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PHASE FAILURE AND PHASE REVERSAL PROTECTIVE DEVICE

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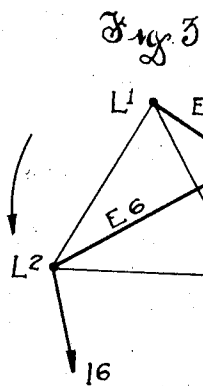
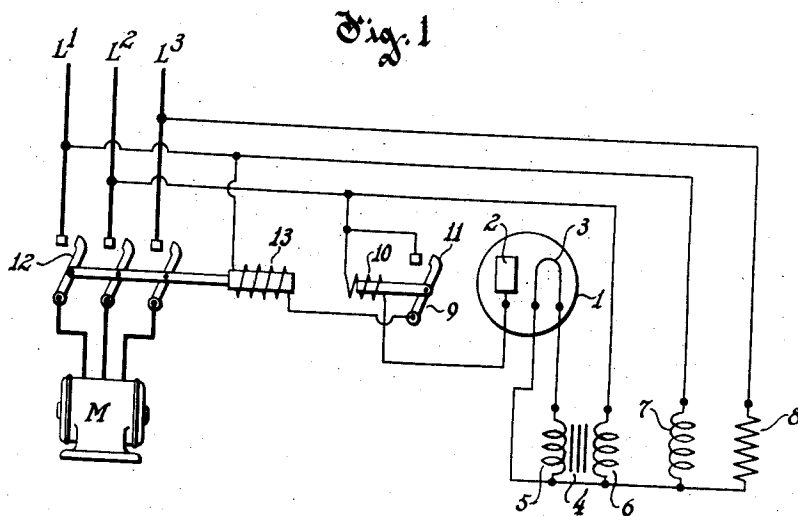


Fig. 2

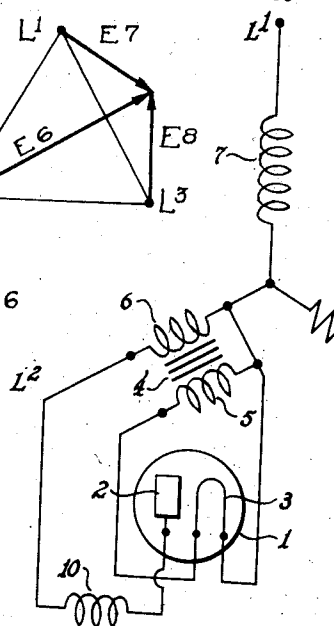


Fig. 4

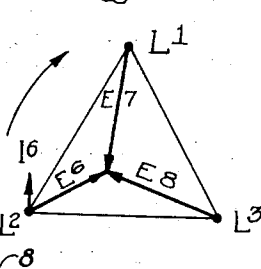
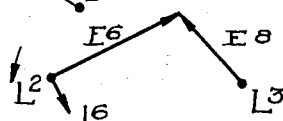


Fig. 5



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PHASE FAILURE AND PHASE REVERSAL PROTECTIVE DEVICE

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This invention relates to low voltage, phase failure and phase reversal protective devices for polyphase alternating current circuits.

cuit which is provided with an electromagnetic switch 12 having actuating coil 13. This coil may be connected across any two of the supply lines and has connections which are controllable by an electroresponsive relay 9.

The relay 9 is provided with an operating winding 10 and contact members 11. One end of the operating winding 10 is connected to line L^2 , while the other end is connected to the anode 2 of an electron tube 1 which is equipped with a heated filament 3, supplied with current from the secondary winding 5 of a transformer 4 having the primary winding 6. One end of the primary winding 6 is connected to line L^2 , while the other end and one end of the secondary winding 5 are connected to the common terminal of impedances 7 and 8 which latter are connected in series between lines L^1 and L^3 .

Thus the transformer primary winding 6 and the impedances 7 and 8 form a star connected impedance system. The impedance 7 is highly inductive while the impedance 8 is preferably a pure ohmic resistance. As the coil 10 is connected in series with the discharge path of the tube 1 between line L^2 and the star point of the system, it forms a shunt path for the transformer winding 6 and I proportion the circuit in such a way that the resultant impedance of the transformer and the winding 10 plus the tube are of proper value to produce the desired result, namely that as long as the phase relation and voltage of the system are normal a sufficient current flows through the winding 10 to keep the relay closed, whereas upon reduction of voltage or reversal or failure of phase the winding 10 is deenergized to cause relay 9 to open the circuit of coil 13 of the circuit breaker 12 and thus effect disconnection of the motor from lines L^1 , L^2 and L^3 .

The action of the device is as follows:

The impedance values of the various circuits including the tube and the coil 10 are selected so that during normal operation the voltage impressed upon the winding 10 is a maximum. The voltage induced in the sec-

Devices embodying electromagnetically operated contactors in combination with impedances connected in a three wire polyphase circuit in star relation and calibrated so as to close and remain closed while a given phase relation and a given voltage of the circuit is maintained and to open when this phase relation changes or when the voltage of the circuit decreases below a certain value, are known in the art. Such a device is described in the Stevens application Serial No. 286,262 assigned to the same assignee. While the Stevens device meets the average operating conditions, the sensitivity to operate upon unbalancing of the phases or upon voltage reduction is such that where used in connection with dynamo electric machines which have inherently close regulation, the load on such machine may reach a considerable value before the device responds.

The present invention has among its objects that of providing an improved protective device embodying the foregoing principle and overcoming the aforementioned difficulties.

Other objects and advantages will hereinafter appear.

The accompanying drawings illustrate diagrammatically one embodiment of the invention and the same will now be described, it being understood that the invention is capable of embodiment in other forms, falling within the scope of the appended claims.

Fig. 1 is a diagrammatic illustration of one form of protective device used in connection with a dynamo electric machine, Fig. 2 is a simplified diagram of certain of the circuits shown in Fig. 1, Fig. 3 is a vector diagram of certain voltages and currents of the system for normal conditions of operation, Fig. 4 is a vector diagram of the condition of phase reversal, while Fig. 5 is a vector diagram for failure of voltage in one of the phases.

Referring to Fig. 1, L^1 , L^2 and L^3 are the supply lines of a three wire polyphase cir-

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ondary 5 of the transformer is therefore also a maximum, insuring a maximum temperature of the filament 3 and thus causing the impedance of the tube to the flow of current to be a minimum.

Fig. 3 shows the relation of the voltages under normal conditions. The arrow indicates the rotation of the voltage vectors as being in a counterclockwise direction. E^6 , E^7 and E^8 are the voltages impressed upon the impedances 6, 7 and 8 respectively, while I^6 is the current flowing through the windings 6 and 10. The heating current of the filament 3 is obviously proportional to the current I^6 .

In case the phases should be reversed or one of the phases of the system should fail, the voltage impressed upon the primary winding 6 of the transformer is reduced, thereby decreasing the temperature of the filament 3, which results in an increase of the resistance of the tube. This causes a decrease of the current of the coil 10 and this current is further decreased due to the fact, that the voltage impressed upon the circuit of the coil is reduced in the same proportion as the voltage impressed upon the primary 6. Due to the cumulative action and the fact that the impedance of the tube varies with a higher power of the voltage impressed upon the filament, the reduction of the voltage in the coil 10 is relatively much greater than the reduction of the voltage impressed upon the corresponding circuit and the device therefore reacts to disconnect the motor upon a very slight voltage reduction of the system or upon unbalancing or phase reversal.

Fig. 4 is a vector diagram for reversal of phases so that the phase rotation is now clockwise, this condition obtaining if the phases applied to the terminals L^2 and L^3 are interchanged. It will be seen that under these conditions, the voltage E^6 and the corresponding current I^6 are greatly reduced.

Fig. 5 is a vector diagram for failure of voltage in phase 1. In this case also the voltage E^6 and the current I^6 are reduced from the values obtaining under normal conditions as illustrated in Fig. 3.

It will of course be understood by those skilled in the art, that instead of employing inductances to produce currents which lag behind or lead the voltages in the respective circuits, condensers may be employed, and in general that the system is capable of a number of modifications all of which are within the scope of the appended claims.

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

1. A protective device for polyphase circuits comprising a controlling device for said circuit including a space discharge tube, a star connected system of impedances and means whereby said tube is caused to respond to changes in a voltage across certain of said

impedances resulting from changes in the electrical conditions of said circuit.

2. A protective device for polyphase circuits comprising an electromagnetic winding, a space discharge tube in circuit with said winding for controlling its current, a star connected system of impedances and means whereby said tube is caused to respond to changes in a voltage across certain of said impedances resulting from changes in the electrical conditions of said circuit.

3. A protective device for polyphase circuits comprising a switch, an electromagnet controlling said switch, a space discharge tube in circuit with said electromagnet for controlling the latter, a star connected system of impedances and means, whereby said tube is caused to respond to changes in a voltage across certain of said impedances resulting from changes in the electrical conditions of said circuit.

4. A protective device for polyphase circuits comprising a controlling device for said circuit including a space discharge tube, a star connected system of impedances and means whereby said tube is caused to respond to changes in voltage across certain of said impedances resulting from variations in voltage and/or changes in phase rotation of said polyphase circuit.

5. A protective device for polyphase circuits comprising a switch, an electromagnet controlling said switch, a space discharge tube in circuit with said electromagnet for controlling the latter, a star connected system of impedances and means whereby said tube is caused to respond to changes in voltage across certain of said impedances resulting from variations in voltage and/or changes in phase rotation of said polyphase circuit.

6. A protective device for polyphase circuits comprising a switch, an electromagnet controlling said switch, a space discharge tube in circuit with said electromagnet for controlling the latter, a transformer and two impedances, said transformer and said impedances being connected in star relation to said polyphase circuit and means whereby said tube is caused to respond to changes in the voltage across certain of said star connected elements resulting from changes in the electrical condition of said circuit.

7. A protective device for polyphase circuits comprising an electromagnetic switch, a space discharge tube in circuit with the winding of said switch to control its operation, a transformer, an inductance and a resistance, said transformer, inductance and resistance being connected in star relation to said polyphase circuit and means whereby said tube is caused to respond to changes in voltage across certain of said star connected elements resulting from changes in the electrical conditions of said circuit.

8. A protective device for polyphase circuits comprising an electromagnetic switch, a space discharge tube in circuit with the winding of said switch to control its operation, a transformer, an inductance and a resistance, said transformer, inductance and resistance being connected in star relation to said polyphase circuit and means to cause said tube to respond to changes in voltage across certain of said star connected elements resulting from variations in voltage and/or changes in phase rotation of said polyphase circuit.

9. A protective device for polyphase circuits comprising an electromagnetic switch, a space discharge tube in circuit with the winding of said switch to control its operation, a transformer, an inductance and a resistance, said transformer, inductance and resistance being connected in star relation to said polyphase circuit and means to cause said tube to respond to voltage variations of said transformer resulting from variations in voltage and/or changes in phase rotation of said polyphase circuit.

10. A protective device for polyphase circuits comprising a transformer, an inductance and a resistance connected in star relation to said circuit, a space discharge tube connected to said transformer so as to respond to voltage variations of the latter resulting from variations in voltage and/or changes in phase rotation of said polyphase circuit, said tube being adapted upon response to control said polyphase circuit.

11. A protective device for polyphase circuits comprising a transformer, an inductance and a resistance connected in star relation to said circuit, an electromagnetic switch, a space discharge tube having a heated cathode connected to the secondary winding of said transformer, so as to respond to voltage variations of the latter resulting from variations in voltage and/or changes in phase rotation of said polyphase circuit and controlling said electromagnetic switch.

12. A polyphase circuit, an electromagnetic switch for controlling said circuit a star connected system consisting of a transformer, an impedance and a resistance connected to said circuit, and a thermionic tube having its cathode heated by the secondary current of said transformer and its anode connected in series with the winding of said switch so as to respond to voltage variations impressed upon the transformer resulting from variations in voltage and/or changes in phase rotation of said polyphase circuit, to thereby control said electromagnetic switch.

In witness whereof, I have hereunto subscribed my name.

EDWARD J. POSSELT.