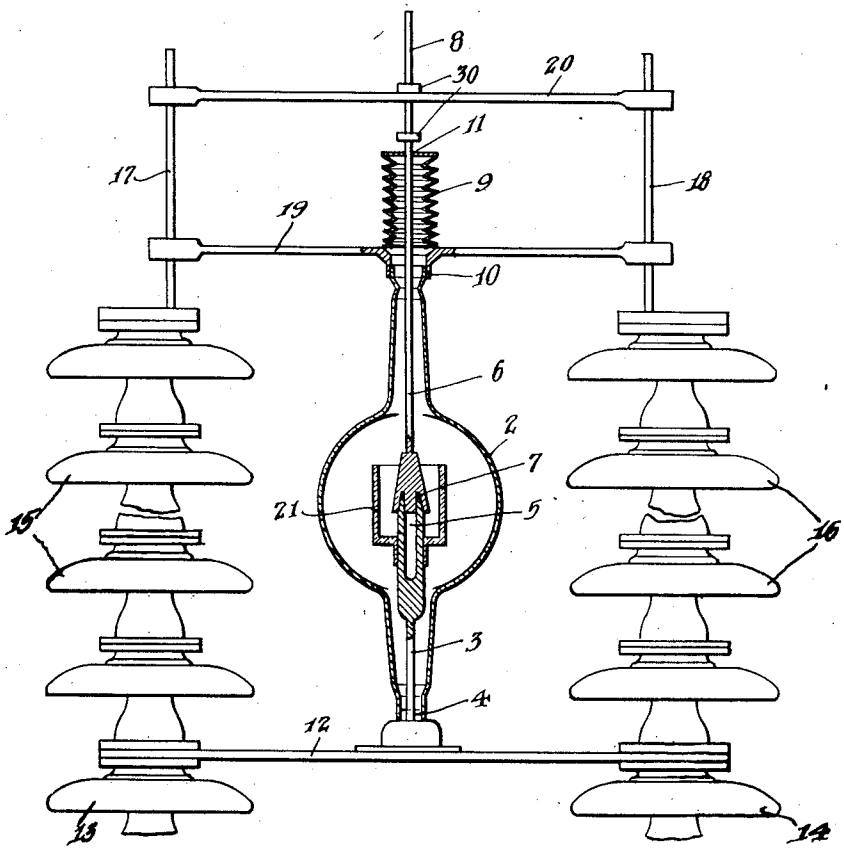
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ELECTRIC SWITCH

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ELECTRIC SWITCH

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5 Claims. (Cl. 200—144)

This invention relates to a method and means for eliminating arcing and refers particularly to electric apparatus, such as electric switches for use upon electric power lines for the transmission of electrical energy. This application is a division of our copending application Serial No. 148,418, filed November 15, 1926, for Switch, now Patent 1,784,302, issued December 9, 1930.

With the development in the transmission and distribution of electrical energy, the potentials and currents employed have increased until the present type of electric switches and circuit breakers and other apparatuses have become unsatisfactory. It is particularly difficult in the control of large amounts of electrical energy to prevent the dangerous arcing in electric switches and similar apparatus employed in power transmission and distribution lines.

An object of the present invention is to provide an apparatus which will be small in size, inexpensive to manufacture, and which can be used for high voltage or high power transmission lines without the dangers encountered in the present apparatuses employed for like purposes.

More particularly, an object of the present invention is to provide an apparatus and method and means for conditioning same which includes an extraordinary insulation surrounding the electrodes, which insulation is suitable for use on lines carrying high power.

More specifically, an object of the present invention is to provide a switch of improved type for interrupting currents on high power transmission lines.

We have discovered that high vacua are the best known means of insulation for electrodes of electric switches, circuit breakers, or other like apparatus, and will permit a relatively short separation of the electrodes of the apparatus without the formation of an arc. Moreover, we have determined that several present theories of electric arm phenomena are in error. Prior to the present invention, it was generally believed that electric circuits carrying large amounts of electrical energy could not be disconnected from or reconnected to other circuits by the separation of contacts or electrodes in a vacuum chamber. This belief was due to the fact that the accepted arc theory was based on the hypothesis that at the instant of separation of contacts of an electric switch it produced at the final points in contact a concentration of current-flow great enough to heat the points last in contact to a temperature which will produce vaporization of a part of the contacts. If such were the case, the vapor liberated would fill the vacuum chamber and change any insulating vacuum to a conducting vacuum by providing a conducting atmosphere between the electrodes, a condition conducive to the maintenance of an arc. It was also believed that the presence of a high potential gradient will detach the electrons from cold electrodes and that high vacua could not be relied upon for the required insulation.

We have discovered that these theories are correct only within certain limits and have discovered that the maintenance of an arc is not a function of gas pressure alone, but is on the other hand, a function of the ease with which free electrons can be obtained from the electrodes in sufficient quantity to sustain arcing.

We have further discovered that arcing can be controlled by the control of the amount of readily freed electrons or ions which can be obtained from the electrodes or the absorbed gases in the electrodes. We have further discovered a means by which such electrodes in the interior of the vacuum chamber can be processed, so that when said electrodes carrying an electric current are separated in such vacuum chamber electrodes will not give off free ions nor sputter off sufficient metal to either pit the contacts or materially reduce the vacuum when the contacts are separated.

In accordance with the present invention, the electrodes of an apparatus such as a switch which is to be employed upon high power lines are freed of all material on the surface of the metal, absorbed by the metal, occluded by the metal, or constituting a part of the metal itself, which matter will come off from the electrodes in quantity sufficient to maintain an arc between the electrodes when the apparatus is being operated.

In the preferred form of the invention the electrodes are freed of this electron-liberating material by high voltage, high current electric arc, applied between the electrodes. It appears that the material which forms or liberates the electrons from the electrodes of the switch may by the energy of the arc be freed from the electrodes and removed from the vessel by pumping the vessel to a high degree of vacuum. The development of electric currents in the electrodes at the time of removing this electron-liberating material from the electrodes also operates to aid in the process by heating the electrodes to the temperatures at which this matter is most readily driven from the electrodes. The extent to which heat and electrical energy must be applied to and between the electrodes depends upon the character

of operation the device is to be put in practice. If the device is to be operated at low power and low voltages, a small amount of treatment will be found sufficient to remove from the electrodes all materials which will form electrons in operation of the apparatus at such conditions of low electric energy, or potential. In cases where the apparatus is to be employed under conditions of high electrical energy and potential, the treatment must be considerably more thorough. In certain cases, this conditioning of the electrodes is carried on by forming an arc with several hundred amperes at potential of 15,000 volts, or higher.

During the process of conditioning the electrodes by driving therefrom the electron forming material, the apparatus is attached to a vacuum pump, or other means adapted to remove all vapors, gases, metallic particles, ionized or neutral, as they are driven off by the arcing. The process of conditioning the electrodes should not be confused with heating the electrodes for outgassing though heating may be used to assist the conditioning operation during the initial stages of operation.

The present invention, together with various additional objects, advantages thereof, will best be understood from the description of a preferred example of an apparatus and process of producing the same embodying the present invention. For this purpose, we have illustrated a preferred form of switch in the accompanying drawing:

In the drawing: The figure discloses the switch in elevation and partially in vertical section.

Referring to the drawing, the switch comprises a vessel 2 of insulating material, such as glass. 3 indicates a fixed contact or electrode sealed at one end 4 to the housing 2 and extending into the center of the housing with the inner end cored out, as indicated at 5, to assist in centering the fixed and moving contacts of the switch and secure adequate contact. 6 indicates a moving contact or electrode for the switch adapted to make contact with the fixed contact 3 when the switch is closed, as illustrated. Said moving contact 6 has an annular recess 7 at its end for engaging the annular end of the stationary contact, thus centering the two contacts in the contacting position and securing a firm, intimate contact.

The moving contact 6 is indicated as connected with a rod 8 which extends without the housing 2, so that the upper end of the rod may be connected with mechanical means (not shown) by which the switch may be operated. To connect the switch in a circuit, one conductor is attached to the end of the rod 3 which extends through the housing 2 and another conductor is attached to the rod 8 without the housing 2. The rod 8 of the moving contact is likewise sealed to the housing of the switch. In order to accomplish this while permitting the rod 8 to be moved for opening and closing the switch, the housing 2 has a portion of its wall flexible or movable relative to the remainder of the housing. This is shown as preferably accomplished by having part of the housing or vessel wall 2 in form of an accordion or bellows 9, including the rod 8. One end of said accordion or bellows 9 is sealed to the glass portion of the housing, as indicated at 10, and the other end of the accordion or bellows 9 is sealed to the rod 8, as indicated at 11.

For mounting the switch, the switch is indicated as mounted at its lower end on the conductor bar 12 which, it is understood, is connected with the rod 3, said bar 12 being indicated as mounted upon insulators 13 and 14. Above the bar 12 at each end, there is a plurality of further insulators 15 and 16 at the respective ends which mount vertical guide bars or standards 17 and 18. Said guide bars mount a bar 19 engaging the housing 2 for holding the same in vertical position and also a bar 20 slidably secured to the rod 8 for guiding said rod 8 to limit the motion of said rod, thereby preventing excessive strains being placed on the accordion.

Secured to one of the contacts or otherwise mounted within the vessel or vacuum chamber 2 is provided a shield 21 indicated as surrounding the contacts and spaced between the contacts and chamber walls. Said shield 21 prevents any metallic ions or atoms thrown off from the contacts in operating the switch from being deposited upon the walls of the chamber 2 and hence prevents said walls from being built up with metal and rendered conductive to electric currents.

In constructing and in operating the switch, the chamber formed by the vessel 2 must be evacuated to such a low pressure as prevents the existence of a gas medium of sufficient density to carry an arc. The electrodes 6 and 3 of the switch must also be in condition to free the same from any material which will emit electrons sufficient to carry an arc under the conditions of operation. To a certain degree the extent to which the vessel must be evacuated to operate satisfactorily depends upon the thoroughness in which the electron-liberating material is removed from the electrodes; preferably, however, the evacuation is as thorough as possible. It is understood that in construction of the switch the vessel 2 is connected with a suitable vacuum pump. In certain forms of the invention, such vacuum pump may be left attached to the switch for operation continuously or intermittently. The degree of evacuation must be beyond the vacuum at which rarefied gas is a conductor for electricity. High degree of vacuum, however, is not of itself sufficient to produce a non-conductive condition around the electrodes of the apparatus. Moreover, if the electrodes have been thoroughly conditioned as hereinafter described, or seasoned, and used for a period, the switch will operate satisfactorily with vacuums very much reduced as compared to the vacuums necessary when the switch is being conditioned or during the early stages of its operation. During the conditioning of the electrodes of the switch, as hereafter described, and also preferably during the early stages of its operation, we generally find that a vacuum of around 10 to the −5 to 10 to the −6 millimeters of mercury is necessary in order that the switch contacts may be properly seasoned. If the switch has had its electrodes fully conditioned and seasoned, it will operate successsfully even at high potentials, with high electric current, with vacuums as low as 10 to the −3 or 10 to the −4 millimeters of mercury.

In order to provide a non-conductive and non-arc-forming condition around the electrodes of the switch, it is necessary, in addition to evacuation, that the electrodes be relieved of matter which emits electrons or ions sufficient to maintain an arc. This requires that the electrodes be more than merely outgassed. Ordinarily, methods of outgassing vacuum apparatus are not adapted for conditioning the electrodes for

operating satisfactorily under high conditions of electric potential current, unless such outgassing is carried on to an extraordinary extent. For example, it has been found that the baking of the switch of the present invention in a furnace at a temperature as high as the glass will stand for two or three weeks while exhausting the expelled gases is insufficient to properly condition the electrodes.

The material which liberates the electrons from the electrodes can be eliminated therefrom only by heating the electrodes by developing electric currents therein to a temperature sufficient to expel such matter therefrom, which temperature is in excess of any temperature derived by mere baking the apparatus and even under such conditions extreme difficulty is encountered in sufficiently conditioning the electrodes. The electrodes are much more readily and generally only can be freed of electron-liberating material by developing between the electrodes a high potential, high current arc, so that the energy of the arc itself repels all material, such as occluded gases, etc., which otherwise would emit electrons from the electrodes.

As an example of a suitable method for conditioning the electrodes, the switch after being baked for the removal of occluded gases may be placed upon a high power line and an arc struck between the electrodes carrying about 400 amperes at 15,000 volts, the arc being maintained for approximately fifteen seconds while the emitted material driven off by the energy of the arc is expelled from the vessel. In this manner the contact surfaces of the electrodes and adjoining area of the switch terminals are definitely relieved of substantially all material which might be detached from the terminals during operation. A switch so treated has been operated successfully to interrupt 900 amperes at approximately 50,000 volts. In case attempt is made to remove such material from the electrodes merely by heating the same, the heating must be carried out to extremely high temperatures, preferably to red heat. Such heat can be obtained by inducing the electric currents into the electrodes. For apparatus to be employed upon high power lines, it is generally necessary to develop some arcing between the electrodes, even if such heating method would properly condition the electrodes. It is also possible to condition the electrodes of the switch entirely by arcing, in which case the potential and current employed in the early stages of the arcing is much reduced until considerable of the occluded gases and other material is driven from the electrodes and expelled from the vessel.

After the switch has been conditioned by this process, the required vacuum may be thereafter maintained on the switch by tightly sealing the vacuum chamber, or the switch may be left connected to a vacuum pump which is operated as required to maintain such vacuum or there may be sealed to the vacuum chamber a pocket containing charcoal made absorbent for gases. When charcoal is used, its absorbent power is increased by cooling with some refrigeration, such as cooled brine, or liquid air. The use of charcoal cooled by a refrigerating agent, such as liquid air, may be employed as an aid in the conditioning of the electrodes to facilitate expelling the materials driven from the electrodes from the vessel.

The switch construction as herein described operates by properly conditioning with the emission of so few metallic particles from the electrodes during switching that no evidence of pitting can be found on the switch terminals. It is also found that the limited number of metallic particles which are emitted do not come off as a gas which will reduce the vacuum to a conducting one, nor as active ions in sufficient quantity to reduce the insulating vacuum to a conducting vacuum. Moreover, the vacuum chamber does not fill with accumulated ions because the small bits of material shot off from the electrodes travel with practically no interference to the walls of the vacuum chamber, or shield, where they become attached and are no longer free to float about in the chamber. The electrodes of the invention may be formed of various materials, such as copper, tungsten, or aluminum.

While the invention has been herein described with more particular reference to its use as a switch, it is understood that the invention may have other uses. The present invention includes the generic discovery that arcing in apparatus of this kind is due to materials liberating electrons from the electrodes and that such electrodes can be conditioned to be sufficiently freed of such electron emitting material that under vacuum arcing can not be maintained between the electrodes.

We claim:

1. A circuit interrupter comprising an evacuated container composed of insulating material, said container having an enlarged body portion in which the circuit is adapted to be interrupted and having a circuit terminal at one end and a reduced neck of substantial length extended from said body portion at the other end, and a contact member disposed within said container and in the neck thereof and having its exposed terminal at the upper end of said neck, said neck being long to insulate the terminals against flash over externally of the container and being remote from any external conducting object, said neck including a flexible vacuum tight metal member sealed in a vacuum tight manner to said contact member, and operating mechanism for the interrupter located at the end of and mainly beyond said neck and said terminal.

2. A circuit interrupter comprising an evacuated container having a wall composed of insulating material and a flexible gas-imperforate metal wall which is sealed to said insulating wall in a vacuum-tight manner, stationary and movable contact members disposed within said container, said stationary contact members being extended through and having a vacuum-tight connection with said insulating wall, said movable contact member having an operative connection with said flexible metal wall in the interior of said casing, and externally disposed operating mechanism having an operative connection with said flexible metal wall on the exterior of said casing.

3. An electric switch circuit interrupter, comprising a vessel evacuated beyond the conducting point, contact members having their contacts disposed within said vessel, one of said contact members extending without the vessel, and a flexible metallic member forming part of the vessel sealed to said contact member in vacuum tight relation and operative to permit the contact member to open the contacts sufficiently to prevent discharge between the contacts, and an insulating neck forming part of said housing, said neck being long to insulate the contacts against flashover externally of the vessel.

4. An electric switch circuit interrupter, comprising a vessel evacuated beyond the conducting point, contact members having their contacts disposed within said vessel, one of said contact members extending without the vessel sealed to said contact member in vacuum tight relation and operative to permit the contact member to open the contacts sufficiently to prevent discharge between the contacts, and an insulating neck forming part of said housing, said neck being long to insulate the contacts against flashover externally of the vessel, the neck being formed of glass and having vacuum tight glass to metal seal with the flexible metallic member.

5. An electric circuit interrupter, comprising a vessel evacuated beyond the conducting point, the vessel including an insulating portion formed in part at least of glass and including also an insulating neck and a flexible metallic portion having a glass to metal seal therewith, contact members having contacts disposed within said vessel and one of said contact members being surrounded by said insulating neck, one of said contact members having a vacuum tight connection with said flexible metallic member and an extension extending outside of said vessel whereby it may be operated to open and close the contacts, the insulating portion being of sufficient length to insulate the contact members against flashover externally of the vessel and being remote from any external conducting object.

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