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[54] **ELECTRIC CIRCUIT INTERRUPTER**

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Related U.S. Application Data

[63] Continuation of Ser. No. 261,266, June 9, 1972, abandoned.

[52] **U.S. Cl.** ..... **200/144 C**, 200/149 A

[51] **Int. Cl.** **H01h 33/08**

[58] **Field of Search** ..... 200/144 C, 149 A, 148 C

[56] **References Cited**

UNITED STATES PATENTS

3,544,747	12/1970	Boersma	200/144 C
3,560,685	2/1971	Bailey	200/147 R X
3,588,405	6/1971	Bailey	200/144 C

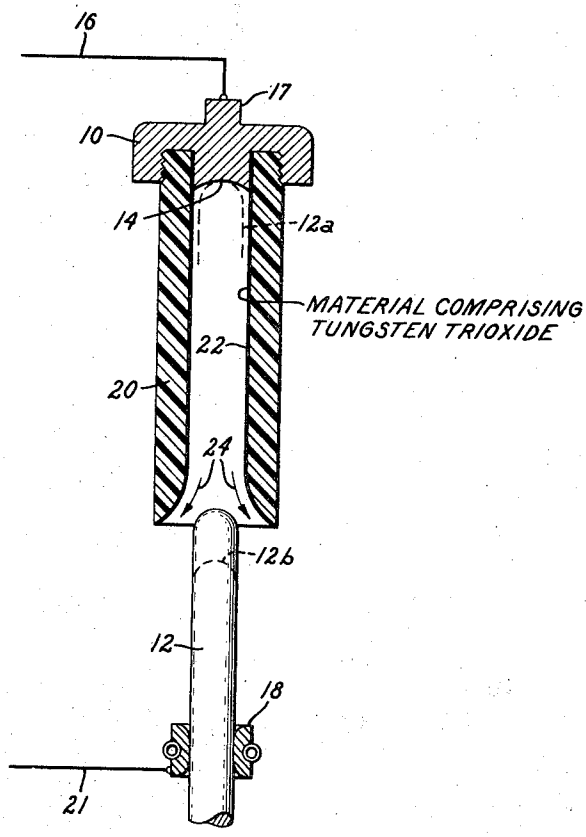
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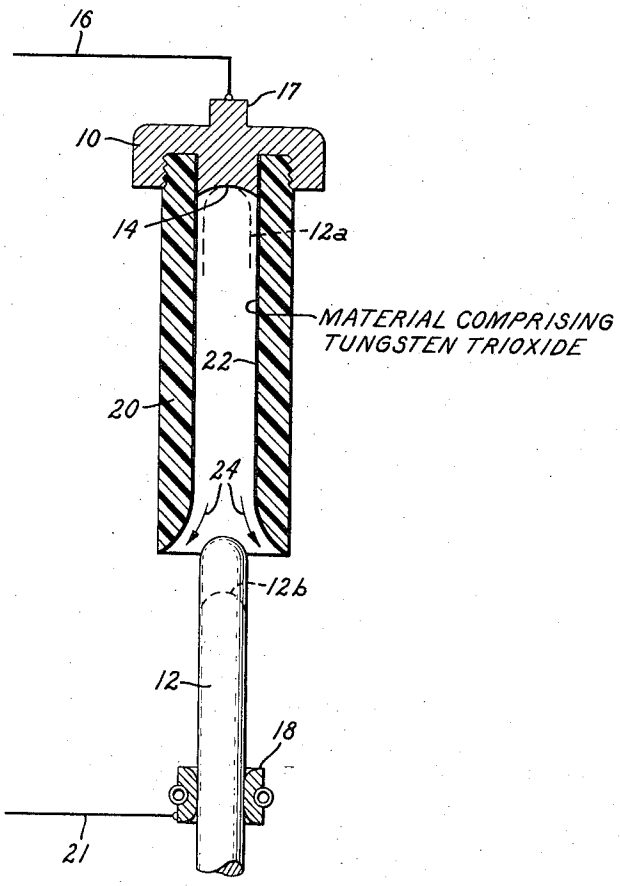
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[57] **ABSTRACT**

Discloses a circuit interrupter in which an arc is established during circuit interruption. Along the path of the arc, there is provided arc-extinguishing structure from which arc-extinguishing gas is evolved by the heat of the arc. The arc-extinguishing structure is of a material comprising tungsten trioxide, and the evolved gas comprises vapors of tungsten trioxide.

5 Claims, 1 Drawing Figure




16
17
10
14
12a
MATERIAL COMPRISING
TUNGSTEN TRIOXIDE
22
20
24
12b
12
18
21

ELECTRIC CIRCUIT INTERRUPTER

This is a continuation of application Ser. No. 261,266, filed June 9, 1972 now abandoned.

BACKGROUND

This invention relates to an electric circuit interrupter and, more particularly, relates to a circuit interrupter of the type that employs an electronegative gas in contact with its arc to aid in arc extinction.

Examples of such circuit interrupters are disclosed in the following U.S. Pat. Nos. 2,757,261-Lingal et al; 3,021,409-Cobine et al; and 1,971,836-Strom et al. Other prior art includes U.S. patents 2,066,129-Triplett, 2,285,602-McMahon and 2,358,407-McMahon.

In an alternating-current circuit, circuit interruption is typically effected by establishing between a pair of spaced electrodes an arc through which current flows until a natural current zero is reached, at which time a recovery voltage transient rapidly builds up across the inter-electrode space. If the inter-electrode space can withstand this recovery voltage transient without breakdown, interruption is successfully completed at this current zero. The likelihood of successfully interrupting the circuit at any given current zero depends upon the rate at which the inter-electrode space can recover its dielectric strength at the current zero. The higher this dielectric rate, the greater the likelihood of withstanding the recovery voltage and thus completing the interruption.

It is recognized that the dielectric recovery rate can be increased by employing an electronegative gas, such as sulfur hexafluoride, in contact with the arc. Such a gas has a strong attraction for free electrons, which carry most of the current in the arc; and by removing these electrons more rapidly and more completely at current zero, a higher rate of dielectric recovery is effected.

Two properties of a gas which play an important role in determining how effectively the free electrons will be removed from the inter-electrode space are its electron attachment cross-section and its electron affinity. The greater the electron attachment cross-section, the more rapidly free electrons will be attracted to and captured by the vapor species present; and the higher the electron affinity, the greater the force preventing subsequent detachment of the captured electron and its return to a free state.

SUMMARY

An object of our invention is to accelerate dielectric recovery at current zero by making available for electron capture a vapor or gas that has, in combination, both an exceptionally high electron affinity and an exceptionally high electron attachment cross-section.

In carrying out our invention in one form, we provide a circuit interrupter in which an arc is established during circuit interruption. Along the path of the arc, we provide arc-extinguishing structure from which arc-extinguishing gas is evolved by the heat of the arc. The arc-extinguishing structure is of a material comprising tungsten trioxide, and the evolved gas comprises vapors of tungsten trioxide.

Both the electron affinity and electron attachment cross-section of tungsten trioxide vapors are exceptionally high, a combination of properties that, insofar as we are aware, has not previously been recognized.

BRIEF DESCRIPTION OF DRAWING

For a better understanding of the invention, reference may be had to the following description taken in conjunction with the accompanying drawing, wherein the single FIGURE is a schematic showing of a circuit interrupter embodying one form of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to the drawing there is schematically shown a circuit interrupter of the expulsion type. This interrupter comprises an upper electrode **10**, which is stationary, and a lower electrode **12** of rod form, which is vertically movable into and out of engagement with stationary electrode **10**. When the interrupter is closed, movable electrode **12** occupies a dotted line position **12***a* where its uppermost surface engages a surface **14** of the upper electrode. Current can then pass through the interrupter via an upper circuit portion **16**, an upper terminal **17**, engaged electrodes **10** and **12**, a lower sliding contact **18**, and a lower circuit portion **21**.

When the interrupter is to be opened to interrupt the circuit therethrough, electrode **12** is driven downwardly by a suitable operating mechanism (not shown). This rapidly moves electrode **12** out of engagement with electrode **10** and through its illustrated solid-line intermediate position into a fully open position shown at **12***b*.

When electrodes **10** and **12** are separated while current is passing therethrough, an arc is established therebetween. For confining the arc and aiding in extinguishing it, a tubular housing **20** is provided. Housing **20** has a bore **22** in which rod electrode **12** is vertically movable with only a small annular clearance space between the bore and the rod. When the material along the bore of housing **20** is heated by the high temperature arc established between the electrodes, a portion of this material vaporizes. Most of these vapors are confined in the arcing space between the electrodes until the downwardly moving rod electrode **12** approaches its solid-line position of FIG. **1**. When the downwardly-moving electrode **12** does approach its position of FIG. **1**, the bore **22** is unblocked and the arc-generated vapors are then free to flow from the inter-electrode space via the path shown by arrows **24**, thus creating a blast action that further aids in extinguishing the arc if it is still present.

In one form of our invention, the tubular housing **20** is made primarily of a ceramic material such as alumina, aluminum silicate, or zircon, and its bore **22** is lined with a coating of tungsten trioxide (WO_3), suitably deposited, as by a thermal spraying process, referred to in greater detail hereinafter. Another suitable coating technique involves mixing the tungsten trioxide powder with a glass frit or with a suitable binder such as monoaluminum phosphate, then painting this mixture onto the surface **22**, and thereafter heat treating.

To facilitate the depositing of such a coating, the housing **20** is preferably made of two semi-cylindrical parts. These parts are first coated on surface **22** and then are suitably secured together (by means not shown) to form the tubular housing **20**.

The arc developed by electrode-separation vaporizes some of the tungsten trioxide lining the bore **22**. The

resulting tungsten trioxide vapors are confined under pressure in the arcing space between the electrodes until the downwardly moving electrode **12** approaches its illustrated position, at which time the vapors are expelled from the bore via paths **24.** Tungsten trioxide vapor is exceptionally effective as an arc interrupting medium. We attribute this to the exceptionally large electron attachment cross-section of tungsten trioxide in combination with its exceptionally high electron affinity. In this respect, both the timer of tungsten trioxide $(WO_3)_3$ and the dimer $(WO_3)_2$, which are the predominant species present in the vapor, have an electron attachment cross-section of about 4×10^{-16} cm^2.

This electron attachment cross-section is very high compared to the attachment cross-section of the more widely used arc-extinguishing gases. For example, sulfur hexafluoride (SF_6) has an electron attachment cross-section of about 2.3×10^{-17} cm^2 (less than 1/10 that of the WO_3 trimer and dimer). SF_5, a compound to which SF_6 decomposes in the presence of an arc, has an attachment cross-section much less even than that of SF_6.

Another widely used arc-extinguishing material, boric acid, decomposes in the presence of an arc to HBO_2; and the electron attachment cross-section of HBO_2 is about 3×10^{-17} cm^2 (only about 1/10 of the WO_3 trimer and dimer).

Turning next to electron affinity, the predominant species of the tungsten trioxide vapor to be considered from an electron affinity viewpoint are the WO_3 dimer and the WO_3 monomer. These each have an electron affinity of about 4.5 electron volts (eV) according to our measurements. This electron affinity is much higher than that of SF_6 (which has an electron affinity of about 1.3 eV) and is appreciably higher than that of SF_5 (which has an electron affinity of about 3.4 eV). Boron dioxide (BO_2), which is the pertinent species to be considered from an electron affinity viewpoint when boric acid is used as an arc-extinguishing material, has an electron affinity of about 4.7 eV. While this too is an exceptionally high electron affinity, probably even slightly higher than that of the tungsten trioxide dimer and monomer, it should be recalled that the electron attachment cross-section of the pertinent species in this reaction, HBO_2, is only about 1/10 that of the pertinent tungsten trioxide species.

The above values of electron affinity and electron attachment cross-section have been computed from data obtained by techniques that involve electron impact by mass spectrometry, such as described, for example, in the article by P.D. Zavitsanos appearing on pages **1–13** of the book Dynamic Mass Spectrometry, edited by Price and Williams, and published in 1969 by Heyden and Sadler of New York, N.Y. and London, England. It is perhaps noteworthy that Jensen and Miller, using a different and, we believe, less accurate technique involving a starting material of tungstic acid, have estimated the electron affinity of the monomer of tungsten trioxide to be between 3.16 and 3.6 eV. This work is described in an article appearing in the Journal of Chemical Physics, Vol. 52, page 3287, 1970. No mention is made in this article of the high electron attachment cross-section of tungsten trioxide.

In another embodiment of our invention, the tungsten trioxide is incorporated in a suitable resin such as methyl methacrylate and the entire housing **20** is molded from such mixture. In this embodiment, the arc formed upon contact-separation vaporizes both materials along the bore **22,** thus rendering the tungsten trioxide vapor available to aid in the arc-extinguishing process by performing its strong electron-attaching action around the time of current zero.

In another embodiment of our invention, powdered tungsten trioxide, held together with a suitable binder, e.g., methyl methacrylate, is used to form a plurality of annular cakes. A stack of these cakes is pressed into the bore of an insulating tube to form a housing corresponding to the illustrated housing **20.** An example of this general type of construction is shown in U.S. Pat. No. 1,971,836-Strom et al.

In still another embodiment of our invention, tungsten trioxide is deposited on the fins and sidewalls of an arc chute of the type shown in U.S. Pat. No. 3,560,685-Bailey et al. or in copending application Ser. No. 162,341-Frind et al, filed July 14, 1971, both assigned to the assignee of the present invention. In that application, an adherent coating of fused silica is deposited by plasma-arc-spraying onto the fins and sidewalls. We use generally the same technique for depositing the tungsten trioxide. More specifically, tungsten trioxide, in powdered form, is fed into the spray gun where it is melted by the hot plasma stream present and converted into molten particles, which are ejected through a suitable nozzle in the plasma stream. The plasma stream containing the molten particles is projected onto the arc chute surface, where the particles, upon impact, flatten and freeze into an adherent coating.

Another suitable technique for spraying the tungsten trioxide particles is the oxy-acetylene flame spraying technique referred to in U.S. Pat. No. 3,009,041-Zlupko. The arc chute shown in the Zlupko patent can also advantageously have its arc-exposed splitter plates and sidewalls coated with tungsten trioxide.

Either of the thermal spraying techniques referred to hereinabove can be used for depositing the tungsten trioxide coating on the bore **22** of the tubular housing **20** of the drawing.

In still another embodiment of our invention, tungsten trioxide is used to coat the metal plates of a metal plate arc-chute such as shown in U.S. Pat. No. 3,641,293-Armitage et al. The tungsten trioxide is applied in any suitable manner as by thermal spraying or by incorporating it in a ceramic cement or other vehicle, which is brushed on each plate.

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

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

1. An electric circuit interrupter comprising:

a. a pair of conductive electrodes between which an arc is established during a circuit interrupting operation,

b. arc-extinguishing structure disposed along the path of said arc from which an arc-extinguishing gas is evolved by the heat of the arc,

c. said arc-extinguishing structure being made of a material comprising tungsten trioxide, and said arc-extinguishing gas comprising vapors of tungsten trioxide.

2. The circuit interrupter of claim 1 in which said arc-extinguishing structure comprises tubular structure having a bore in which said arc is located during interruption, said bore being lined with a material comprising tungsten trioxide.

3. A circuit interrupter as defined in claim 1 in which said circuit interrupter is an arc chute comprising arc-extinguishing structure against which said arc is adapted to move and evolve tungsten trioxide.

4. A circuit interrupter as defined in claim 1 comprising transverse plates against which the arc is adapted to move during interruption, said plates having a covering thereon of a material comprising tungsten trioxide from which tungsten trioxide vapors are evolved during interruption.

5. The circuit interrupter of claim 1 in which said pair of electrodes are separable electrodes between which said arc is established upon separation of said electrodes and said arc is adapted to move against said arc-extinguishing structure and evolve tungsten trioxide vapors therefrom.

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