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VACUUM SWITCH

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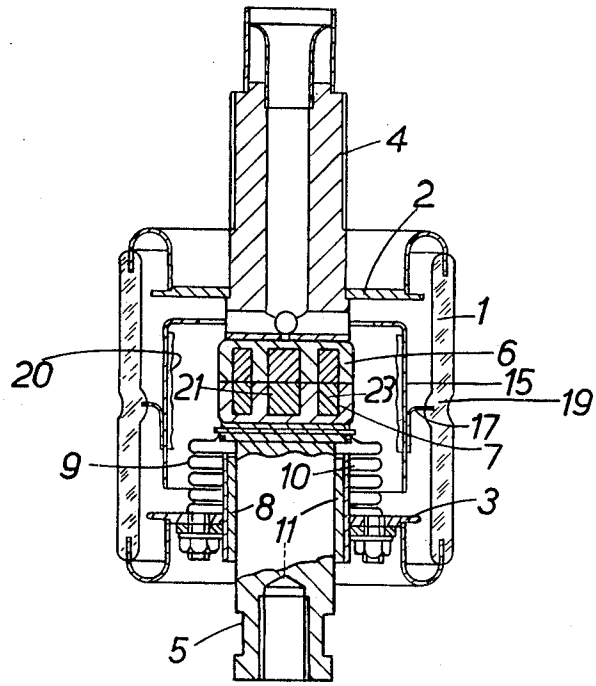



FIG. 1.

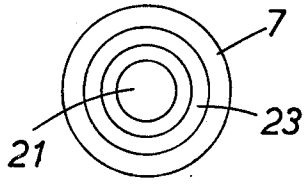



FIG. 2.

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# VACUUM SWITCH

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U.S. Cl. 200—144 13 Claims

## ABSTRACT OF THE DISCLOSURE

A vacuum switch has a contact face with zones of higher-arcing-voltage material and lower-arcing-voltage material, the latter being an Sb/Bi alloy with an Sb content of 70–95%, preferably 90%. The former material can be molybdenum or tungsten. The alloy is preferaby melted into an annular groove in the contact face. Other advantageous features of the contact and constructional features of a switch unit suitable for 300 a. 3.3 kv. contactor duty are disclosed.

The present invention relates to electrical vacuum switches adapted to interrupt alternating currents of at least some tens of amperes and below a few thousands of amperes.

A vacuum switch comprises an evacuated envelope, two conductors extending within said envelope with their inner ends adjacent, and means for providing relative movement between said conductors so that said inner ends can abut and can be separated in order to interrupt a current flowing from one conductor into the other conductor.

It has been found desirable that the adjacent inner ends of the conductors should be formed with contact surfaces for the most part of metal of higher-arcing-voltage, for example molybdenum or tungsten, but formed with reservoirs containing a non-fluid lower-arcing-voltage metal or alloy.

The physical contact between the contacts when they abut is formed between the portions of the contacting surfaces made from the higher-arcing-voltage material, and this material is sufficiently strong to maintain the required contact pressure between the contacts. When the contacts are separated an arc will be formed between the contacting surfaces and will continue to burn until the current is fully interrupted, which normally occurs at or close to the first current zero in the applied alternating current waveform. The negative or cathode end of the arc tends to burn preferentially on the lower-arcing-voltage material, and will travel quickly to such material. This lower arcing-voltage material therefore tends to vaporise, and the arc current is carried by the ionised vapour. The higher-arcing-voltage material does not tend to wear away, and in fact becomes coated with an adherent layer or film of the lower-arcing-voltage material which provides further protection. The travel of the moving contact relative to the fixed contact does not change, even after a large number of operations of the switch.

In known designs for contacts in vacuum switches each contacting surface is formed with a plurality of reservoir recesses of circular or similar shape and spaced apart over the contacting surfaces. In use either the arc ends must stay in the recesses in which they originate or the arc must move across the contacting surfaces, so that the ends of the arc will repeatedly move from one recess to another. Unless the surface between the recesses has a substantial deposit of the lower-arcing-voltage, the arc ends will remain in the original recesses.

An object of the present invention is the provision of



vacuum switches having improved contacts including improved lower-arcing-voltage material.

According to the present invention, a vacuum switch comprises an evacuated envelope; a first conductor extending within the envelope and having an inner end; a second conductor extending within the envelope and having an inner end disposed adjacent the inner end of the first conductor; operating means by which relative movement between the two conductors can be produced to move their inner ends into and out of contact with one another; a contact face on the first conductor inner end; a first zone of the contact face, of higher-arcing-voltage material; and a second zone of the contact face, of lower-arcing-voltage material in the form of an alloy consisting essentially of from 70–95% by weight antimony with the remainder bismuth apart from incidental impurities and mere adulterants; the zone of higher-arcing-voltage material being level with or projecting slightly beyond the zone of lower-arcing-voltage material to provide an effective contact surface.

For optimum results, the alloy should contain less than 50 parts per million of metallic impurities, and in the finished switch should be substantially free from gases and gas forming impurities.

In a preferred alloy the antimony content is about 90%.

The contact preferably is used in combination with another similar contact, and preferably the corresponding zones on the two contacts are of equal size and extend coterminously.

The contact face of the contact may be formed with at least one annular groove containing lower-arcing-voltage material.

The invention will now be described, by way of example, with reference to the accompanying drawing, in which:

FIGURE 1 is a sectional side elevation of a vacuum switch including a contact according to the invention and with a normal rating of 300 amperes at 3.3 kv. and with an overload rating of at least 2000 amperes at 3.3 kv.; and

FIGURE 2 is a plan view of the lower contact illustrated in FIGURE 1.

The vacuum switch comprises an envelope including a cylindrical body portion **1** of electrically insulating material, glass in this instance, and two metal end plates 2 and 3 suitably sealed to the body portion. Two conductors **4** and **5** extend within the envelope from opposite ends so that their inner ends, which are provided with contacts **6** and **7** respectively, are adjacent. Conductor **4** extends through end plate **2** in a gas tight manner. Conductor **5** extends freely through an aperture **8** in end plate **3** and is connected thereto by a bellows member **9** which provides a gas tight seal but permits longitudinal movement of conductor **5**. A sleeve **10** carried by plate **3** and provided with a bush **11** provides a self-lubrication guide for the conductor **5**. The envelope is adapted to be evacuated by any suitable method after assembly of all the components. The contacts **6** and **7** are encircled by a cylindrical shield **15** which is provided with four external lugs **17** which are secured to the body portion **1** by inwardly nipped portions **19**. A metallic mesh **20** on the inside of shield **15** enhances the adhesion of evaporated contact material.

Each of the contacts **6** and **7** has a body made from a higher-arcing-voltage material, for example molybdenum, and the contacting surface of each contact is formed with a central circular recess **21** and with a concentric annular groove **23**, substantially filled with lower-arcing-voltage material.

The grooves in the contacting surfaces of the contacts **6** and **7** are aligned so that when the contacts abut the

portions of the contacting surfaces made from higher-arcing-voltage material are in contact, although a thin film of the reservoir alloy will appear in use. With this arrangement the required contact pressure can be applied without damaging the contacting surfaces.

Each contact **6** and **7** is formed of molybdenum, has an overall diameter of one inch, the central recess **21** has a diameter of ¼ inch, and the groove **23** has a width of ⅛ inch and outer and inner diameters of ¾ inch and ½ inch respectively. The lower-arcing-voltage material used in the recess **21** and the groove **23** is an alloy of 90 parts by weight of antimony with **10** parts by weight of bismuth.

In order to assist in the provision of this filling, the molybdenum contacts are machined with an additional axially extending peripheral lip. The machined contacts are vacuum fired at 900 degrees centrigrade after degreasing and electrolysing. The contacts are then nickel plated, again vacuum fired brazed with a silver/copper eutectic material to the conductors **4** and **5**, which are of oxygen free copper, and the nickel is removed from the outer periphery of the contacts. The prepared alloy of 90 parts antimony and 10 parts bismuth by weight is received in the form of broken bar, and further broken into random shaped pieces with a maximum dimension of about ¼ inch. These are placed within the encircling additional axially extending peripheral lip mentioned above, and melted into the recess **21** and the groove **23** in an atmosphere of pure, dry hydrogen, the arrangement being such that the hydrogen can circulate about the pieces of the alloy and reduce any oxides which may be present. This is found to produce fillings free from blowholes and leaves the contacts clean. The filled contact is then machined to remove the peripheral lip and to expose the molybdenum in the regions surrounding recess **21** and groove **23**. A nickel plated interface remains between the regions of exposed molybdenum and both the recess region **21** and the groove region **23**. The fillings of the central recess **21** and the groove **23** are then undercut or recessed by about 0.005 inch to ensure that during the period when the switch is closed the contacts will engage over their molybdenum surfaces, which are coated in use with a film of the filler alloy. This avoids welding between the filler alloy surfaces.

With contacts of this construction when an arc is formed between the contacting surfaces each end of the arc will be located in a mass of lower-arcing-voltage material in one of the grooves. If the ends of the arc move over the contacting surfaces, or when one arc splits into two or more arcs, the ends of the arc or arcs can still be located on the mass of low-arcing-voltage material and need not pass over the portions of the contacting surfaces formed from higher-arcing-voltage material.

The switch described is able to meet the onerous working conditions inside the envelope, and under test conditions has been found to allow $2\times10^6$ interruptions of 300 amperes with 0.004 to 0.008 inches eroded from each contact per $10^6$ interruptions. The molybdenum contact surfaces are hard wearing, have a high melting point, and require a high arcing potential. The novel alloy used as the filler material does not alloy in use with the molybdenum to produce deleterious alloys. Whereas antimony is found to have a large crystal grain size, which has the result that when the switch opens two antimony grains respectively on the two contacts can adhere and one pull the other out of its matrix, the novel alloy has a finer grain structure and is not subject to this defect. Since the novel alloy expands as it cools, and since it is put in place in a molten form, the alloy filler is tightly fixed in place in its recess or groove. The alloy has a low-arcing-voltage compared with the molybdenum, which causes the arc struck between the two molybdenum contacts to transfer very quickly to the alloy filler; since the arcing voltage is only about 10 volts at the currents involved, the heat dissipation in the switch is relatively low giving consequently small contact damage; it has a relatively low tensile strength, so that welds which occur between parts respectively on the two contacts readily break; it has a high vapour pressure at the arc temperature but a sufficiently low vapour pressure and high melting-point to allow bake-out at a temperature of between 350 to 400 degrees centrigrade in treating the assembled switch, so that no problem arises, during bake-out and in service, of serious vaporisation or melting of the filler material. It does not readily oxidise and it is stable. Its low thermal conductivity ensures efficient vaporisation and ensures that much of the heat generated in the arc will remain in the arc and will not be dissipated in the mass of filler material and passed on to the molybdenum contacts. Its properties are such that it can support a low current arc of 1 ampere or less so that the arc persists until the current has fallen very nearly to zero on the alternating current waveform. Thus the arc is not extinguished prematurely so excessive voltages are not generated in inductive circuits. Since the alloy is in the form of a solid solution of two low arcing voltage metals, no intermetallic compounds appear in use to contaminate the working surfaces of the switch. After much use, during which some of the filler material vapourises, the surface of the filler material remains uncontaminated since both the antimony and the bismuth evaporate, leaving no scum or crust.

What I claim is:

**1.** A vacuum switch comprising:

(a) an evacuated envelope;

(b) a first conductor extending within the envelope and having an inner end;

(c) a second conductor extending within the envelope and having an inner end disposed adjacent the inner end of the first conductor;

(d) operating means by which relative movement between the two conductors can be produced to move their inner ends into and out of contact with one another;

(e) a contact face on the first conductor inner end;

(f) a first zone of the contact face, of higher-arcing-voltage material; and

(g) a second zone of the contact face, of lower-arcing-voltage material in the form of an alloy comprising consisting essentially of from 70 to 95% by weight antimony with the remainder bismuth apart from incidental impurities;

the zone of higher-arcing-voltage material being level with or projecting slightly beyond the zone of lower-arcing-voltage material to provide an effective contact surface.

**2.** A vacuum switch according to claim **1**, in which the lower-arcing-voltage material contains less than 50 parts per million of metallic impurities.

**3.** A vacuum switch according to claim **1**, in which the antimony content is about 90%.

**4.** A vacuum switch according to claim **1**, in which the higher-arcing-voltage material is molybdenum.

**5.** A vacuum switch according to claim **1**, in which the higher-arcing-voltage material is tungsten.

**6.** A vacuum switch according to claim **1**, in which the contact is used in combination with another similar contact, and the corresponding zones on the two contacts are of equal size and extend coterminously.

**7.** A vacuum switch according to claim **1**, in which the contact face is formed with at least one annular groove containing lower-arcing-voltage material.

**8.** A vacuum switch according to claim **7**, in which:

(a) the contact face is circular with an overall diameter of about one inch;

(b) the higher-arcing-voltage material is molybdenum;

(c) the annular groove is circular with an outer diameter of about ¾ inch and an inner diameter of about ½ inch; and

(d) the lower-arcing-voltage material has an antimony content of about 90%.

9. A vacuum switch according to claim 8, in which the contact face is also formed with a central circular recess with a diameter of about ¼ inch containing lower-arcing-voltage material having an antimony content of about 90%.

10. A vacuum switch according to claim 1, in which the first and second zones of the contact face are provided by respective regions of the first conductor inner end and these regions have a nickel-plated interface between them.

11. A vacuum switch according to claim 1, in which the evacuated envelope includes an end plate having an aperture through which one of the conductors freely extends and a bellows member connecting the end plate to, and permitting said relative movement of, that conductor, and in which a sleeve carried by the end plate has a bush providing a self-lubrication guide for that conductor.

12. A vacuum switch according to claim 1, in which the evacuated envelope includes a cylindrical body portion of glass and the contacts are encircled by a cylindrical shield having external lugs which are located in the body portion by inwardly nipped dimple portions of the glass.



13. A vacuum switch according to claim 1, in which the contacts are encircled by a cylindrical shield having on its inside a metallic mesh for enhancing the adhesion of evaporated contact material to the shield.

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U.S. Cl. X.R.

75—149; 200—166