In a high-tension circuit breaker including, in the high-tension side thereof insulated from the ground side by porcelain insulating tubes or the like, a contact mechanism which operates interrupting contacts of the circuit breaker utilizing electric energy stored in a capacitor, there is provided means for charging the capacitor from the high-tension line voltage of the circuit breaker. Various modifications of the charging means are also described.
HIGH-TENSION CIRCUIT BREAKER

BACKGROUND OF THE INVENTION

This invention relates to high-tension circuit breakers, and more particularly to those wherein electrostatic energy stored in a capacitor is discharged through an electromagnetic coil and a repulsive force caused between the electromagnetic coil and a flange portion of a movable contact is utilized for operating the circuit breakers.

High-tension circuit breakers of the type which has a capacitor charged from the ground side, and in which the energy stored in the capacitor is utilized for operating the circuit breaker are known (one example being disclosed in the specification of Japanese Patent No. 437140 (Patent Publication No. 8917/1964)).

The capacitor in this type of circuit breaker is charged from the ground side through a plurality of cascade connected transformers accommodated in a porcelain insulator separating the breaker portion of the circuit breaker from the ground side.

However, the number of stages of the cascade connected transformers is much increased when the voltage of the transmission line becomes high, and the production cost of the circuit breaker will also be much increased.

Furthermore, in a circuit breaker to be employed in a superhigh-voltage or ultrahigh-voltage transmission line, there are ordinarily provided a plurality of breaker units connected in series for increasing the interrupting capacity of the circuit breaker. In this case, it is essential that the plurality of breaker units be operated simultaneously.

In addition, it is required that the interruption of the circuit breakers be initiated only by a regular command signal, and any possibility of erroneous operation of a circuit breaker due to a surging voltage caused by ON-OFF operations of adjacent circuit breakers must be eliminated.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide a circuit breaker whereby all of the above-mentioned requirements are substantially satisfied.

Another, more specific, object of the present invention is to provide a circuit breaker wherein necessity for supplying power required for operating the circuit breaker from the ground side thereof is totally eliminated.

Still another object of the invention is to provide a circuit breaker wherein erroneous operation caused by, for instance, ON-OFF surge along the transmission line can be substantially eliminated.

An additional object of the invention is to provide a circuit breaker wherein a plurality of breaker units provided in series are made operable simultaneously.

These and other objects of the present invention can be achieved by a high-tension circuit breaker including, in the high-tension side thereof insulated from the ground side by means of porcelain insulating tubes, a contact mechanism which operates the interrupting contacts of the circuit breaker utilizing electric energy stored in a capacitor, wherein, according to the invention, means are provided for charging the capacitor from the high-tension line voltage of the circuit breaker.

The nature, principle, and utility of the present invention will be more fully understood from the herein-after described detailed description of the invention when read in conjunction with the accompanying drawings, throughout which like parts are designated by like reference numerals and characters.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 and 2 are diagrams schematically showing circuit breakers respectively constituting different embodiments of the present invention;

FIGS. 3 and 4 are diagrams showing electric circuit compositions of the circuit breakers;

FIG. 5 is an electrical circuit diagram of a synchronizing control device employed in the circuit breakers;

FIG. 6 is an electrical circuit diagram showing a synchronizing detector employed in the circuit shown in FIG. 5;

FIG. 7 is a waveform diagram indicating the operation of the synchronizing detector shown in FIG. 6; and

FIG. 8 is a vertical sectional view of a circuit breaker showing clearly a breaker unit included therein.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, there is indicated schematically a circuit breaker, constituting an embodiment of the present invention, wherein two breaker units, one comprising a stationary contact 2 and a movable contact 3, and the other comprising a stationary contact 2a and a movable contact 3a, are connected in series with line conductors 1 and 1a, respectively. Although the two breaker units are both normally placed in the thrown-in state, these units are provided with their own operating mechanisms as indicated in FIG. 8.

The movable contacts 3, 3a are formed with flange portions 3s and 3as, respectively. Coils 4 and 4a are provided in the flange portions 3s and 3as. In this embodiment of the invention, two flange portions 3s and 3as are connected together through a conductor 10. A current transformer 11, the primary circuit of which is formed through the conductor 10, is included in a casing 14 of the circuit breaker. The secondary winding 10s of the transformer 11 is connected to a full-wave rectifier 15, and a storage battery is connected to the output terminals of the rectifier 15 via a load resistor 20, an over-voltage relay 21, and normally closed contacts 21a of the same relay 21.

Although it is not clearly indicated, numeral 13 designates a known stationary inverter such as a controlled rectifier SCR, and the output of the inverter is connected to the primary winding 9s of a charging transformer 9 for a capacitor 5. In the secondary circuit of the charging transformer, there are provided a rectifier 8 and a discharge gap device 6 having a starting electrode 6a. The casing 14 of the circuit breaker is supported by an insulator tube 16 which in turn is supported by a pedestal 17. A light sensitive device 18 is included in the casing 14 and is connected to a light source device 22 in the pedestal 17 through a light conducting rod 19 passing through the insulator tube 16.

Whenever a load current is flowing through the conductor 10, the current in the secondary winding 10s of the current transformer 11 is rectified into a D.C. current by the rectifier 15 thereby to charge the storage battery 12. When the terminal voltage of the battery 12 exceeds a predetermined value, the relay 21 operates,
thus opening the contacts 21a, whereby the charging of the battery 12 is interrupted.

The inverter 13 is supplied with a constant d.c. voltage from the battery 12, and hence a constant a.c. voltage is obtained at the output of the inverter 13. This a.c. voltage is stepped up by the transformer 9, rectified by the rectifier 8, and charged into the capacitor 5. The terminal voltage of the capacitor 5 can be raised to a desired value by selecting the winding ratio of the transformer 9 to a suitable value. Even if the load current through the conductor 10 is nullified, the operation of the circuit breaker can be accomplished because of the existence of the battery 12.

When the light source device 22 is ignited in response to a cutoff command, the light is transmitted to the light-sensitive device 18 through the light-conducting rod 19 thereby to operate the discharge-gap device 6 under the action of an electric signal created in the photosensitive device 18. The energy stored in the capacitor 5 is then discharged through the coils 4 and 42, and the two breaker units are cut off.

Since no insulating transformers are used in the circuit breaker shown in FIG. 1, and the capacitor 5 is charged by energy taken from the line current, the construction of the circuit breaker is greatly simplified and the production cost thereof can be substantially economized.

In FIG. 2, there is indicated a circuit breaker constituting another embodiment of the present invention. In this example, a plurality of capacitors 24, 25, and 26 are connected in series between the line conductor 10 and the ground, and a voltage across at least one of the capacitors is utilized for charging the capacitor. As is apparent from FIG. 2, a conductor 10 connecting two movable contacts of the two breaker units is further connected to one of the terminals of a primary winding 9a of the transformer 9, and the other terminal of the primary winding 9a is connected to the other side of the capacitor 24 within the voltage dividing capacitors 24, 25, and 26.

Two terminals of the last capacitor 26 are led out of the pedestal 29 to be utilized as voltage measuring terminals 28. All of the remaining parts are similar to those of the example shown in FIG. 1, and hence are designated by reference numerals and characters. Although it is not shown in FIGS. 1 and 2, the line conductor section between the breaker units is connected through a voltage-distribution improving capacitor to the casing 14.

In the above described organization of the circuit breaker, whenever the conductor 10 is connected to the line voltage, the latter is divided by the voltage dividing capacitors 24, 25, and 26. Thus, if the capacitance ratios of these capacitors are selected suitably, the primary winding 9a of the transformer 9 can be thereby excited at a predetermined voltage, and the capacitor 5 can be charged from the secondary voltage. In the case where the movable contact is placed in the interrupting position of the circuit breaker, the casing 14 is maintained at a high potential through the voltage distribution improving capacitor 23 because either one of the line conductors 1 or 1a is connected to the power source side of the transmission line, and the above-mentioned predetermined voltage is obtained across the terminals of the capacitor 24.

In the above described organization of the circuit, a relation of \( C_{32} > C_{25} \) is essential. However, there may also exist a case where the relation of \( C_{32} > C_{25} \) is not economically advantageous. Furthermore, there may also be a case where a capacitance greater than that of the capacitor \( C_{25} \) is connected in parallel with the capacitor \( C_{32} \).

In addition, when both of the line conductors 1 and 1a in the circuit of FIG. 2 are not connected to the power source voltage, the capacitor 5 cannot be charged. For this case, a storage battery may be connected across the terminals of the capacitor 5 through a relay ON-OFF operated by the terminal voltage of the capacitor 5, or a storage battery and an inverter may be employed as shown in FIG. 1 for charging the capacitor 5.

In the example shown in FIG. 2, the interruption thereof can be carried out in a similar manner as in the example shown in FIG. 1, i.e., by applying an electrical signal to the starting electrode 6a of the discharge gap device 6.

FIGS. 3 and 4 illustrate basic organizations of the circuit breaker wherein are employed a plurality of breaker units connected in series and operated simultaneously.

In either of these examples, those encircled by one-dot chain lines and designated by A and B are the breaker units each having a construction as shown in FIG. 8 and connected together in series.

In a casing 14 kept at a high potential of the breaker unit A shown in FIG. 3, there are included a current transformer 11, a synchronizing control device 31 (as shown in FIGS. 5 and 6) operated by the secondary current of the current transformer 11, a device including a capacitor 5 as its essential element and operable for driving the movable contact of the circuit breaker, and a light-sensitive device 18 which converts a strip-command signal given from the ground side, that is, a light signal conducted through a light conducting rod 19, into an electric signal, and sends out the electric signal to the synchronizing control device 31.

On the other hand, in a casing 14a kept at a high potential of the breaker unit B shown in FIG. 3, there is included another light-sensitive device 18 which is coupled through a light conducting rod 19a to another light source device 22 included in the breaker unit A, which is operated by the output signal from the synchronizing control device 31.

In the example shown in FIG. 3, likewise in the example shown in FIG. 4, there are indicated well known insulating-transformer groups 32 for charging the capacitor 5 from the ground side. However, these are shown only for convenience in the description of the examples, and these may be replaced by the novel charging devices according to the present invention as shown in FIGS. 1 and 2.

In the operation, a command signal is applied to terminals 34 in the breaker unit A shown in FIG. 3. The light source device 22 is thereby operated to create light, which is passed through the light conducting rod 19 to the light-sensitive device 18 in the casing 14 maintained at a high potential. An electrical signal generated in the photosensitive device 18 is applied to an SCR (FIG. 5) in the synchronizing control device 31.

Since the secondary circuit of the current transformer 11 monitoring the load current in the line conductors is connected to the synchronizing control device 31, the latter device 31 can be operated in re-
sponse to a signal sent from an SCR, in synchronism with the load current.

While the construction and operation of the synchronizing control device 31 will be hereinafter described with reference to FIG. 5, the output signal of the synchronizing control device 31 is employed to start the discharge gap device 6, whereby the energy stored in the capacitor 5 is discharged through the coil 4 for driving the movable contact 2. The output signal from the synchronizing control device 31 is otherwise employed for operating the light source device 22a. The light created in the device 22a is transmitted to the other breaker unit B through the light conducting rod 19a, and is received by the light-sensitive device 18 included therein. Upon the reception of the light, the light-sensitive device 18 sends out an electrical signal to the discharge gap device 6, and the movable contact 3 in the breaker unit B is thereby operated.

As is apparent from the above description, the organization shown in FIG. 3 having a plurality of breaker units connected in series makes possible transmission and reception of an operating signal between the casings, and the plurality of breaker units are thereby operated simultaneously.

In the embodiment of the invention shown in FIG. 4, transmitting and receiving procedure of the operating signal between the breaker units is different from that in the example shown in FIG. 3.

More specifically, the operating signal to be transmitted from the breaker unit A to the breaker unit B at the time when the synchronizing control device 31 operates, namely a light signal, is returned once to the ground side through the light-conducting rod 19 and then transmitted to the breaker unit B. In the breaker unit B, another light conducting rod 19 is provided with a light source device 22 on the ground side and a light-sensitive device 18 on the light voltage side thereof.

On the ground sides of the breaker units A and B, the light-sensitive device 18 of the breaker unit A is electrically connected to the light source device 22 of the breaker unit B. It will be apparent that, in this embodiment of the invention, any restriction imposed on the construction of the high voltage sides of the breaker units A and B can be eliminated.

The synchronizing control device 31 described above operates as follows. Referring to FIG. 5, terminals 35 and 36 are connected to the secondary winding of the current transformer 11, and a synchronizing detector D, which is illustrated in more detail in FIG. 6, picks up signals at a predetermined time before the zero points in the secondary current. Because of the signals thus picked up, the gate of the SCR is excited periodically through a transformer TS and a rectifier D. However, the synchronizing control device 31 is not operated as long as the SCR, which is connected in series with the SCR, is held in the nonconducting state.

To place the SCR in a conductive state, it is necessary that a capacitor C included in the device 31 be charged beforehand. Accordingly, the device 31 cannot be operated even if a surge created in the transmission line intrudes into the synchronizing control device through the detector D.

The interruption command signal for the circuit breaker is applied through the light conducting rod 19. An SCR 37, 38, and a diode D from a suitable power source device as shown in FIGS. 1 and 2, or through a known insulating transformers.

Charging of the capacitor C does not always mean the capacitor C is charged. The capacitor C will be charged whenever the SCR conducts, and a circuit from the capacitor C, one terminal K, branch points L, M, N, the SCR points O, P, and back to the capacitor C, is thereby closed. Furthermore, when the SCR conducts, the gate of the SCR is energized from a circuit through K, L, Q, R, N, SCR, O, and P, whereby the SCR is brought into a conducting state.

Thus, after the capacitor C has been charged from an outer power source, conduction of the SCR causes the SCR to become conductive and charges the capacitor C. When the voltage of the capacitor C reaches a predetermined value and the SCR conducts further, an impulsive current flows from the capacitor C through L, Q, S, SCR, SCR, N, R, M, primary winding of a transformer TO, T, and U, whereby an impulsive voltage is obtained across the output terminals 39, 40. This output voltage is utilized for operating the discharge gap device 6 and for commanding other breaker units to interrupt.

The organization of the synchronizing device D is best illustrated in FIG. 6. The input terminals 35, 36 are connected to the secondary winding of the current transformer 11, and the secondary current of the transformer 11 is subjected to full-wave rectification in rectifiers D1, D2, D3, and D4 in a rectifying portion 101 of a time setting device 100. The thus rectified current is converted into a voltage in a resistor R1. The resistor R1 is in the form of a potentiometer, and the sliding contact thereof is connected to a capacitor C100 through a rectifier D5.

During periods wherein the instantaneous value of the above-mentioned voltage is increasing as represented by A-B and C-D in FIG. 7, a capacitor C100 is connected across a portion Rn of the potentiometer, and is charged along voltage curves V. The maximum value of the V is proportional to the maximum value of the terminal voltage V across the resistor R1.

During the descending periods of the voltage V, represented by BE and DF, the voltage of the capacitor C100 is maintained at a constant value because of the existence of the rectifier D2. When the voltage V has descended in excess of a value represented by E and F, the charge stored in the capacitor C100 is discharged through the resistor R, and a rectifier Dn into a pulse-transformer Ts.

The output pulses G1, G2 shown in FIG. 7 are applied to the gate of the SCR in the above described synchronizing control device 31, shown in FIG. 5, through the rectifier D. However, the SCR does not conduct unless the SCR is conducting.

As will be apparent from the above description, the internal circuit portion of the synchronizing control device 31 is placed in an inoperable state (having no operating power) regardless of whether a load current is flowing through the circuit breaker or not, whereby the device 31 cannot be operated by any spontaneous intrusion of a surging voltage other than the regular tripping signal. The internal capacitor C1 of the synchronizing control device 31 starts to be charged upon reception of the regular tripping signal. Further, it will be apparent that erroneous operation of the circuit breaker can be prevented when capacitors of suitable values are
provided in the gate circuit and between the poles of the SCR.

We claim:

1. In a high-tension circuit breaker including, on the high-tension side thereof insulated from the ground side by insulating tubes, a contact mechanism which operates interrupting contacts of the circuit breaker utilizing electric energy stored in a capacitor, an improvement comprising means for charging the capacitor from the high-tension line voltage of the circuit breaker.

2. A circuit breaker as set forth in claim 1 wherein a current transformer through which a line current of the circuit breaker is passed as its primary current is provided on the high-tension side, and the secondary current of the transformer is utilized for charging said capacitor.

3. A circuit breaker as set forth in claim 2, comprising means for rectifying the secondary current of said current transformer, a storage battery charged by the rectifying means, and an inverter for converting the output of the storage battery into an a.c. voltage.

4. A circuit breaker as set forth in claim 1 wherein a plurality of voltage dividing capacitors connected in series are provided between a line conductor of the circuit breaker and the ground, and the voltage obtained across one of the voltage dividing capacitors is utilized for charging said capacitor for operating the interrupting contacts of the circuit breaker.

5. A circuit breaker as set forth in claim 4 wherein said voltage dividing capacitors are included in said insulating tubes for supporting the high-tension side of the circuit breaker.

6. A circuit breaker as set forth in claim 1 wherein a synchronizing control device including a synchronizing detector is further provided on the high-tension side, and an interruption commanding signal synchronized with the line current is obtained therein by synthesizing a command signal sent from the ground side and a signal obtained from the synchronizing detector.

7. A circuit breaker as set forth in claim 1 wherein one portion thereof corresponding to one phase of the power line — further comprises a plurality of breaker units connected in series and means for operating the plurality of breaker units simultaneously when an interrupting command signal is applied to one of the breaker units.

8. A circuit breaker as set forth in claim 7 wherein an electro-magnetic wave is employed for conveying the interrupting command signal from one of the breaker units to the others.

9. A circuit breaker as set forth in claim 7 wherein the transmission and reception of an electromagnetic wave between a breaker unit receiving the command signal from the ground side and other breaker units commanded by the breaker unit are carried out in the high-tension side casing of each of the breaker units.

10. A circuit breaker as set forth in claim 8 wherein the electro-magnetic wave is light.

11. A circuit breaker as set forth in claim 7 wherein the commanding signal issued from the one breaker unit to the other breaker units is sent back once to the ground potential side of the breaker unit and then transmitted to the other breaker units through the ground-potential side portions of these breaker units.