Oct. 18, 1927. 1,646,028

J. D. LEWIS ET AL

ELECTRIC SAFETY APPARATUS

Filed Aug. 27, 1923 2 Sheets-Sheet 1

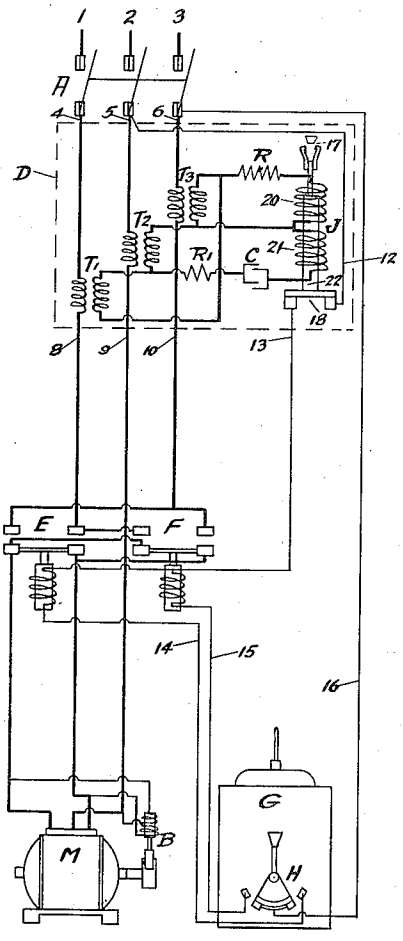


FIG. 1

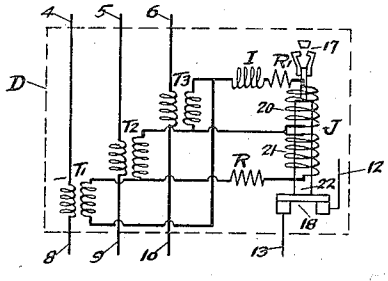


FIG. 2

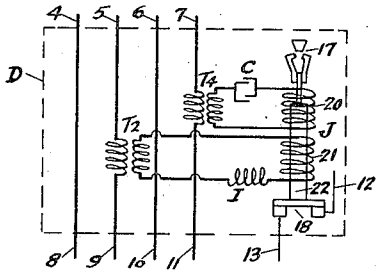


FIG. 3

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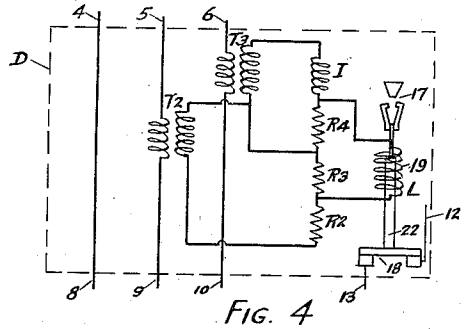


FIG. 4

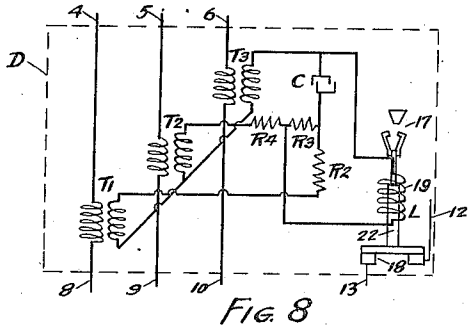


FIG. 8

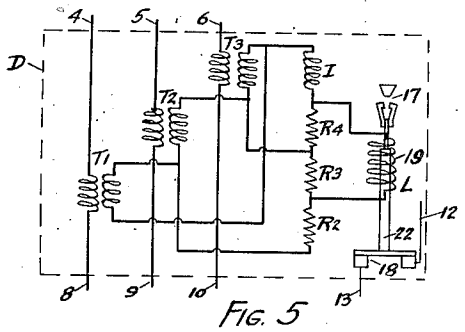


FIG. 5

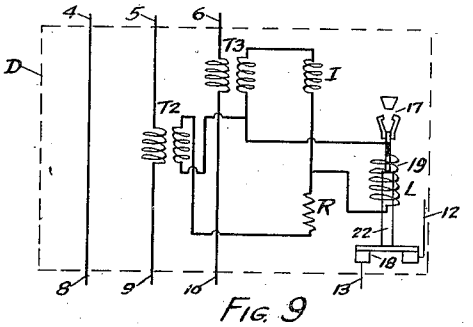


FIG. 9

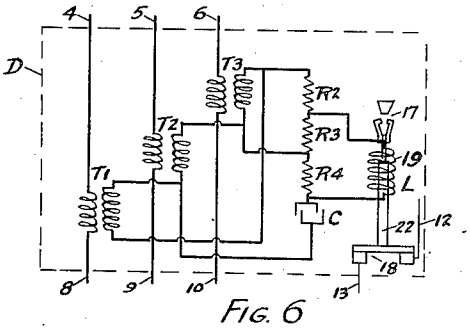


FIG. 6

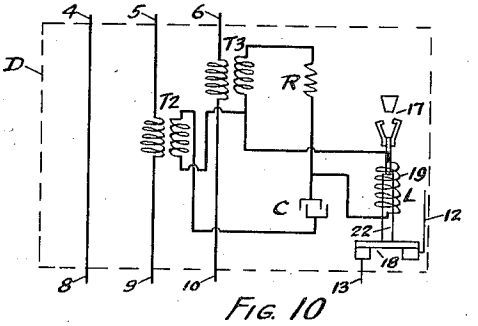


FIG. 10

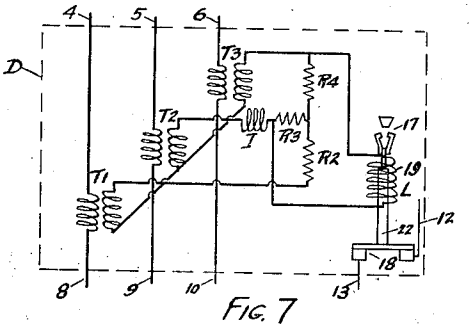


FIG. 7

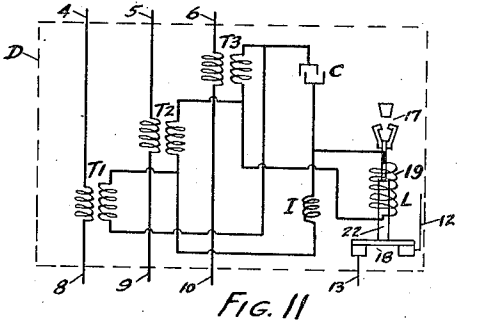


FIG. 11

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Patented Oct. 18, 1927. 1,646,028

UNITED STATES PATENT OFFICE.

JACOB D. LEWIS, OF YONKERS, AND ANTHONY PINTO, OF NEW YORK, N. Y., ASSIGNORS TO OTIS ELEVATOR COMPANY, OF JERSEY CITY, NEW JERSEY, A CORPORATION OF NEW JERSEY.

ELECTRIC SAFETY APPARATUS.

Application filed August 27, 1923. Serial No. 659,447.

Our invention relates to a protective apparatus for polyphase alternating current electric systems.

One object of our invention is to provide means whereby the power supply will be automatically disconnected from the load in the event of the interchange of any two of the supply lines, or the failure or open circuit of one or several of the supply lines, irrespective of whether the failure occurs on the supply line side or the load side of the protective means.

A further object of our invention is to provide protective means that shall be operative under practically all conditions of load.

We attain the above mentioned objects by the apparatus illustrated in the accompanying drawings in which—

Figure 1 shows an embodiment of our invention in connection with an elevator system. The protective apparatus is in current relation to the supply lines.

Figures 2 to 11 inclusive show modifications of the protective apparatus shown in Figure 1.

All of the figures, except Figure 3, show the protective apparatus applied to a three-wire three-phase system.

Similar numerals refer to similar parts throughout the several views.

Referring to Figure 1, a three-wire three-phase system is shown with power supply lines 1, 2 and 3 connected to a main line switch A. The protective apparatus D is connected to the wires 4, 5 and 6 of an elevator system comprising reversing switches E and F, hoisting motor M, electromagnet brake B for the motor, and car switch H in a car G. The reversing switches are operated by the usual coils, the circuits for them being from the supply line 2, through main line switch A, by wire 12, and, in the present case, through a contact 18 of a relay magnet switch J of the protective apparatus, by wire 13 to the coils of the reversing switches, by wires 14 or 15, car switch H, by wire 16 to the main line switch and supply line 3. As the elevator system shown is conventional and well known, it is thought that the foregoing description of it is sufficient for the purpose herein of illustrating the application of the protective apparatus to the elevator system.

The protective apparatus D comprises current transformers T_1, T_2, and T_3, whose primary windings are inserted in conductors 4, 5 and 6 respectively leading to the motor to be protected by the protective device. The secondaries are connected in delta. The coil 20 has resistance R connected in series with it and is across the secondary of transformer T_3. The coil 21 has capacity C and resistance R_1 in series with it and is accross the secondary of transformer T_2. Coils 20 and 21 are connected in series with resistance R, capacity C and resistance R_1 across the secondary of transformer T_1. In certain cases transformer T_1 may be omitted. Coils 20 and 21 surround a magnetic core 22 which is mounted for longitudinal movement on the axis of the coils.

If the car switch H is moved either to the right or left, the corresponding reversing switch will close, and thereby admit current to the motor. If the relation of the phases is normal and if all phases are intact, the current in the coil 20 will be practically in phase with the voltage across the secondary of the transformer T_3 and the current in coil 21 will lead the voltage across the secondary of the transformer T_2. Since these two voltages are 120 electrical degrees apart, the currents in the two coils may be made practically 180 electrical degrees apart by the use of capacity C. By adjusting the values of resistance R and capacity C, the ampere turns in coil 20 may be made equal as well as opposite to the ampere turns in coil 21, and thereby the result is that the contact 18 remains closed. If, however, any pair of supply lines 1, 2 or 3 are interchanged, the phase angle between the currents in the two coils 20 and 21 is no longer 180 electrical degrees and their ampere turns are no longer opposite and, therefore, the magnetizing effects of the coils act cumulatively and open contact 18. Again, if any one of the supply lines or lines to the motor is interrupted at any point, either coil 20 or 21 will be energized alone or both coils will be energized with substantially no phase displacement between the currents in the two coils, thereby causing the contact 18 to open. In either event, the opening of contact 18 will open the circuit of the reversing switch coils and thereby disconnect the motor from the power supply. After the contact 18 has once opened, it will be held open by a latch 17

until reset by hand. If the current transformers used are highly excited the operation of the protective relay J will be insured under abnormal conditions practically regardless of the load on the motor, since the high saturation of the current transformers results in a small variation of the secondary current for a wide variation of the primary current.

Figure 2 shows an arrangement of the protective apparatus wherein inductance I and resistance R_1 are used in series with each other in the conductor between the secondary of the transformer T_3 and the coil 20, and resistance R is used in the conductor between the coil 21 and the secondary of the transformer T_2 in order to obtain the desired ampere turns in the coils 20 and 21 and phase displacement between the currents in the two coils. The current in coil 20 lags behind the voltage in the secondary of the transformer T_3 due to the inductance I, and the current in coil 21 is practically in phase with the voltage in the secondary of the transformer T_2. By properly proportioning the values of inductance I and resistance R_1 in series with inductance I, and resistance R, the ampere turns of coil 20 may be made equal and opposite to the ampere turns of coil 21, and thereby allow the contact 18 to remain closed. If, however, phase reversal or phase failure occurs, the protective relay magnet J will operate and open its contact 18.

Figure 3 shows an arrangement of the protective apparatus applied to a two-phase four-wire supply system. In this case two independent current transformers T_2 and T_4 are used, one in each phase, and the coils are not connected together. A capacity C is inserted between the secondary of the transformer T_4 and the coil 20 and an inductance I is inserted between the secondary of the transformer T_2 and the coil 21 to obtain the required phase relation between the currents in the coils 20 and 21. In this case the inductance I causes the current in coil 21 to lag behind the voltage in secondary of transformer T_2 and the capacity C causes the current in coil 20 to lead the voltage in secondary of transformer T_4. Since the voltages in the secondaries of transformers T_2 and T_4 are substantially 90 electrical degrees apart, the proper proportioning of the values of inductance I and capacity C will result in the ampere turns in coil 20 being equal and opposite to the ampere turns in coil 21, thereby allowing the contact 18 to remain closed. If phase reversal or phase failure occurs, the ampere turns in the coils will no longer be opposite to each other and the protective relay magnet J will operate to open its contact 18. In Figure 3 the inductance I or the capacity C may be omitted in some cases.

Figure 4 shows two current transformers T_2 and T_3, the secondaries of which are connected in open delta, and resistances R_2 and R_3 connected in series across the secondary of transformer T_2, and resistance R_4 and inductance I connected in series across the secondary of transformer T_3, and only one coil 19, one end of which is connected to the junction point of the resistances R_2 and R_3, and the other end to the junction point of resistance R_4 and inductance I. If the relation of all of the phases is normal and if all phases are intact, the voltage drop across the resistance R_3 will be practically in phase with the voltage of the secondary of transformer T_2, while the voltage drop across the resistance R_4 will lag behind the voltage of the secondary of transformer T_3 due to the inductance I in series with the resistance R_4. By properly proportioning the resistances R_2, R_3 and R_4 and inductance I, the voltage drops across the resistances R_3 and R_4 may be equal and approximately 180 electrical degrees apart. This results in no voltage across coil 19 and therefore the coil remains substantially deenergized and the contact 18 closed. If, however, any pair of the supply lines are interchanged or any one of the supply lines or the lines to the motor is interrupted, the voltage drop across resistances R_3 and R_4 will no longer be 180 electrical degrees apart and therefore there will be voltage across the coil 19 and the coil will be energized and open the contact 18 and disconnect the motor from the power supply.

Figure 5 shows a modification in which three transformers, T_1, T_2 and T_3 are used. This form is similar to that shown in Figure 4, except in the number of transformers used.

Figure 6 shows an arrangement similar to that shown in Figure 5 except that resistance and capacity, instead of resistance and inductance, are used to obtain the necessary phase displacement.

Figures 7 and 8 also show three current transformers, T_1, T_2 and T_3, a protective relay L with contact 18 and one coil 19, and resistances R_2, R_3 and R_4, and in Figure 7 inductance I, and in Figure 8 capacity C. In Figure 7 the secondaries of the transformers are connected in star and the resistances R_2 and R_4 are connected in series across the ends of the secondaries of transformers T_1 and T_3, and the inductance I is connected in series with the resistance R_3 between the end of the secondary of transformer T_2 and junction point of resistances R_2 and R_4. The coil 19 is connected across the resistances R_3 and R_4. In Figure 8, the secondaries of the transformers are connected in star, and the resistance R_2 and capacity C are connected in series across the ends of the secondaries of the transformers

T_1 and T_3 and the resistances R_4 and R_3 are connected in series between the end of the secondary of the transformer T_2 and the junction point of resistance R_2 and capacity C. The coil 19 is connected across the resistance R_3 and capacity C. By suitably proportioning the values of the three resistances, the inductance and the capacity, the potential difference across the coil 19 may be made low when the circuit conditions are normal and high when phase reversal or phase failure occurs; therefore, when the circuit conditions are normal, the contact 18 of the protective relay L will remain closed, and upon phase reversal or phase failure the coil 19 will become energized and open the contact 18.

Figures 9 and 10 show two current transformers T_2 and T_3 with their secondaries star connected, and the protective relay L with contact 18 and coil 19, and resistance R; and in Figure 9, inductance I, and in Figure 10, capacity C. In Figure 9 resistance R and inductance I are connected in series across the ends of the secondaries of the transformers, and the coil 19 is connected between the junction point of resistance R and inductance I and the star or neutral point of the secondaries of the transformers. In Figure 10, the capacity C and resistance R are connected in series across the ends of the secondaries of the transformers and the coil 19 is connected between the junction point of capacity C and resistance R and the star or neutral point of the secondaries of the transformers. In either case by suitably proportioning the values of the resistance, inductance and capacity the potential difference across coil 19 can be made low when the circuit conditions are normal, and permit the contact 18 to remain closed, and high when phase reversal or phase failure occurs and cause the coil 19 to open the contact 18.

In Figure 11 three transformers T_1, T_2 and T_3 are shown with their secondaries connected in delta, and inductance I and capacity C connected in series across the secondary of transformer T_1, and coil 19 connected between the junction point of capacity C and inductance I and the junction point of the secondaries of transformers T_2 and T_3. By suitably proportioning the values of the capacity and inductance the potential difference across the coil 19 can be made low when the circuit conditions are normal and high when phase reversal or phase failure occurs, and therefore, the contact 18 of the protective relay will remain closed or will be opened by the coil 19 as the case may be.

Wherever an inductance or a capacity is shown, resistance R_1 may be introduced when needed, the object in each case being to obtain the correct phase relations.

The protective device may be applied to any system of control in which a main line magnet switch is used, its application not being confined to the simple car switch system illustrated in Figure 1.

It is obvious that many arrangements of resistance, inductance and capacity in connection with the coil or coils of the relay magnet switch will accomplish the desired result of protecting the motor. The drawings show sufficient of these arrangements to illustrate the principle of the invention. It is plain that persons skilled in the art can make other arrangements of the resistances, inductances and capacities in the protective device to accomplish the same or similar results as attained by the different modifications shown in the drawings without departing from the principle involved in the invention.

It will be observed that the principle of our invention permits of its embodiment in various forms or modifications of structure and arrangement, all of which are rugged in construction and thereby insure that our protective apparatus will remain operative throughout its life in actual service conditions.

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

1. A protective apparatus for a polyphase system, responsive to phase reversal and phase failure, comprising, a winding, a movable member controlled thereby, means for connecting a portion of said winding in current relation with the conductors for one phase of said system, and means for connecting another portion of said winding in current relation with the conductors of another phase of said system, said last included means comprising phase displacing means.

2. A protective apparatus for a polyphase system, responsive to phase reversal and phase failure, comprising the combination of a plurality of coils, a movable contact switch member controlled thereby, one of said coils being connected in current relation with the conductors of one phase of a polyphase system, another of said coils being connected in current relation with the conductors of another phase of said system and phase displacing means in circuit with one of said coils.

3. A protective apparatus for a polyphase swstem, responsive to phase reversal and phase failure, comprising the combination of a plurality of coils, a movable contact switch member controlled thereby, one of the coils being connected in current relation with the conductors of one phase of a polyphase system, another of said coils being connected in current relation with the conductors of another phase of said system and phase displacing means comprising a capacity in circuit with one of said coils.

4. A protective apparatus for a polyphase system, responsive to phase reversal and

phase failure, comprising the combination of a plurality of coils, a movable contact switch member controlled thereby, one of the coils being connected in current relation with the conductors of one phase of a polyphase system and another of said coils being connected with the conductors of another phase of said system, and phase displacing means in circuit with one of said coils, whereby upon phase reversal or phase failure said movable contact switch member is actuated.

5. A protective apparatus for a polyphase system, responsive to phase reversal and phase failure, comprising the combination of a current transformer having its primary connected in said system, a capacity, a plurality of coils, a movable contact switch member controlled thereby, one of the coils being connected in current relation with the conductors of one phase of the polyphase system and another of said coils being connected in circuit with the secondary of said transformer and said capacity.

6. A protective apparatus for a polyphase system, responsive to phase reversal and phase failure, comprising the combination of a plurality of coils, a movable contact switch member controlled thereby, a transformer between one of said coils and the conductors of one phase of a polyphase system, a transformer between another of said coils and the conductors of another phase of said system and phase displacing means in circuit with one of said coils.

7. A protective apparatus for a polyphase system, responsive to phase reversal and phase failure, comprising the combination of a current transformer having its primary connected in said system, a capacity, a plurality of coils, a movable contact switch member controlled by the coils, said coils being connected with said capacity and the secondary of the transformer.

8. A protective apparatus for a polyphase system, responsive to phase reversal and phase failure, comprising the combination of a current transformer having its primary connected in said system, a capacity, a plurality of coils, a movable contact switch member controlled by the coils, one of said coils being connected to said capacity and secondary of the transformer and another of said coils being connected to said system.

9. A protective device for a polyphase system, responsive to phase reversal and phase failure, comprising the combination of a plurality of current transformers having their primary windings connected in different phases of said system, a phase displacing device, a plurality of coils, a movable contact switch member controlled by said last mentioned coils, one of said coils being connected to said phase displacing device and the secondary winding of one of said transformers, and another of said coils being connected to the secondary winding of another transformer.

10. A protective apparatus for a polyphase system, responsive to phase reversal and phase failure, comprising the combination of a plurality of current transformers having their primary windings connected in different phases of said system, a resistance, a capacity, and a plurality of coils, a movable contact switch member controlled by said last mentioned coils, one of said coils being connected in circuit with said capacity and the secondary winding of one of the transformers and another of said coils being connected in circuit to the said resistance and the secondary winding of another of said transformers.

11. A protective apparatus for a polyphase system, comprising the combination of a coil, a movable contact switch member controlled thereby, a transformer having its primary in series with one conductor of said system, another transformer having its primary in series with another conductor of said system, said coil being connected with the secondaries of said transformers, and phase displacing means in circuit with said coil.

12. A protective apparatus for a polyphase system responsive to phase reversal and phase failure, comprising the combination of a coil, a movable contact switch member controlled thereby, said coil being connected in current relation with the conductors of different phases of a polyphase system, and phase displacing means in circuit with said coil.

13. A protective apparatus for a three-wire polyphase system responsive to phase reversal and phase failure, comprising the combination of two coils, a movable contact switch member controlled thereby, one of said coils being connected in current relation with the conductors of one phase of a polyphase system, another of said coils being connected in current relation with the conductors of another phase of said system and both coils being connected in current relation with the conductors of still another phase of said system and phase displacing means in circuit with one of said coils.

In testimony whereof, we have signed our names to this specification.

JACOB D. LEWIS.
ANTHONY PINTO.