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PARALLEL ASSISTED CIRCUIT INTERRUPTING DEVICE

Filed May 19, 1967

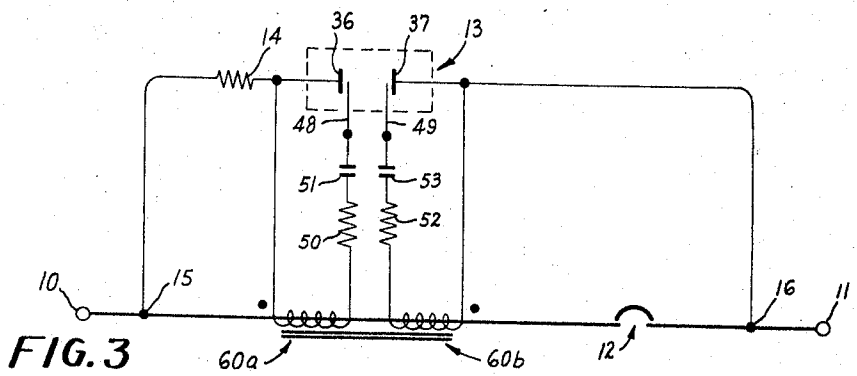

FIG. 3

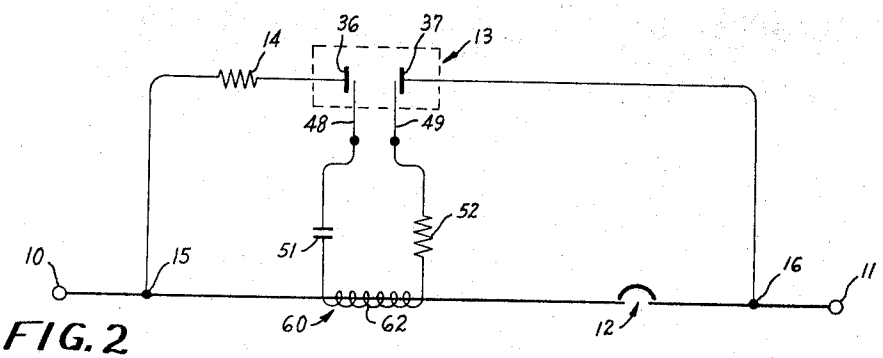

FIG. 2

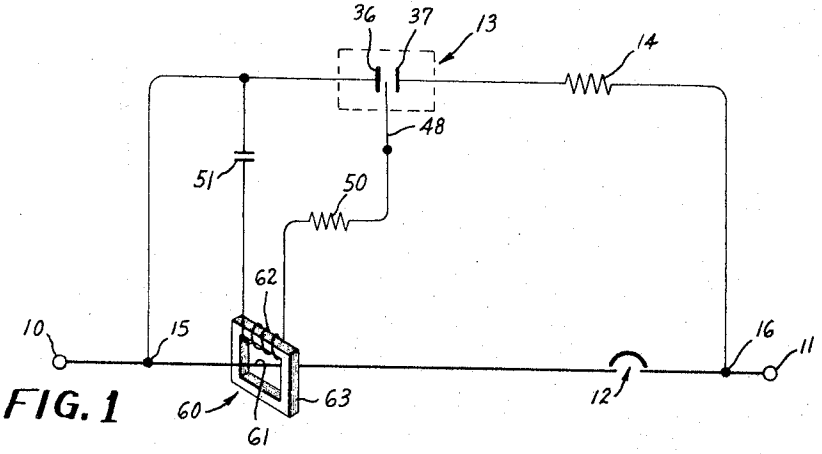

FIG. 1

INVENTOR
CHARLES F. HOBSON, JR.
BY Robert P. Casey
ATTORNEY

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PARALLEL ASSISTED CIRCUIT INTERRUPTING DEVICE

Charles F. Hobson, Jr., Southington, Conn., assignor to General Electric Company, a corporation of New York

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5 Claims

ABSTRACT OF THE DISCLOSURE

An electric circuit interrupter includes separable contacts and a "by-pass" path including a controlled breakdown gap device, which can be broken down or "triggered" by voltage applied between a "trigger" electrode and a main electrode. Triggering voltage is obtained from the secondary winding of a transformer whose primary winding is in series with the interrupter contacts. When the gap device fires, current by-passes the contacts and simultaneously eliminates the trigger voltage.

The present invention relates to electric current interrupting devices, and, more particularly, to a device of the type in which interruption of electric current in a load-carrying circuit is achieved in a combination of a main circuit path and a parallel circuit path which assists in the carrying and dissipation of currents which are to be interrupted. For convenience, this technique of circuit interruption is referred to as "parallel assisted circuit interruption."

A preferred type of device for use in a parallel current interruption assisting path is a controlled breakdown gap device shown in United States Patent No. 3,087,092, Lafferty, issued Apr. 23, 1963, and assigned to the same assignee as the present invention. This device has a pair of current-carrying terminals and a control electrode. Normally, the device is non-conducting; however, upon the application of a sufficient triggering voltage between the control conductor and one of the main current-carrying terminals, the device is transformed into a current-carrying state in which electric current flows between the main terminals there. Removing the triggering voltage from the control electrode permits the current to go to zero during a first current null, such as within a quarter cycle of a current peak in an AC circuit.

A similar device having a pair of control electrodes is described in a copending application of Lafferty, Ser. No. 510,562, filed Nov. 30, 1965, now Patent No. 3,303,376 and assigned to the same assignee as the present invention, wherein each of a pair of control electrodes is associated with one of the main current-carrying terminals and wherein a suitable potential applied across either of the control electrodes and its associated main electrode will cause the device to break down so that current will flow between the main electrodes. Three devices are preferably used in series with current-limiting resistances that limit the current to through the device to a value within the interruption capacity of the device. Thus, when current is interrupted by a circuit breaker in a load-carrying line, either of these electrodes may cause triggering of the controlled breakdown gap device so as to divert at least a portion of the current flowing through the circuit breaker and reduce the current through the breaker to a value that it can successfully interrupt.

The application of these devices in a parallel assisted current interruption apparatus is disclosed in a copending application of Hurtle, Ser. No. 542,806, filed May 15, 1966, and assigned to the same assignee as the present invention. Therein, the high arc voltage created by a circuit interrupter having diverging arc runners is utilized

to supply the triggering potential for the controlled breakdown gap device. Although circuit control devices or circuit breakers constructed in accordance with the aforesaid Hurtle application exhibit very high performance characteristics in terms of their ability to interrupt a given magnitude of available short circuit current, there is a need for relatively simple and more economical devices which will perform similarly in affording parallel assisted current interruption action.

It is an object of the present invention to provide a novel electric current interrupting device which is relatively simple and yet highly effective.

Another object is to provide such a device having relatively simple means for triggering a controlled breakdown gap device utilized as a parallel current interruption assisting device.

Still another object is to provide such a device which may be readily constructed, which utilizes relatively few parts, and which is relatively long-lived.

Other objects of the invention will in part be pointed out in the following detailed description and in part will become obvious from the following detailed description of specific embodiments of the invention, and the scope of the invention will be pointed out in the appended claims.

It has now been found that the foregoing and related objects and advantages may be attained in an electric circuit interrupter wherein an electric circuit breaker is combined with a controlled-breakdown gap device having a control electrode inductively coupled to the load-carrying line so that surges of current in the line sufficient to require that assistance be afforded to the circuit breaker will induce a voltage across the control electrode or terminal of the controlled breakdown gap device, and the controlled breakdown gap device thereby assumes the current-carrying load of the circuit breaker.

More particularly, the circuit interrupter includes an electric circuit breaker for connection in series between two points of an electric current-carrying circuit to be controllably interrupted by the circuit interrupter. An interruption assisting device, including at least two main conducting terminals and a control means actuable upon the impression of a sufficient predetermined voltage thereacross to change the device from a normally substantially non-conducting condition to a conducting condition in which current is conducted by the main conducting terminals. Upon cessation of the current between the main conducting terminals in the absence of the predetermined voltage across the control means, the interruption assisting device returns to the normally non-conducting condition.

Means are provided inductively coupling the control means of the interruption assisting device to the electric current-carrying circuit so that a predetermined abnormal current condition through the breaker will produce a predetermined voltage across the control means. In addition, circuit means connect each of the main conducting terminals of the interruption assisting device to one of the two points respectively of the electric current-carrying circuit so that current passing between the terminals will shunt the circuit breaker. Moreover, the inductive coupling means is connected in the branch of the circuit which includes the circuit breaker. As a result, when the current through this branch is reduced to zero by the opening of the circuit breaker, the coupling means ceases to generate the aforesaid voltage, and when the main current is reduced to zero, it remains at zero until the circuit breaker is again closed and another abnormal current condition occurs.

The means inductively coupling the control means of the interruption assisting device to the current-carrying

circuit includes an electrical power transforming means having a primary circuit connected in series with the circuit breaker and a secondary circuit connected across the control means. It will be apparent that two secondary windings may comprise the secondary circuit and that each of the secondary circuits may be connected across a control electrode in the control means.

The control means of the interruption assisting device may assume a variety of forms. In one embodiment it is a control electrode cooperating with one of the main conducting terminals to initiate the conducting condition upon the application of the predetermined voltage between the main conducting terminals. In another form, it includes a pair of control electrodes cooperating with each other to initiate the conducting condition upon the application of the predetermined voltage between them. In still another embodiment, it includes a pair of control electrodes for each pair of main conducting terminals with the control electrodes of each pair each cooperating with one of each pair of main conducting terminals to initiate the conducting condition upon the application of the predetermined voltage between them.

It will be appreciated that the various components of the circuit interrupter may be duplicated depending upon the requirements of the circuit and that although a single element or pair of elements may be recited, a greater number is intended to be encompassed thereby.

The invention provides a relatively simple means for controlling a parallel assisted current interruption device whereby the need for a highly complex basic circuit breaker is avoided while still providing the high quality circuit breaking characteristics required for lines carrying a heavy load. In accordance with the invention in its preferred form, the controlled breakdown gap device having a pair of control electrodes, each operatively connected to one of the main current-carrying terminals and each independently inductively coupled to the load-carrying line, reduces the necessity for adjusting the potential characteristics of the controlled breakdown gap device to the possible effects of line fluctuation upon the inductive coupling used for triggering the controlled breakdown gap device.

The invention will be more fully understood from the following detailed description, and its scope will be pointed out in the appended claims.

In the drawings,

FIGURE 1 is a schematic diagram of an electric circuit interrupter embodying the present invention and utilizing a controlled breakdown gap device having a single control electrode;

FIGURE 2 is a schematic diagram of another embodiment of the present invention in which a double controlled breakdown gap device having two control electrodes is utilized; and

FIGURE 3 is a schematic diagram of a third embodiment of the present invention in which a pair of control electrodes are separately driven.

Referring now in detail to FIGURE 1, the invention is shown as incorporated in an electric circuit interrupting device having a line terminal **10** and a load terminal **11** and comprising a main circuit breaker indicated generally at **12** and a controlled breakdown gap device indicated generally at **13**. The circuit breaker **12** may be of conventional construction. The controlled breakdown gap device **13** is connected electrically in series with a resistor **14**, and the combination of the breakdown gap device **13** and resistor **14** is connected at points **15** and **16** to the line terminal **10** and the load terminal **11** so as to be electrically in parallel with the circuit breaker **12**.

In series with the main circuit breaker **12** is a transformer **60** which includes a single turn primary winding **61** and a multiple turn secondary winding **62** disposed about the core **63**. The single turn winding **61** may comprise, in a preferred form, the main current-carrying conductor between the line terminal **10** and the load terminal **11**.

The controlled breakdown gap device **13** comprises a pair of main conducting terminals or electrodes **36, 37** and a control electrode **48**. This device may be of the form shown in the aforementioned Lafferty Patent No. 3,087,092. Therein, a complete description of such a device is found, which will not be repeated herein. In this device, the application of a sufficient triggering voltage between the control electrode **48** and the current-carrying electrode **36** initiates a spark discharge between them. As described in said Lafferty patent, this causes heating of a titanium film in the vicinity of the arc which releases hydrogen which becomes ionized and creates a highly conducting arc between the electrodes **36, 48**. Since this arc is also between the electrodes **36** and **37**, it substantially reduces the breakdown potential required for conduction across the gap between the electrodes **36, 37**. If sufficient voltage exists across the main electrodes **36** and **37**, a breakdown will now occur across the main gap between these electrodes, creating an arc capable of carrying high current. Once an arc has been established across the main arc gap, a subsequent decrease of such arc current to zero, such as, for example, upon the decrease of current in an alternating current circuit to the zero point, will quickly extinguish the arc and the conduction carriers or charged particles within the discharge device disappear. As described in said Lafferty Patent No. 3,087,092, the charged particles are essentially electrons and ionized copper atoms which emanate from the electrodes **36, 37**. These charged particles flow to the electrodes or to other portions of the structure within the device where their charge is lost so that they are removed from the conduction area between the electrodes. Since the device is maintained at a high vacuum with essentially no ionized gases normally present, the gap between the main electrodes rapidly recovers and no further current flow is possible until triggering occurs again. Such recovery may occur in a range of from 25 to 100 microseconds after extinction of the arc.

The secondary winding **62** of the transformer **60** is connected through a resistor **50** to the control electrode **48** and through a capacitor **51** to the current-carrying electrode **36** (and the terminal point **15**). The resistor **50** and the capacitor **51** are included in series with the secondary winding **62** so as to limit the current which flows through the control electrode **48** to that which is essential to cause triggering of the controlled breakdown gap device **13**.

In series with the controlled breakdown gap device **13** is a resistor **14** which limits the flow of current through the device **13** in order to prevent damage to the device. As described in said Hurtle application, Ser. No. 542,806, the resistor **14** is preferably composed of material having a positive temperature coefficient so the resistance increases rapidly and limits the magnitude of the current. Once the current reaches the next null or zero point in the alternating current cycle, the current is extinguished within the controlled breakdown gap device since the conventional circuit breaker **12** has, by this time, had sufficient time in which to recover dielectric strength and no substantial voltage is then generated by current flowing through the primary winding **61** of the transformer **60**. Without a continuing control electrode triggering potential, the controlled breakdown gap device **13** is able to cease the flow of current. In operation a high current rate of change of such as is caused by a short circuit in the load, will induce a potential to trigger the controlled breakdown gap device **13**.

Thus, there has been described one embodiment of the invention in its simplest form, in which a controlled breakdown gap device having a single control electrode is triggered inductively by current surging in a main line between the line terminal **10** and the load terminal **11**.

A second embodiment of the present invention is illustrated in FIGURE 2, wherein the secondary winding **62** of the transformer **60** is connected in series between a pair of control electrodes **48**. **49**. As can be seen in the aforementioned applications of Hurtle, Ser. No. 542,806 and Lafferty, Ser. No. 510,562, the control electrodes **48**, **49** are situated in the region between the main electrodes **36**, **37** so that a breakdown between them will reduce the breakdown potential required for conduction across the gap between the main electrodes **36**, **37**. As described therein, the use of two trigger electrodes assures adequate triggering regardless of the polarity condition of the main electrodes. The embodiment of FIGURE 2, is, however, subject to the possibility that fluctuations in the current flowing between the line terminal **10** and the load terminal **11** during normal usage in some circumstances may tend to generate potentials at the control terminals **48**, **49** which are substantial. Such potential could conceivably cause breakdown directly between the trigger electrodes **48**, **49**, which would of course be undesirable.

In any case where such breakdown is a hazard, the embodiment of FIGURE 3 is preferred. Therein, instead of a single secondary winding, a pair of secondary windings **60***a*, **60***b* are provided, one for each combination of control electrode and main current-carrying electrode **36** and **48**, or **37** and **49**. In this case, the potentials generated by the secondary windings **60***a*, **60***b* are not impressed between the trigger electrodes **48**, **49**.

When an excess of current is passed through the terminals **10**, **11** the transformers **60***a*, **60***b* will generate a potential across each pair of electrodes **36** and **48** or **37** and **49**. The controlled breakdown gap device **13** will therefore commence conduction, and the current passing between the load terminal **11** and the line terminal **10** will split between the conventional circuit breaker **12** and the controlled breakdown gap device **13** together with its series resistance **14**. Operation is thereafter as described hereinbefore with respect to FIGURE 1.

The invention has been described herein as incorporated in a parallel assisted current interruption device used with a conventional circuit breaker **12**. The specific nature of the circuit breaker **12** is immaterial to the invention since such devices are well-known and capable of operating thermally, magnetically, or in response to manual or other automatic means, and in various combinations of such actuating principles. The significance of the circuit breaker relates only to choice of the proper components in connection with the magnitude of electric potentials and currents involved in the circuit in which the apparatus of the present invention is to be utilized.

Accordingly, it is therefore intended by the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

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

1. An electric circuit interrupter for controlling the flow of current in an electric circuit, comprising:

(a) an electric circuit breaker for serial connection between two points of an electric current-carrying circuit to be controllably interrupted by said circuit interrupter;

(b) an interruption-assisting device including two main conducting terminals and a control means, said interruption-assisting device being normally in a substantially non-conducting condition, said control means being actuatable upon the impression of a sufficient predetermined voltage thereacross to change said device to a conducting condition in which current is conducted between said main conducting terminals, said interruption-assisting device returning to said non-conducting condition upon cessation of current between said main conducting terminals in the absence of said predetermined voltage across said control means;

(c) means inductively coupling said control means of said interruption-assisting device to the electric current-carrying circuit, said means being electrically connected with said control means so that substantial change in current through said circuit breaker will produce said sufficient predetermined voltage across said control means; and

(d) circuit means connecting each of said main conducting terminals of said interruption-assisting device to one of said two points, respectively, of the electric current-carrying circuit, whereby current passing between said terminals will shunt said circuit breaker.

2. An electric circuit interrupter in accordance with claim **1** wherein said means inductively coupling said control means to the electric current-carrying circuit includes an electric power transforming means having a primary circuit means connected in series with said circuit breaker and a secondary circuit means connected across said control means.

3. An electric circuit interrupter in accordance with claim **1** wherein said control means of said interruption-assisting device includes a control electrode cooperating with one of said main conducting terminals to initiate said conducting condition upon the application of said predetermined voltage between them.

4. An electric circuit interrupter in accordance with claim **1** wherein said control means of said interruption-assisting device includes a pair of control electrodes cooperating with each other to initiate said conducting condition upon the application of said predetermined voltage between them.

5. An electric circuit interrupter in accordance with claim **1** wherein said control means of said interruption-assisting device includes a pair of control electrodes each cooperating with a main conducting terminal to initiate said conducting condition upon the application of said predetermined voltage between them.

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BERNARD A. GILHEANY, *Primary Examiner.*

H. BROOME, *Assistant Examiner.*