

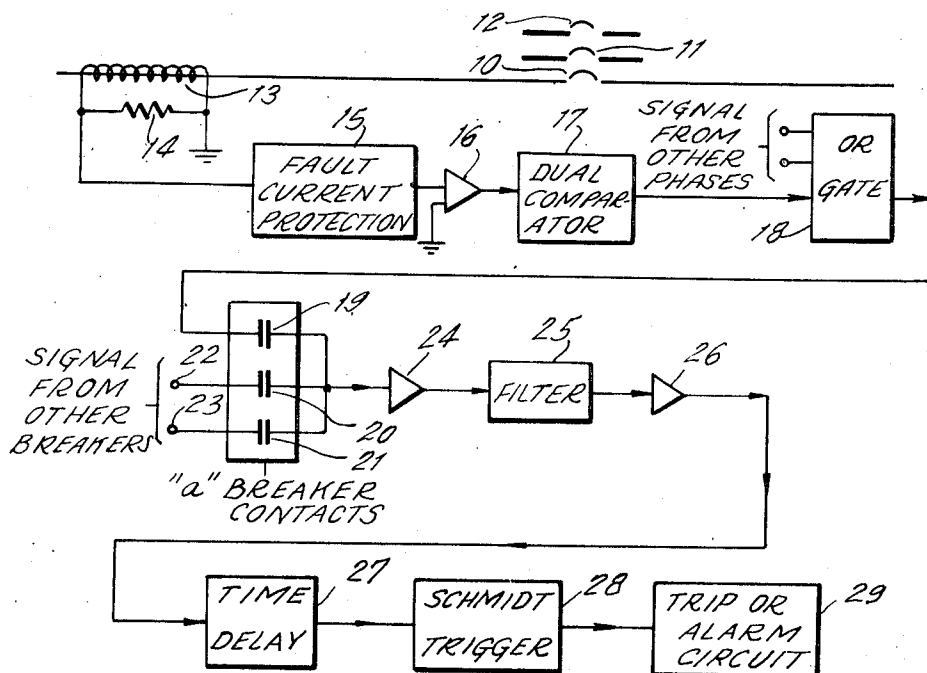
[54] **ARCING TIME RELAY**
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340/253 R
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317/11 R, 62, 33 R, 46; 307/136; 340/253 R

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[57] **ABSTRACT**
An arcing time relay is provided for vacuum circuit breakers, and measures the length of time that arcing occurs after the circuit breaker contacts are open, or measures the time that excessive leakage current flows while the contacts are open, and provides an output signal if arcing time or leakage current exceeds given bounds which indicate improper vacuum conditions.

10 Claims, 3 Drawing Figures



2 Sheets-Sheet 1

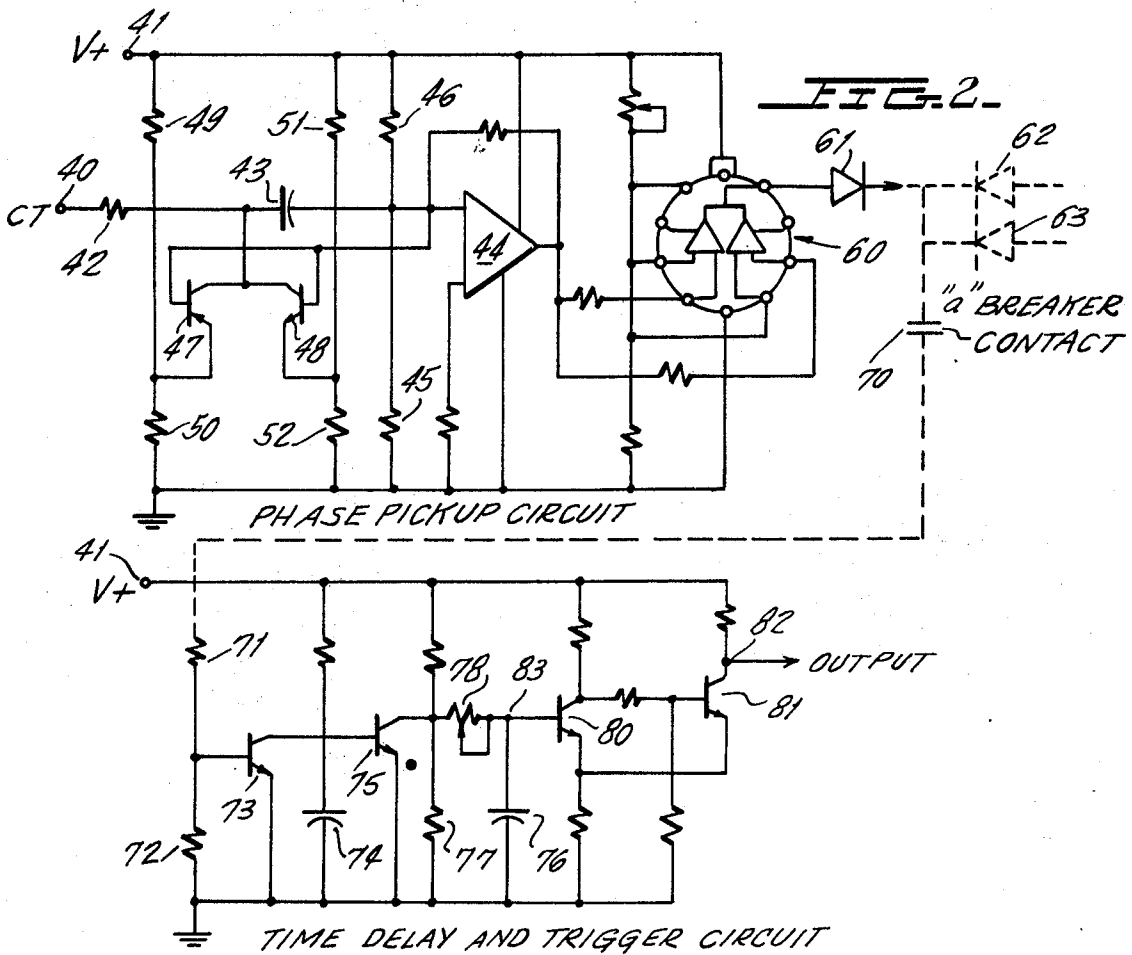
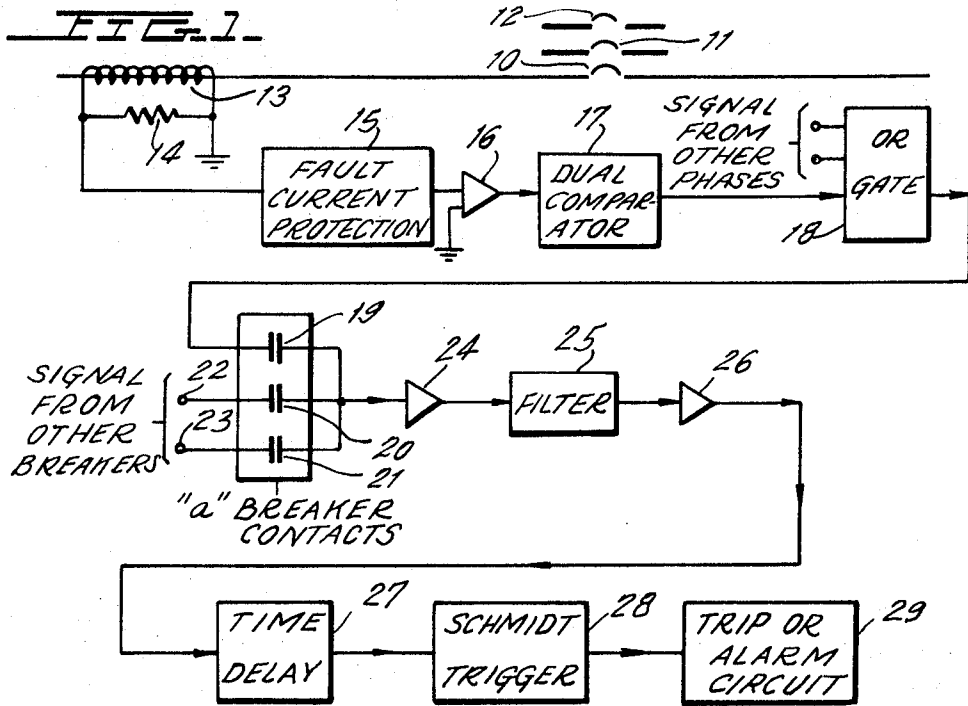
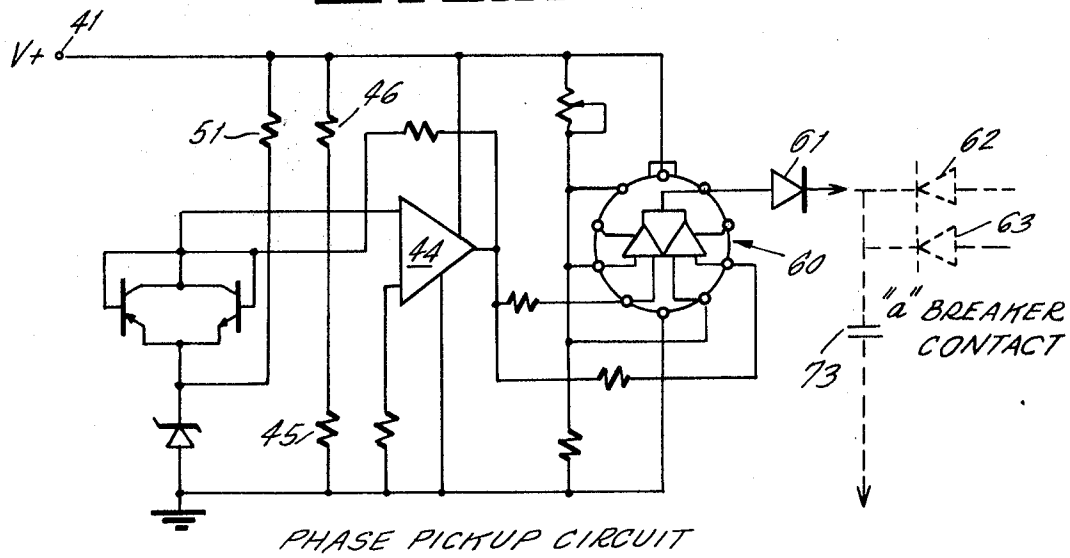


FIG. 3.



ARCING TIME RELAY

BACKGROUND OF THE INVENTION

This invention relates to solid state relays, and more specifically to a relay which produces an output signal in response to extended circuit breaker arcing time or leakage current flow while the circuit breaker contacts are open.

While the invention may be applied to any type of circuit breaker, it is particularly applicable to circuit breakers using vacuum interrupters. In commercially available vacuum interrupters, a pair of butt contacts which are relatively movable are enclosed in a sealed envelope which is evacuated to a hard vacuum. It is, however, possible that air can leak into the vacuum due to mechanical failure, aging, defective materials, or the like, with the loss of vacuum taking place slowly and unnoticeably. As the vacuum is lost, the operational ability of the vacuum interrupter and its interrupting ability decreases, and can lead to unexpected failure of the circuit breaker. The loss of vacuum can be determined by an increase in arcing time, or the length of time taken for the interrupter to clear a fault.

The failure of the vacuum beyond a given value may occur while the breaker is standing open. This could cause a flashover of the contacts, due to decreased dielectric strength between them, so that a circuit is established through the open breaker contacts. Such failures are extremely dangerous and could cause serious personnel and property damage.

BRIEF SUMMARY OF THE INVENTION

In accordance with the present invention, a high-sensitivity relay is connected to the standard current transformers which are conventionally provided with high power circuit breakers to monitor the current through each phase of a circuit breaker. The relay device is a completely solid state device and contains a pickup circuit which delivers its signal through the conventional *a* breaker contact, which is the contact which is closed when the breaker is opened. Thus, a signal can be delivered through the *a* breaker contacts only beginning with the instant that the breaker contacts open or while they have been standing in an open position.

The *a* breaker contact signal, which can be derived from any phase of the breaker, may be combined with the signals from other *a* breaker contacts of other breakers in a local system and this output signal is then amplified and applied to a time delay circuit. Thus, if arcing current, which begins to flow with the opening of the contacts, lasts for longer than some preset time in any phase being monitored, the common time delay circuit will produce an output to operate a trip circuit or alarm circuit. Similarly, if leakage current begins to flow while the breaker is standing open due to a defective vacuum in any phase, and this current flows for a given length of time, the time delay will similarly develop an output to actuate an alarm circuit or to trip a backup breaker.

It will be noted that the present invention does not affect the normal electromechanical relay operation of the relays conventionally connected to the current transformers, since the relay of the invention has an extremely high input impedance. Thus, the novel relay of the invention can be easily attached to existing circuit breaker installations in order to monitor the vacuum condition of the vacuum interrupters.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic block diagram of the circuit of the present invention.

FIG. 2 is a circuit diagram of one circuit which can carry out the functions illustrated in FIG. 1.

FIG. 3 is a modified diagram of the circuit shown in FIG. 2, wherein the circuit contains a modified fault-current protection circuit from that shown in FIG. 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, the novel arcing time relay is shown in connection with a three-phase circuit breaker in which each circuit breaker pole includes a vacuum interrupter 10, 11 and 12, respectively. Note, however, that the invention is also applicable to any type of circuit breaker, where arcing time must be closely monitored.

Each of the vacuum interrupters 10, 11 and 12 are connected in a phase which contains a conventional current transformer or other suitable current monitoring device. By way of example, the phase containing interrupter 10 has a conventional current transformer 13 which has a grounded burden resistor 14. Any other type of signal pickup circuit could also be provided. By way of example, it is possible to place a magnetic core on a circuit which carries current from the current transformer output to an overcurrent relay which would commonly be provided in the protective circuit of the breaker. The input of the arcing time relay is then magnetically coupled to the current flow to the overcurrent relay, so that the input of the arcing time relay will be unaffected by tap and time settings for the overcurrent relay which might affect the operation of the arcing time relay when the pickup is taken from the burden resistor 14.

The output of the burden resistor 14 serves as the input to the relay of the invention, and is initially connected to a fault current protection circuit 15. This circuit is needed since the relay of the present invention is to monitor extremely small currents. Therefore, it is possible that the relay could be damaged by the relatively high output signal of the current transformer under fault current conditions. Thus, the fault current protection circuit 15 limits relay output current under fault current conditions.

The output of fault current protection circuit 15 is then connected to operational amplifier 16 which is, in turn, connected to a dual comparator circuit 17. The dual comparator circuit 17 is a commercially available integrated circuit type device which operates to produce a small positive output when the output of the amplifier 16 deviates by some given value from a given steady state signal level. In the case of the relay of the invention, the steady state level is selected to be at zero current. The output of dual comparator 17 is applied to one terminal of an OR gate 18. The OR gate 18 has two additional inputs which are derived from the phase pickup circuits associated with the phases containing vacuum interrupters 11 and 12, which circuitry will be identical to the circuitry described above and which included components 13, 14, 15, 16 and 17. Thus, an output is produced from the OR gate 18 if a low current signal appears for either of the phases including interrupters 10, 11 and 12.

The output of OR gate 18 is then connected to the *a* breaker contact 19 of the circuit breaker which contains interrupters 10, 11 and 12. The *a* breaker contact of a circuit breaker is the contact conventionally used for relaying purposes, which contact is closed the instant the interrupter contacts separate, and which is opened the instant interrupter contacts close. Thus, so long as the interrupter contacts 10, 11 and 12 are closed, the *a* breaker contact 19 is open so that no signal passes through the remainder of the relay circuit.

In accordance with one feature of the invention, the remainder of the relay circuit could serve a common function for a group of circuit breakers. Thus, further *a* breaker contacts 20 and 21, of other vacuum circuit breakers being monitored, may be provided with input terminals 22 and 23, respectively, which are, in turn, connected to respective groups of phase pickup circuits associated with these other breakers.

The output of the *a* breaker contacts including contact 19 is then connected to an amplifier 24, and the output of amplifier 24 is filtered in filter 25 and again amplified in amplifier 26. The output of amplifier 26 is then connected to a suitable time delay circuit 27, which produces an increasing output with time so long as current flows from amplifier 26. Note that a signal current output is applied to time delay circuit 27 only when current continues to flow through any interrupter contact after the interrupter contact has opened. That is, the opening of the interrupter contacts closes its respective *a* breaker contact 19, 20 or 21 to permit transmission of a signal to time delay circuit 27.

If the current flow in time delay 27 exceeds a given value after some given length of time, the output signal of time delay 27 reaches a sufficiently high value to switch a Schmidt trigger circuit 28, which can, in turn, actuate a trip circuit of a backup breaker or an alarm circuit 29. Thus, if the arcing time of any interrupter is greater than some given value, due to vacuum leakage or some other problem, arcing current will flow long enough to cause actuation of time delay 27, and thus the operation of an alarm circuit or the tripping of a backup breaker by the trip or alarm circuit 29. Similarly, if, while the contacts of the interrupter stand open, a current greater than some given value begins to and/or continues to flow, the time delay circuit 27 will also operate Schmidt trigger 28 to produce an alarm and/or tripping of an appropriate backup breaker.

FIG. 2 is a detailed circuit diagram of one circuit which can produce the desired results described in connection with FIG. 1. Referring now to FIG. 2, there is illustrated a current transformer input terminal 40, which corresponds to the input from burden resistor 14 in FIG. 1. The circuit of FIG. 2 is also provided with a source of positive biasing voltage $V+$ connected at terminals 41, which provides the biasing voltages for the relay circuit. The current transformer signal is then connected through resistor 42 and capacitor 43 to the input terminal of operational amplifier 44 (corresponding to operational amplifier 16 of FIG. 1). Note that resistors 45 and 46 set the d-c bias level to which is added the current transformer input signal from terminal 40.

Since the relay must be sensitive to the lowest possible current transformer primary current, it is necessary to protect the operational amplifier 44 from the higher voltages associated with fault level current. To this end a fault current protection circuit (circuit 15 of FIG. 1) is provided, which includes transistors 47 and 48,

which are associated with biasing resistors 49, 50, 51 and 52. Transistor 47 is a PNP transistor and its emitter is biased slightly below the level set by resistors 45 and 46. The emitter of transistor 48, which is an NPN transistor, is biased slightly above this same level. The bases of transistors 47 and 48 are then connected to the input of operational amplifier 44. Thus, whenever the input signal from terminal 40 goes above or below the biasing levels set by resistors 49-50 or 51-52, respectively, either transistor 47 or transistor 48 conducts to reduce the input signal to operational amplifier 44.

The output signal of operational amplifier 44 is connected to an integrated circuit structure 60, which defines a dual comparator device (shown as comparator 17 in FIG. 1). This circuit separately compares two inputs with two references and if either input exceeds its reference, the output voltage becomes positive. By inverting one input and connecting two references to a level identical to the steady state (not signal) level of the output of amplifier 44, the time comparator 60 will produce a positive output when the level of amplifier 44 deviates from the no signal steady state level.

The output of dual comparator 60 is then connected through a diode 61 which serves as a component of an OR gate (OR gate 18 in FIG. 1). Thus, a phase pickup circuit, such as the one shown in FIG. 2 and described to this point, is provided for each current transformer which is monitored in a circuit breaker system. Each individual phase pickup circuit is connected at its output through a diode, such as the diodes 62 and 63, which form an OR gate with the diode 61, so that an output signal is produced if current flow is monitored in any phase of the breaker.

The output of the OR circuit, as shown in dotted lines in FIG. 2, is then connected through the *a* breaker contact 70 of the breaker in question and the output of the *a* breaker contact is connected to ground through resistors 71 and 72. Note that the outputs of other *a* breaker contacts of other breakers which are to be monitored by a common relay will also be connected to resistors 71 and 72 of FIG. 2.

The output from the *a* breaker contact 70 is then coupled to the amplifier defined by transistor 73 (amplifier 24 of FIG. 1). Capacitor 74 connects the collector of transistor 73 to ground, thereby to filter the input applied to the base of transistor 75, which defines a second amplifier. Note that the filter circuit, including capacitor 74, is shown as filter 25 in FIG. 1 while the amplifier including transistor 75 is shown as amplifier 26 in FIG. 1.

The capacitor 74 of FIG. 2 provides continuity of the timing cycle during zero crossing of the a-c input signal. The transistor 73 is so biased that it is normally off, but is turned on due to a signal from any phase pickup circuit. Transistor 75 is so biased that it normally conducts but is turned off in response to the conduction of transistor 73.

When transistor 75 normally conducts, it shorts out the timing capacitor 76 of the timing circuit. This timing circuit (equivalent to timing circuit 27 of FIG. 1) includes capacitor 76, resistor 77 and adjustable resistor 78 which can be used to adjust the time delay required before the relay of the invention will trip. Thus, with the appearance of a signal following the instant of opening of any of the interrupters being monitored, the transistor 75 turns off and capacitor 76 begins to charge, thereby to begin to measure the length of time

that the signal output from the *a* breaker contacts continues to exist.

The output of the capacitor 76 is then connected to a Schmidt trigger circuit, which monitors the voltage across capacitor 76. This Schmidt trigger includes transistors 80 and 81 and operates such that the relay output at terminal 82 switches positive when the capacitor voltage at terminal 83 exceeds some preset value.

The output of the Schmidt trigger of FIG. 2 may then be suitably connected to any output circuit which can include a trip circuit for tripping backup breakers or for activating an alarm circuit.

It will be understood that the novel circuit of the present invention allows the timing of the length of time that the arc current flows after interrupter contacts open. Thus, when the main interrupter contacts open, the *a* breaker contacts close, so that a signal is produced to permit the charging of capacitor 76 so long as arcing current flows between the open contacts. Once the arcing current is extinguished, the signal at dual comparator 60 is switched off so that transistor 73 is turned off and transistor 75 is turned on to disable the timing circuit and to prevent the production of a voltage at terminal 83 which can switch the Schmidt trigger and cause the production of an output signal. However, if, due to a faulty vacuum, arc current flows too long in any phase, the Schmidt trigger will switch to produce an alarm or the like. In a similar manner, if leakage current beyond some given level begins to flow while the circuit breaker contacts are open, an output warning signal will ultimately be developed after a given time delay.

FIG. 3 shows a modified phase pickup circuit arrangement, as compared to the phase pickup circuit of FIG. 2, wherein the fault current protection portion of the circuit has been changed. Thus, in FIG. 3, all components similar to those in FIG. 2 have been given similar numerals. The phase pickup circuit of FIG. 3 has a modified connection for transistors 47 and 48 and adds a zener diode 90, connected between the emitters of transistors 47 and 48 and ground. In addition, the bases of transistors 47 and 48 are connected together and to their collector electrodes and the bias resistors 49, 50 and 52 of FIG. 2 have been removed.

The fault-current protection circuit of FIG. 3 has greater accuracy than that of FIG. 2 in its protection function. In the circuit of FIG. 3, the bias level set by resistors 45 and 46 is the same as the zener voltage across the zener diode 90. This arrangement limits the voltage excursion at the input of operational amplifier 44 to the base-emitter junction drops of transistors 47 and 48. That is, when the input voltage at terminal 40 tends to exceed the junction voltage drop of transistor 48, transistor 48 conducts and provides the desired protection. Similarly, if the input voltage falls below the junction drop of transistor 47, then transistor 47 conducts to provide the desired protection. Note that in the circuit of FIG. 3, as contrasted to the circuit of FIG. 2, the emitter voltage is held constant for the transistors 47 and 48.

Although the present invention has been described in connection with a preferred embodiment thereof, many variations and modifications will now become apparent to those skilled in the art. It is preferred, therefore, that the present invention be limited not by the specific disclosure herein, but only by the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows:

1. An arcing time relay for a circuit breaker; said circuit breaker including at least one interrupter having a pair of separable contacts, a current monitor means for monitoring current flow through said pair of separable contacts and contact means which are closed when said pair of separable contacts are opened, and which are opened when said pair of separable contacts are closed; said arcing time relay including:

- a. a phase pickup circuit connected to said current monitor means and producing an output current in response to the measurement of current in excess of a given magnitude by said current monitor means,
- b. a time delay circuit having input means connectable to an input circuit and producing a given output after an input current is connected to its said input means for longer than a given time,
- c. circuit means connecting said output current of said phase pickup circuit to said input means of said time delay circuit through said contact means,
- d. and output circuit means connected to the output of said time delay circuit and operable in response to said given output of said time delay circuit, wherein said given output is produced only in response to current flow through said pair of separable contacts after said separable contacts are opened.

2. The relay of claim 1 wherein said circuit breaker contains a plurality of interrupter phases and a corresponding plurality of phase pickup circuits identical to said phase pickup circuit, one for each of said phases; the output current of each of said plurality of phase pickup circuits being connected to said input means.

3. The relay of claim 1 wherein said circuit breaker contains a plurality of interrupter phases and a corresponding plurality of pickup circuits identical to said phase pickup circuit, one for each of said phases; the output current of each of said plurality of phase pickup circuits being connected to said input means, and wherein there is a plurality of circuit breakers of identical construction to said circuit breaker; each of the phases of each of said plurality of circuit breakers containing respective phase pickup circuits; the contact means of each of said plurality of circuit breakers connected in parallel, whereby excessive arcing current in any phase of any of said plurality of circuit breakers causes the production of said given output by said time delay circuit.

4. The relay of claim 1 wherein said interrupter is a vacuum interrupter.

5. The relay of claim 1 which further includes fault current protection circuit means connected between said current monitor means and said phase pickup circuit for preventing the application of excessive signals to said phase pickup circuit produced by fault current through said pair of separable contacts.

6. The relay of claim 1 which further includes fault current protection circuit means connected between said current monitor means and said phase pickup circuit for preventing the application of excessive signals to said phase pickup circuit produced by fault current through said pair of separable contacts, and wherein said phase pickup circuit includes operational amplifier means coupled to said current monitor means through

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said fault current protection circuit means, and a dual comparator circuit means coupled to said operational amplifier means for producing an output signal from said phase pickup circuit when the output of said operational amplifier means deviates from a given steady state level.

7. The arcing time relay of claim 1 wherein said output circuit means includes a Schmidt trigger circuit which is switched in response to said time delay circuit producing said given value and which further includes alarm circuit means actuated by the switching of said Schmidt trigger circuit.

8. The relay of claim 6 wherein said interrupter is a vacuum interrupter.

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9. The relay of claim 8 wherein said circuit breaker contains a plurality of interrupter phases and a corresponding plurality of pickup circuits identical to said phase pickup circuit, one for each of said phases; the output current of each of said plurality of phase pickup circuits being connected to said input means.

10. The arcing time relay of claim 8 wherein said output circuit means includes a Schmidt trigger circuit which is switched in response to said time delay circuit producing said given value and which further includes alarm circuit means actuated by the switching of said Schmidt trigger circuit.

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