

Oct. 8, 1968

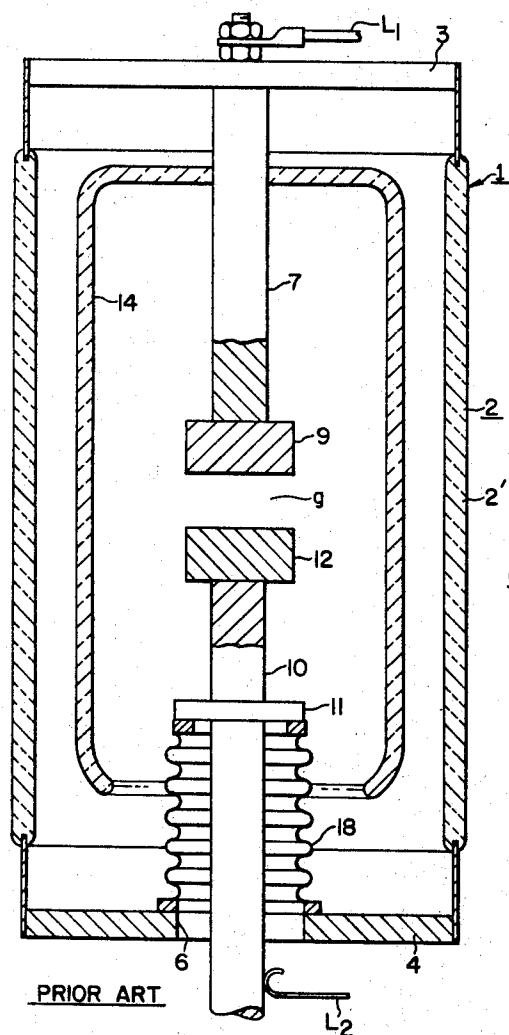
TOSHIO ITO ET AL

3,405,245

MULTIPLE-BREAK VACUUM-TYPE CIRCUIT INTERRUPTERS

Filed May 26, 1965

2 Sheets-Sheet 1



PRIOR ART

FIG. 1.

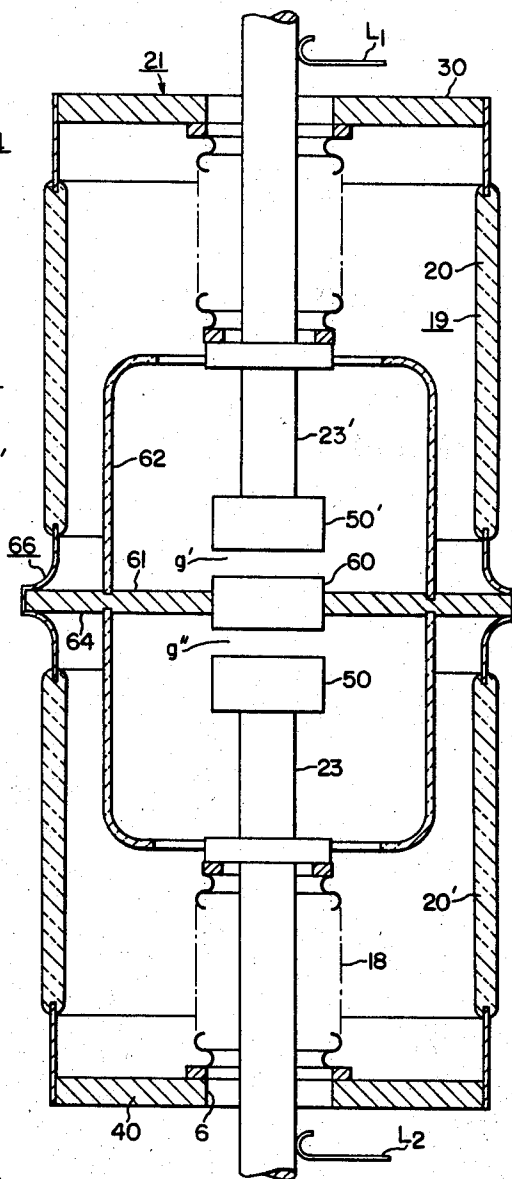


FIG. 2.

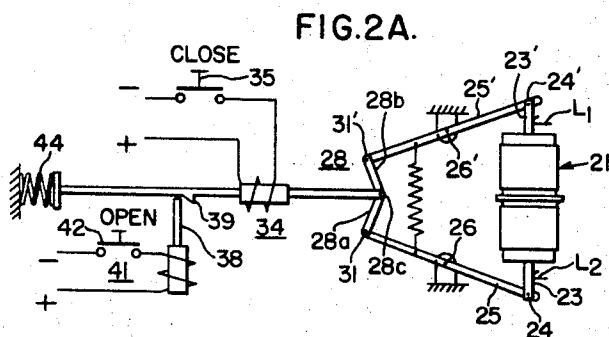


FIG. 2A.

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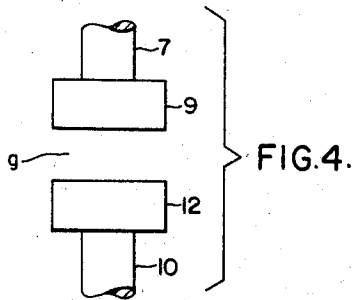


FIG. 4.

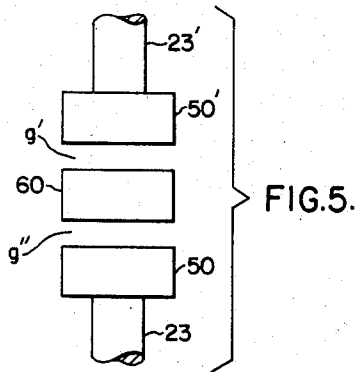


FIG. 5.

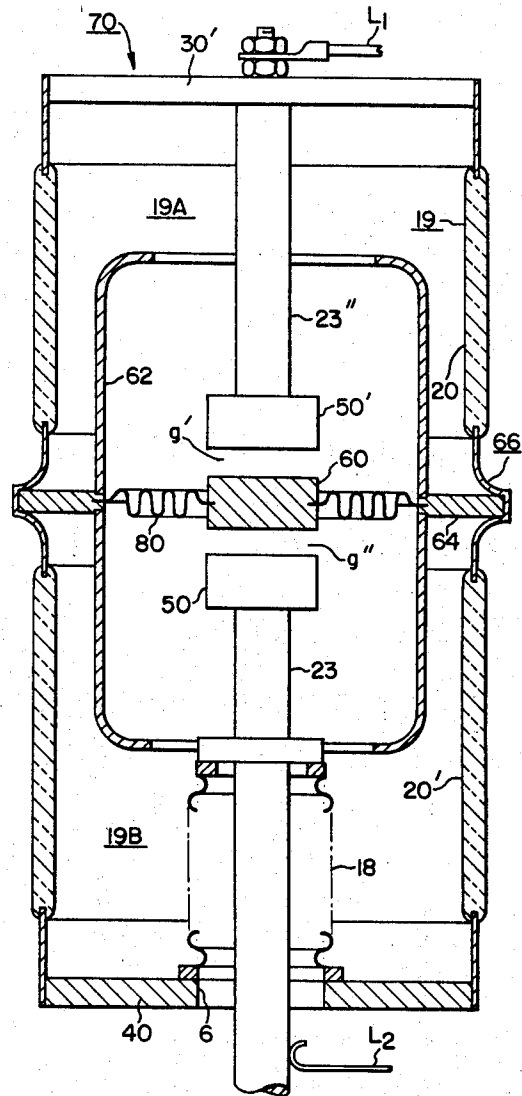


FIG. 3.

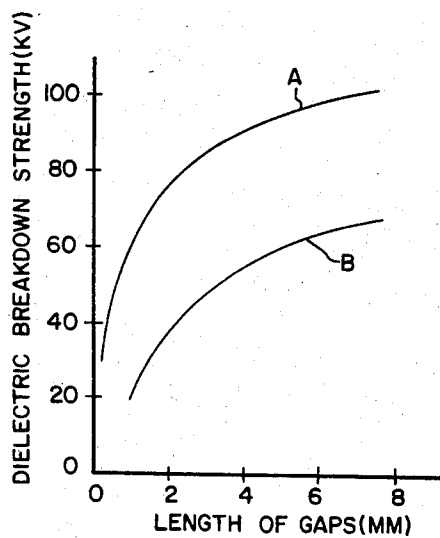


FIG. 6.

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MULTIPLE-BREAK VACUUM-TYPE
CIRCUIT INTERRUPTERS

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39/30,197

3 Claims. (Cl. 200—144)

ABSTRACT OF THE DISCLOSURE

A multiple-break vacuum-type circuit interrupter is provided having three separable arcing contacts disposed within an evacuated enclosure. A cylindrical condensing shield is interposed between the arcing contacts and the outer insulating portions of the evacuated enclosure. A flexible diaphragm-like supporting plate supports an intermediate arcing contact which makes abutting engagement with two outer arcing contacts. One of the outer arcing contacts is moved to abut the flexibly mounted intermediate contact and force the latter into and out of contacting engagement with an outer stationary contact. A double-break device with the intermediate contact at the potential of the floating condensing shield is thus provided.

This invention relates generally to multiple-break vacuum-type circuit interrupters, and, more particularly, to multiple-break vacuum-type circuit interrupters having improved contact and shielding structures.

A general object of the present invention is to provide an improved vacuum-type circuit interrupter of the multiple-break type.

Another object is to provide an improved multiple-break vacuum-type circuit interrupter having a condensing shield structure which is preferably mechanically and electrically connected to an intermediate contact structure and which is at a floating potential.

Still a further object of the present invention is the provision of an improved multiple-break vacuum-type circuit interrupter having a very short opening stroke.

Still a further object of the present invention is the provision of an improved multiple-break vacuum-type circuit interrupter having two vacuum chambers, so that a loss of vacuum in one vacuum chamber will not cause flashover, but the adjacent intact operative vacuum chamber with its own series break will hold the voltage.

Vacuum-type circuit interrupters are generally composed of a vacuum container including an insulating portion having accommodated therein contact members, and a shielding member for preventing a metallic vapor, evolved from opening and closing these contact members, from adhering to the aforesaid insulating portion. A dielectric breakdown voltage for a vacuum gap is approximately proportional to the 0.5th power of the length of the gap. Even if the length of the gap would increase, there is little hope of a great increase in withstand voltage. An increase in the length of the gap is rather disadvantageous from an economical standpoint. For these reasons, the conventional vacuum-type circuit interrupters have their rating voltages limited to from 15 to 20 kv.

Generally, the vacuum-type circuit interrupter according to the present invention comprises a vacuum container including an insulating portion, first and second contact members disposed in opposing relationship within the vacuum container with at least one of the contact members being movable, a shielding member at a floating potential mounted intermediate the insulating members to enclose these contact members through a predetermined

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spacing, and a contact member at a floating potential mounted to the shielding member so as to form a plurality of gaps substantially equal in length between the two contact members upon opening. By further interposing the separate contact member between the contact members to provide a plurality of gaps, the invention can provide a circuit interrupter having a withstand voltage which is extremely high, as compared with prior-art vacuum-type circuit interrupters having the same length of gap. Further, due to its floating potential, the contact member which must be mounted to a portion not applied with the potentials of a first and second contact member, that is, to the insulating portion is mounted to the shielding member which should similarly be at the floating potential, and which is mounted to the insulated portion of the vacuum container resulting in important advantages, such as extreme compactness of construction and a simplicity of arrangement.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings, in which:

FIGURE 1 is a vertical cross-sectional view taken through a conventional-type circuit interrupter, the contact structure being illustrated in the open-circuit position;

FIG. 2 is a vertical cross-sectional view taken through a vacuum-type circuit interrupter embodying principles of the present invention, again the contact structure being illustrated in the open-circuit position;

FIG. 2A is a somewhat diagrammatic view illustrating how the two movable contact members of the vacuum-type circuit interrupter of FIG. 2 may be mechanically operated in unison, the interrupter being shown in the open-circuit position;

FIG. 3 is a vertical cross-sectional view taken through a modified-type circuit interrupter embodying principles of the present invention;

FIG. 4 is a fragmentary view of a pair of cooperating contacts having a certain gap spacing therebetween;

FIG. 5 is a view somewhat similar to FIG. 4, but illustrating the use of an intermediate contact member with a total gap spacing equal to that of the separation between the contact members of FIG. 4; and,

FIG. 6 is a graph illustrating the relationship between the withstand voltage and the total gap distance.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral 1 generally designates a vacuum-type circuit interrupter of a conventional type. A casing 2 contains a high vacuum. Preferably, the casing 2 includes a cylindrical insulating wall 2' and opposing metallic end portions 3, 4, secured in any suitable manner to the end extremities of the insulating envelope 2'. The reference numeral 3 designates an upper enclosure plate forming an upper wall for the vacuum container 2, and the reference numeral 4 designates the lower closure end plate for forming the lower wall of the vacuum container 2. Preferably, as well understood by those skilled in the art, the end closure plates 3, 4 are composed of a suitable conductive material, such for example, as copper.

Provided centrally through the lower closure end plate 4 is an aperture 6, which accommodates the opening and closing movement of a contact rod 10. Extending downwardly from the upper end closure plate 3 is a stationary contact rod 7, which supports a relatively stationary contact 9, as shown. Cooperating with the relatively stationary contact 9 is a movable cooperating contact 12, which is supported at the upper extremity of the movable contact rod 10. Any suitable operating mechanism may be provided to effect reciprocal opening and closing movement of the movable contact rod 10, a bellows 18 being provided to maintain the vacuum within the container 2.

As shown in FIG. 1, the movable contact rod 10 has a radially outwardly-extending flange portion 11, which is secured, as by soldering, to the upper extremity of the bellows 18. The lower end of the bellows 18 may be secured by a suitable solder or brazing connection adjacent the aperture 6 provided in the lower end closure plate 4.

In the open-circuit position of the circuit interrupter 1, as illustrated in FIG. 1, there is provided a gap g , as shown in FIG. 4 of the drawings. Additionally, there is provided interiorly of the casing 2 a shielding member 14, which is mounted at one end to the stationary contact rod 7. As shown, the shielding member 14 encloses both cooperable contact members 9, 12 through a predetermined lateral spacing.

The vacuum-type circuit interrupter 1 of FIG. 1, typical of prior-art vacuum-type circuit interrupters, exhibits the relationship between the length of gap g and the withstand voltage, as shown by curve B in FIG. 6 of the drawings. For example, if it is desired to make the dielectric breakdown voltage equal to 60 kv., the gap distance is necessary to be approximately 5 mm. in length.

Embodiments of vacuum-type circuit interrupters incorporating the principles of the present invention are described below in particular relationship with FIGS. 2 and 3 of the drawings. With particular reference being had to these figures, it will be noted that the reference numeral 19 designates a vacuum container maintaining a high vacuum. The reference numeral 20 designates a first insulating portion formed as a cylindrical tube, and the reference numeral 20' designates a second insulating portion in the form of a cylindrical tube, and disposed in alignment with the said first insulating portion 20, with both insulating portions 20, 20' forming a surrounding envelope 19 for the vacuum-type circuit interrupter 21.

The reference numeral 30 designates an upper end closure plate forming an upper wall for the vacuum-type circuit interrupter 21 and the reference numeral 40 forms a lower wall for the vacuum circuit interrupter, with both end plates 30 and 40 preferably being formed of a conductive metal. Provided through the end closure plate 40 is an aperture 6, which accommodates reciprocal opening and closing movement of a movable contact rod 23. Additionally, FIG. 2 shows a second movable contact rod 23' which may be actuated simultaneously with the lower movable contact rod 23 in a manner diagrammatically indicated in FIG. 2A of the drawings.

With reference to FIG. 2A of the drawings, it will be noted that the two movable contact rods 23, 23' are pivotally connected, as at 24, 24', to pivotally-mounted operating levers 25, 25' respectively pivoted upon stationary supports 26, 26'. The ends of the two pivotally-mounted operating levers 25, 25' are connected to a toggle device 28 comprising a pair of toggle links 28a, 28b pivotally connected by a toggle knee pin 28c. The outer extremities of the toggle links 28a, 28b are pivotally connected, as at 31, 31', to the left-hand extremities of the operating levers 25, 25', as illustrated in FIG. 2A of the drawings.

To effect leftward closing movement of the knee pin 28c of the toggle device 28, there is provided, for example, an actuating solenoid 34, which may be energized by the pressing of a suitable "close" button 35. Also, as will be apparent, the circuit interrupter may be latched in the closed-circuit position by a latching pin 38, which will latch over a catch 39, and may be released by the energization of a suitable solenoid 41 by the closing of an "open" button 42 connected in circuit with a suitable energizing source, as shown.

From the foregoing description, it will be apparent that upon closing the "close" button 35, the solenoid 34 will become energized, causing leftward closing movement of the toggle links 28a, 28b to effect inward closing motion of the contact rods 23, 23'. The breaker 21 may be latched in the closed position, and upon closing the "open" button 42, the solenoid 41 will become en-

ergized thereby causing a retraction of the latch rod 38 thereby releasing the solenoid rod 42 as caused by a suitable biasing compression spring 44.

Disposed at the inner extremities of the movable contact rods 23, 23' are movable contacts 50, 50', which make abutting engagement with an intermediate third contact 60. In the vacuum-type circuit interrupter 21 of FIG. 2, it will be noted that the intermediate contact 60 is fixedly supported upon a metallic partition plate 61 constituting an inward extension of the condensing shield structure 62. A radially outwardly-extending plate portion 64 extends outwardly from the condensing shield 62, and is secured, such as by soldering, to an outer peripheral envelope plate 66. The plate 66 may, as shown, be suitably secured to the end extremities of the insulating portions 20, 20'.

With the construction illustrated in FIG. 3, the intermediate contact 60 is resiliently supported by a flexible diaphragm-type supporting plate 80, which is secured to the outer condensing shield structure 62. The latter is supported in a manner similar to that illustrated in FIG. 2 of the drawings.

In the open-circuit position of the vacuum devices of FIGS. 2 and 3, it will be noted that the gap spacing g' , g'' is substantially equal to that of the gap g illustrated in FIG. 4, the multiple-break contact arrangement being illustrated in FIG. 5 of the drawings for comparison purposes.

The reason for rendering both gaps g' and g'' to be substantially equal in length to each other is that the third contact member 60 be put at a potential equal to an intermediate potential between the potentials of the first and second contact members 50, 50'. The tubular shielding member 62 for enclosing the contact members 50, 50' through a predetermined spacing may be, for example, of an insulating material, such as glass, or a metallic material, such as aluminum. The shielding member 62 is at the same potential as the third contact member 60.

It will be noted that in the construction set forth in FIG. 2, the third contact member 60 is stationary, whereas in the multiple-break construction of the device illustrated in FIG. 3, the intermediate contact member 60 is resiliently supported and is movable. The third contact member 60, the mounting therefor, and the shielding member 62, together with this mounting are insulated from the first and second contact members 50, 50' and are at a floating potential.

The vacuum-type circuit interrupter in accordance with the principles of the present invention exhibits the relationship between length of gap and withstand voltage as shown in curve A in FIG. 6 of the drawings. For example, if it is desired to make the dielectric breakdown voltage equal to 60 kv., the gap is required to be approximately 1 millimeter in length. This results in the gaps g' and g'' being required only to be 0.5 millimeter in length respectively.

The operation of the vacuum-type circuit interrupters according to the present invention will now be described: Referring first to the construction of FIG. 2, there is shown a vacuum-type circuit interrupter 21 in its open position. To change the interrupter from its open position to its closing position, a suitable operating mechanism, described hereinafter, is operated to drive both movable supporting rods 23, 23' in an inward direction to move the first and second contact members 50, 50' inwardly until these two movable contact members engage the intermediate relatively stationary contact 60. The interrupting operation is obtained by a reversal of the aforementioned operation.

During the opening operation suitable mechanism, such as indicated in FIG. 2A of the drawings, may be provided to provide an outward opening movement of the two movable contact members 50, 50'.

With reference to the vacuum-type circuit interrupter 70 of FIG. 3 incorporating principles of the present in-

vention, it will be observed that to move the contacts 50, 50' from their open positions, as shown, to their closed-circuit position, it is necessary to effect upward closing movement of the lower movable contact rod 23. This is obtained by any suitable operating mechanism. In the closing direction, it will be apparent that when the lower movable contact rod 23, carrying the second movable contact 50, engages the intermediate, or third movable contact 60, it will cause upward closing movement of the latter until abutment is obtained with the first or relatively stationary contact 50'. During the opening operation, downward opening movement of the movable contact rod 23 will permit the resiliency of the flexible supporting diaphragm 80 to cause downward opening movement of the intermediate contact 60, and consequent separation between the first and third contact members 50', 60 until the gap distance g' is obtained. Continued opening downward travel of the lower movable intermediate contact rod 23 will cause subsequent disengagement between the second movable contact member 50 and the third intermediate movable contact member 60 resulting in a gap spacing g'' .

As previously described, vacuum-type circuit interrupters 21, 70 according to the present invention comprise the intermediate contact member 60 at a floating potential disposed between the first and second contact members 50, 50' or 50, 50'' to result in the formation of first and second gaps g' and g'' during the opening operation of substantially equal length. The third contact member 60 has an intermediate potential with respect to the first and second contact members 50, 50'. For example, assuming that the dielectric breakdown voltage has a magnitude of 60 kv., prior-art-type vacuum circuit interrupters were required to include a gap of approximately 5 mm. in length, whereas the circuit interrupter 21 or 70 of the present invention is only required to include a gap spacing of approximately 0.5 mm. in length provided that the number of gaps is, for example, two in number. Thus, the invention can provide for an extremely high dielectric breakdown voltage with extremely short gaps. Also, since the vacuum circuit interrupter according to the present invention may include a plurality of independent gaps with independent vacuum chambers, there results no disadvantage in that the occurrence of a dielectric breakdown across one gap may cause a short circuiting of the contact members, as in the case of a conventional-type circuit interrupter including only a single gap. This results from the fact that if any of the gaps is short-circuited for any reason, the other series independent gaps will exist. Further, in order to put the third contact member 60 at a floating potential so as to cause the same to be at an intermediate potential with respect to the first and second contact members, it must be insulated from the first and second contact members. However, the shielding member 62 has been connected to a portion 66 insulated from the first and second contact members 50, 50', and thus put at a floating potential, and the intermediate contact member 60 which is at the floating potential has been directly connected to this portion. This not only greatly reduces a fear of short-circuiting the shielding member 62 with the first and second contact members, but also eliminates the necessity for mounting the shielding member 62 and the contact member 60 at the floating potential to separate mounting positions within the vacuum container 19. The result is a compact-type vacuum circuit interrupter.

If the power circuit has been interrupted by a conventional-type vacuum circuit interrupter, a reverse or residual flows through the same for a long period of time after the interruption, the magnitude of the current reaching the order of approximately 1 ampere. As such a high residual current flows through two interruption points

(the gaps g' and g'' serially connected), the division of voltage depended upon the construction is negligible in the transient state occurring immediately after the interruption. Also the flow of residual current determines the potentials of the contact member 60 at the floating potential, and of the shielding member 62 and serves to cause such contact and shielding members 60, 62 to be at intermediate potentials in the transient interruption state.

While the vacuum container 19 may be arranged to be hermetically divided into two separate parts 19A, 19B for maintaining its integrity if one part should lose its vacuum, the performance of the vacuum circuit interrupter is not changed regardless of whether or not both sides of the mounting for the condensing shield communicates with each other by means of holes provided through the supporting plate 61, 80.

Although there have been illustrated and described specific interrupting structures, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may be readily made therein by those skilled in the art without departing from the spirit and scope of the invention.

We claim as our invention:

1. A vacuum-type circuit interrupter including casing means defining an evacuated envelope, said casing means including two axially-aligned cylindrical insulating sections (20, 20') with annular metallic supporting means (66) interposed therebetween, a cylindrical condensing shield structure (62) supported adjacent its mid portion to a radially-outwardly extending portion (64) sealed to said annular supporting means, a flexible metallic diaphragm (80) sealed to and extending inwardly from the mid portion of said shield structure and supporting an intermediate contact button (60) at its center, a stationary contact supported on an end plate of said evacuated casing means and extending axially into one of said cylindrical insulating sections (20) and having a contact face close to but spaced from said intermediate contact button, a moving contact movably supported on an opposite end plate of said evacuated casing means and extending axially into the other cylindrical insulating section (20') for abutting engagement with said intermediate contact button to force the latter into abutment with the contact face of the stationary contact, said flexible metallic diaphragm and said outwardly extending portion of said sealed structure collectively defining an impervious partition means constituting part of two completely independent evacuated chambers (19A, 19B), whereby the loss of vacuum in one chamber does not affect the evacuated state in the other chamber which itself will hold the impressed voltage in the open-circuit position of the interrupter.

2. The vacuum-type circuit interrupter of claim 1, wherein the cylindrical condensing shield structure is of metal.

3. The vacuum-type circuit interrupter of claim 1, wherein the flexible metallic diaphragm has annular concentric corrugations provided therein surrounding the intermediate contact button for providing flexibility.

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