

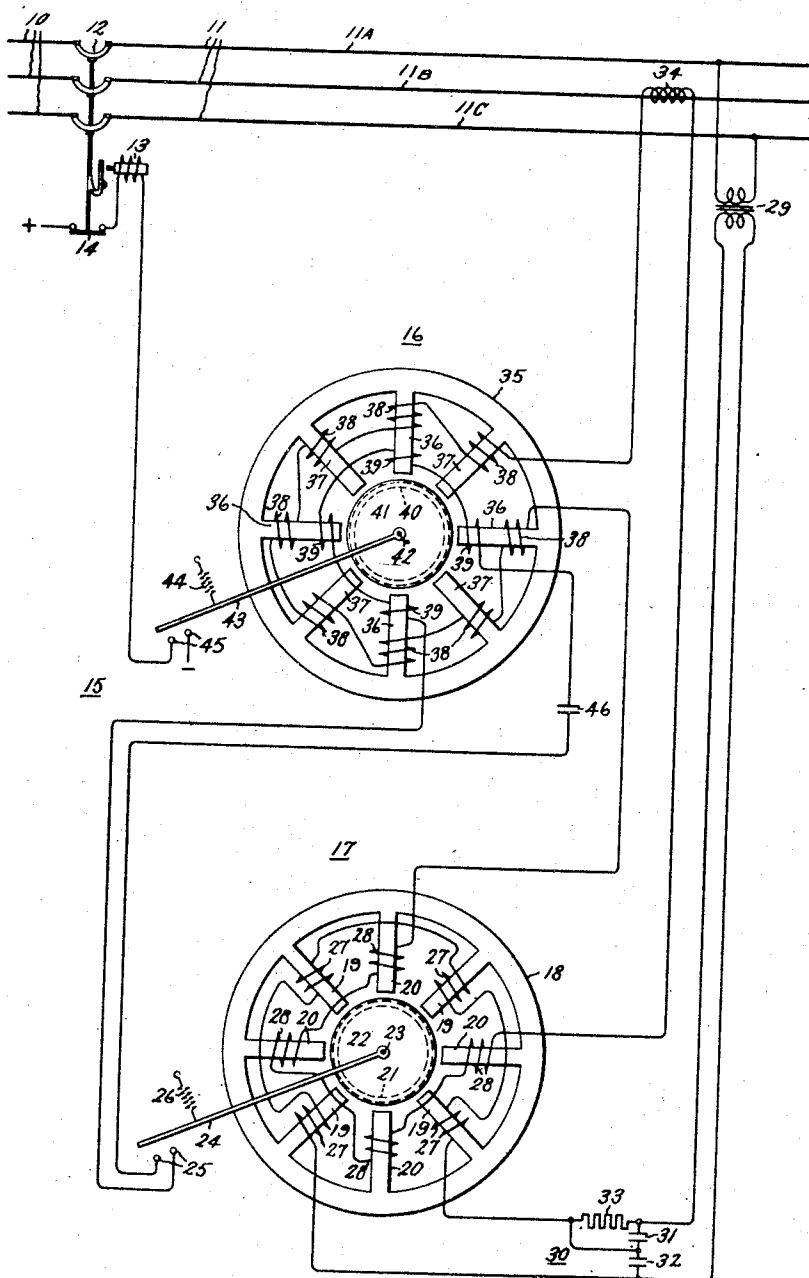
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2,432,328

CURRENT RESPONSIVE TIME DELAY RELAY

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CURRENT RESPONSIVE TIME DELAY
RELAY

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My invention relates to protective systems, and more particularly to a protective system for an electric circuit forming part of an electric system in which upon the occurrence of a fault upon the electric circuit said circuit is isolated from the associated system.

For many years directional overcurrent relays have been used to protect certain electric circuits against faults occurring thereon. The directional relay is provided in order to prevent effective operation of the protective system unless the fault is in the protected portion of the system and the overcurrent relay provides the means by which the fault is distinguished from other conditions. Generally, the overcurrent relay and directional relay are two separate devices. Sometimes the contacts of the two separate devices are connected in series with each other to control the operation of a suitable circuit interrupting device for isolating the faulted portion or section of the system. Such an arrangement is disclosed in Traver Patent 1,669,149, assigned to the same assignee as the present application. Directional overcurrent relays have been used in which the contacts of the directional relay are not connected in series with the contacts of the overcurrent relay, but rather the contacts of the overcurrent relay alone control the energization of the trip circuit of the circuit interrupting device which is provided to isolate the faulted circuit. The directional relay is provided to control the effectiveness of the overcurrent relay by controlling the energization of a winding associated with the overcurrent relay. My invention is particularly concerned with an improvement on this type of instantaneous directional overcurrent protection where the directional relay has its contacts connected to control a winding of the overcurrent relay.

In instantaneous directional overcurrent relays used heretofore difficulties have been encountered by virtue of a contact race between the contacts of the overcurrent unit and the contacts of the directional unit. The reason for the failure of the prior art directional overcurrent relays was then due to the failure of the correct unit to win the contact race. There are two important situations where this contact race occurs, both of which have caused difficulty heretofore. The first of these is when the contacts of the directional relay are closed but no high currents are flowing in the system and suddenly an external fault occurs, i. e., one external to the circuit which is being protected, causing high currents to flow in the protected section. In such a case false operation of

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the circuit interrupting device associated with the protected circuit will occur unless the contacts of the directional relay open before the overcurrent relay can operate to close its contacts.

The second situation in which failure of prior art devices to operate correctly occurs is when a fault outside of the protected section is cleared. In such a case it is essential that the overcurrent relay is prevented from operating by the immediate closing of the directional relay upon clearing of the fault and before the high current has had time to die down sufficiently so that the overcurrent relay is deenergized.

It is an object of my invention to provide a new and improved instantaneous directional overcurrent relay.

It is another object of my invention to provide a directional overcurrent relay in which failure to operate correctly in the situations enumerated above is substantially eliminated.

It is a further object of my invention to provide a new and improved directional overcurrent relay in which the correct unit substantially always wins the contact race thereby eliminating false operation of the protective apparatus.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention reference may be had to the accompanying drawing in which the single figure thereof illustrates schematically a protective system embodying my invention.

Referring now to the drawing, I have illustrated a portion of a polyphase electric system specifically illustrated as a three-phase system which, for example, may comprise a bus such as 10 connected to an electric circuit such as a feeder circuit 11 through a circuit interrupting device 12 specifically illustrated as a latched closed circuit breaker having a trip coil 13 and an "a" switch 14 which is closed when the circuit breaker is closed and open when the circuit breaker is open.

For protecting the feeder circuit 11 which may comprise phase conductors 11A, 11B, 11C, respectively, I provide electroresponsive overcurrent and directional means generally indicated at 15 for controlling the operation of circuit interrupting device 12. This electroresponsive overcurrent and directional means 15 as illustrated comprises an overcurrent unit or relay generally indicated

at 16 and a directional unit or relay generally indicated at 17.

In accordance with my invention the electromagnetic unit or directional relay 17 is of the induction motor type and as schematically illustrated, is an induction cylinder device of the type disclosed and claimed in United States Letters Patent Re. 21,813, Verrall, assigned to the same assignee as the present application. This directional relay 17 comprises an outer stationary hollow magnetic stator 18 having a plurality of inwardly projecting salients or poles 19 and 20 which extend toward a central magnetic stator 21. Between the ends of the salients 19 and 20 and the stator 21 there is defined an air gap in which a non-magnetic metallic cylinder 22 is adapted to rotate while suitably mounted on a shaft 23. A contact controlling element 24 is rotatable with induction cylinder 22 to control contacts 25. A weak spring 26 tends to bias contacts 25 toward their open position. Each of the salients 19 and 20 is provided with a winding and the windings of the salients characterized by the numeral 19 are designated by the reference numeral 27, while the windings associated with the salients 20 are designated by the reference numeral 28.

It will be obvious to those skilled in the art that directional action of an electroresponsive device may be obtained by energizing an induction type relay with a voltage quantity and a current quantity so that a torque is applied to the relay proportional to the product of the current and the voltage quantity multiplied by the sine of the angle between these quantities. Since the voltage will remain more or less fixed in direction the torque in a directional relay will vary directly with the direction of current flow. Accordingly, in the drawing the windings 27 associated with the salient 19 have been illustrated as polarizing windings which are energized with a suitable potential obtained from feeder circuit 11 through a potential transformer 29.

A severe fault in the immediate vicinity of directional relay 17 might reduce the potential obtained at the terminals of potential transformer 29 substantially to zero so that no polarizing current would flow with the consequent result that directional relay could not operate. To overcome this difficulty, a "memory action" network generally indicated at 30 is provided between the relay windings 27 and potential transformer 29. This "memory action" network as the name implies, tends to maintain a potential on the windings 27 for a short time having the same phase relationship as the potential which existed just previous to the severe fault so that in effect the directional relay remembers what the voltage was insofar as phase position is concerned. This "memory action" network 30 which comprises capacitors 31 and 32 and a resistance 33 is substantially identical with the "memory action" network disclosed and claimed in Warrington Patent 2,287,504, granted June 23, 1942, and assigned to the same assignee as the present application.

The current windings 28 of directional unit 17 are connected in series with one another and are energized with the current flowing in the secondary winding 34 of a current transformer which has been indicated as associated with the phase conductor 11a of feeder circuit 11. I have specifically illustrated the well known "quadrature connection" type of directional unit 17 which implies that the relationship between the currents flowing in the windings 27 and 28 is such

that these currents are displaced by substantially 90 electrical degrees. It should be understood that the quadrature connection has been illustrated by way of example only, and any other suitable connections for directional relay 17 may be employed.

The overcurrent unit 16 is schematically illustrated as of the induction cylinder type such as is disclosed and claimed in the above mentioned reissue patent to Verrell. As illustrated, overcurrent unit 16 comprises an outer stationary hollow magnetic stator 35 having a plurality of inwardly projecting poles 36 and 37, a series of interconnected energizing windings 38, one for each of these poles, a series of interconnected flux displacing windings 39 one for each of the poles 36, a central stationary magnetic stator 40, a non-magnetic metallic cylinder 41 mounted on a shaft 42 so as to rotate in the gaps between the poles 36 and 37 and the inner stator 40, and the circuit controlling member 43 which may be mounted directly on the shaft 42 as shown. A light biasing or return means such as spring 44 may be provided to tend to rotate circuit controlling member 43 in a clockwise direction especially when overcurrent unit 16 is deenergized. Contact controlling member 43 is adapted to bridge contacts 45 which are connected in series with the trip coil 13 and "a" switch 14. Whenever contact controlling element 43 bridges contacts 45 trip coil 13 is energized and circuit interrupting device 12 is opened to isolate feeder circuit 11 from bus 10.

The series of interconnected energizing windings 38 on overcurrent unit 16 are energized from the secondary winding 34 of the current transformer associated with phase conductor 11a of feeder circuit 11. The windings 38 are so arranged and connected with the secondary winding 34 of the current transformer that successive groups of two poles each, each group comprising a pole 36 and a pole 37, are energized with flux of the same polarity while the remaining poles also arranged in groups of two adjacent poles, each group comprising a pole 36 and a pole 37, are energized with flux of the opposite polarity. The flux phase displacing windings 39 are connected in series with one another in a circuit which includes the contacts 25 of directional unit 17 and a capacitive reactance comprising capacitor 46, the purpose of which will be described in greater detail hereinafter. When the contacts 25 are closed the windings 39 in effect provide a short circuited winding for each of the poles or salients 36 which tends to retard the flux in the associated poles so as to produce a torque on rotor 41 tending to cause counterclockwise rotation of contact controlling element 43. The windings 39 are so arranged on the associated salients 36 that the proper displacement in the phase of the flux will occur with respect to the adjacent pole having the same potential applied to the winding 38 thereof but not provided with a flux phase displacement winding 39.

The capacitor 46 mentioned above has such a capacitive reactance at the frequency of the alternating current flowing in feeder 11 with respect to the inductive reactance of windings 39 as to tune the circuit including windings 39 and capacitor 46 substantially to resonance. Oscillograms of the current flowing in the circuit including windings 39 and capacitor 46 show that by virtue of this resonant circuit the current in windings 39 does not reach its full magnitude until at least two cycles after the current in wind-

ings 38 have reached their full magnitude, it being obvious from the drawing that the current flowing in windings 39 is caused by transformer action. This time delay in build up of current in windings 39 is a relatively short delay so that overcurrent unit 16 will close contacts 45 in approximately one cycle after current of sufficient magnitude flows in windings 38. Consequently, this short delay provided by employing capacitor 46 in the manner indicated enables the instantaneous overcurrent electroresponsive means of my invention to function so that the contact race between units 16 and 17 is substantially always won by the correct unit. In other words, in the case of a fault on the electric system, but not on protected circuit 11, when just preceding such fault the flow of current in the circuit 11 was such that the contacts 25 of directional relay 17 were closed, it is essential for the contacts 25 of directional unit 17 to be opened before the contacts 45 of overcurrent unit 16 are closed if false operation of circuit breaker 12 is to be avoided. Overcurrent relay 16 cannot close its contacts until the current in windings 39 has built up to a sufficient value which is retarded by virtue of the oscillating circuit including these windings and capacitor 46. This slight delay provided by the resonant circuit will insure that contacts 25 are open before overcurrent relay 16 can begin to close contacts 45.

This same delay will also prevent transients, caused for example by the sudden reversal of power when a faulty section of the system is isolated, from causing overcurrent relay 16 to close its contacts before directional relay 17 has had time to open its contacts.

In view of the detailed description included above the operation of the protective system described above will be obvious. Overcurrent relay 16 cannot operate to close contacts 45 unless directional relay 17 has closed its contacts 25 indicating that the fault exists on the protected circuit 11. Also by virtue of the provision of capacitor 46 and its particular relationship with the windings 39 the race between contact controlling members 24 and 43 will always be such as to substantially eliminate false operation of circuit interrupting device 12.

It should be understood that as a still further precaution directional unit 17 may be provided with another set of contacts similar to contacts 25 which may be connected in the trip circuit in series with contacts 45.

While I have shown and described my invention in considerable detail, I do not desire to be limited to the exact arrangement shown, but seek to cover in the appended claims all those modifications which 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 a protective device for a circuit interrupting means in an electric circuit, electroresponsive means comprising an overcurrent relay for controlling the operation of said circuit interrupting means, a pair of windings on said overcurrent relay, a power directional relay comprising a plurality of windings, means for energizing one of the windings of said overcurrent relay and the windings of said power directional relay from said circuit, a capacitor, a series circuit including said capacitor, the other winding of said overcurrent relay and the contacts of said power directional relay, said overcurrent relay being rendered ineffective whenever the

contacts in said series circuit are open, and means including said capacitor for producing a time delay in the operation of said overcurrent relay after said directional relay has operated to prevent false operation of said circuit interrupting means.

2. A directional overcurrent electroresponsive device for protecting an electric circuit comprising an overcurrent unit including circuit controlling means, a plurality of windings on said overcurrent unit, a power directional unit comprising a plurality of windings, a capacitor, a series circuit including said capacitor, one of the windings of said overcurrent unit, and the contacts of said power directional unit, said electroresponsive device being so constructed and arranged that said overcurrent unit is rendered ineffective to operate said circuit controlling means whenever the contacts in said series circuit are open, and means including said capacitor which has a capacitive reactance substantially equal to the inductive reactance of said one winding for producing a time delay in the operation of the circuit controlling means of said overcurrent unit after said directional relay has operated.

3. In a protective device for a circuit interrupting means in an alternating current circuit, electroresponsive means comprising an overcurrent relay of the multipole motor type for controlling the operation of said circuit interrupting means, a pair of windings on said overcurrent relay, a power directional relay comprising a plurality of windings, means for energizing one of the windings of said overcurrent relay and the windings of said power directional relay from said circuit, a capacitor, a series circuit including said capacitor, the other winding of said overcurrent relay and the contacts of said power directional relay, said overcurrent relay being rendered ineffective whenever the contacts in said series circuit are open, said capacitor having such a capacitive reactance as to cause said series circuit to be in resonance at the frequency of said alternating current circuit, and means including said capacitor for producing a time delay in the operation of said overcurrent relay after said directional relay has operated to prevent false operation of said circuit interrupting means.

4. In a protective arrangement for an alternating current circuit, a time delay current relay having two windings arranged so as to produce an operating torque when both windings are simultaneously energized, one of said windings being connected to said circuit so as to be energized by a predetermined current thereof and the other of said windings being normally open circuited, a capacitor having a capacitive reactance equal to the inductive reactance of said winding so that when they are connected together in a series circuit said series circuit is tuned substantially to resonance at the frequency of said alternating current circuit, and means for connecting said other of said windings and said capacitor in a series circuit to effect the operation of said relay.

5. In a protective arrangement for an alternating current circuit, a time delay current relay having two windings arranged so as to produce an operating torque only when both windings are simultaneously energized, one of said windings being connected to said circuit so as to be energized by a predetermined current thereof and the other of said windings being induc-

tively energized from said one of said windings and being normally open circuited, a capacitor, and means for connecting said other of said windings and said capacitor in a series circuit tuned substantially to resonance at the frequency of said alternating current circuit.

6. In a protective arrangement for an alternating current circuit, a time delay current relay having two windings arranged so as to produce an operating torque only when both windings are simultaneously energized, one of said windings being connected to said circuit so as to be energized by a predetermined current thereof and the other of said windings being inductively energized from said one of said windings and being normally open circuited, a capacitor, and a directional relay responsive to a power flow in a predetermined direction through said electric circuit for connecting said other of said windings and said capacitor in a series circuit tuned substantially to resonance at the frequency of said alternating current circuit.

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