Inventor:
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by Harry E. Dunham
His Attorney.
This is a division of my application Serial No. 222,497, filed August 1, 1938, and assigned to the same assignee as the present application.

My invention relates to methods and apparatus for testing circuit interrupting devices such as circuit breakers and oil switches, for example. It is an object of my invention to provide a simple, reliable arrangement for applying to circuit interrupting devices a synthetic test subjecting them to the conditions which would take place if tested under actual operating conditions at full line voltage without the necessity of consuming the energy which would be wasted in such a test with usual operating voltage, and without the necessity for generating equipment of sufficient capacity to supply such energy.

Other and further objects and advantages will become apparent as the description proceeds. In accordance with a simple form of my invention I provide a relatively low voltage high current source for passing power current through a circuit breaker to be tested and I provide a relatively low power high voltage source for supplying an additional voltage across the terminals of the breaker when it is opened, to simulate the recovery voltage which would exist under full voltage, full power conditions. I provide a connection between the voltage supplying device and the terminals of the breaker, which connection includes a spark gap set to break down at a voltage exceeding either the additional voltage provided by the voltage supply device, or the actual recovery voltage of the circuit breaker under test conditions, but not exceeding the sum of the recovery voltage and the additional voltage.

The invention will be understood more readily from the following detailed description when considered in connection with the accompanying drawings and those features of the invention which are believed to be novel and patentable will be pointed out in the claim appended hereto.

In the drawing Fig. 1 is a circuit diagram representing a connection constituting a simple form of my invention. Fig. 2 is a circuit diagram of a modified arrangement for causing the additional voltage to have the same polarity as the actual recovery voltage and Fig. 3 is a circuit diagram of another modified arrangement in which a transformer is utilized to step up the actual recovery voltage of the circuit interrupting device. Like reference characters are utilized throughout the drawing to designate like parts.

In the arrangement illustrated in Fig. 1 there is a current source for supplying full power current to the circuit breaker to be tested, but at reduced voltage, there is a voltage source for supplying voltage across the contacts of the circuit breaker when the contacts are separated, and both current sources and voltage source are connected to a pair of terminals and between which a circuit breaker to be tested may be connected. A spark gap is inserted in one of the connections between the terminals of the voltage source and the terminals and of the tested circuit breaker. Inductances and may be included in the connections between the terminals of the current source and the terminals and of the circuit breaker tested in order to fix the magnitude of the short circuit current provided by the current source, and in order to delay a tendency for the current source to short circuit the voltage source. Furthermore, a condenser may be connected across the current source to protect it against excessive voltage stresses. The spark gap is so designed or so set that the voltage of the voltage source alone will be insufficient to cause the gap to break down, and likewise the actual recovery voltage across the contacts and of the circuit breaker when its current is interrupted will be insufficient to cause the gap to break down. However, the design of the gap is such that it will break down in response to the sum of the two voltages.

A test upon the circuit breaker may be carried out in the following manner. Assuming that the breaker contacts and are initially separated, these contacts will be closed to cause the current source to be short circuited and to pass a short circuit current of the desired value through the circuit breaker, whereupon the contacts and are separated by the usual breaker-operating mechanism, not shown, which may be of a type well known in the art. Opening of the contacts in the circuit breaker results in an actual recovery voltage being built up between the contacts and, but one which is smaller than the recovery voltage which would exist if the breaker were interrupting a current at full voltage supplied by a power system of virtually unlimited power. The actual recovery voltage between the contacts and in the test circuit, however, is added to the voltage between the terminals and of the voltage source and appears across the electrodes of the gap to cause the gap to break down whereupon its impedance becomes negligible, and the voltage of the source is supplied across the contacts of the breaker to simulate the effect of interrupt-
It will be observed that in order for the actual recovery voltage and the additional voltage supplied by the source 2 to act cumulatively in the gap 4, it will be necessary for the source 2 to have an opposite polarity from the source 1. The recovery voltage or the voltage induced between the contacts 3a and 3b by opening of the circuit is of such a polarity, as shown by the arrow, to tend to cause current to pass through the source 2 in the direction shown by arrows. Accordingly, the additional voltage applied across the opening contacts of the circuit breaker 3 by the source 2 has an opposite polarity to that of its actual recovery voltage. Useful information may be obtained from such tests but such tests do not in all respects simulate actual operating conditions and may not be as severe as actual operating conditions.

In order that the additional voltage supplied by the voltage of the source 2 may be of the same polarity as the recovery voltage across the contacts of the circuit breaker 3, suitable cross connections may be employed, for example, as in the arrangement of Fig. 2. In this arrangement spark gaps are provided in both connections between the terminals of the voltage source 2 and the circuit breaker 3 and the spark gaps in each connection are double spark gaps. That is, they may be three-electrode gaps or two double-electrode gaps in series. As shown, there is a double gap consisting of gap portions 4 and 6 in series between the voltage-source terminal c and the circuit breaker terminal d and there is likewise a double gap consisting of gap section 4′ and gap section 6′ in series between the voltage-source terminal c and the circuit breaker terminal d. The terminal e between the gap portions 4 and 6 is connected to the terminal a of the circuit breaker 3 through a complex impedance 7, and the terminal f between the gap sections 4′ and 6′ is connected to the terminal b of the circuit breaker 3 through a complex impedance 7′.

It will be understood that the impedances 7 and 7′ are relatively high in value. They may be made so low that they transmit the voltages of the points d and e and f without time lag. They may, for example, be capacitative impedances consisting of condensers and resistors in series.

A condenser 8 may be connected across the voltage source 2 for maintenance of voltage an adequate length of time after the collapse of the spark gaps, and also to facilitate providing a more powerful flash-over spark to permit power current to follow through an arc across the contacts of the circuit breaker 3, even after diminution of voltage provided by the source 2. If desired, a closely adjusted spark gap 10 may also be provided in series with the condenser 8 for protecting it from the prolonged current.

In the arrangement of Fig. 2 the gaps 4 and 4′ are so designed as not to be broken down by either the normal voltage of the source 2 alone or the actual recovery voltage of the breaker 3 alone, but to be broken down only by the sum of the voltages. When the circuit breaker 3 is opened and the recovery voltage appears, the potential of the terminal b is transmitted to the terminal f and the potential of the terminal a is transmitted to the terminal e. Accordingly, the polarity of the generator 2 must be the opposite to that shown in the arrangement of Fig. 1 for the gaps 4 and 4′ to break down. It will be understood that to maintain the polarity relationships, the generators 1 and 2 should be run synchronously. When these gaps break down the voltages of the terminals c and d are connected to the points e and f whereupon the gaps 4 and 4′ also break down.

Consequently, there is a reversal in polarity of additional voltage passing to the points e and f so that this voltage appears across the switch contacts with the same polarity as the recovery voltage.

The construction of the complex impedances 7 and 7′ calls for particular care in view of the unavoidable capacities cooperating therewith. In order that there may be no time lag, the capacities of the points e and f may be made as small as possible. This purpose is served by the use of double spark gaps 4 and 4′ by means of which the high earth capacity of the voltage source 2 is kept away from the points e and f. The impedances 7 and 7′ may be constructed as purely ohmic resistances. However, it is preferable for protection to connect in series condensers having a relatively high reactance at the testing frequency. Complex impedances such as condensers, for example, which are large in comparison with the characteristic impedance of the gaps 4 and 4′, may be included in the condensers 2–c and 3–d, respectively, for the purpose of delimiting the current of the voltage source 2.

The precision of the arrangement depends preferably on the adjustment of the spark gaps 4 and 4′. These are stressed by a slowly variable additional voltage and, by a sudden considerable lower actual recovery voltage. In the case of substantial variations of the calculated momentary value of the recovery voltage serving the purpose of the spark gap collapse, the variation of the adjustment of the spark gaps 4 and 4′ is but slight. This can be obviated by a further improvement of the arrangement in which the spark gaps 4 and 4′ are constructed as controlled multiple spark gaps, whereby the control used is capacitative and ohmic. The ohmic control, which is determinative for the low frequency, provides for the highest possible flash-over strength at low frequency, while the capacitative control provides for as low a flash-over strength as possible at high frequency. The adjustment of the spark gaps can be undertaken with greater precision by such means.

Another arrangement for adding voltage to produce collapse of the spark gaps is illustrated in the arrangement of Fig. 3 in which a transformer is employed. In the arrangement of Fig. 3 there is a transformer 11 having a primary winding connected across the terminals a and b of the circuit breaker 3 and having a step-up secondary winding connected on one side to the terminal g which is connected through condensers 12 and 12′ across the double spark gap 4 and 4′ and is connected on the other side to the terminal h constituting the midpoint of double spark gaps 4 and 4′. The transformer 11 is preferably having the lowest possible leakage in order to produce a minimum of time lag. The ratio of transformation of the transformer 11 may be such that the transformed recovery voltage is brought up to the order of magnitude of the additional voltage of the source 2. The condensers 12 and 12′ are small in comparison with the condenser 8 and regulate the potential of the point g 70 by providing a predetermined potential distribution in the gap sections 4 and 4′.

In the arrangement of Fig. 3 the voltage between the terminals g and h is proportional to the arc voltage of the circuit breaker 3. As long as
this voltage is low the potential of the point \( h \) corresponds to that of the point \( g \) and the spark gaps 4, 4' are stressed substantially only by the additional voltage of the source 2, and the adjustment is such that the gaps do not break down at this voltage. If, however, a high recovery voltage appears, then the potential of the terminal \( h \) is displaced while the potential of the point \( g \) remains fixed and one of the gap sections breaks down. The second gap section thereupon breaks down in sympathy.

In the arrangements actually illustrated in Figs. 1 and 2 and thus far described in connection with Fig. 3, the additional voltage of the source 2 passes simultaneously with the switch terminals to the leakage circuit and therefore to the short circuited generator or supply source 1. The additional voltage source is thus short circuited by the generator so that it can appear on the circuit breaker 3 only in the form of an impulse or a quickly damped oscillation.

It will be understood, however, that this may be avoided by providing an auxiliary circuit breaker in series with the tested input device 3, in a well-known manner so arranged that the auxiliary breaker is opened simultaneously when the opening of the testing device 3 has disconnected the short circuit source 1 from the terminals of the tested device 4. For example, as shown in the arrangement of Fig. 3 there may be an auxiliary circuit 13 with contacts included in the connections between the source 1 and the terminals \( b \) and \( c \) of the tested device 3, and the operating mechanisms of the circuit interrupting devices 3 and 13 may be connected together or operated simultaneously in any desired well-known manner.

I have herein shown and particularly described certain embodiments of my invention and certain methods of operation illustrated therein for the purpose of explaining its principle and showing its application but it will be obvious to those skilled in the art that many modifications and variations are possible and I aim, therefore, to cover all such modifications and variations as fall within the scope of my invention which is defined in the appended claim.

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

An arrangement for testing circuit interrupting devices comprising a pair of test terminals to which a circuit interrupting device to be tested may be connected, a relatively high current, low voltage source connected to said terminals, a relatively high voltage source with connections to said terminals including a double section spark gap having a mid terminal, a step-up transformer having a primary winding connected across said test terminals and having a secondary winding connected at one end of said mid terminal, a pair of condensers connected in series across said double section spark gap having a common terminal connected to the remaining end of said transformer secondary winding, said spark gaps being adjusted to break down at a voltage exceeding the voltage of said voltage source but falling within the sum of said voltage and the transformer secondary voltage corresponding to the actual recovery voltage of the circuit interrupting device connected between said test terminals.

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