May 21, 1963 A. GREENWOOD 3,090,852

GETTERING ARRANGEMENT FOR A VACUUM CIRCUIT INTERRUPTER

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Fig.1.

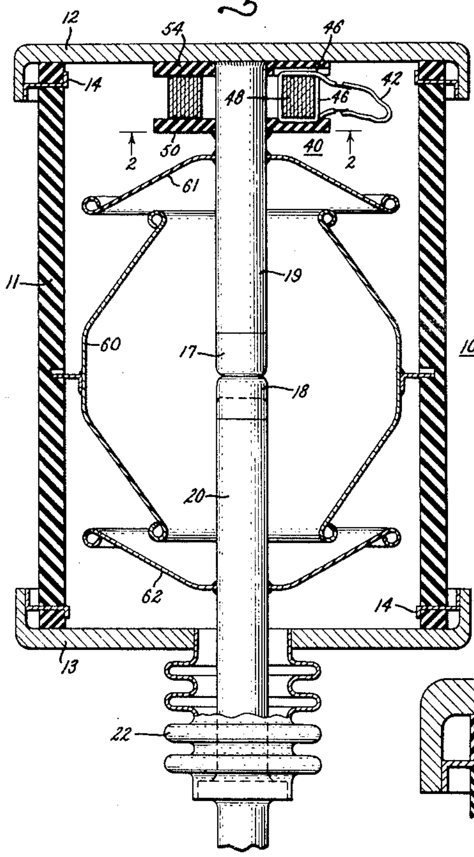


Fig.2.

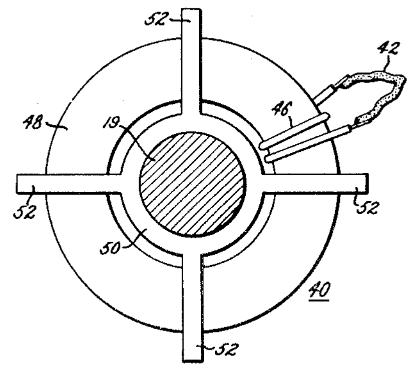


Fig.4.

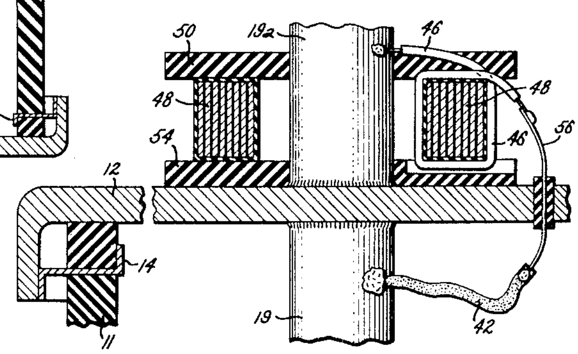
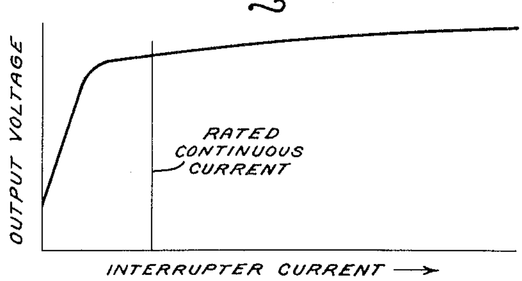


Fig.3.



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GETTERING ARRANGEMENT FOR A VACUUM CIRCUIT INTERRUPTER

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This invention relates to a vacuum-type circuit interrupter and, more particularly, to a gettering arrangement for maintaining the pressure within such an interrupter at the desired low level over a prolonged period.

Successful operation of a vacuum-type circuit interrupter depends to an important extent upon the maintenance of a very low pressure within the interrupter. In this regard, if the static pressure within the interrupter is allowed to appreciably exceed a value of about 10^{-4} mm. of mercury for devices of the usual dimensions, the dielectric strength of the vacuum becomes impaired, and, as a result, the likelihood of a breakdown between the parts of the interrupter greatly increases. In addition, if any significant amount of gas is present in the interrupter for an appreciable period, it tends to be adsorbed by or react with the surfaces of the device, and a breakdown is more likely to be initiated from a relatively dirty surface such as this than from a gas-free surface.

Moreover, an excessive pressure within the interrupter can seriously impair the ability of the interrupter to perform its intended interrupting operation. In this regard, the usual vacuum-type circuit interrupter comprises a pair of separable contacts disposed within an evacuated envelope. Circuit interruption is initiated by separating these contacts to establish an arc across the resulting gap. Assuming that the circuit is an alternating current circuit, the arc maintains itself until about the time a natural current zero is reached. The arc then vanishes, and the usual recovery voltage transient begins building up across the gap, in some cases approaching a peak value of twice normal system voltage. If the interruption is to be a successful one, the vacuum must have a sufficiently high dielectric strength during build-up of the recovery voltage transient to prevent the transient from breaking down any of the electrically-stressed gaps of the interrupter.

Any significant amount of free gas present inside the interrupter or on the surfaces of the interrupter during this interval could interfere with establishment of the required dielectric strength across the stressed gaps of the interrupter and could allow the recovery voltage transient to break down these gaps. Accordingly, it is highly desirable to minimize the amount if gases present within the interrupter and to maintain the pressure at a low level, preferably below 10^{-4} mm. of mercury.

For assuring that the pressure within the vacuum envelope and the gas content will be maintained at the desired low levels, I provide a gettering arrangement that operates to clean up any gases that might be present. This gettering arrangement comprises a getter element that is maintained at a useful working temperature during energization of the interrupter by current supplied from a winding that is inductively coupled to the main circuit through the interrupter. The amount of current supplied from the winding to heat the getter element depends upon the value of current flowing through the interrupter and increases as interrupter current increases.

Under short circuit conditions, the interrupter current can rise to values many times greater, e.g. twenty times greater, than the maximum continuous current for which the interrupter is rated. Since the amount of current supplied to my getter element increases as the interrupter current increases, a problem arises as how to prevent the getter element from being overheated and

possibly destroyed under overload and short circuit conditions.

Accordingly, one of the objects of my invention is to provide a getter arrangement for a vacuum interrupter in which the getter element is heated to a useful working temperature during normal operating conditions of the interrupter by means of current derived from the main power circuit through the interrupter and is protected from overheating during abnormal overcurrent conditions.

In carrying out my invention in one form, I provide an alternating current circuit interrupter of the vacuum-type having a predetermined rated continuous current. The interrupter comprises an evacuated envelope and a pair of separable contacts disposed within the envelope that are supplied with current by means of a conductor connected to said contacts. Disposed within the envelope is a getter element that is operable when heated to a predetermined temperature to clean up gases present within the envelope. For heating the getter element to at least this predetermined temperature during normal operation of the vacuum interrupter, I provide a saturable core of magnetizable material disposed about said conductor and a secondary winding inductively coupled to the core. The getter element is electrically connected across the terminals of the secondary winding. The core has magnetization characteristics that cause saturation of the core to occur at a level of current through said conductor not substantially exceeding the rated continuous current of the interrupter. This saturating effect causes normal currents through the interrupter to heat the getter element to a useful working temperature and limits the heating effect of overload and short circuit currents to such an extent that the temperature of the getter element is maintained sufficiently low to prevent the release of gases from the getter element.

For a better understanding of my invention, reference may be had to the following description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a sectional view of a vacuum-type circuit interrupter embodying one form of my invention.

FIG. 2 is an enlarged cross-sectional view taken along line 2—2 of FIG. 1.

FIG. 3 is a graphical representation of certain electrical operating characteristics present in the device of FIG. 1.

FIG. 4 illustrates a modified form of my invention.

Referring now to FIG. 1, there is shown a highly evacuated envelope **10** comprising a casing **11** of suitable insulating material and a pair of metallic end caps **12** and **13** closing off the ends of the casing and constituting terminals for the interrupter. Suitable seals **14** are provided between the end caps and the casing to provide for vacuum-tight connections between these parts.

Located within the envelope **10** is a pair of separable contacts **17** and **18** shown in the contact-closed or engaged position. The upper contact **17** is a stationary contact suitably secured, as by brazing, to the lower end of a conductive rod **19**. This conductive rod **19** is integrally united at its end with the upper end cap **12**. The lower contact **18** is a movable contact brazed to the upper end of a conductive operating rod **20**. This conductive operating rod **20** is mounted for vertical movement and projects through an opening in the lower end cap **13**. A flexible metallic bellows **22** interposed between the lower end cap **13** and the movable operating rod **20** provides a seal about the operating rod and allows for vertical movement thereof without impairing the vacuum inside the interrupter. As shown in the drawing, the bellows **22** is secured at its respective opposite ends to the operating rod **20** and the end cap **13** by means of suitable sealed joints.

Coupled to the lower end of the movable operating rod **20**, suitable actuating means (not shown) is provided for driving the movable contact **18** downward from its solid line position of FIG. 1 and into its dotted line position out of engagement with the stationary contact **17** so as to open the interrupter. This actuating means is also capable of returning the movable contact **18** to its solid line position so as to close the interrupter.

When the operating rod **20** is driven downwardly to open the interrupter, an arc is established between the contacts **17** and **18**. Assuming that the interrupter is connected in an alternating current circuit, this arc will persist until about the time a natural current zero is reached. The arc will then vanish and be prevented from reigniting by the high dielectric strength of the vacuum, assuming that the interruption is a successful one.

As was pointed out hereinabove, successful operation of a vacuum-type circuit interrupter depends to a high degree upon the maintenance of a pressure within the envelope less than about 10^{-4} mm. of mercury. If the static pressure within the envelope is allowed to appreciably exceed this value, the dielectric strength of the vacuum becomes impaired and, as a result, the likelihood of a damaging breakdown between the parts of the interrupter greatly increases.

This is of importance not only when the breaker is standing in its open position with its contacts separated but also during the above-described interrupting operation. In this regard, if the pressure within the interrupter is excessive, the dielectric strength of the vacuum is incapable of withstanding the usual recovery voltage transient that builds up across the stressed gaps of the interrupter immediately following a current zero.

To insure that the pressure within the envelope is maintained at the desired low level, I provide gettering means **40** which is capable of cleaning up any gases present in the envelope. This gettering means comprises a getter element **42** in the form of a ribbon made from a metal which is capable of acting as a clean-up agent for any gases present when heated to a useful working temperature. For specific examples of metals capable of acting in this manner, reference may be had to the zirconium-titanium alloys disclosed and claimed in application Serial No. 683,339—Stout et al. filed September 11, 1957, now Patent No. 2,926,981, and assigned to the assignee of the present invention. In a preferred embodiment of my invention, I use a zirconium-titanium alloy of 85 atomic percent zirconium and the balance substantially all titanium. This alloy is a highly effective getter material for both oxygen and hydrogen, even at relatively low temperatures, such as 300 to 400° C. In the preferred embodiment of my invention, the getter element is heated to a temperature of about 375° C. during the flow of normal currents through the interrupter.

For heating the ribbon to the desired temperature, current is supplied to the ribbon from a winding **46** across the terminals of which the ribbon **42** is connected. This winding **46** may be thought of as a secondary winding of a current transformer which has as its primary winding the main power circuit through the interrupter. These two windings are coupled together in flux-exchanging relationship by means of a core **48** of magnetizable material surrounding the conductive rod **19** which forms a part of the primary circuit. This core is preferably formed from a strip of appropriate material coated with a thin layer of insulation and helically wound to produce a laminated structure having its individual laminations insulated from each other. This laminated construction acts in a known manner to minimize eddy currents in the core. The secondary winding **46** is wound about this core **48**, and, thus, alternating current flowing through the conductive rod **19** induces a flow of current through the secondary winding **46** and the getter element **42**.

In general, the magnitude of this secondary current varies as a direct function of the amount of current flowing through the rod **19**.

In an interrupting device, such as the vacuum interrupter shown, the current flowing through the interrupter under short circuit conditions can rise to values many times the continuous rated current of the device. In this regard, it is not unusual for an interrupter to be required to withstand short circuit currents as high as twenty or more times its rated continuous current. If the current flowing through the secondary winding were allowed to increase to anywhere near this extent, then the getter ribbon **42** would quickly become overheated. Such overheating could release gases adsorbed by the ribbon or could even vaporize the ribbon itself in extreme cases.

To protect the ribbon **42** against such overheating during short circuit conditions, the core **48** is so designed that it has effectively saturated when the R.M.S. value of the current flowing through the interrupter exceeds the rated continuous current of the interrupter or at least exceeds a value slightly in excess of this rated continuous current. This relationship is illustrated in FIG. 3 where the instantaneous voltage output from the secondary winding **46** is plotted against the instantaneous primary current flowing through the conductive rod **19**. To simplify this description, the voltages developed only during the flow of positive values of primary current are plotted on this graph, but it is to be understood that corresponding negative voltages are produced when the primary current is negative, i.e., during negative half-cycles. It will be apparent from this graph that when the primary current exceeds the rated continuous current of the interrupter, a condition of saturation is present which causes the output voltage from the secondary winding **45** to increase only slightly and at a much slower rate than it increased for lower primary current within the rated continuous current of the interrupter. The core is so designed that this condition of saturation limits the output voltage even under the most severe short circuit conditions to a value which will result in insufficient current through the ribbon **42** to produce harmful overheating. Preferably, the core is so designed that saturation occurs at a value of primary current substantially lower than the rated continuous current of the interrupter, but satisfactory results are obtained even if saturation does not occur until rated continuous current or a value slightly in excess thereof is reached.

If the core design was such that saturation did not occur until a value of primary current considerably in excess of rated continuous current was reached, then under normal operating conditions, there would be insufficient output voltage from secondary winding **46** to maintain the getter element **42** at a useful working temperature. Thus, saturation of the core should occur before the primary current has exceeded rated continuous current or a value slightly in excess of rated continuous current.

The term "rated continuous current" used hereinabove is intended to denote the limit of current in R.M.S. amperes at rated freuency that the interrupter will carry continuously without exceeding the limits of observable temperature rise that industry standards have established for this class of interrupter. This generally conforms to the definition of this term given in section 4–6.7 of the American Standards Association publication, C37.4—1953 reprinted in 1957. Insofar as present industry standards are concerned, the controlling temperature rise for a sealed interrupting device, such as the disclosed vacuum device, would be the maximum temperature rise of the external parts of the device. Present industry standards allow the maximum temperature rise for the external parts to be as high as 70° C. when carrying continuous rated current. This figure could be revised slightly upward in the future, but the principles of the present invention are considered to be sufficiently general to comprehend any such minor revisions as are presently anticipated. The term "normal current" as used herein is intended to denote any current within the continuous current rating of the device. This usage conforms to that contained in American Standards Association definition 4–3.1 in the aforesaid publication C37.4—1953.

For supporting the core **48** within the envelope **10**, a spider **50** having arms **52** radiating from its hub portion is provided beneath the core **48**. This spider **50** is suitably secured to the rod **19** to hold the core **48** in the position of FIG. 1. A disc **54** of suitable insulating material is interposed between the core **48** and the end plate **12** to prevent the laminations of the core from possibly being short circuited by the conductive plate **12**. The disc **54** is suitably slotted in a radial direction to allow the turns of the secondary winding **46** on the upper side of the core to be disposed between the core **48** and the end plate **12**. On the lower side of the core, the space between the arms **52** of the spider accommodates the turns of the winding **46**. The conductor forming the winding **46** is provided with a suitable insulating coating to prevent any of the turns of winding **46** from being short circuited through the core **48**. Preferably, the secondary winding **46** and the core **48** are both electrically connected to the conductive rod **19**, but at only a single point, so as to assure that each of these first two parts operates at a definite potential relative to the conductive rod **19**.

In the embodiment of FIG. 1, the getter arrangement **40** is disposed entirely within the envelope **10** and thus requires that the envelope **10** have no seals or joints beyond those otherwise needed. If the core is disposed within the envelope as shown in FIG. 1, it is necessary that the material of the core be such that its magnetic characteristics are not impaired by the high temperatures that accompany the usual bake-out procedure that is used in building the interrupter.

To obviate the requirement that the core material be capable of withstanding high bake-out temperatures, reliance may be had upon the modified form of the interrupter shown in FIG. 4. In this embodiment, both the core **48** and the secondary winding **46** are disposed outside the envelope **10**. Only the getter element **42** is disposed inside the envelope. One terminal of the getter element is connected to the conductive rod **19** and the other terminal to a lead-in conductor **56** extending in sealed relationship through the end plate **12**. By using the rod itself as one of the terminal conductors for the getter element, the embodiment of FIG. 4 requires only one extra sealed opening for effecting energization of the getter element from a source disposed externally to the envelope. In the arrangement of FIG. 4, the envelope **10** and its contents can be baked out and sealed in the usual manner, and the core and secondary winding assembled in the external position shown after the bake-out operation, thus eliminating any need to subject the core to bake-out temperatures. In FIG. 4, the core **48** is shown positioned about a rod **19*a*** that serves as a terminal connection for carrying all of the interrupter current to and from the end cap **12**.

In the interrupter of FIG. 1, a central shield **60** and two end shields **61** and **62** are provided for protecting the insulation of the interrupter against condensation of arc-liberated metallic vapors thereon. These shields generally correspond to those shown and claimed in U.S. Patent 2,892,912, Greenwood et al., assigned to the assignee of the present invention. It is to be noted that the getter arrangement **40** of FIG. 1 is disposed behind one of the end shields **61**. Since the end shield **61** and the end cap **12** are electrically connected together at all times, the getter is disposed in a region of low dielectric stress and, hence, in a region where the presence of the projecting parts of the getter arrangement will not produce stress concentrations that might lead to a breakdown.

While I have shown and described particular embodiments of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects, and I, therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An alternating-current circuit interrupter of the vacuum-type having a predetermined rated continuous current, said interrupter comprising an evacuated envelope, a pair of separable contacts disposed within said envelope, a conductor for supplying current to said contacts, a getter element disposed within said envelope and operable when heated to a predetermined temperature to clean-up gases present within said envelope, means for heating said getter element to at least said predetermined temperature level during the flow of normal current through said vacuum interrupter comprising a saturable core of magnetizable material disposed about said conductor, a secondary winding inductively coupled to said core, and means for arranging said getter element to be heated by current flowing through said secondary winding, said core having magnetization characteristics that cause saturation of said core to occur at a level of current through said conductor not substantially exceeding the rated continuous current of the interrupter.

2. The combination of claim 1 in which said core, said secondary winding and said getter element are all disposed within said evacuated envelope.

3. The arrangement of claim 1 in which said getter element is disposed within said envelope and said core and said secondary winding are disposed externally to said envelope, and in which the means for connecting said getter element across said secondary winding includes one lead extending through said envelope in sealed relationship thereto and a second lead constituted by said conductor for supplying current to said contacts.

4. The vacuum interrupter of claim 1 in which said getter element is disposed within said envelope in a region of low dielectric stress in comparison to the stress in the region generally around said separable contacts, said region being located between two metallic parts that have substantially the same potential when said interrupter is energized.

5. The vacuum interrupter of claim 1 in which said getter element is formed of a zirconium-titanium alloy and is heated to a temperature exceeding a value of about 300° C. by current flowing through said secondary winding during normal operation of said interrupter.

6. An alternating-current circuit interrupter of the vacuum-type having a predetermined rated continuous current, said interrupter comprising an evacuated envelope, a pair of separable contacts disposed within said envelope, a conductor for supplying current to said contacts, a getter element disposed within said envelope and operable when heated to a predetermined temperature to clean-up gases present within said envelope, means for heating said getter element to at least said predetermined temperature level during the flow of normal current through said vacuum interrupter comprising a saturable core of magnetizable material disposed about said conductor, a secondary winding inductively coupled to said core, and means for arranging said getter element to be heated by current flowing through said secondary winding, said core having magnetization characteristics that cause saturation of said core to occur during the flow of normal currents through said interrupter.

7. An alternating-current circuit interrupter of the vacuum-type having a predetermined rated continuous current, said interrupter comprising an evacuated envelope,

a pair of separable contacts disposed within said envelope, a conductor for supplying current to said contacts, a getter element disposed within said envelope and operable when heated to a predetermined temperature to clean-up gases present within said envelope, means for heating said getter element to at least said predetermined temperature level during the flow of normal current through said vacuum interrupter comprising a saturable core of magnetizable material disposed about said conductor, a secondary winding inductively coupled to said core, and means for arranging said getter element to be heated by current flowing through said secondary winding, said core having magnetization characteristics that cause saturation of said core to occur at a sufficiently low level of interrupter current that normal currents through said interrupter heat the getter element to a useful working

temperaure and short circuit currents heat said getter element to an insufficient temperature to release gases therefrom.

References Cited in the file of this patent

UNITED STATES PATENTS

805,021	Soddy	July 2, 1907
1,733,904	Prince	Oct. 29, 1929
1,859,029	De Boer et al.	May 17, 1932
2,813,216	Dailey et al.	Nov. 12, 1957
2,864,998	Lee	Dec. 16, 1958
2,977,446	Baker	Mar. 28, 1961

FOREIGN PATENTS

1,033,757	Germany	July 10, 1958