

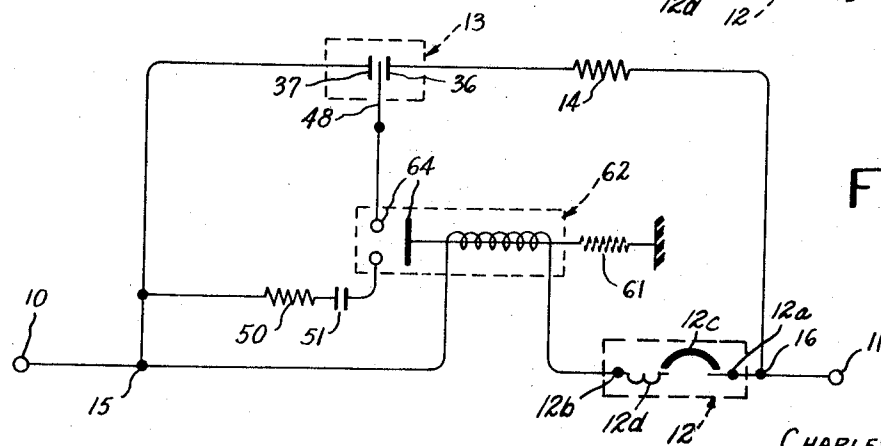
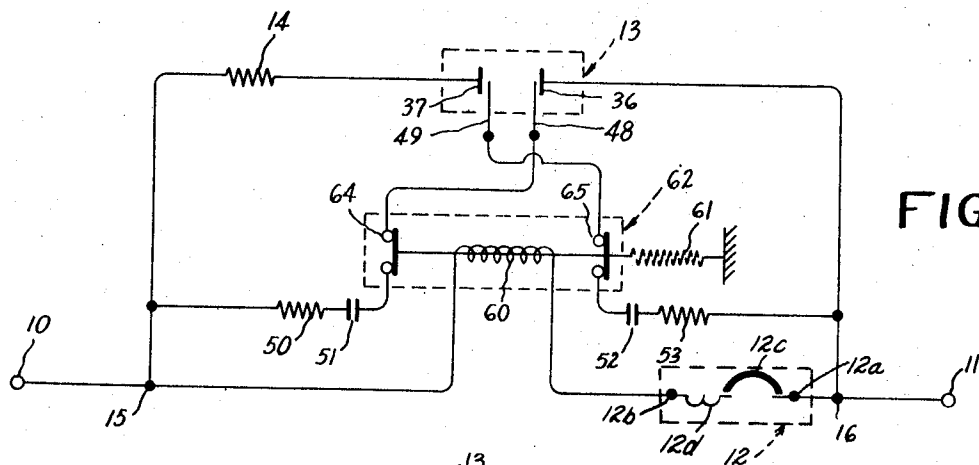
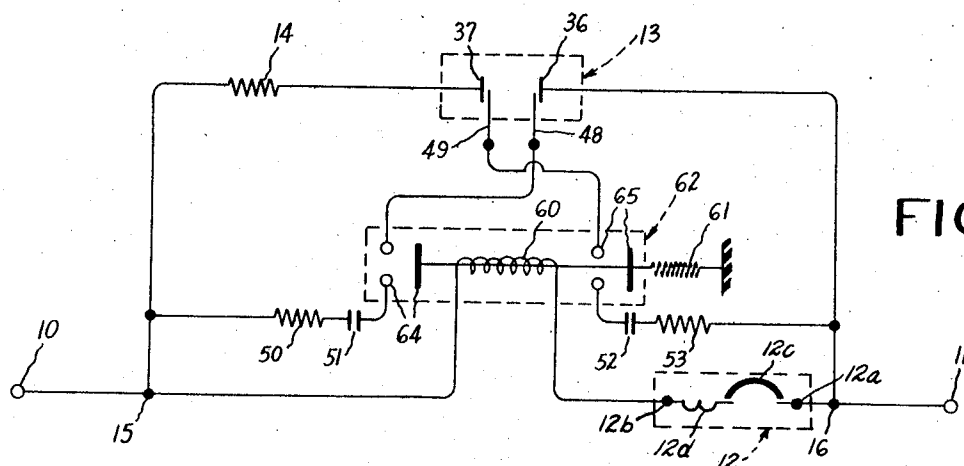
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C. F. HOBSON, JR

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PARALLEL-ASSISTED CIRCUIT INTERRUPTING DEVICE

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INVENTOR
CHARLES F. HOBSON, JR.

BY Robert H. 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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4 Claims

ABSTRACT OF THE DISCLOSURE

A parallel-assisted circuit interrupting device including a circuit breaker having a controlled-breakdown gap device connected electrically in parallel therewith; the gap device includes a control electrode which is connected through normally-open contacts of a current-responsive relay which is in series with the circuit breaker; upon occurrence of an abnormally high current, the contacts of the current-sensitive relay close, "firing" the gap device; at the same time, the same current actuates the current-responsive trip device of the circuit breaker, tripping it; since the gap device is turned on, it bypasses most of the current around the breaker, permitting the breaker to open without serious arcing; when the current goes to the zero point in the A-C cycle, the gap device becomes non-conductive; by this time the contacts of the current-responsive relay have re-opened because of the decrease of current through it, thereby removing the triggering voltage and establishing a permanent "off" condition.

Background of the invention

Various devices have been employed for interrupting the flow of electric current in response to overcurrents of relatively large magnitude or short circuit currents of relatively low magnitude continuing over a period of time. Where the current to be interrupted is of relatively large magnitude, it has been necessary to employ circuit breaker devices of relatively expensive and/or complex construction or to employ an auxiliary device in combination with the main circuit breaker to assist it in the carrying and dissipation of currents which are to be interrupted. This latter technique of circuit interruption is commonly referred to as "parallel assisted circuit interruption."

Various constructions have been proposed for use in parallel assisted circuit interruption both with respect to an auxiliary device coupled to the main breaker and with respect to the means for coupling the auxiliary device to the main circuit breaker. A preferred type of auxiliary device for use in a parallel current interruption assisting circuit is the controlled-breakdown gap device shown in United States Pat. 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. 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.

In United States Pat. No. 3,303,376 of Lafferty, issued Feb. 7, 1967 and assigned to the same assignee as the present invention, there is disclosed a similar device utilizing a pair of control electrodes 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 current-carrying terminal

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will cause the device to break down so that current will transfer between the main current-carrying terminals. These devices are preferably used in series with current-limiting resistances that tend to force the current to zero as rapidly as possible. Thus, when current is interrupted by a circuit breaker in a load-carrying line, either of these devices may be triggered so as to assist in carrying the interruption current and reducing the current to zero.

These devices are applied in a parallel assisted current interruption apparatus disclosed in a copending application of Hurtle, Ser. No. 542,806, filed Apr. 15, 1966, now issued as Pat. No. 3,430,016, and assigned to the same assignee as the present invention. Therein, the high arc voltage created by a circuit interrupter having a diverging arc runner is utilized to supply the triggering potential for the controlled breakdown gap device. Although circuit control devices or circuit breakers 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.

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

Another object is to provide such a device utilizing a relatively inexpensive 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 utilizes components which are readily available in a combination which is relatively easy to assemble.

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

Summary of the invention

It has now been found that the foregoing and related objects and advantages may be readily attained in an electric circuit interrupter having an electric circuit breaker and an overcurrent-responsive solenoid connected electrically in series with said circuit breaker for serial connection therewith between two points of the electric current carrying circuit to be controlled thereby. Combined with the electric circuit breaker is an interruption assisting device including two main conducting terminals and a control means with the interruption assisting device being normally in a substantially non-conducting condition and the control means being actuatable upon impression of a sufficient predetermined voltage thereon to change the device to a conducting condition in which current is conducted between the main conducting terminals. The interruption-assisting device will return to the non-conducting condition upon cessation of flow of current between the main conducting terminals in the absence of the predetermined voltage on the control means. Means forming a normally open relay device in combination with the overcurrent-responsive solenoids includes an armature and normally open contact means which will close in response to a predetermined current flowing through the solenoid, and the interrupter includes means for concurrently opening the contacts of the breaker. The contact means in the closed condition connects the control means to one of the two points of the electric current-carrying circuit controlled thereby so that current passing between the main conducting terminals will shunt the breaker when each of such terminals is electrically connected to one of the two points, respectively, of the electric current-carrying circuit.

Brief description of the drawings

FIG. 1 is a schematic diagram of an electric circuit interruption device embodying the present invention using a pair of control electrodes separately connected through related relay contacts and showing the contacts in the open position;

FIG. 2 is a similar diagram of the embodiment of FIG. 1 with the contacts shown in closed position; and

FIG. 3 is a schematic diagram of another embodiment of the present invention utilizing a controlled breakdown gap device with a single control electrode.

Detailed description of the illustrated embodiments

Referring first to the embodiment of FIGS. 1 and 2, 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 by the numeral 12 and a controlled breakdown gap device indicated generally by the numeral 13. The circuit breaker 12 may be of conventional construction and is not specifically described herein 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 is related 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.

The particular circuit breaker shown comprises a circuit breaker of the overload opening type, including main terminals 12a and 12b respectively, separable contact means 12c, and overload-actuated current-responsive means 12d which causes opening of the contact means 12c upon the occurrence of predetermined current through the circuit breaker. Alternatively, I may utilize a circuit breaker the contacts of which are operated to open position by the action of the solenoid 60 as it closes the contacts 64, 65 of the relay 62. As still another alternative, I may utilize a circuit breaker having a trip mechanism which is mechanically linked to the solenoid 60.

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.

The controlled breakdown gap device 13 comprises a pair of main conducting terminals or electrodes 36, 37 and a pair of control electrodes 48, 49. This device may be of the form generally shown in the aforementioned Lafferty Pat. No. 3,087,092 wherein a complete description is to be found and which will not be repeated herein. In this device, the application of a sufficient triggering voltage between the control electrodes 48, 49 and the respective current-carrying electrodes 36, 37 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 and 37, 49. 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, 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

Pat. 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.

In series with the main circuit breaker 12 is the solenoid 60 of the relay generally designated by the numeral 62. As can be seen, the current-carrying electrode 48 of the controlled breakdown gap device 13 is connected to the connection point 15 of the electric circuit through the contacts 64 of the relay 62, capacitor 51 and resistor 50. The resistor 50 and the capacitor 51 are included in series with the control electrode 48 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.

As can be seen, the current-carrying electrode 49 of the breakdown gap device 13 is connected to the connection point 16 through the contacts 65 of the relay 62, the capacitor 52 and resistor 53. The resistor 53 and capacitor 52 similarly limit the current which flows through the control electrode 49 to that which is essential to cause triggering of the device 13. As can be seen in the aforementioned application of Hurtle and the Lafferty Pat. 3,303,376, each controlled electrode 48, 49 is situated in the region near the corresponding main electrodes 36, 37 so that a breakdown between either control electrode and the remaining main electrode will reduce the breakdown potential required for conduction across the gap between the main electrodes 36, 37.

The resistor 14, which is in series with the controlled breakdown gap device 13, limits the flow of current through the device 13 in order to prevent damage thereto. As described in the aforesaid 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 applied to the control electrodes 48, 49 since the lack of current through the circuit breaker 12 will allow the solenoid 60 to release and thereby open the contacts 64, 65. Without a continuing control electrode triggering potential, the controlled breakdown gap device 13 is able to stop the flow of current. In operation, a heavy current (such as is caused by a short circuit in the load) will close the relay 62 and apply the potential between points 15 and 16 to trigger the controlled breakdown gap device 13.

In normal operation, current flows between the line terminal 10 and the load terminal 11 through the connection points 15 and 16, the solenoid 60 of the relay 62 and the main circuit breaker 12. So long as a normal current flows, the circuit breaker 12 will remain closed, and the current through the solenoid 60 is not sufficient to generate a force great enough to overcome the action of a spring 61 which tends to maintain the relay contacts 64, 65 in the open position (as shown in FIG. 1). However, if there is a marked increase in the current flowing between the line terminal 10 and the load terminal 11, such as may result from a short circuit in the load (not shown), then the current through the solenoid 60 develops sufficient electromagnetic force to overcome the operation of the spring 61 and to close the contacts 64, 65 (as shown in FIG. 2). This connects the connection point 15 with the

control electrode 48 and the connection point 16 with the control electrode 49 so that there appears between the control electrodes 48, 49 and the respective main conducting terminals 36, 37 any potential which develops between the connection points 15, 16. This potential may be very high in comparison with normal line potential, due to the fact that an inductive power factor in the load, and even the inductance of the relay solenoid 60 will produce a high potential across the contacts of the main circuit breaker 12 once the circuit breaker 12 begins to open as the result of the overcurrent. Thus the potential across the circuit breaker 12 is applied between the control electrodes 48, 49 and the main conducting terminals 36, 37 and causes a spark discharge between them which triggers the controlled breakdown gap device 13 thereby causing conduction between its main conducting terminals 36, 37 as described hereinbefore. The characteristics of the relay 62 may be selected so that the contacts 64, 65 will be closed in response to a current of a given magnitude in order to effect the aforesaid operation in response to an appropriate selected current in a circuit operating with any given parameters of nominal circuit potentials, load impedances, etc.

The contacts of the circuit breaker 12 open concurrently with the closing of the contacts 64, 65 of the relay 62 so that current flow therethrough terminates. Although the short circuit current initially operates the relay 62 and actuates the breakdown gap device 13, the absence of further current flow will allow the spring 61 to reopen the contacts 64, 65 and disconnect the control electrodes 48, 49. Thus, the short circuit current will be extinguished in the breakdown gap device 13.

Turning now to the embodiment of FIG. 3, therein illustrated is a device utilizing a single control electrode 48 and a single set of contacts 64 which is otherwise similar in construction to the embodiment shown in FIGS. 1 and 2. In this particular embodiment, the application of a sufficient triggering voltage between the control electrode 48 and the current-carrying electrode 36 initiates a spark discharged between them. Since this arc is between the pair of current-carrying electrodes 36, 37, it substantially reduces the breakdown potential required for conduction across the gap. If sufficient voltage is now applied across the main electrodes 36, 37, a breakdown will occur across the main gap therebetween and create an arc capable of carrying high current.

If desired, it is possible to duplicate the controlled breakdown gap device 13 and to provide additional relay contacts similar to contacts 64, 65 in the embodiment of FIGS. 1 and 2 so as to provide even greater current-assisting capability in devices utilized in circuits carrying heavier loads. Additionally, the particular parameters of the controlled breakdown device 13, the main circuit breaker 12, the relay 62 and the resistor 14 may be selected so as to meet the design requirements of a parallel assisted circuit interruption device having characteristics for use with any of a variety of combinations of current-carrying lines and loads. Specifically, the circuit breaker construction and its characteristics may be varied widely in accordance with conventional technology, and means may be provided for adjusting the force of the spring resisting the action of the solenoid.

If so desired, a single control electrode cooperating with one of the main conducting terminals may be employed to initiate the conducting condition or a pair of control electrodes may be utilized in combination with the pair of main conducting terminals. Similarly, it will be appreciated that the various components of the device may be duplicate depending upon the requirements of the circuit. In this manner, the invention provides a relatively simple means for controlling a parallel assisted current interruption device which avoids the need for a highly complex basic circuit breaker while still providing the high quality circuit breaking characteristics required for lines carrying a heavy load.

Thus it can be seen that the present invention provides a novel electric current interrupting device which is relatively simple and yet highly effective and which utilizes relatively inexpensive means for triggering a controlled breakdown gap device utilized as a parallel current interruption assisting device. The assembly utilizes components which are readily available and which may be assembled relatively easily to provide the highly effective combinations disclosed herein.

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 having a pair of main terminals and at least two separable contacts;
- (b) an overcurrent-responsive solenoid connected electrically in series with said circuit breaker for serial connection between two points of the electric current-carrying circuit to be controlled thereby;
- (c) 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 and said control means being actuatable upon impression of a sufficient predetermined voltage thereon 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 flow of current between said main conducting terminals in the absence of said predetermined voltage on said control means;
- (d) means connecting said main conducting terminals of said interruption-assisting device to said two points of said circuit so as to connect said interruption-assisting device electrically in parallel with said circuit breaker;
- (e) means forming a normally open relay device in combination with said overcurrent-responsive solenoid including an armature and normally open contact means, said contact means closing in response to a predetermined current flowing through said solenoid, means connecting said normally open contact means between said control means of said interruption-assisting device and one of said terminals of said circuit breaker whereby closing of said normally open contact means connects said control means to said one terminal of said circuit breaker;
- (f) and means for opening said contacts of said circuit breaker concurrently with closing of said contact means of said relay device whereby a voltage is created across said circuit breaker and said voltage is applied between said control means of said interruption-assisting device and one of said main conducting terminals of said interruption assisting device to change said device to a conducting condition and to cause current to be diverted from said circuit breaker to aforesaid parallel path including said interruption-assisting device.

2. 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 corresponding main conducting terminal to initiate said conducting condition upon the application of said predetermined voltage therebetween.

3. An electric circuit interrupter in accordance with claim 1 wherein said contact means includes a pair of contacts with one of said contacts being carried by said armature for movement between open and closed contact position, said relay device means including a spring acting upon said armature and normally biasing said armature and its contact into open contact position, said

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solenoid overcoming the biasing pressure of said spring upon flow of a predetermined current therethrough to move said armature and its contact into closed contact position.

4. An electric circuit interrupter in accordance with claim 1 wherein said circuit interrupter includes circuit means for connecting the contact means of the normally open relay device to the electric circuit including resistance means and capacitor means to limit the current flowing through the control means to that which is essential to cause actuation of the interruption assisting device.

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References Cited

UNITED STATES PATENTS

1,595,768	8/1926	Eschholz	317—11
2,215,804	9/1940	West	317—11
3,435,288	3/1969	Greenwood	307—136

RAYMOND F. HOSSFELD, Examiner

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