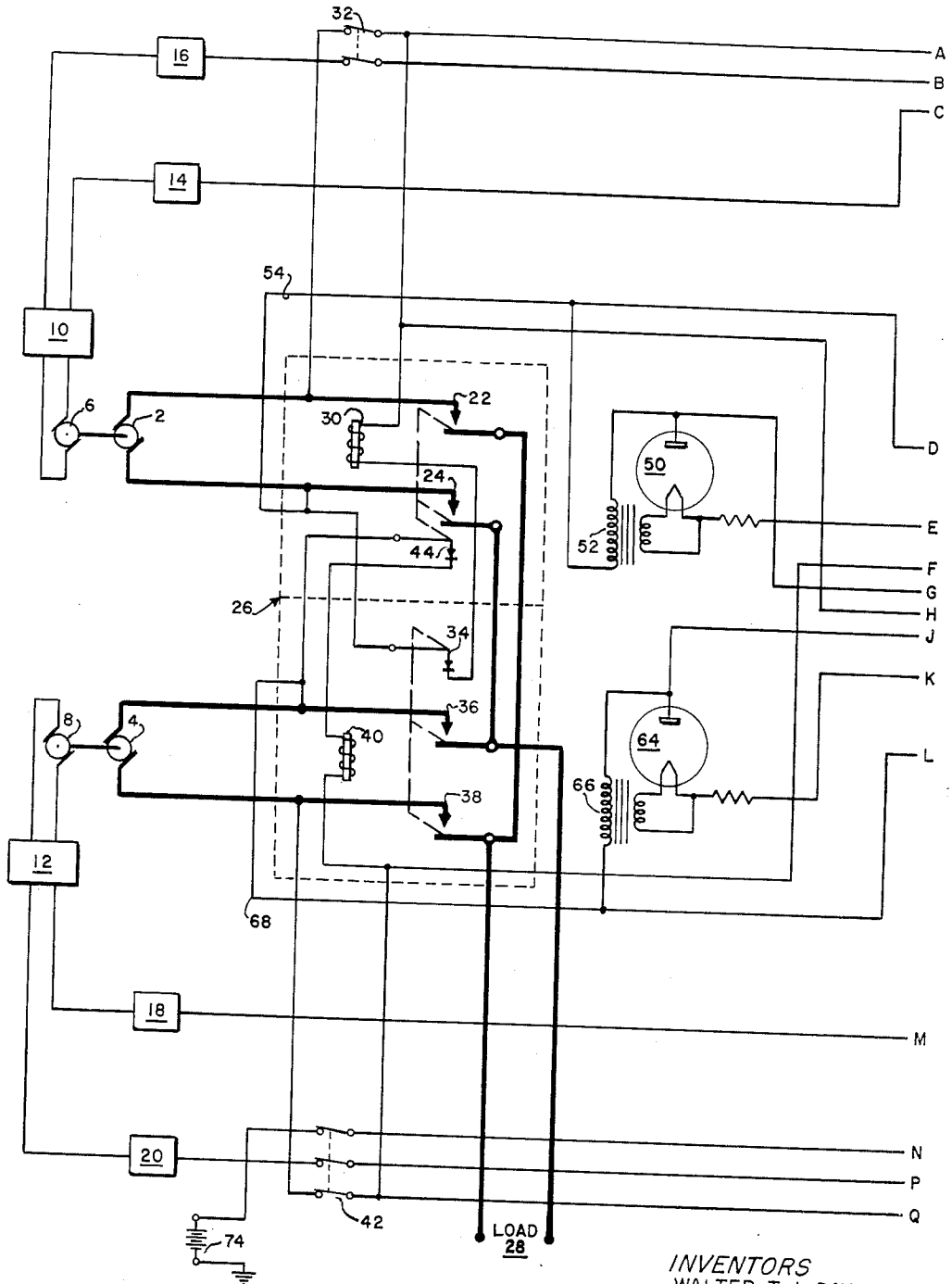


FIG. 1

INVENTORS
WALTER T. J. DAY
BENJAMIN LEVINE
WILLIAM E. SABLESAK

BY
Harry M. Saragovitz
Attorney

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3 Sheets--Sheet 2

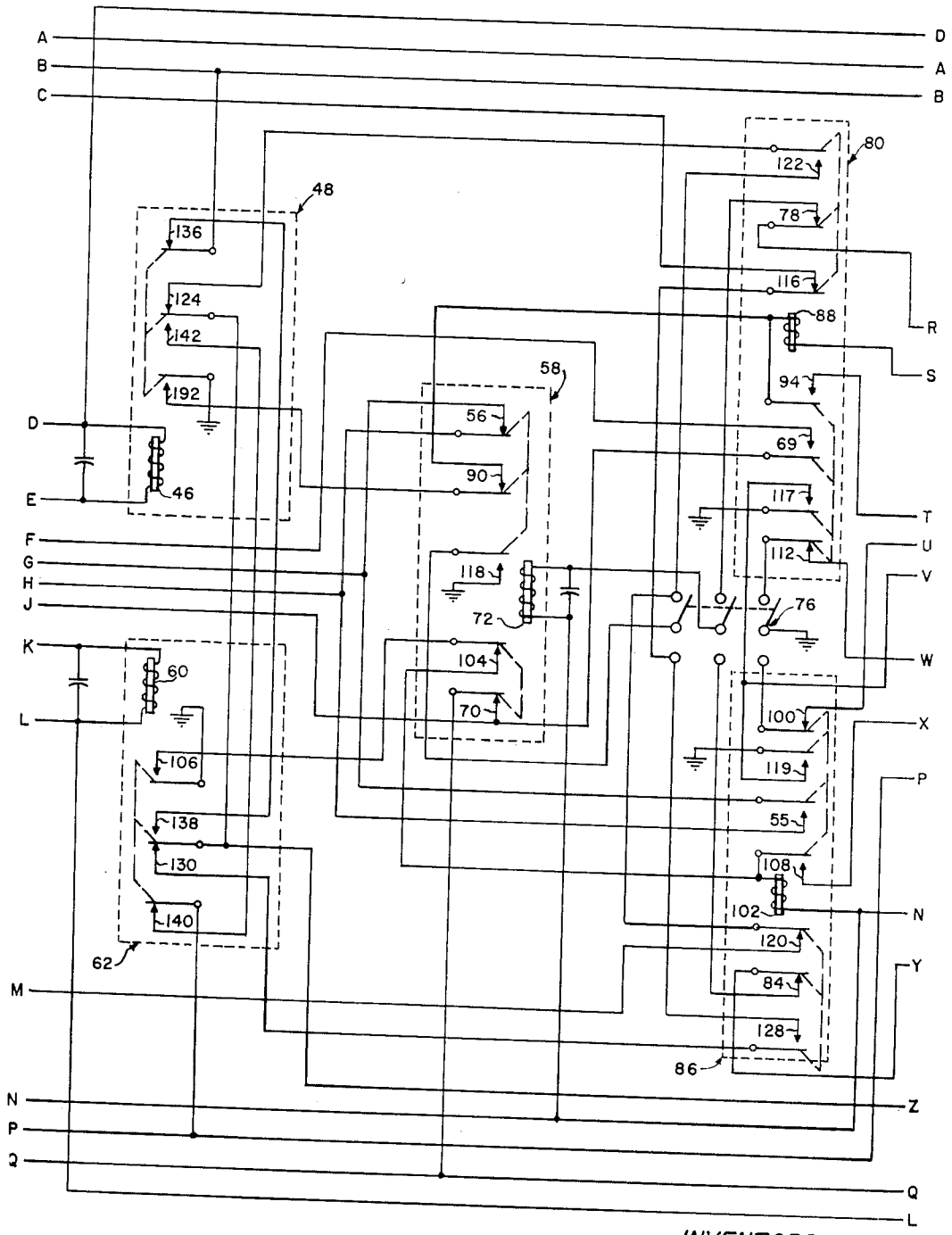


FIG. 2

INVENTORS
WALTER T. J. DAY
BENJAMIN LEVINE
WILLIAM E. SABLESAK

BY Harry M. Saragovitz
Attorney

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3 Sheets-Sheet 3

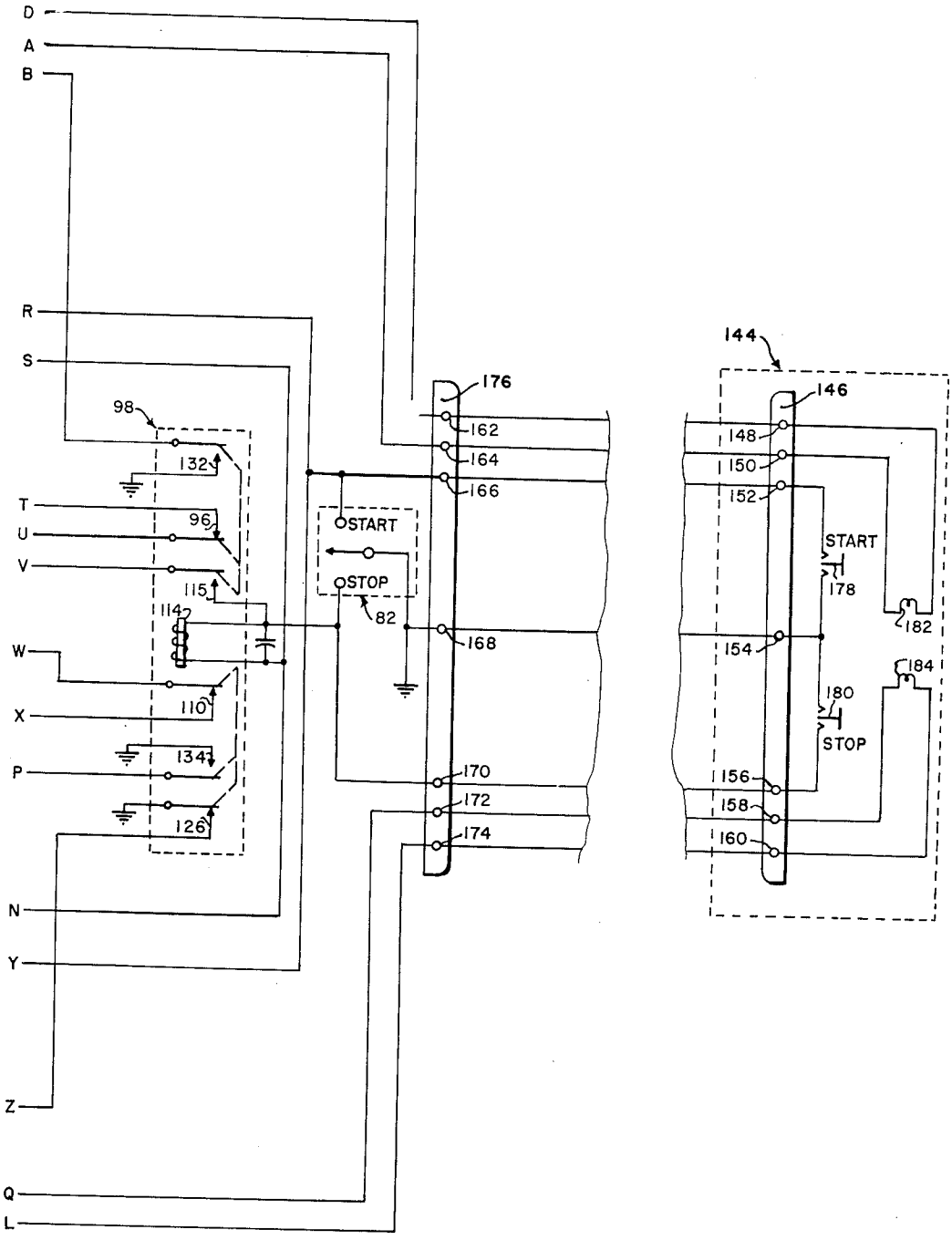


FIG. 3

INVENTORS
WALTER T. J. DAY
BENJAMIN LEVINE
WILLIAM E. SABLESAK

BY Harry M. Saragovitz
Attorney

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2,728,865

AUTOMATIC POWER CONTROL SYSTEM

Walter T. J. Day, Neptune, N. J., William E. Sablesak, New York, N. Y., and Benjamin Levine, Long Branch, N. J., assignors to the United States of America as represented by the Secretary of the Army

Application November 5, 1951, Serial No. 254,966

7 Claims. (Cl. 307—80)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment of any royalty thereon.

This invention relates to power switching systems and more particularly to power switching systems wherein automatic switching from a primary to an auxiliary source is accomplished upon failure of the primary source.

An object of this invention is to provide an automatic switching means which positively switches an auxiliary power source into a circuit upon failure of a primary source.

A further object of this invention is to provide for control means by which choice of primary and auxiliary source may be changed after operation has begun.

Former switching circuits known to the art have definitely predetermined primary and auxiliary sources, wherein the auxiliary source is intended merely for emergency use in the event of primary source failure, and usually provide for automatic reconversion to primary source use upon normal conditions returning to the primary source. It is a further object of this invention to provide a switching system for a plurality of sources whereby continued operation can be obtained through alternate operation of individual sources, such sources having their primary or auxiliary character manually determined during operation so that no particular source will be automatically favored by the switching system.

A further object of this invention is to provide for manual control of the automatic transfer system.

A further object of this invention is to provide an automatic switching system capable of remote control supervision.

Another object of this invention is to provide an improved automatic switching system in which either one of at least two power sources can be initially energized, and which, upon the failure of the initially energized power source, will cause the other power source to be activated. Another object is to provide an improved means to automatically couple a single load only to the activated source. A still further object is to provide an improved means to prevent the reenergization of the first activated power source, after its output has dropped and a second power source has been activated, by the second power source, thus enabling repairs upon the defective power source to be made without disturbing the load and yet preserving the automatic power source and load transfers.

These and further objects of this invention will appear in the following description and appended claims, reference being had to the appended drawing consisting of one figure.

In the appended drawing, consisting of three figures, one embodiment of the switching system as it could be used with single phase A. C. power sources is shown. It is obvious to those skilled in the art that, with slight modification, the same system could be made to control polyphase A. C. circuits or D. C. circuits, but, for the sake of simplicity, a single phase A. C. network is here shown.

In the drawing, power source generators 2 and 4 are shown mechanically connected to prime movers 6 and 8, respectively. Prime movers 6 and 8 are shown connected to motor control means 10 and 12, respectively. Motor control means 10 and 12 may be of any standard type known to the art and, because they are not part of the invention here, they are indicated and not described. Motor control means 10 is electrically connected to and controlled by start relay 14 and stop relay 16. Motor control means 12 is electrically connected to and controlled by start relay 18 and stop relay 20.

In the drawing, all relay arms are shown in their normal position with power sources 2 and 4 inoperative and electrically connected as follows. Power source 2 is connected through normally open arms 22 and 24 of relay 26 to load 28. Coil 30 of relay 26 is paralleled across power source 2 by means of switch 32 and arm 34 of relay 26. Power source 4 is connected through normally open arms 36 and 38 of relay 26 to load 28. Coil 40 is paralleled across power source 4 by means of switch 42 and arm 44 of relay 26. Coil 46 of relay 48 is connected to and derives its power from power source 2 through rectifier 50, transformer 52 and lead 54. Transformer 52 is connected across power source 2 through lead 54, arm 56 of relay 58 and switch 32. An auxiliary connection is provided for transformer 52 during manual transfer through relay 86. Thus, during manual transfer, transformer 52 is connected across power source 2 through lead 54, arm 55 of relay 86, and switch 32. Coil 60 of relay 62 is connected to and derives its power from power source 4 through rectifier 64, transformer 66 and lead 68. Transformer 66 is connected across power source 4 through lead 68, arm 70 of relay 58 and switch 42. An auxiliary connection is provided for transformer 66 during manual transfer through relay 80. Thus, during manual transfer, transformer 66 is connected across power source 4 through lead 68, arm 69 of relay 80 and switch 42. Coil 72 of manual start relay 58 is connected to D. C. source 74 through switch 42 and derives its operative ground through selector switch 76 and either arm 78 of relay 80 and manual start-stop button 82 or arm 84 of relay 86 and manual start-stop button 82, depending on the position of selector switch 76. Coil 88 of relay 80 is connected to D. C. source 74 through switch 42 and derives its operative ground through arm 90 of relay 58 and arm 192 of relay 48. If selector switch 76 is in its lower position, relay 80, upon operating, locks itself to ground through its own arm 94, arm 96 of relay 98, arm 100 of relay 86 and selector switch 76. Coil 102 of relay 86 is connected to D. C. source 74 through switch 42 and derives its operative ground through arm 104 of relay 58 and arm 106 of relay 62. If selector switch 76 is in its upper position, relay 86, upon operating, locks itself to ground through its own arm 108, arm 110 of relay 98, arm 112 of relay 80 and selector switch 76. Coil 114 of relay 98 is connected to D. C. source 74 through switch 42 and derives its operative ground through start-stop button 82. In addition to the grounding network thus provided, for coil 114 of relay 98, two other grounding circuits are provided to provide for time delay in the opening of relay 98 during the time that the operating power source is being de-energized. These circuits are provided by relays 80 and 86, depending on whether power source 2 or 4 is operating. If power source 2 is operating, coil 114 is grounded through arm 115 of relay 98 and arm 117 of relay 80; and if power source 4 is operating, coil 114 is grounded through arm 115 of relay 98 and arm 119 of relay 86.

Start and stop relays 14, 16, 18 and 20, indicated by squares in the drawing, are so connected to a power source (not shown) that they will operate as soon as they are grounded. The operative ground connections of these relays are as follows. When selector switch 76 is in its lower position and start-stop button 82 is pressed

to its start position, start relay 14 is connected to ground through arm 116 of relay 80, selector switch 76 and arm 118 of relay 58. In the event of power failure in power source 2, and while selector switch 76 is in its lower position, start relay 18 is connected to ground through arm 120 of relay 86, arm 122 of relay 80, arm 124 of relay 48 and arm 126 of relay 98.

When selector switch 76 is in its upper position and start-stop button 82 is pressed to its start position, start relay 18 is connected to ground through arm 120 of relay 86, selector switch 76 and arm 118 of relay 58. In the event of power failure in power source 4 and while selector switch 76 is in its upper position, start relay 14 is connected to ground through arm 116 of relay 80, arm 128 of relay 86, arm 130 of relay 62, and arm 126 of relay 98. When start-stop button 82 is pressed to its stop position, relay 98 operates so that stop relay 16 is grounded through switch 32 and arm 132 of relay 98 and stop relay 20 is grounded through switch 42 and arm 134 of relay 98.

Auxiliary grounding circuits are provided for stop relays 16 and 20 so that there is no possibility that one power source will cut in while the other is in operation. The auxiliary grounding circuit for stop relay 16 is provided by relay 62 which causes stop relay 16 to be connected to ground through switch 32, arm 136 of relay 48, arm 138 of relay 62 and arm 126 of relay 98, when power source 4 is operating. The auxiliary grounding circuit for stop relay 20 is provided by relay 48 which causes stop relay 20 to be connected to ground through switch 42, arm 140 of relay 62, arm 142 of relay 48, and arm 126 of relay 98.

In the operation of a system according to this invention, switches 32 and 42 are closed at all times. Said switches are not necessary to the system, but are merely provided as a safety feature. A choice is first made as to which of the two power sources 2 and 4 is to be used as a primary source. Selector switch 76 is then manually placed in a position corresponding to this choice. Assuming that it is desired to use power source 2 as a primary source, selector switch 76 is closed in its lower position. Start-stop button 82 is then placed in its start position. The placing of start-stop button 82 in its start position energizes relay 58 through the circuit D. C. source 74, coil 72 of relay 58, selector switch 76, arm 84 of relay 86 and start-stop button 82. Relay 58 then operates connecting ground to start relay 14 through arm 116 of relay 80, selector switch 76 and arm 118 of relay 58. Start relay 14 then operates through motor control 10 to start prime mover 6 and thus activate power source generator 2. Power source 2 then activates coil 30 of relay 26 through the circuit: switch 32, coil 30, and arm 34 of relay 26. The operation of coil 30 connects power source 2 to load 28 through arms 22 and 24 of relay 26 and breaks the contact made by arm 44 of relay 26 so that power source 4 has no possibility of being across load 28. Once power source 2 is operating properly, start-stop button 82 is released which removes ground from coil 72 of relay 58. This causes the contactor arms of relay 58 to return to the position shown in the drawing which connects the power developed by power source 2 to transformer 52 through arm 56 of relay 58 and switch 32. Transformer 52, through rectifier 50, then supplies D. C. power to coil 46 of relay 48, causing relay 48 to operate. The operation of relay 48 connects ground to stop relay 20 of motor 8 through arm 140 of relay 62, arm 142 of relay 48, and arm 126 of relay 98, thus preventing motor 8 and, consequently, power source 4, from operating. Further, the operation of relay 48 serves to operate relay 80 by grounding coil 88 through arm 90 of relay 58 and arm 92 of relay 48. When relay 80 operates, it locks coils 88 across D. C. supply 74 and ground through the circuit, D. C. supply 74, switch 42, coil 88, arm 94 of relay 80, arm 96 of relay 98, arm 100 of relay 86 and selector switch 76. At this time the system has completed its starting cycle and power source 2 is supplying the load 28.

In the event that power source 2 fails or its output falls below a predetermined level, the system of this invention causes power source 4 to be switched into operation in the following manner. The loss of voltage by power source 2 causes coil 30 of relay 26 to become inoperative, which breaks the contacts of arms 22 and 24 of relay 26 and removes load 28 from power source 2. Further, the inoperative character of coil 30 causes arm 44 of relay 26 to connect coil 40 of relay 26 across power source 4 through the circuit, arm 44 of relay 26, coil 40 of relay 26, and switch 42. At the same time, the failure of voltage in power source 2 causes coil 46 of relay 48 to become inoperative, returning the contact arms of relay 48 to the position shown in the drawing. The opening of arm 142 of relay 48 removes ground from stop relay 20. The closing of arm 124 of relay 48 causes ground to be connected to start relay 18 through said arm 124, arm 122 of relay 80 and arm 120 of relay 86. Start relay 18 then starts prime mover 8 through motor control 12. Power source 4 then begins operation. Power source 4 supplies power to coil 40 of relay 26, closing arms 36 and 38 and opening arm 34 of relay 26. Arms 36 and 38 of relay 26 then connect power source 2 to load 28. The opening of arm 34 of relay 26 opens the circuit of coil 30 of relay 26 so that power source 2 can not develop voltage and place itself back on load 28. Also, when power source 4 begins operation, it supplies power to transformer 66 through arm 70 of relay 58 and switch 42. Transformer 66, through rectifier 64, then supplies D. C. power to coil 60 of relay 62, causing relay 62 to operate. The operation of relay 62 connects ground to stop relay 16 of motor 6 through arm 136 of relay 48, arm 138 of relay 62 and arm 126 of relay 98, thus preventing motor 6 and, consequently, power source 2, from operating. Further, the operation of relay 62 serves to operate relay 86 by grounding coil 102, through arm 104 of relay 58 and arm 106 of relay 62. Further, the operation of relay 86 opens arm 100 of relay 86, thus opening the lock circuit of relay 80 and causing relay 80 to release. The fact that selector switch 76 is in its lower position prevents relay 86 from locking itself to D. C. source 74 and ground, thus making the operative condition of relay 86 dependent on the continued operation of power source 4. The dependence of relay 86 on power source 4 therefore prevents the system from attempting to switch back to power source 2 operation, in the event of power failure in power source 4 because the system is symmetrical, so that just as switching from power source 2 to power source 4 was dependent on relay 80 remaining operative through its selector switch lockin, so would automatic switching from power source 4 to power source 2 be dependent upon the continued operation of relay 86.

In the event that the difficulty that caused power source 2 to fail is corrected, and it is desired to cause the system to transfer the load to power source 2 when power source 4 fails, selector switch 76 may be thrown to its upper position which provides a lock-in circuit for coil 102 of relay 86 as follows: D. C. source 74, switch 42, coil 102, arm 108 of relay 86, arm 110 of relay 98, arm 112 of relay 80 and selector switch 76. The system will then cause load 28 to be switched to power source 2 in the event that power source 4 fails in the same manner as the load was automatically transferred from power source 2 to power source 4 when power source 2 failed, the only difference being that the corresponding parts of the symmetrical circuit will be utilized.

The system, according to this invention, also provides a manual transfer feature which can be used to switch from one power source to the other without waiting for power failure in the power source that is supplying the load. To illustrate this feature, assume that power source 2 is supplying load 28 and that it is desired to transfer

to power source 4, then coil 30, relay 26, relay 48, and relay 80 would be operative, and coil 40, relay 26, relay 62, and relay 86 would be inoperative, as shown in the drawing, and selector switch 76 would be in its lower position. To initiate manual transfer, start-stop button 82 is pushed to the start position which completes the supply circuit of coil 72 of relay 58 through selector switch 76, arm 84 of relay 86, and start-stop button 82. Coil 72 then operates relay 58. When relay 58 operates, arm 56 opens the circuit of coil 46 of relay 48, causing relay 48 to become inoperative. When relay 48 becomes inoperative, arm 142 opens the circuit of stop relay 20 to ground and acting through arm 124 of relay 48, arm 122 of relay 80, and arm 120 of relay 86, grounds start relay 18. Start relay 18 starts prime mover 8 by means of motor control 12, which causes power source 4 to operate.

Power source 4 then supplies power to coil 60 of relay 62. It should be noted that the circuit of coil 60 utilizes the auxiliary contacts provided by arm 69 of relay 80 in order to complete its circuit because its normal circuit through arm 70 of relay 58 is not available, due to the operative condition of relay 58 caused by start-stop button 82 being in the start position. Coil 60 operates relay 62 which places ground on stop relay 16 through arm 138, thereby causing power source 2 to become inactive.

The inactive character of power source 2 causes coil 30 of relay 26 to become inactive which opens contact arms 22 and 24, removing power source 2 from load 28. Further, arm 44 of relay 26 closes when coil 30 loses its voltage, thus placing coil 40 of relay 26 across power source 4. Power source 4 then supplies coil 40, which closes arms 36 and 38 of relay 26 connecting power source 4 to load 28. Coil 40 also operates arm 34 of relay 26, which disconnects coil 30 from power source 2 and prevents the possibility of power source 2 going back across load 28, in case power source 2 develops voltage.

The operation of relay 62 also completes the power circuit to coil 102 of relay 86 through arm 106, if start-stop button 82 has been released. If start-stop button 82 has not been released, then relay 62 remains ineffective with regard to coil 102, but will serve to energize coil 102 just as soon as start-stop button 82 is released and arm 104 of relay 58 returns to its normal closed position. Once coil 102 is energized, it operates relay 86 which, through the opening of arm 100, unlocks coil 88 of relay 80 from its lock-in circuit. When coil 88 loses its energy, relay 80 releases and the action of the system is complete.

From the foregoing explanation of system operation and the parts played by selector switch 76 and relays 80 and 86, it can be seen that one and only one transfer of power sources, either automatic or manual, may be made through this system unless, and until, selector switch 76 is reversed after a transfer, in order to set up the next transfer.

At any time during the operation of a system according to this invention, that it is desired to disconnect all power sources from the load, start-stop button 82 is pushed to its stop position. This completes the power circuit of coil 114 of relay 98. Coil 114 then operates relay 98 which places ground on stop relay 16 through arm 132 and switch 32 and connects ground to stop relay 20 through switch 42 and arm 134. Also, in order that the system will respond to an instantaneous push of the start-stop button 82 when it is pushed to the stop position, an auxiliary hold circuit is provided by arm 115 acting in conjunction with arm 117 of relay 80 or arm 119 of relay 86, depending on whether relay 80 or relay 86 is operated.

An auxiliary or remote control switch panel 144 is shown to illustrate the adaptability of this system to remote control techniques. Terminal board 146 is provided with terminals 148, 150, 152, 154, 156, 158 and 160 which correspond to terminals 162, 164, 166, 168, 170, 172 and 174, respectively, of terminal board 176. Start button 178 is connected to points common with the connections of start-stop switch 82 and its function is the same as that of start-stop switch 82 with respect to starting the operation of the system or with respect to initiating manual transfer. Stop button 180 is connected to points common with the connections of start-stop switch 82 and its function is the same as that of start-stop switch 82 with respect to stopping the operation of the system. Lights 182 and 184 are provided in remote control panel 144 to indicate the operation of power sources 2 and 4. Light 182 is connected across power source 2 through terminals 148 and 162, switch 32, and terminals 164 and 150. Light 184 is connected across power source 4 through terminals 158 and 172 and switch 42 and terminals 174 and 160. Thus, when either power source 2 or 4 is operating, its corresponding light operates at the remote control panel 144 to apprise the operator of the operative condition of the power source.

The system according to this invention as shown and described, is applied to a single phase two power source system, however, those skilled in the art will readily appreciate the adaptability of the system to multiphase circuits employing more than two power sources. Accordingly, it is to be understood that the invention is not limited to its specific embodiments, except as defined in the appended claims.

What is claimed is:

1. In a power switching system, the combination comprising a first and second motor generator set, a load circuit, a first relay having a first and second winding for connecting said first and second generators, respectively, to said load, the first and second winding of said first relay being connected across said first and second generators respectively, said first winding of said first relay being connected through one normally closed arm of said second winding of said first relay and said second winding of said first relay being connected through one normally closed arm of said first winding of said first relay; means for starting said motor-generator sets comprising an initiating switch, an initiating relay connected to be energized through said initiating switch, a multiple position selector switch, connected to said initiating relay, a first pair of relays connected to said selector switch and controlled thereby, a second pair of relays connected to said first pair of relays and energized through said first pair of relays, and a pair of motor controls operated by said second pair of relays; means for automatically transferring said load between said motor-generator sets when the voltage of the load connected generator falls below a predetermined level comprising a third pair of relays, the first and second relays of said third pair of relays being voltage actuated by said first and second motor-generator sets respectively, the first and second relays of said third pair of relays having arms through which the first and second relays of the aforementioned first pair of relays are respectively actuated when said first and second relays of said third pair of relays are respectively actuated, the aforementioned multiple position selector switch connected intermediate said first pair of relays so that in a first position it completes a lock-in circuit for the first relay of said first pair of relays and in a second position it completes a lock-in circuit for the second relay of said first pair of relays; and means for stopping said motor-generator sets comprising the aforementioned pair of motor controls and a fourth pair of relays, the first and second relay of said fourth pair of relays connected, respectively, to the first and second motor control of said pair of motor controls for operating said motor controls, said fourth pair of relays being connected to and energized through the aforementioned third pair of relays.

2. In a power switching system according to claim 1, means for stopping said motor-generator sets comprising a stopping switch and a stopping relay connected to be

energized through said stopping switch, said fourth pair of relays being connected to and energized through said stopping relay.

3. A power transfer system in which any one of at least two power sources can be the primary source of power, comprising at least two power sources, first means for selectively energizing any one of said power sources, second means coupled through said first means to the output of said one power source and responsive thereto for energizing said other power source when said one power source is not operating normally, third means coupled through said first means to the output of said other power source and responsive thereto, when said first means selects said other power source to be initially energized, for energizing said one power source when said other power source is not operating normally, fourth means coupled to the output of said one power source and responsive thereto for connecting a load circuit thereto when said one power source is operating normally, and fifth means coupled to the output of said other power source and responsive thereto for connecting said load circuit thereto when said other power source is operating normally, said fourth and fifth means being interconnected so that the operation of either one prevents the operation of the other, said second and third means being coupled together through said first means so as to prevent the reenergization of the initially energized power source after the other power source has been energized.

4. A power transfer system in which any one of at least two power sources can be the primary source of power, comprising at least first and second power sources, an initiating relay, a multiple position selector switch coupled to said initiating relay for coupling either one of said power sources to said initiating relay to selectively energize one of said power sources, said first power source having associated therewith a first relay responsive to the output thereof and coupled to said selector switch and said second power source, said first relay energizing said second power source only when said first power source falls below a predetermined level after being initially activated, said second power source having associated therewith a second relay responsive to the output thereof and coupled to said selector switch and said first power source, said second relay energizing said first power source only when said second power source falls below a predetermined level after being initially activated, a third relay associated with said first power source and responsive to the output thereof for connecting a load circuit thereto, and a fourth relay associated with said second power source and responsive to the output thereof for connecting said load circuit thereto, said third and fourth relays being interconnected so that the operation of either one prevents the operation of the other, said first relay being coupled to said second relay through said selector switch so as to prevent the reenergization of the initially energized power source after the other power source has been energized.

5. A power transfer system in which any one of at least two power sources can be the primary source of power, comprising at least two power sources, first means for selectively energizing any one of said power sources, second means coupled through said first means to the output of said one power source and responsive thereto for energizing said other power source when said one power source is not operating normally, third means coupled through said first means to the output of said other power source and responsive thereto, when said first means selects said other power source to be initially energized, for energizing said one power source when said other power source is not operating normally, and fourth means coupling said second and third means together through said first means to prevent the reenergization of the initially energized power source after the other power source has been energized.

6. A power transfer system in which any one of at least two power sources can be the primary source of power, comprising at least first and second power sources, an initiating relay, a selector switch coupled to said initiating relay for coupling either one of said power sources to said initiating relay to selectively energize one of said power sources, said first power source having associated therewith a first relay responsive to the output thereof and coupled to said selector switch and said second power source, said first relay energizing said second power source only when said first power source falls below a predetermined level after being initially activated, said second power source having associated therewith a second relay responsive to the output thereof and coupled to said selector switch and said first power source, said second relay energizing said first power source only when said second power source falls below a predetermined level after being initially activated, a third relay associated with said first power source and responsive to the output thereof for connecting a load circuit thereto, and a fourth relay associated with said second power source and responsive to the output thereof for connecting a load circuit thereto, said third and fourth relays being interconnected so that operation of either one prevents the operation of the other.

7. A power transfer system in which any one of at least two power sources can be the primary source of power, comprising at least first and second power sources, an initiating relay, a selector switch coupled to said initiating relay for coupling either one of said power sources to said initiating relay to selectively energize one of said power sources, said first power source having associated therewith a first relay responsive to the output thereof and coupled to said selector switch and said second power source, said first relay energizing said second power source only when said first power source falls below a predetermined level after being initially activated, said second power source having associated therewith a second relay responsive to the output thereof and coupled to said selector switch and said first power source, said second relay energizing said first power source only when said second power source falls below a predetermined level after being initially activated, and said first relay being coupled to said second relay through said selector switch so as to prevent the reenergization of the initially energized power source after the other power source has been energized.

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