United States Patent

Zajic

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[54] **HIGH VOLTAGE DIRECT CURRENT CIRCUIT BREAKER**

[72] Inventor: **Vladislav Zajic**, Montreal, Quebec, Canada

[73] Assignee: **Institut De Recherche De L'Hydro-Quebec**, Varennes, Province of Quebec, Canada

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[52] **U.S. Cl.** ....**317/11 C,** 200/147

[51] **Int. Cl.** **H02h 7/22**

[58] **Field of Search**...............317/11 D, 11 C, 11 B; 200/147

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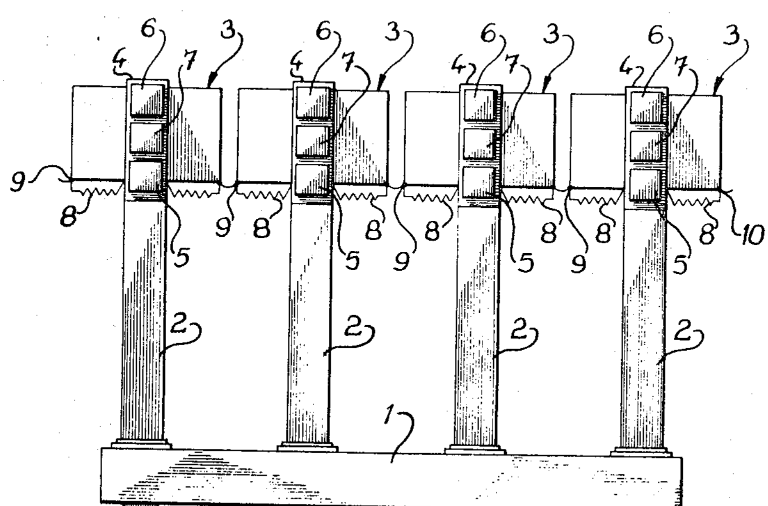
Primary Examiner—James D. Trammell
Attorney—Raymond A. Robic

[57] **ABSTRACT**

A high voltage direct current circuit breaker comprising several modules connected in series, each module including an electrodynamic mechanism connected to the mobile contacts of the circuit breaker and permitting to open very rapidly such contacts under load thus creating an electric arc between the contacts. Each module includes at least one deionizing chamber comprising a suitable number of parallel metallic plates disposed perpendicularly to the electric arc to form quenching channels for the electric arc. Finally, each module comprises at least one magnetic arc extinguishing system for deflecting the electric arc of the contacts into the deionizing chamber and for forcing such arc to enter into the quenching channels to break it into a number of short arcs so as to create an arc voltage which is higher than the nominal voltage of the circuit, and for quenching such small arcs and finally extinguish them.

8 Claims, 12 Drawing Figures



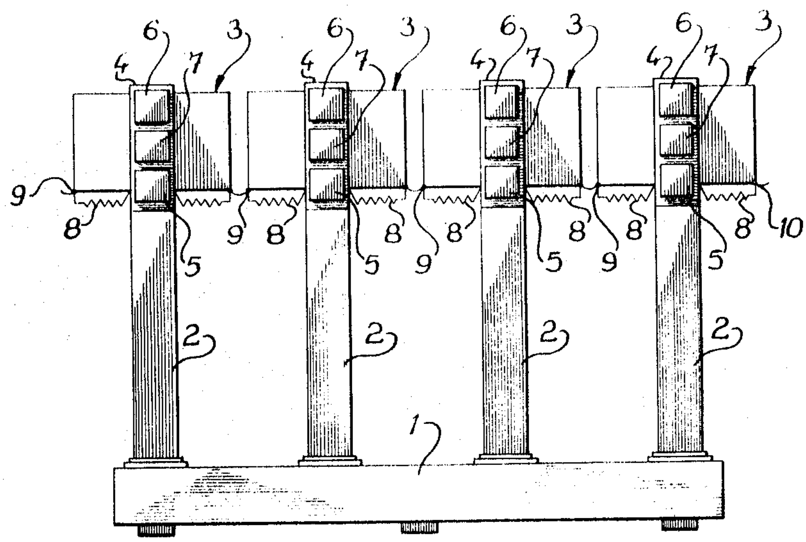


FIG. 1

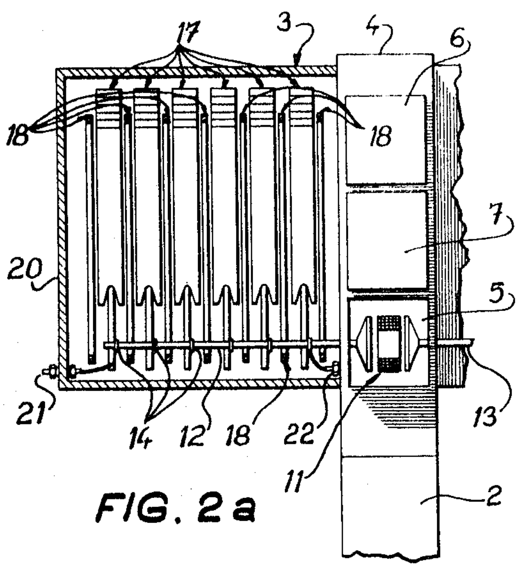


FIG. 2a

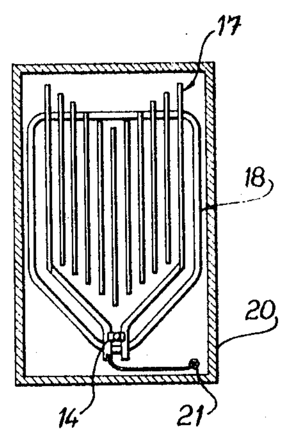


FIG. 2b

INVENTOR
Vladislav ZAJIC

ATTORNEY

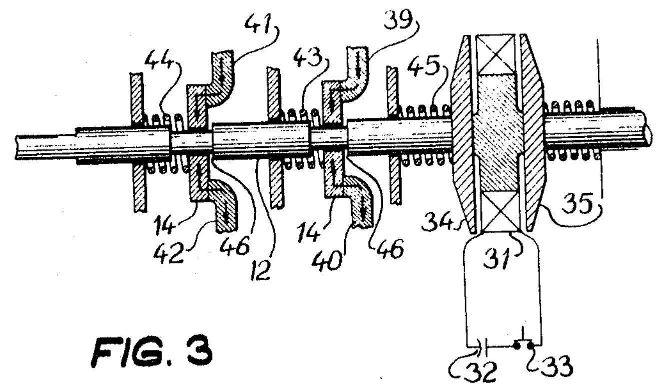
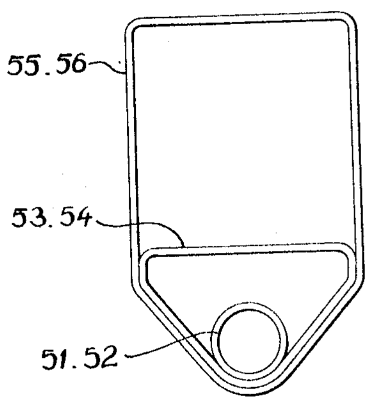


FIG. 3



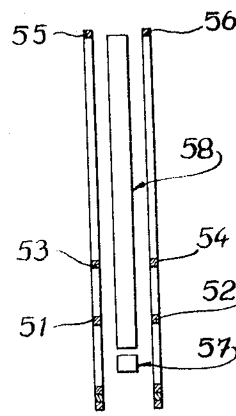


FIG. 4a

FIG. 4b

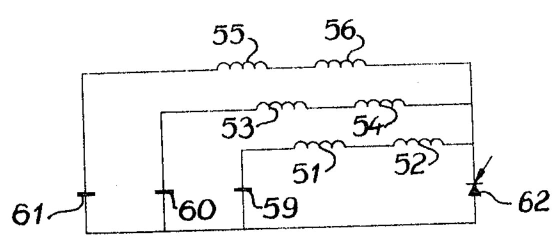
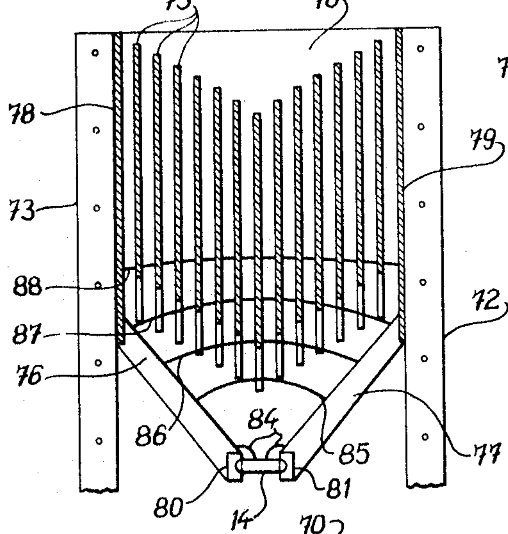


FIG. 4c

INVENTOR
Vladislav ZAJIC

Raymond A. Robic
ATTORNEY

FIG. 5a



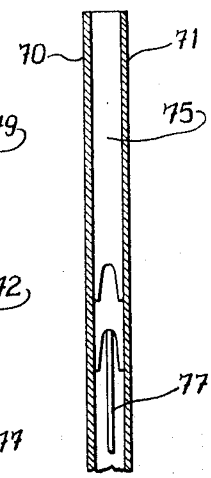


FIG. 5b

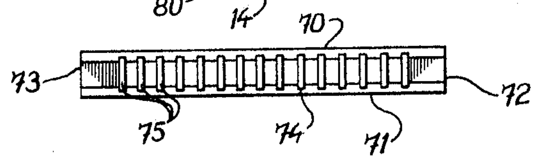


FIG. 5c

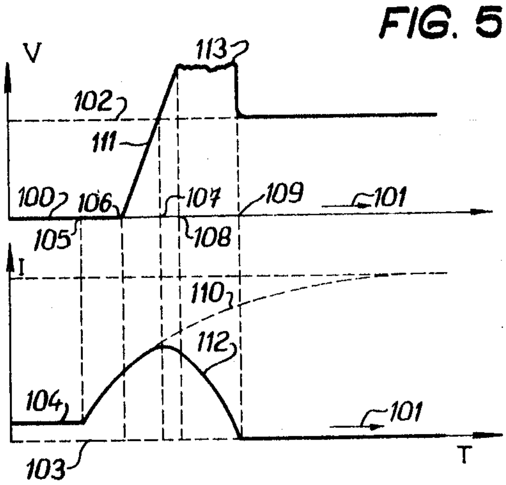


FIG. 7

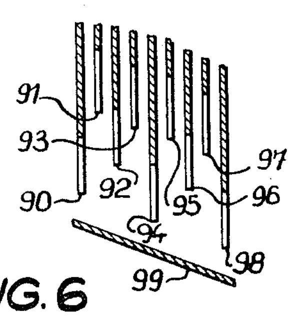


FIG. 6

INVENTOR
Vladislav ZAJIC

Raymond A. Robic
ATTORNEY

HIGH VOLTAGE DIRECT CURRENT CIRCUIT BREAKER

This invention relates to a high voltage direct current circuit breaker.

The direct current transmission systems used until now were only concern with direct connections between two remote points. However, in the setting-up of high voltage direct current networks having a large number of branches and loops, it becomes necessary to insert circuit breakers in the network.

It is fundamentally more difficult to interrupt a DC current than an AC current. This is due to the fact that, in a DC current circuit, the magnetic energy stored in the inductances of the circuit must be dissipated while, in an alternating current circuit, the alternating current is always interrupted at its passage through zero.

Three methods have been proposed to date for interrupting the current into a high voltage DC circuit:

a. by using an auxiliary oscillating circuit, a current is injected into the circuit breaker thus creating, by superposition to the load current or to the short circuit current, an artificial zero of the current; a conventional alternating current circuit breaker is then used to interrupt the current; the energy of the circuit is transferred to the capacitances of the injection circuit and, at a later date, dissipated into discharge resistances;

b. the progressive insertion of a series of resistances by means of switching elements forming low voltage arcs; to suppress the overvoltages thus created, a certain number of steps are necessary; the energy is progressively dissipated into the resistances;

c. the conventional method of interrupting the direct current circuit using deionizing chambers capable of developing an adequate arc voltage higher than the nominal voltage of the circuit; the energy of the circuit is dissipated in the chambers themselves.

The circuit breaker in accordance with the invention is based on the third method mentioned above and comprises a series of modules, each provided with an electrodynamic mechanism connected to the mobile contacts of the circuit breaker and permitting to break the contacts under load in a very short interval thus creating an electric arc between the contacts. Each module comprises at least one deionizing chamber composed of a suitable number of parallel metallic plates disposed perpendicularly to the arc to form quenching channels for the arc. Finally, each module comprises at least one magnetic arc extinguishing system for transferring the electric arc between the contacts into the deionizing chamber, for forcing such arc to enter into the quenching channels to cut the electric arc into plural small arcs thus creating an arc voltage higher than the nominal voltage of the circuit, and for quenching such small arcs and finally extinguish them.

The electrodynamic mechanism uses two disk shaped coaxial windings. The primary winding is connected to a circuit including a bank of pre-charged condensers and the secondary winding is usually made of a single short-circuited turn in the shape of a disk. The primary winding is fixed while the secondary winding is mechanically connected to the mobile contacts of the circuit breaker. The discharge of the condensers into the primary winding produces a strong repulsive force between the two windings thus causing a rapid separation of the contacts.

The use of such an electrodynamic mechanism thus permits to obtain a very short delay until the separation of the contacts and a very high acceleration of such contacts. A time delay until the separation of the contacts in the order of a fraction of a milli-second and an acceleration which is many times the one of gravity may be easily obtained.

The deionizing chamber may be formed by an insulating housing consisting of two insulating and refractory plates interconnected by two spacers and provided with grooves in which are inserted the parallel metallic plates. The deionizing chamber further comprises two bar members each having one end thereof adjacent to the contacts and the other end thereof connected of the most outside metallic plate.

To increase the arc voltage up to a value exceeding the nominal voltage of the high voltage direct current circuit, the well known principle of producing a large number of short electric arcs in series is proposed. However, instead of using a system of arc extinguishing windings connected in series with the main circuit as it is usually done, the system of arc extinguishing windings is connected across a bank of condensers. This offers plural advantages over the series connected arc extinguishing windings as follows:

a. by using a bank of condensers having an appropriate voltage and a winding having an appropriate inductance, it is possible to increase the magnetic arc extinguishing field much more rapidly and, consequently, to deflect in a much shorter time the arc into the deionizing chamber;

b. the increase of the magnetic field is completely independent of the rate of increase of the current in the main circuit and, consequently, the rapid action of the arc extinguishing system is maintained for all conditions of the main circuit;

c. there is no permanent current circulating in the arc extinguishing windings thus permitting to have relatively low gage wires; this permits to the windings to be easily adapted to the space and time characteristics of the magnetic arc extinguishing field.

The use of pre-charged condensers to operate the electromagnetic mechanism and the windings of the magnetic arc extinguishing system permits to obtain, firstly, a very short delay until the separation of the contacts and, secondly, a very high rate of increase of the arc voltage. This permits to limit the increase of the current in the main circuit in a manner such as to maintain the energy in the inductances of the main circuit as low as possible.

The use of a great number of short arcs in series requires the use of a great number of electrodes (plates) between the arcs. Indeed, a 400 kV voltage requires about 20,000 electrodes.

The electrodes are located very close to each other and the voltage drop on the positive column of electrodes is very small with respect to the sum of the voltage drops on the anode and the cathode. The two voltage drops on the electrodes depend very little on the current so that as soon as the arcs are deflected into the deionizing chamber, the total arc overvoltage remains substantially constant. By using an appropriate number of electrodes, the overvoltage may be maintained at a desired value.

The arc extinguishing period may be divided in two phases as follows:

In the first phase, the arc is rapidly removed from the contacts and deflected by a very high magnetic field into the deionizing chamber. At the same time the arc is successively divided in several small arcs in series, and the total voltage increases rapidly to a value corresponding approximately to the product of the sum of the voltage drops on the electrodes by the number of the small arcs.

In the second phase, the arcs are rapidly moved along the electrodes, in the narrow channels, while the length and the number of the arcs remain constant. This gives a voltage approximatively constant in the deionizing chambers which is higher than the nominal voltage of the circuit. The decrease of the current in the circuit is about proportional to the difference between the two voltages.

When a high short-circuit current is interrupted, the shape of arc in the narrow channels between two electrodes is similar to a cylinder having a diameter which is much larger than its length. The quenching of such arc is realized by the transfer of the heat of the arc to the electrodes, through the circular bases of the cylinder. This way, the energy of the circuit to be broken is lead via the arc, to the electrodes. The thermal capacity of the electrodes is large enough to accumulate such energy. Later, after extinction of the arc, the energy is gradually dissipated in the ambiant air as usual. The electrodes thus perform a double function: the one of electrodes creating the anode and cathode voltage drops and the one of a heat accumulator taking up the energy of the circuit.

The invention will now be disclosed with reference to a particular embodiment thereof and to the accompanying drawings in which:

FIG. 1 illustrates a side view of the circuit braker;

FIGS. 2*a* and 2*b* illustrate a side section view and a transversal section view respectively of a module of the circuit breaker;

FIG. 3 illustrates the electrodynamic mechanism in detail;

FIGS. 4*a*, 4*b* and 4*c* illustrate the magnetic arc extinguishing system of a deionizing chamber;

FIGS. 5*a*, 5*b* and 5*c* illustrate the deionizing chamber;

FIG. 6 illustrates an alternative arrangement of the plates of the deionizing chamber; and

FIG. 7 illustrates the amplitudes of the current and of the voltage during the opening of a direct current circuit under a short circuit condition.

The circuit breaker illustrated in FIG. 1 comprises a base 1 which is normally grounded and upon which are mounted insulating columns 2 supporting modules 3 into which are arranged deionizing chambers together with magnetic arc extinguishing systems for breaking a number of contacts connected in series. In the central box 4 of each module is located a compartment 5 housing the electrodynamic mechanism, and compartments 6 and 7 housing the banks of condensers for operating the electrodynamic mechanism and the magnetic arc extinguishing systems. The parts mentioned above are identical for all the modules. The modules are electrically connected in series and, in parallel with the modules, are connected impedances 8 which are adapted to regulate the voltage distribution along the modules, if necessary.

In the closed position of the circuit breaker, the current enters into the circuit breaker by terminal 9, flows through all the modules 3 and exits through terminal 10. In the open position, the circuit breaker is capable of supporting between terminals 9 and 10 the normal voltage of the system with the eventual overvoltages thereof.

FIG. 2*a* illustrates a longitudinal section view through one half of a module and FIG. 2*b* a transversal section view through a module of the circuit breaker. Each module is composed of an electrodynamic mechanism 11 (illustrated schematically) which transmits through insulated rods 12 and 13 a longitudinal movement to mobile contacts 14. Above the mobile contacts 14 are located the deionizing chambers 17 and a system of arc extinguishing windings 18 (illustrated schematically). Each half of the module is placed in an insulating box 20. The current is fed to each module through a terminal 21, goes through all the pairs of contacts 14 of one half of the module and to the other half of the module through terminal 22.

FIG. 3 illustrates in more detail the electrodynamic mechanism illustrated schematically by reference numeral 11 in FIG. 2. The electrodynamic mechanism comprises a primary winding 31 connected to an electric circuit with a bank of condensers represented by reference numeral 32 which, as mentioned in FIG. 1, is placed in compartment 7. The electric circuit comprises a switching device 33 which may be a controlled spark-gap device, a semi-conductor switching device, or even a mechanical contact as illustrated. The bank of condensers 32 is pre-charged at a suitable voltage by a charger which is not illustrated in the figure. In the same axis as winding 31 are located two conducting disks 34 and 35 performing the function of two secondary windings having a single short-circuited turn. The disks are each connected with the insulated rod 12 which is arranged to operate contacts 14.

In the position illustrated in FIG. 3, the bridging contacts 14 (two illustrated) rest on the fixed contacts 39, 40 and 41, 42. A force exerted by springs 43 and 44 insures a normal flow of current through the contacts without excessive heating of the contacts.

In comparing FIGS. 2 and 3 it may be noted that FIG. 2 illustrates a vertical cross-section, while FIG. 3 illustrates an horizontal cross-section.

Another spring 45 insures that disk 34 is pressed against winding 31 and that there is a suitable gap between the bridging contacts 14 and abutment 46 of the insulated rod 12.

The operation of the mechanism is as follows:

In operating switching device 33, an oscillating discharge is initiated in the circuit including the bank of condensers 32 and winding 31, which causes two currents of opposite direction to be induced in disks 34 and 35. The above causes a great repulsive force which moves the two disks away from each other and such disks cause the separation of the bridging contacts 14 from the fixed contacts 39, 40 and 41, 42 and, consequently, the creation of electric arcs across all the points of contact.

The arcs so created are deflected and elongated by the magnetic arc extinguishing systems one of which is illustrated in FIGS. 4a and 4b and pushed into the deionizing chambers one of which is illustrated in FIGS. 5*a*, 5*b* and 5*c*.

In the open position of the contacts, the mobile system including the contacts 14, the rod 12 and the disk 34 are locked by a system which is not illustrated in the figure.

FIGS. 4*a*, 4*b* and 4*c* illustrate the magnetic arc extinguishing system of a deionizing chamber. FIGS. 4*a* and 4*b* illustrate in elevation and in section respectively the structure of three pairs of arc extinguishing windings 51–52, 53–54 and 55–56, which are disposed on each side of the region 57 of the contacts and of the region 58 of the deionizing chamber.

FIG. 4*c* illustrates the electric circuit in which the above mentioned windings are connected. Each pair of windings 51–52, 53–54, and 55–56 is in series with a bank of condensers 59, 60 and 61 respectively, and the three branches which are connected in parallel are connected in series with a switching element 62, which may take the form of a thyristor. The three banks of condensers 59, 60 and 61 are pre-charged by a charger which is not illustrated in the figure. At the time of operating the circuit breaker, the switching element 62 closes the circuit and the banks of condensers 59, 60 and 61 start to discharge through windings 51 to 56 giving three different discharge currents. The magnetic coupling between the pairs of windings being relatively small, the three circuits are fairly independent of each other and give three oscillating currents. The inherent frequency of the three circuits is however different. The circuit including elements 51, 52 and 59 is the fastest and gives a very rapid magnetic field in the zone of the contacts to deflect the electric arc established between the contacts, which results in an appreciable reduction of the burning of the contacts. The circuit including elements 53, 54 and 60 is slower but fast enough to move the arc in a limited time into the deionizing chamber. Finally, the circuit including elements 55, 56 and 61 is slower and is used to deflect the arc towards the inside of the deionizing chamber with an appropriate speed until extinction of the arc.

The magnetic arc extinguishing system illustrated in FIGS. 4*a*, 4*b* and 4*c* is much more flexible than the known systems. It is obvious that the shape of the windings, the number of the turns of the windings and the capacity of the banks of condensers offer an almost unlimited possibility to find a form of magnetic field in terms of space and time which gives an optimum breaking condition in function of the wear of the contacts, of the energy dissipated in the deionizing chamber, and the overvoltage created by such chamber.

It is to be understood that the number of parallel circuits, which is shown as being 3, and the number of windings, which is illustrated as being 6, in FIGS. 4*a*, 4*b* and 4*c* of the drawings, have been chosen by way of example only and that the principle illustrated above is applicable to any number of such elements.

A deionizing chamber is illustrated in FIGS. 5*a*, 5*b* and 5*c*. The chamber is formed of an insulating box consisting of two insulating and refractory plates 70 and 71 connected together by two spacers 72 and 73. The plates 70 and 71 have grooves 74 therein into which are inserted insulating plates 75. Below the plates, there are two bar members 76 and 77 which are connected at their upper ends to outside plates 78 and 79 and at their lower ends to fixed contacts **80** and **81** (**39**, **40** or **41**, **42**, FIG. 3). In the closed position of the circuit breaker, the fixed contacts are connected by the bridging mobile contacts **14** such as illustrated in FIGS. 2 and 3.

When the contacts are opened, two arcs are established which, under the action of the magnetic field created by the arc extinguishing system illustrated in FIGS. *4a*, *4b* and *4c*, are deflected upwardly. The position of the two arcs soon after the separation of the contacts is illustrated in FIG. *5a* by reference numeral **84**. A little later, the two arcs are united and the resulting arc is moved upwardly, between the two plates **70** and **71**, towards the position illustrated by reference numeral **85** and,a little bit higher, at the position illustrated by reference numeral **86**, the arc hits the central metallic plate **75** where it is divided in two. The arc is subsequently cut in 4, in 6, etc. until it reaches the position illustrated by reference numeral **88**, in which the arc is cut into small arcs having a length equal to the space between plates **75**. In such position, the sum of the arc voltage drops in all the chambers in series is higher than the nominal voltage of the source, which is the condition required for a drop of the interrupted current towards zero. The interruption of the current is realized at the center of the deionizing chamber, in such manner that the higher portion of the chamber is used to quench the hot products before they exit from the quenching channels.

One of the things which limits the power of a deionizing chamber is the thermodynamic effect at the entrance of the chamber. The narrowing of the chamber due to the introduction of the metallic plates in the path of the chamber is the reason for the reflection of the pressure wave. When a certain value of current is reached, for a given structure of the chamber and for a given arc extinguishing field, the reflection wave causes a force to be exerted on the arc which is higher than the force of the magnetic field and, consequently, the arc does not enter into the quenching channels.

In the circuit breaker in accordance with the invention, means have been used to increase the interrupting power. As illustrated in FIG. *5a*, the quenching plates **75** are not arranged in a straight line as it is usually done, but in the form of a wedge oriented in the direction opposite to the movement of the arc, so that the electric arc successively hits the quenching plates starting with the central plates towards the lateral ones, the intermediate position of the arc being illustrated by reference numeral **87**. In this manner, the thermodynamic reflection is spreaded in a longer period which increases the current interrupting power of the chamber.

Another means to increase the interrupting power of the chamber is illustrated in FIG. 6. In such figure, there is illustrated a section of the quenching plates at the entrance of the chamber only. The plates are arranged in three levels. The first level is formed by plates **90**, **94** and **98**, the second level by plates **92** and **96**, and the third level by plates **91**, **93**, **95** and **97**. If an arc **99** is deflected upwardly, it will first be cut by plates **90**, **94** and **98** so that, in the section illustrated, there will be two arcs in series. At the second level, the two arcs are cut each one in two by plates **92** and **96** and higher, at the third level, the four arcs are cut again in two by plates **91**, **93**, **95** and **97** so that there are finally eight arcs in series. In this manner, the quenching plates are successively hit by the electric arc, and this results in a reflexion wave which is less steep so that the magnetic field will more easily overcome the thermodynamic resistance at the entrance of the chamber as compared with an arrangement wherein the plates are arranged in a straight line.

Let us now review the operation of the circuit breaker disclosed. In FIG. **1**, the circuit breaker is composed of plural modules of which one is illustrated in more details in FIG. **2**. Each module comprises a bank of condensers for the electrodynamic mechanism and a second bank of condensers for each arc extinguishing system. All the banks of condensers are pre-charged by a known charging device which is not illustrated in the figures.

At a selected time, chosen by the operator or by an automatic protection system, a signal is fed to the two switching elements, the one of the electrodynamic mechanism (FIG. 3) and the one of the magnetic arc extinguishing system (FIGS. *4a*, *4b* and *4c*). This causes the operation of the electrodynamic mechanism as disclosed above and the creation of a magnetic field through the deionizing chamber (FIGS. *5a*, *5b* and *5c*). The electric arc is deflected from the contacts and pushed into the deionizing chamber where it is extinguish as disclosed above. The interruption of the current is thus terminated.

To close the circuit breaker, the locking system mentioned above in the description of the electrodynamic mechanism, but not illustrated in the figure, is freed and the springs **44**, **45** and **46** push the system of mobile contacts to the closed position. It must be understood that this operation must be locked with the charging of the banks of condensers in order to prepare the circuit breaker for a second opening.

FIG. **7** illustrates, for example, the paths of the voltage (upper portion) and of the current (lower portion) during the opening of the circuit breaker under a short-current condition. The line **100** represents the zero of the voltage at the terminals of the circuit breaker, the arrow **101** illustrating the time. The line **102** illustrates the nominal voltage value of the system. The line **103** represents the zero of the current and the line **104** the normal load current before a short-circuit is caused in the circuit.

The point of time **105** is the moment at which the short-circuit is created, the point **106** the moment of the separation of the contacts, the point **107** the peak of the current, the point **108** the time at which the arc voltage reaches its final value, and finally the point **109** the time of the interruption of the current.

At time **105**, the short-circuit is created and the current increases rapidly. If it was not for the operation of the circuit breaker and of the protection system in the control station, the current would increase in accordance with curve **110** which is called the prospective current curve. But the circuit breaker operates at time **106**, the time interval **105**, **106** representing the sum of the time taken by the protection system and the circuit breaker to operate. From time **106**, the voltage across the terminals increases rapidly following the curve **111** as the number of small arcs formed in the deionizing chambers increases.

At the same time, the current in the circuit breaker deviates from curve **110** and follows curve **112** which represents the value of the current which is limited by the arc voltage. Point **107** on the time axis, corresponds to the point where the arc voltage **111** is equal to the nominal voltage **102** of the system, which corresponds, neglecting the resistance of the circuit, to the peak of the current curve **112**.

After time **107**, the arc voltage increases until it reaches value **113**, the point of time **108** corresponding to the final entrance of the arc into all the quenching channels, the final number of the small arcs being reached. The arcs continue to move upwardly in the deionizing chambers until point of time **109** corresponding to the extinction of the arcs. At this time, the voltage on the circuit breaker falls from the value **113** to the value **102** which is the nominal voltage of the circuit.

To sum up the main ideas of the present invention, the main three points of the invention are as follows:

a. an electrodynamic mechanism which operates rapidly;
b. a magnetic arc extinguishing system which is independent of the main circuit and uses the discharge of the energy accumulated in a bank of condensers;
c. a deionizing chamber using a series of parallel metallic plates disposed across the arc to cut the arc in plural small arcs to quench such arcs and finally extinguish them.

Each one of the three main points of the invention are known per se. However, until now, they have never been used simultaneously and in a coordinate fashion to accomplish the results wanted by the present invention. To illustrate the result of such simultaneous and coordinate application, the results of a series of experiments realized with a circuit breaker having a nominal voltage of 1,000 V, a nominal current of 1,000 DC A and a value of break current of 20,000A will be mentioned. Let us say first of all that the best direct current circuit breakers known until now are capable of limiting the current to a value which is about 40 percent of the prospective current, that is in the example disclosed above, to a value of 8,000 A. The mechanical stress is thus reduced to 16 percent of the one given by the prospective current. The circuit breaker based on the principle of the simultaneous and coordinate application of the three basic ideas mentioned above has limited the same current to 2,800 A, that is 14 percent. This results in a mechanical stress which is reduced to 2 percent of the one of the prospective current and is at the same time eight times less than that of a conventional circuit breaker.

At the same time, the use of a deionizing chamber having parallel metallic plates to cut the arc in several small arcs in series presents the following advantages:

a. after having reached the final number of arcs, the arc voltage remains substantially constant; this is due to the fact that the total voltage is given by the sum of the cathode and anode drops of the small arcs which depend very little on the current, the voltage drops on the positive columns being negligeable; in this way, the circuit breaker incorporates a intrinsic protection against overvoltage caused by itself;

b. at the same time, the choice of the number of plates is a convenient means of obtaining a desired overvoltage level which, on one hand, does not damage the insulation and, on the other hand, insures a sufficient slope to the drop of the current towards zero.

Apart from the main idea recited above, there has been incorporated in the present invention plural secondary ideas concerning the structure of the circuit breaker. As illustrated in FIG. 3, the electrodynamic mechanism is composed of a single primary winding **31** and of two disk - type secondary windings **34** and **35** disposed back to back. This symmetrical arrangement does not only provide a simple multiplication of the mechanism having only one disk, but brings forward the following results:

a. firstly, the symmetrical arrangement of the electrodynamic mechanism eliminates all the forces acting on the primary winding, because the two forces on each side thereof are balanced;

b. secondly, the presence of the two disks disposed one on each side of the primary winding limits a large portion of the leakage of the magnetic field so that the total efficiency of the mechanism is substantially increased. A secondary feature of the invention may thus be defined as the symmetrical arrangement of the mechanism illustrated in FIG. 3.

The arc extinguishing system, using the discharge of a bank of condensers in a winding is known in principle. However, as illustrated in FIGS. **4*a***, **4*b*** and **4*c***, the system applied in the circuit breaker in accordance with the invention comprises plural windings **51** to **56** and plural banks of condensers **59** to **61**, connected in plural oscillating circuits. Instead of using a single switching element **62**, it is obvious that a larger number of switching elements may be used which offers the possibility of successively energizing predetermined portions of the magnetic circuits.

All the above means offer the possibility to coordinate the distribution of the magnetic field in space and its path in a more flexible fashion, which was not possible with the means known to date. It is then possible to define as another feature of the invention a magnetic arc extinguishing system which is electrically independent of the main circuit of the circuit breaker, and composed of at least two windings and of at least two banks of condensers which are discharged in a circuit by a switching element permitting through the variations of the form, of the number and the disposition of the windings and by the variations of the size and of the number of the banks of condensers as much as by the appropriate timing of the energization of the various sections of windings, to obtain an optimum coordination of the parameters of the arc extinguishing system in terms of the distribution of the magnetic field in the space of the deionizing chamber, and in terms of its path in time.

There are also two other secondary features of the invention which are, firstly, the arrangement of the entrance of the plates which are oriented in a wedge shape against the movement of the arc as illustrated in FIG. **5*a***, and, secondly, the arrangement of the entrance of the plates in two or plural levels which are shifted one with respect to the other in the direction of movement of the arc as illustrated in FIG. **6**.

Although the invention has been disclosed with regard to a particular embodiment of an electrodynamic mechanism of a magnetic arc extinguishing system, and of a deionizing chamber, it is obvious that other forms of equivalent elements could be used. Consequently, the invention is not necessarily limited to the structure of the elements disclosed but may be adapted to other alternative arrangements.

I claim:

1. A high voltage direct current circuit breaker comprising a series of modules, each including:

a. at least one electrodynamic mechanism connected to the mobile contacts of the circuit breaker to separate the contacts under load in a very short interval thus creating an electric arc between the contacts;

b. at least one deionizing chamber composed of a suitable number of parallel metallic plates disposed perpendicularly to the arc so as to form quenching channels for the arc; and

c. at least one magnetic arc extinguishing system for deflecting the electric arc into the deionizing chamber and for forcing the arc to enter into the quenching channels to break up the arc into a number of small arcs so as to create an arc voltage which is higher than the nominal voltage of the circuit so as to quench the small arcs and finally extinguish them, said magnetic arc extinguishing system being independent of the main circuit of the circuit breaker and including at least two windings each connected to a separate bank of pre-charged condensers and means for discharging said banks of condensers so as to obtain an optimal coordination of the parameters of the arc extinguishing system in term of the distribution of the magnetic field in space in the deionizing chamber and in term of its path in time with the shape and the magnitude of the interrupted current.

2. A circuit breaker as defined in claim **1**, in which the electrodynamic mechanism comprises a primary winding in the shape of a disk and at least one secondary winding made of a single short-circuited turn and coaxial with the primary winding, and switching means for creating a sudden electric discharge through the primary winding so as to produce a repulsive force between the primary winding and the secondary winding resulting in a rapid movement which is transmitted to the electric contacts.

3. A circuit breaker as defined in claim **2**, in which the switching means is a mechanical contact.

4. A circuit breaker as defined in claim **2**, in which the switching means is a controlled spark-gap device.

5. A circuit breaker as defined in claim **2**, in which the sudden electric discharge is provided by a bank of pre-charged condensers.

6. A circuit breaker as defined in claim **2**, comprising two secondary disks arranged back to back permitting to operate two sets of contacts, one placed in one half of a module and the other in the other half.

7. A circuit breaker as defined in claim **1**, in which the ends of the metallic plates located at the entrance of the deionizing chamber are in the form of a wedge oriented against the movement of the electric arc.

8. A circuit breaker as defined in claim **1**, in which the ends of the metallic plates located at the entrance of the deionizing chamber are in three levels shifted from each other in the direction of movement of the arc, the ends of the metallic plates being alternately placed in different levels.

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