Dec. 9, 1930. R. A. MILLIKAN ET AL 1,784,302

PROCESS FOR CONDITIONING ELECTRIC SWITCHES

Filed Nov. 15, 1926 2 Sheets-Sheet 1

Fig. 1

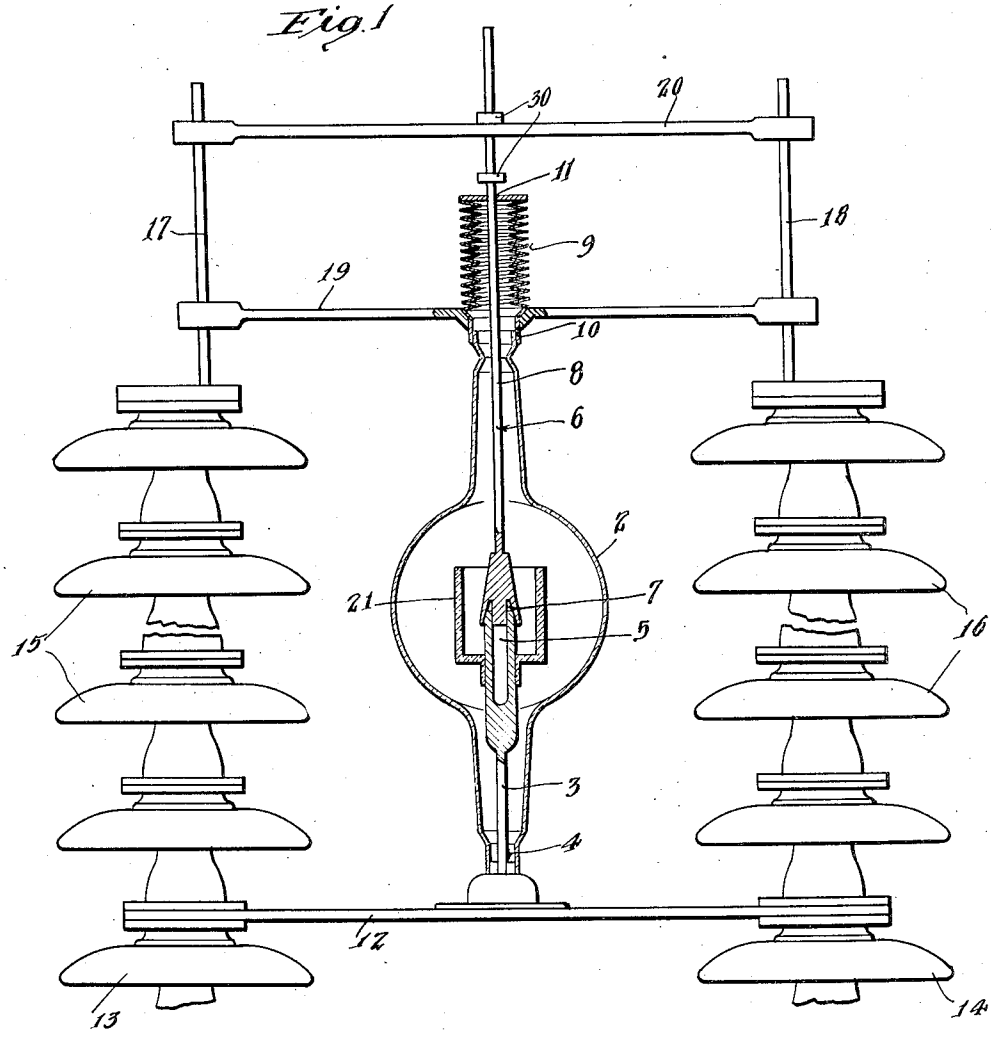

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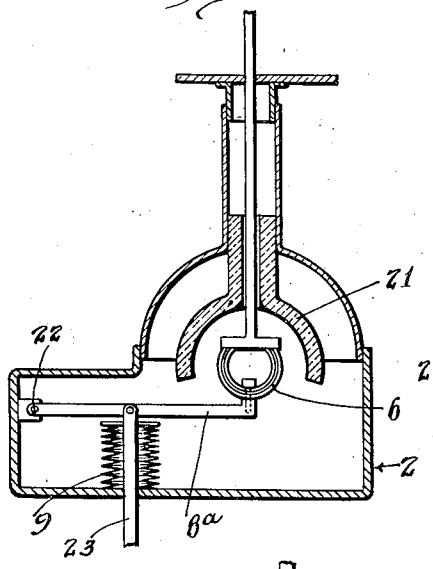
Fig. 2



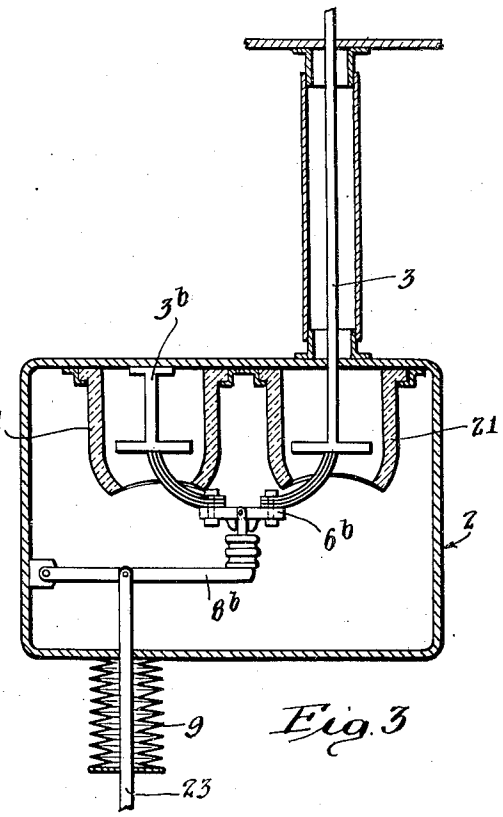
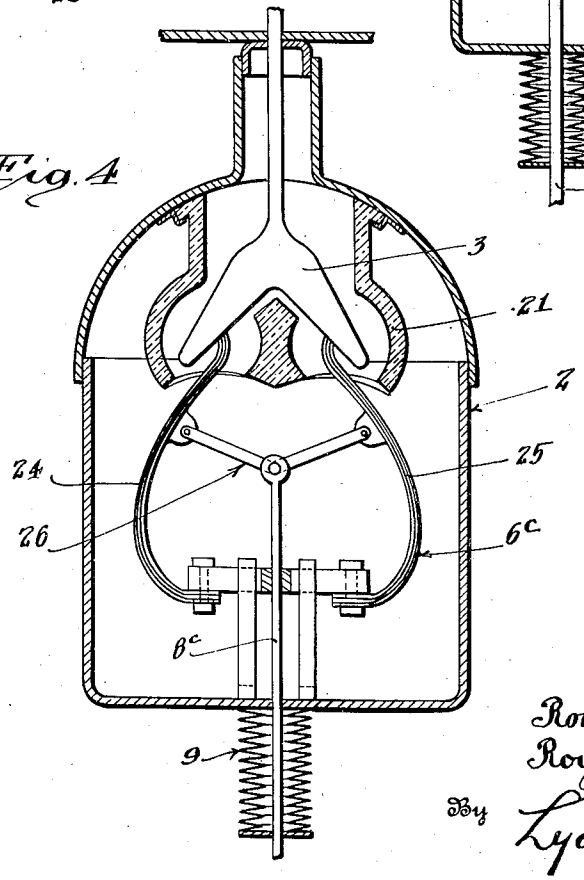


Fig. 3

Fig. 4



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UNITED STATES PATENT OFFICE

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PROCESS FOR CONDITIONING ELECTRIC SWITCHES

Application filed November 15, 1926. Serial No. 148,418.

This invention relates to a process for conditioning electrical switches and refers particularly to switches adapted for use on high tension or high voltage transmission lines or for lines intended to handle high power.

With the development in the transmission of electrical energy whereby voltages around 200,000 volts or over are frequently employed, the present types of electrical switches have proven extremely unsatisfactory for switching such high tension or high power lines.

An object of the present invention is to provide a process for producing a switch 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 use of the present switches employed for like purposes.

The present invention apprehends that extremely high vacuums are the best known means of insulation and if employed as an insulation for an electrical switch will permit a relatively short separation of the contact blades of the switch to break the current without causing arcing thereof. Before the present invention, while the value of high vacuum for insulating purposes was generally known, including even the value of such vacuum as in insulation in purely disconnect switches, it was generally believed that electrical currents could not be opened by the separation of contacts in a vacuum chamber because the arc formed at that separation would in its very operation vaporize some of the contact material and change the insulating vacuum to a conducting vacuum. The vacuum necessary to be employed must not contain any mercury, mercury vapor, or vapors from other metal or gas ordinarily occluded in metals and other materials of construction.

In accordance with the present invention, contacts of copper, tungsten, or other suitable material properly conditioned for high vacuum switch operation are enclosed in an insulating vacuum and thoroughly out-gassed. The out-gassing process consists of heating the materials within the vacuum chamber and exhausting the gases as they are driven off. The preliminary heating may be done by external heat applied to the vacuum container, by heating the parts to be gassed, or by induction of electrical currents in them, these currents being induced by placing a primary winding in which an alternating current is flowing around the vacuum chamber, the final outgassing is performed by connecting the switch in an electric circuit and allowing a charge of electric current to flow through the switch contacts and opening the contacts in such a way as to maintain for a short interval of time an arc between the contacts. During all these out-gassing processes, the gases must be pumped out of the switch chamber by means of a high vacuum pump capable of producing a vacuum of at least 10^{-5} cm. of mercury according to a McLeod gage.

After the switch has been conditioned by this out-gassing process, the required vacuum may thereafter be maintained on the switch in operation 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 absorbing power is increased by cooling with some refrigerating agent, such as cooling brine or liquid air.

The moving contact or contacts of the switch must be entirely sealed within the vacuum switch inasmuch as no present-day known form of stuffing box which could be used for running an operating rod for such contact through the chamber walls, while at the same time sufficiently tightly closing the chamber as to maintain the necessary extremely high vacuum. Inasmuch as for practical operation it is highly desirable that a switch of this kind can be successfully operated by mechanical means, such as rods, links, or levers assembled outside the chamber, an important feature of the present invention is the development of a means for permitting a mechanical connection between outside rods or levers and the internal moving contact without loss of vacuum. This is

accomplished in the present invention by using a metal vacuum-tight accordion or bellows-like device, one end of which is sealed to the vacuum chamber and the other end of which is sealed to a movable operating link or rod used in transmitting motion from mechanism outside the vacuum chamber to the moving contact parts contained within the vacuum chamber. When so used, the accordion or bellows-like device permits, by its flexibility, the required motion without loss of vacuum due to leaks, such as would occur if the rod were brought through a stuffing box.

While the use of such accordion or bellows-like device for connecting the moving contacts of the switch and with outside mechanism is of extreme value for a commercial use of the switch, it is possible to substitute therefor other means for operating the moving contacts without leaks into the vacuum chamber. For example, the moving contact may be loosely mounted within the vacuum chamber and operated to and from the contacting position by gravity through tipping or turning the switch body as a whole. Also the moving contacts of the switch may be loosely mounted within the vacuum chamber and connected with a plunger likewise located within the vacuum chamber but positioned to be actuated by a solenoid outside the vacuum chamber for forcing the contacts to and from the contacting position.

Another feature of the present invention is the provision of means by which the slight disintegration of the contacts of the switch at the breaking of the switch is prevented from coating the inner walls of the vacuum chamber and eventually making said vacuum chamber conductive. In the operation of a switch of this type, each time the switch is opened a certain amount of material is thrown off the contacts and after repeated operation, said material will build up and coat the vacuum chamber walls, rendering the same conductive if means are not provided for preventing this action. Accordingly the present invention includes a shield for preventing metal thrown from the contacts from depositing and accumulating upon the chamber walls.

Various further objects and advantages of the present invention will be understood from a description of an example of a preferred switch and process of producing the same embodying the present invention. For this purpose, we have illustrated a switch embodying the present invention. Such switch is illustrated in the accompanying drawings wherein:

Figure 1 discloses the switch in elevation and partially in vertical section, and

Figures 2, 3, and 4 indicate modified forms of the switch likewise in elevation and mainly in vertical section.

Referring to the drawings, the switch comprises a chamber housing 2 of insulating material, such as glass. 3 indicates a fixed contact sealed at one end 4 to the housing 2 and extending into the center of the housing with the inner end cored out as at 5 to assist in centering the fixed and moving contacts of the switch and secure adequate contact. 6 indicates a moving contact for the switch adapted to make contact with the fixed contact 3 when the switch is closed, as illustrated in Figure 1. 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 may be connected with a mechanical mechanism (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 still permitting the rod 8 to be moved for opening and closing the switch, the housing 2 includes an accordion or bellows 9 enclosing 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 switch housing 2 for holding the same in vertical position and also a bar 20 slidably secured to the rod 8 for guiding said rod in its vertical motion. 30 indicates stops on 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 the chamber walls. Said shield 21 prevents the metallic ions or atoms thrown off from the contacts in opening 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 electrical currents.

In constructing and in operating the switch, the chamber formed by the housing

2 must be evacuated to an extremely low pressure. Preferably this evacuation is as thorough as possible. In the construction of the switch, it is understood that a suitable vacuum pump is connected with the vessel housing 2. This pump connection is not shown inasmuch as the connection is fused together after the conditioning of the switch herein described. In other forms of the invention, the vacuum pump may, as before described, be left attached to the switch for operation continuously or intermittently to maintain the necessary high vacuum. The vacuum chamber of the switch must be reduced in pressure to nearly a complete vacuum. This degree of evacuation must be beyond the vacuum in which rarefied gas is a conductor for electricity. The degree of vacuum required is at least approximately 10^{-4} cm. mercury. The present invention is to be distinguished by the use of such exceptionally high vacuums. It is to be understood that in evacuating the vessel, the gases within the vessel first become more conductive to electricity and finally a point is reached where the ionized gases are reduced to such an extent as to cause a decrease in the conductivity to electricity. This point of evacuation must be passed for operation of the switch of the present invention.

After securing the desired vacuum on the switch the switch then should be conditioned by out-gassing the switch. This step is employed for thoroughly removing all gases adsorbed within the metals of the contacts and their rods. Said out-gassing preliminarily may be carried out in any of the ways previously pointed out but preferably it is finally accomplished by placing the switch in a high powered line and opening the contacts slightly to permit arcing until the contacts are heated and the gases driven out of the metals and removed by the vacuum pump. After the completion of this operation, if desired, the connection with the vacuum pump may be sealed and the vacuum pump removed, and the switch will thereafter operate satisfactorily.

In Figures 2, 3, and 4, the switch is illustrated as slightly modified in form or shape, the similar elements of the switch being designated in these figures by similar numerals. In Figure 2, the moving contact 6 is indicated as mounted upon a pivot arm 8*a* pivoted to the housing as at 22 and connected with a separate rod 23 which extends outside the vessel 2 through an accordion 9. In this case, the accordion 9 is indicated as positioned within the balance of the housing.

In Figure 3, the switch is illustrated as modified to provide a plurality of breaks on opening the switch, the switch having a stationary contact 3 and another stationary contact 3*b*. The moving contact 6*b* is adapted for bridging said fixed contacts 3 and 3*b*. Said moving contact 6*b* is also indicated as provided with the pivoted arm 8*b* and the rod 23. The bellows 9 for said rod are indicated as extending without the remainder of the housing 2.

In Figure 4, the switch is constructed in a form to give a snap or quick motion in breaking the contacts. In this case, the stationary contact 3 is engaged by the moving contact 6*c* which is provided with two spring arms 24 and 25, which are adapted to be forced outwardly in assuming the contacting position by the toggle connection 26 with the moving rod 8*c*. Said rod 8*c* is sealed to the outside bellows 9. This form of the invention produces a rapid motion of the moving contacts away from the stationary contacts in opening the switch.

Each of the switches of the modified forms may be produced or conditioned in the same manner as described in connection with Figure 1, it being understood that on all of said switches it is necessary to produce the vacuum within the housing and out-gassing the same.

In operating a switch of the present invention on high powered lines the separation of the electrodes even when the electrodes are surrounded by a perfect vacuum, results in the instantaneous establishment of an arc. It appears that even perfectly conditioned electrodes in a perfect vacuum will generate an arc at the instant of separation. This follows from the reason that the electrode surfaces are never absolutely flat and there is always a last infinitesimal point of separation. At the instant of separation there is concentrated upon this infinitesimal point, for an infinitesimal distance of separation, the entire voltage between the electrodes. These conditions cause electrons to be actually pulled from the cold electrodes or contacts and also due to heating of the point of separation, result in the formation of an ionized vapor which will establish an arc. This arc maintains itself for the balance of the current half cycle or until the current passes again to the zero value. During this period of time there is a tremendous electrical energy available for freeing occluded gases from the contacts, if any remain occluded therein, operating comparatively deeply into the contacts for such gases. If even comparatively deeply buried occluded gases exist in the contacts during this instantaneous establishment of the arc, they will be drawn into the arc field and when in sufficient amount will furnish a means for re-establishing or maintaining the arc after the current has passed through the point of zero value.

The action of the switch in establishing an arc for that moment in which the current is passing to the point of zero value is of great benefit to the switch in that it prevents the current from being interrupted instantaneously at a time of full value. If the current

were interrupted instantaneously at a time of full value, a current surge would be placed on the line which would be ruinous to electrical apparatus thereon. For successful operation of the switch of the type of the present invention, it is essential that after the current passes to the point of zero value, the arc will not be maintained or re-established. The fact that electrodes, when separated on high potential lines in a perfect vacuum, produce an arc, however, causes switches of this type to extract occluded gases from the contacts which are not removed by ordinary methods of removing occluded gases and has led the art in previous experiments with vacuum switches to come to the conclusion that switching in vacuum without persistent arcing was impossible. By following the procedure of removing occluded gases herein described it has been found, however, that the occluded gases can be removed sufficiently so that sustained arcing does not take place. The occluded gases of the contacts can be removed therefrom by establishing an arc discharge between the electrodes at the potentials at which the switch is to be operated. Thereafter when the switch is operated at such potential an arc will be established for a fractional cycle only and will not be maintained and will not re-establish itself after the current has passed through the point of zero value.

While the process of conditioning or outgassing the switches, herein described, is well adapted to carry out the objects of the invention, it is understood that the invention includes all such changes and modifications as come within the scope of the appended claims.

We claim:

1. A process of producing an electrical switch, which comprises mounting contacts within a gas-tight chamber, exhausting the chamber to a pressure lower than the pressure at which gases are conductive, imposing an electrical potential on the contacts, opening the contacts to establish an arc therebetween, and exhausing from the chamber expelled occluded gases.

2. A process of the class described, comprising establishing an arc in a gas-tight chamber, and exhausting from the chamber occluded gases expelled by the arc until the arc is extinguished.

3. A process of expelling absorbed gases from metallic parts within a gas-tight chamber, which includes establishing an arc between the parts and exhausting the expelled gases until the arc is extinguished.

4. A process of conditioning an electrical switch for operation in breaking power circuits carrying high power, which comprises, removing the gases from around the electrodes to such an extent that the gases present contain insufficient ions to establish an arc, applying a potential between the contacts, and opening the contacts to effect an electronic discharge in both directions operative for pulling occluded gases from the contacts, removing such gases from the electrode field, and continuing the operation until the electrodes may be separated under the potential without arcing after the current passes to the point of zero value.

5. A process of conditioning a switch for operation in interrupting power circuits carrying high power, which comprises removing from the field of the electrodes, the gases so that there are insufficient ions around the electrodes to sustain an arc, subjecting the electrodes to a preliminary outgassing treatment by heating the electrodes and removing the expelled gases from the field of the electrodes, then applying potential between the electrodes and opening the electrodes so as to effect an electrical discharge between the electrodes in both directions, sufficient to expel additional occluded gases from the contacts, removing such occluded gases from the field of the electrodes, and continuing the operation until the electrodes may be repeatedly separated without the development of a sustained arc therebetween.

6. A process of conditioning an electrical switch for operation of interrupting power transmission of distribution circuits which comprises, removing the gases around the electrodes to such an extent that a vacuum ambient is provided for the electrodes containing insufficient gas to itself establish an arc when the electrodes are separated, applying a potential between the electrodes, and opening the electrodes to establish a discharge therebetween to free the electrodes of occluded gases or gas-evolving material, removing gases from the electrode ambient, and continuing the operation until the electrodes may be used for breaking power circuits without sufficient occluded material being drawn from the electrodes to establish an alternating current arc.

7. A process of conditioning an electrical switch for operation in interrupting power circuits which comprises, removing the gases around the electrodes to form an ambient therefor containing insufficient gas to itself establish an arc when the electrodes are separating, establishing an alternating current arc between the electrodes for removing occluded gases therefrom, removing the expelled occluded gases from the electrode ambient, and continuing the operation until the electrodes have been denuded of gas-forming material to such a depth that an alternating current arc will not be established when the electrodes are separating.

8. A process of conditioning an electrical switch for operation in interrupting power circuits which comprises, removing the gases around the electrodes to such an extent that

the electrode ambient contains insufficient gases to itself establish an arc when the electrodes separate, removing gas and gas-evolving materials from the electrodes, by establishing an arc therebetween, to such a depth that the electrodes are capable of emitting vapors of the material of the electrode only on separating, and will establish an arc for a fractional cycle only.

9. A process of conditioning an electrical switch for operation of interrupting power transmission or distribution circuits which comprises, removing the gases around the electrodes to such an extent that a vacuum ambient is provided for the electrodes containing insufficient gas to itself establish an arc when the electrodes are separated, applying a potential between the electrodes and opening the electrodes to establish a discharge therebetween to free the electrodes of the occluded gases or gas-evolving material, removing gass from the electrode ambient, and repeating the discharge operations until the electrodes have been denuded of gas-forming material to such a depth that they may be separated without the potential of the circuit establishing an alternating current arc.

10. A process of conditioning a switch for operation in interrupting power circuits which comprises removing from the electrode ambient the gases so that there is insufficient material around the electrodes to establish an arc when the electrodes separate, sending an electric current through the switch and then opening the electrodes so as to effect a discharge between the electrodes, removing the gases expelled from the electrodes, applying an increased potential to the switch circuit and effecting a further discharge between the electrodes, and repeating the operations until the electrodes may be repeatedly separated without the development of an alternating current arc therebetween.

Signed at Los Angeles, Calif., this 30th day of October, 1926.

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