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Description

This invention relates to a method for processing a vacuum switch utilizing an axial magnetic field in which a contact piece made of a copper-chromium alloy is specifically processed to improve the surface condition thereof.

Vacuum switches utilizing an axial magnetic field are widely known in the art. FIG. 1 illustrates a typical construction of the conventional vacuum switch. In this construction, a vacuum vessel 1 made of a substantially tubular insulating material has two ends closed by flanges 2 and 3. A stationary electrode S and a movable electrode M are provided in the vessel 1 opposingly, and supported by current carrying rods 4 and 5 that penetrate the flanges 2 and 3 in an air-tight manner. The stationary electrode S comprises a main electrode 6 and a coil electrode 7, while the movable electrode M comprises a main electrode 8 and a coil electrode 9. The electrodes 6, 7, 8 and 9 are basically made of copper. The current carrying rod 5 supporting the movable electrode M is driven in its axial direction by a driving device, not shown. Bellows 10 is provided for ensuring an air-tight condition during the movement of the rod 5 through the flange 3. The coil electrodes 7 and 9 produce an axial magnetic field in parallel with the arc created between the main electrodes 6 and 8 at the time of current interruption. A shield 12 is further provided in the vacuum vessel 1 for preventing deposition of metal vapor created during current interruption on the internal surface of the vessel 1, and further preventing deterioration of the insulation and ultimate damage of the vessel 1.

Both of the electrodes M and S are basically of a similar construction. FIG. 2 illustrates the movable electrode M having the main electrode 8 comprising an electrode 14 and a contact piece 13 secured to the upper surface of the electrode 14. in order to improve the impact-resisting and current interrupting capability and the fusion resisting property of the contact piece 13, various copper alloys are used for producing the contact piece 13. In the above described vacuum switch wherein an axial magnetic field is provided for preventing concentration of arc and improving the current interrupting capability, radial slits 15 are formed along the upper surface of the contact piece 13, as viewed in FIG. 2, so as to improve efficiency of the magnetic field. Furthermore, the coil electrode 9 has a portion formed into a coil which extends circumferentially in a plane perpendicular to the central axis of the current carrying rod 5 for generating the axial magnetic field.

In the above described construction of the conventional vacuum switch, the contact piece 13 made of a copper alloy tends to absorb impurities such as oxygen and hydrogen more than the remaining portions of the electrode M made of copper. Since the impurities tend to react with the copper alloy to form compounds, the impurities cannot be removed easy. Although various methods have been proposed for removing the impurities, methods utilizing glow discharge which is caused by applying a voltage across the electrodes, or utilizing arc which is produced by flowing an electric currrent through the electrodes are widely used. However, either of the methods requires in considerable length of time which is varied in accordance with the amount of the surface area of the contact piece. Furthermore the impurities contained in the slits 15 and nearby area could not be removed satisfactorily even by the application of the above described methods.

US—A—4420346 discloses a technique of subjecting a contact to be processed to a concentrated thermal flux of 10^4 to 10^6 W/cm^2 in a vacuum or in the environment of an inert gas for 21 to 100 ms and then subjecting the contact to cooling at a cooling rate ranging from 10^4 to 10^6 K/s.

Summary of the invention

An object of this invention is to provide a method for producing a vacuum switch wherein the above described difficulties can be eliminated substantially.

Another object of the invention is to provide a method for producing a vacuum switch wherein the impurities absorbed in the contact piece can be removed effectively and any defects presenting on the surface of the contact piece can be eliminated sufficiently.

These objects are achieved by a method according to the claim.

Brief Description of the Drawings

In the accompanying drawings:

FIG. 1 is a longitudinal sectional view of a conventional vacuum switch;

FIG. 2 is a perspective view showing a movable electrode of the conventional vacuum switch shown in FIG. 1;

FIG. 3 is a perspective view showing a novel construction of an electrode provided in accordance with this invention;

FIG. 4 is a diagram for explaining the method of this invention;

FIG. 5 is a diagram showing an advantageous effect of this invention; and

FIG. 6 is a plan view showing another embodiment of this invention.

Description of the Preferred Embodiments

The invention will now be described with reference to FIGS. 3 through 6.

Since the movable electrode M and the stationary electrode 5 provided in a vacuum vessel are basically constructed in a similar manner to that described hereinbefore, only the movable electrode M is illustrated in FIG. 3 which comprises a main electrode 8 and a coil electrode 9 supported by a current carrying rod 5. The main electrode 8 further comprises an electrode portion 14 and a contact piece 16 secured on the surface of the electrode portion 14. According to this invention, the contact piece 16 is made of a copper-chromium alloy containing chromium in a range of 20—70%, preferably 25—55% by weight, and formed into a planar configuration. Preferably, the surface area of the contact piece 16 is selected about or less than 30% of the surface area of the central portion of the electrode portion 14.

The movable electrode M of the above described construction is assembled in a vacuum vessel shown in FIG. 1 together with a stationary electrode S of a similar construction with or without the contact piece, and air is removed out of the vessel while the thus assembled switch is subjected to a baking process. Then an electric current of a currrent density higher than 1000 A/cm^2 (in effective value) is caused to flow through the electrodes M and S and interrupted several times while maintaining the movable electrode M having the contact piece 16 to be anode and the stationary electrode S to be cathode, thereby creating arc between the two electrodes for eliminating the impurities and improving the surface condition of the contact piece.

Then an electric current of a current density ranging from 500 to 1000 A/cm^2 (in effective value) is cause to flow through the electrodes and interrupted several times preferably 2—3 times and less than 10 times, while maintaining the movable electrode M to be cathode and the stationary electrode S to be anode, thereby creating arc between the two electrodes for creating a recrystallized layer on the surface of the contact piece.

Impurities contained in the electrodes made of copper can be removed comparatively easily by the baking process carried out during the air exhausting process. However, the impurities contained in the contact piece 16 made of copper-chromium alloy cannot be removed sufficiently by the baking process because chromium easily combines with oxygen. The first mentioned arc discharging process is thus required for eliminating impurities from the contact piece made of copper-chromium alloy.

Since the time and energy required for accomplishing the arc discharging process increase in proportion to the surface area of the contact piece 16, a smaller surface area thereof is advantageous from an economical point of view.

The surface area of the contact piece 16 is reduced to approximately 30% of the surface area of the electrode portion 14 supporting the contact piece 16 for economizing the arc discharging process.

Since the reduction of surface area of the contact piece reduces the current interrupting capability of the vacuum switch, the above-described surface area of 30% is found to be advantageous for compromizing the two requirements.

By carrying out the first-mentioned arc discharging process after the baking process, large amount of metal vapor is delivered from the cathode as shown in FIG. 4, most part of which is deposited on the surface of the opposite electrode 6. Since the defects ordinarily presenting on the copper surface have been substantially eliminated by the baking process, a layer 18 consisting of cooper and chromium and therefore having a high impact-resisting property is deposited on the copper surface of the opposite electrode 6 substantially free from the defects.

At the same time, the defects presenting on the surface of the contact piece 16 are melted by the energy supplied to the anode and eliminated from the surface of the contact piece 16. The layer 18 formed by a single interruption step of the current is thin and weak, easily evaporated by the arc produced during ordinary interrupting operations of the vacuum switch. For this reason, the interruption process utilizing the heavy current density must be repeated several times for increasing the thickness and strength of the deposited layer 18.

The second-mentioned arc discharging process at a current density ranging from 500 to 1000 A/cm^2 with the contact piece 16 utilized as a cathode then produces a recrystallized layer 19 on the surface of the contact piece 16, as shown in FIG. 5, whose defects have been eliminated as described before, thereby smoothing the surface of the contact piece 16. At this time, one part of the copper-chromium layer 18 deposited on the surface of the opposing stationary electrode S is vaporized again to be deposited on the contact piece 16 and nearby area. Since no large amount of energy is required in this process, the current density utilized in the process is held in a range of from 500 to 1000 A/cm^2. After execution of the arc discharging processes, the surface of the contact piece 16 is made smooth and clean having substantially no defects, and a copper-chromium layer is deposited all over the electrodes of the vacuum switch inclusive of the interior of the slits 15, and particularly with a thickness of about seveal tens μm or less than 100 μm on the contact piece 16, so that the impact-resisting property and the current interrupting property of the electrodes can be substantially improved.

Furthermore, the reduction in size of the contact piece 16 renders the formation of the slits thereon to be utterly unnecessary, thereby reducing the source of trouble to produce defects.

Since the electrodes are basically made of copper from which any defect can be eliminated easily, while a small amount of copper-chromium material, which is superior in the impact-resisting and current-interrupting properties, is utilized in the contact piece, the time and cost required for removing defects in the copper-chromium material can be significantly reduced. Furthermore, by executing arc discharging processes in a predetermined sequence, a copper-chromium layer is deposited to cover most part of the surfaces of the electrodes, thereby providing a vacuum switch of high impact resistivity and high current-interrupting property in a comparatively simple manner.

Although an embodiment utilizing a contact piece of a circular disc-like configuration has been described. It is apparent that the invention is not necessarily restricted to such an embodiment, and a contact piece of, for instance, a rounded cross shape as shown in FIG. 6 adapted to the arrangement of the slits 15 may also be utilized. Although the contact piece is ordinarily provided at the center of the electrode 14, the contact piece may otherwise be provided at an off-center position. The electrode 14 made of copper may also be constructed into any suitable configuration other than the above described circular planar configuration so far as a contact piece of a small surace area can be provided on the electrode.

Furthermore, a plurality of contact pieces may be provided on the electrode 14 instead of the above described single contact piece 16, so far as the copper-chromium material can be deposited evenly on the surfaces of the plurality of contact pieces.

Claims

1. A method for processing a contact (16) made of a copper-chromium alloy used in a vacuum switch of a type comprising a vacuum vessel (1), a pair of relatively separable electrodes (M, S) arranged along a central axis of said vessel (1), a coil electrode (9) provided in each of said electrodes (M, S) for producing an axial magnetic field in parallel with the central axis of said vessel (1), and a pair of current carrying rods (4, 5) extending outwardly from said electrodes (M, S) in an air-tight manner, said contact (16) being secured onto a surface of at least one of said electrodes (M, S), said vessel (1) being closed thereafter for removing air out of the vessel (1), **characterized by** the steps of causing an electric current of a density higher than 1 000 A/cm^2 to flow through the electrodes (M, S) in repetition under the effect of the axial magnetic field produced by said coil electrode (9) while maintaining an electrode having said contact (16) as an anode, and then causing an electric current of a density ranging from about 500 to 1 000 A/cm^2 to flow through the electrodes (M, S) in repetition under the effect of the axial magnetic field while maintaining the electrode having said contact as cathode.

Patentansprüche

1. Verfahren zur Behandlung eines aus einer Kupfer-Chrom-Legierung bestehenden Kontaktes (16) eines Vakuumschalters mit einem Vakuumgefäß (1), einem Paar relativ voneinander trennbarer Elektroden (M,S), die in Richtung einer Mittelachse des Gefäßes (1) angeordnet sind, mit einer in jeder der Elektroden (M,S) vorgesehenen Spulenelektrode (9) zu Erzeugung eines parallel zur Mittelachse des Gefäßes verlaufenden axialen Magnetfeldes und mit einem Paar stromführender, sich von den Elektroden (M,S) luftdicht nach auswärts erstreckender Stangen (4,5), wobei der Kontakt (16) auf der Oberfläche wenigstens einer der Elektroden (M,S) befestigt ist und wobei anschließend das Gefäß (1) geschlossen wird, um Luft aus dem Gefäß zu entfernen, **gekennzeichnet durch** folgende Schritte: wiederholtes Erzeugen eines elektrischen Stromflusses mit einer Stromdichte von mehr als 1000 A/cm^2 durch die Elektroden (M,S) unter der Einwirkung des durch die Spulenelektrode (9) erzeugten axialen Magnetfeldes, wobei eine den Kontakt (16) enthaltende Elektrode als Anode beibehalten wird, und anschließendes wiederholtes Erzeugen eines elektrischen Stromflusses mit einer Stromdichte im Bereich von 500 bis 1000 A/cm^2 durch die Elektroden (M,S) unter der Einwirkung des axialen Magnetfeldes, wobei die den Kontakt (16) enthaltende Elektrode als Kathode beibehalten wird.

Revendications

1. Procédé de traitement d'un contact (16) fait d'un alliage cuivre-chrome utilisé dans un interrupteur sous vide d'un type comprenant une enceinte sous vide (1) , une paire d'électrodes (M,S) pouvant être mutuellement séparées qui sont disposées le long de l'axe central de ladite enceinte (1), une électrode de bobine (9) placée dans chacune desdites électrodes (M,S) afin de produire un champ magnétique axial parallèle à l'axe central de ladite enceinte (1), et une paire de tiges de transport de courant (4,5) so prolongeant vers l'extérieur depuis lesdites électrodes (M,S) de manière hermétique, ledit contact (16) étant fixé sur une surface d'au moins une desdites électrodes (M,S), après cela ladite enceinte (1) étant fermée pour retirer l'air de ladite enceinte (1), caractérisé par les opérations qui consistent à faire circuler dans les électrodes (M,S), de manière répétée, un courant électrique d'une densité supérieure à 1000 A/cm^2 sous l'effet du champ magnétique axial produit par ladite électrode de bobine (9) tout en gardant une électrode possédant ledit contact (16) comme anode, puis à faire circuler dans les électrodes (M,S), de manière répétée, un courant électrique d'une densité compris entre 500 et 1000 A/cm^2 environ sous l'effet

du champ magnétique axial tout en gardant l'électrode qui possède ledit contact (16) comme cathode.

FIG. 1
PRIOR ART

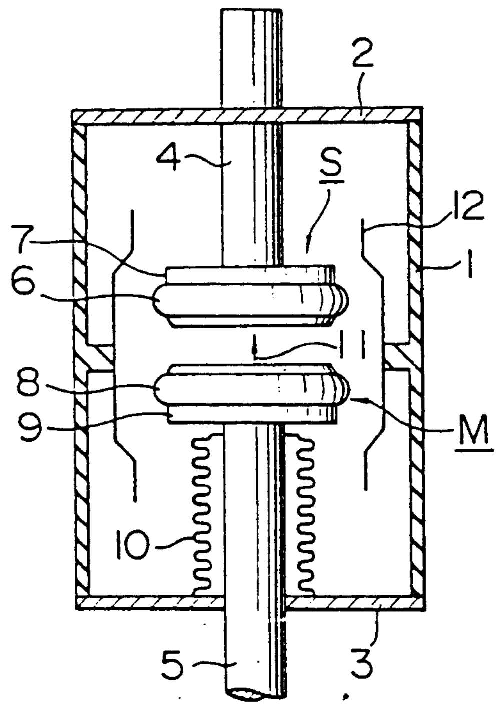

FIG. 2
PRIOR ART

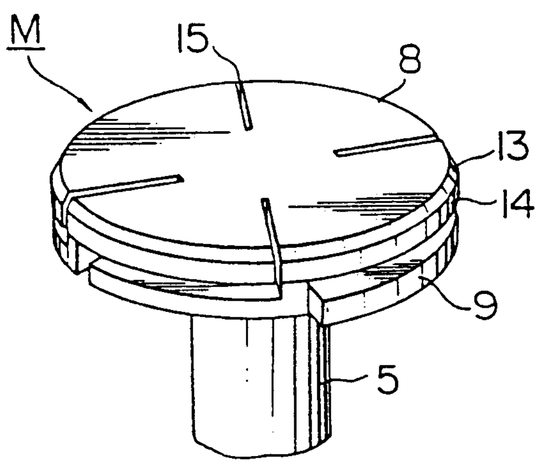

FIG. 3

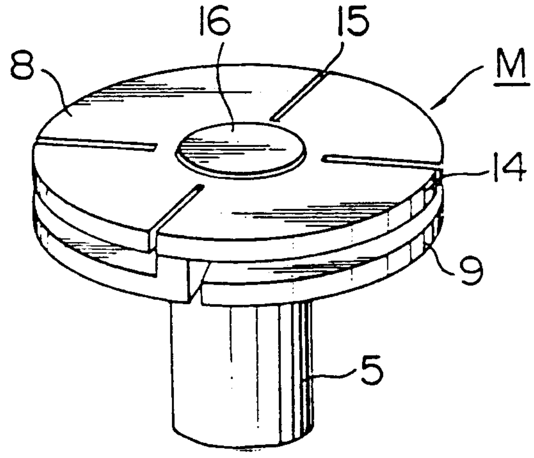

FIG. 4

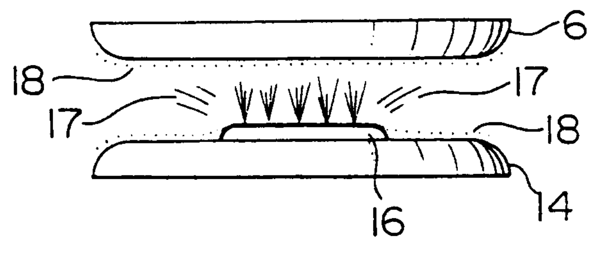

FIG. 5

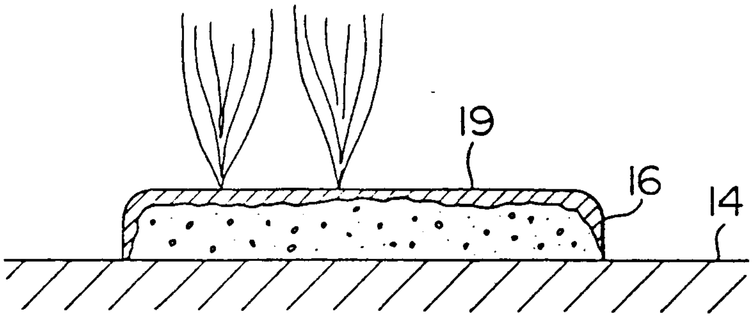

FIG. 6