

[54] VACUUM INTERRUPTER WITH CONTACTS CONTAINING A MINOR PERCENTAGE OF ALUMINUM

[72] Inventors: Fordyce H. Horn, deceased, late of Schenectady, N.Y. by Helen W. Horn, executrix; Joseph W. Porter; Joseph L. Talento, both of Media, Pa.

[73] Assignee: General Electric Company

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[58] Field of Search200/144 B, 166 C

[56]

References Cited

UNITED STATES PATENTS

2,975,255	3/1961	Lafferty.....	200/144 B
3,497,652	2/1970	Horn et al.	200/144 B

Primary Examiner—Robert S. Macon

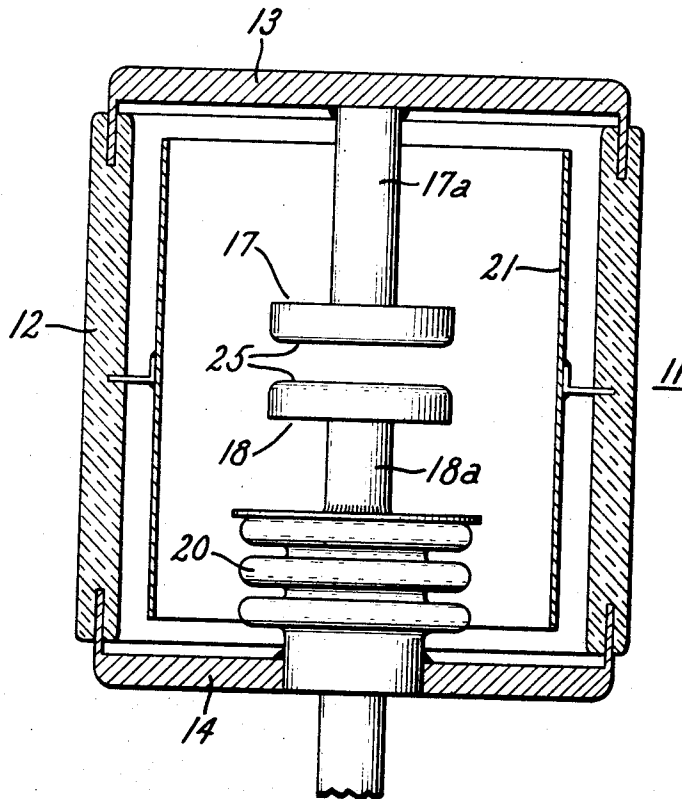
Attorney—J. Wesley Haubner, William Freedman, Frank L. Neuhauser, Oscar B. Waddell and Joseph B. Forman

[57]

ABSTRACT

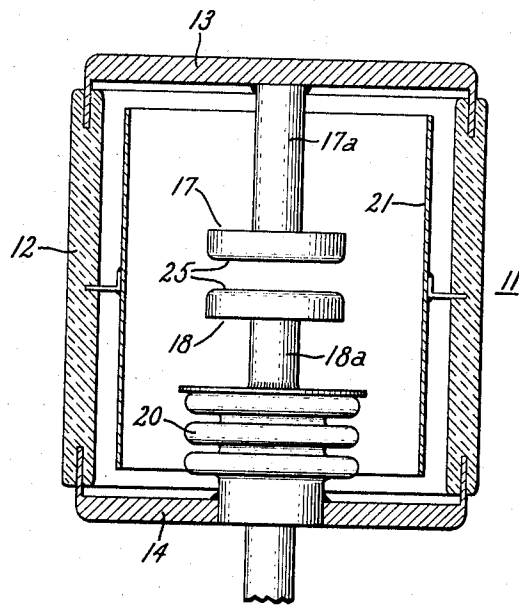
Discloses a vacuum-type electric circuit interrupter having its contacts formed of a porous refractory metal matrix and an alloy filling the pores of the matrix consisting essentially of copper, aluminum, and bismuth. In the alloy, the aluminum is present in a quantity of between 9 and 15 percent by weight of copper-aluminum, and the bismuth is present in a quantity of less than 5 percent by weight of the total alloy.

11 Claims, 1 Drawing Figure



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VACUUM INTERRUPTER WITH CONTACTS CONTAINING A MINOR PERCENTAGE OF ALUMINUM

In our U.S. Pat. No. 3,497,652, there is disclosed and claimed a vacuum-type electric circuit breaker having contacts formed of an alloy consisting essentially of copper, aluminum, and a weld-inhibiting metal, such as bismuth, that is substantially insoluble in copper or in aluminum in the solid state. Contacts having their circuit-making and breaking regions formed entirely of such an alloy have been found to provide exceptional ability to withstand a high transient voltage immediately following a contact-separating operation that fractures a weld between the contacts. Such ability is of special importance during capacitance switching operations inasmuch as a voltage building up to twice normal peak voltage is applied between the contacts during the half-cycle following arc-extinction at current zero.

Contacts having their circuit-making and breaking regions formed entirely of this alloy are, however, subject to the disadvantage that their operational life may be too short, because of arc erosion, to permit their commercial use for highly repetitive switching applications.

An object of the present invention is to impart to such contacts increased operational life without losing their exceptional ability to withstand high transient voltages immediately following contact separation which fractures a weld.

In carrying out the invention in one form, we form the vacuum interrupter contacts of a porous refractory metal matrix and an alloy of copper, aluminum, and bismuth filling the pores of the matrix, the aluminum being present in a quantity of between 9 and 15 per cent by weight of the copper-aluminum and the bismuth being present in a quantity of less than 5 per cent by weight of the copper-aluminum-bismuth alloy, preferably about 1 percent.

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 represents one embodiment of the present invention.

Referring now to the drawing, there is shown a vacuum-type circuit interrupter comprising a sealed envelope 11 evacuated to a pressure of 10^{-4} torr or lower. The envelope 11 comprises a tubular casing 12 of insulating material and a pair of metal end caps 13 and 14 suitably sealed to the opposite ends of casing 12.

Within the evacuated envelope 11 there are a pair of separable disc-shaped contacts 17 and 18. Contact 17 is a stationary contact brazed to the lower end of a stationary conductive contact rod 17a; and contact 18 is a movable contact brazed to the upper end of a vertically movable conductive rod 18a. The movable contact rod 18a projects freely through an opening in the lower end cap 14, and a flexible metal bellows 20 provides a suitable seal thereabout that allows vertical movement of the contact rod 18a without impairing the vacuum inside envelope 11.

All of the internal parts of the interrupter are substantially free of surface contaminants. These clean surfaces are obtained by suitable conventional vacuum processing, which involves baking-out the interrupter during its evacuation.

Closing of the interrupter is effected by driving the contact rod 18a in an upward direction to drive movable contact 18 into engagement with stationary contact 17. Opening is effected by returning the movable contact from its engaged position downwardly to its solid line position shown. When the contacts are separated during an opening operation, an arc is drawn therebetween. Assuming an alternating current, this arc persists until a natural current zero, at which time it vanishes and is prevented from reigniting by the high dielectric strength of the vacuum in the envelope 12. A suitable metal shield 21 of tubular form surrounds the contact to condense the metal vapors generated by the arc, thus assisting in the interrupting process. A typical gap length when the contacts are fully open is about one-quarter inch. The opposed forward faces 25 of the contacts 17 and 18 may be thought of as circuit-making and breaking regions of the contacts.

When the contacts are driven into engagement during closing, they may bounce apart slightly and draw an arc between their circuit-making and breaking regions 25 before being driven back into engagement. This arc tends to produce welding together of the contacts when they reengage under pressure. The contacts of a vacuum interrupter have a greater tendency toward such welding than those of other type interrupters because their surfaces are exceptionally clean and free of weld-inhibiting films.

One of the problems that the present invention is concerned with is providing an interrupter that can withstand high transient voltages immediately following a contact-separating operation that fractures a weld between the contacts. In the aforesaid U.S. Pat. No. 3,497,652, we disclose and claim a vacuum interrupter that has its contacts formed of an alloy of copper, aluminum and a weld-inhibiting metal, such as bismuth, that is substantially insoluble in copper and aluminum in the solid state and is distributed throughout the copper-aluminum. The aluminum is present in this alloy in a quantity of 9 to 15 percent by weight of the copper-aluminum and the bismuth in a quantity of below 5 percent. This alloy has shown exceptional ability to meet the above-described voltage-withstand requirement.

Contacts having their circuit-making and breaking regions formed entirely of this alloy are, however, subject to the disadvantage that their operational life may be too short, because of arc-erosion, to permit their commercial use for highly repetitive switching applications. We overcome this disadvantage, and, in particular, do so without losing the exceptional ability of the contacts to withstand a high transient voltage after weld-fracture by constructing the contacts 17 and 18 of a porous refractory metal matrix having its pores filled with the aforesaid alloy. As a specific example, we construct the contacts of a refractory metal matrix of tungsten having its pores filled with an alloy of copper-aluminum-bismuth, with the aluminum present in a quantity of 12 percent by weight of the copper-aluminum and the bismuth in a quantity of 1 percent by weight of the copper-aluminum-bismuth alloy. For the reasons explained in our aforesaid U.S. Pat. No. 3,497,652, the aluminum content of this alloy should be between about 9 and 15 percent by weight of the copper-aluminum. The bismuth content should be less than 5 percent by weight of the alloy and, preferably, as low as possible, consistent with the need to reduce contact-welding to an acceptable level. The bismuth is distributed throughout the copper-aluminum.

These contacts are made by employing the following steps in the sequence stated: (1) pressing tungsten powder in air to about 60 percent density; (2) sintering the pressed tungsten powder in hydrogen at a temperature of 2,300° F.; (3) impregnating the resultant structure in hydrogen with the copper-aluminum-bismuth alloy at about the same temperature; (4) cooling the composite in hydrogen to solidify the alloy; (5) reheating the composite in an inert gas such as argon to a sufficient temperature to remelt the alloy and for a sufficient period to accomplish degassing of the composite structure; (6) allowing the composite to cool in the argon atmosphere; and (7) machining off the excess material and machining to size. The alloy is substantially freed of gas before it is used to impregnate the tungsten. The degassing step, in driving off the hydrogen from the composite, leaves the composite substantially free of absorbed gas.

Although tungsten is preferred for the refractory metal, other refractory metals are also suitable for this purpose, e.g., molybdenum, tungsten carbide, and molybdenum carbide.

Although we have described the invention specifically with respect to a refractory metal matrix filled with an alloy of copper-aluminum-bismuth, the invention in its broader aspects is applicable to the other aluminum-containing alloys disclosed and claimed in our aforesaid patent. These other alloys are silver-aluminum-bismuth and silver-aluminum-lead, each containing about 5 to 10 per cent aluminum by weight of the silver-aluminum, and nickel-aluminum-bismuth, containing about 8 to 13 per cent aluminum by weight of the nickel-

aluminum. The tertiary metal is present in each of these alloys in less than 5 per cent by weight of the total alloy for weld-inhibiting purposes and is distributed throughout the alloy. The first-mentioned or major constituent of each alloy is referred to as the primary metal.

The weld-inhibiting agent in each of the alloys discussed hereinabove has a lower freezing temperature than the primary metal-aluminum alloy, is substantially insoluble in the other constituents of the alloy in the solid state, and is distributed throughout the alloy. In referring to weld-inhibiting agents that are substantially insoluble in the other constituents in the solid state, we are referring to weld-inhibiting metals that have a solid state solubility in the other constituents of less than about 2 percent by weight of the alloy considered at the eutectic temperature of said alloy or the freezing temperature of the weld-inhibiting constituent if there is no eutectic.

In those applications where a moderate amount of weld strength can be tolerated, the weld-inhibiting metal can be entirely, or almost entirely, eliminated from the final contact material. This can be done by performing the aforementioned manufacturing steps (5) and (6), i.e., the reheating and cooling steps, in a vacuum instead of in the argon atmosphere. The reheating in vacuum evaporates substantially all of the low-melting-point weld-inhibiting metal, e.g., bismuth, leaving the contact substantially free of the weld-inhibiting metal.

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

1. A vacuum-type electric circuit interrupter comprising:
 - a. an envelope evacuated to a pressure of 10^{-4} mm. of mercury or less,
 - b. a pair of contacts within said envelope relatively movable into and out of engagement,
 - c. said contacts being substantially free of absorbed gases and surface contaminants,
 - d. at least one of said contacts having its circuit-making and breaking regions formed of a porous refractory metal matrix and an alloy filling the pores of said matrix consisting essentially of copper-aluminum and bismuth,
 - e. the aluminum being present in a quantity of between 9 and 15 percent by weight of the copper-aluminum, and
 - f. the bismuth being present in a quantity of less than about 5 percent by weight of the total alloy and in a sufficient quantity to inhibit contact-welding, and being distributed throughout said alloy.
2. The vacuum-type circuit interrupter of claim 1 in which the aluminum is present in a quantity of between 11 and 13 percent by weight of the copper-aluminum.
3. The vacuum-type circuit interrupter of claim 1 in which the aluminum is present in a quantity of about 12 percent by weight of the copper aluminum.
4. The vacuum type circuit interrupter of claim 1 in which said refractory metal is tungsten.
5. A vacuum-type electric circuit interrupter comprising:
 - a. an envelope evacuated to a pressure of 10^{-4} mm. of mercury or less,
 - b. a pair of contacts within said envelope relatively movable into and out of engagement,
 - c. said contacts being substantially free of absorbed gases and surface contaminants,
 - d. at least one of said contacts having circuit-making and breaking regions formed of a porous refractory metal matrix and an alloy filling the pores of said matrix consisting essentially of copper-aluminum and a weld-inhibiting metal having substantially no solid-state solubility in copper or aluminum and having an effective freezing temperature below that of copper-aluminum,

- e. the aluminum being present in a quantity of between 9 and 15 percent by weight of the copper-aluminum, and
- f. the weld-inhibiting metal being present in a quantity of less than about 5 percent by weight of the total alloy and in a quantity sufficient to inhibit contact-welding, and being distributed throughout said alloy.
6. A vacuum-type electric circuit interrupter comprising:
 - a. an envelope evacuated to a pressure of 10^{-4} mm. of mercury or less,
 - b. a pair of contacts within said envelope relatively movable into and out of engagement,
 - c. contacts being substantially free of absorbed gases and surface contaminants,
 - d. at least one of said contacts having circuit-making and breaking regions formed of a porous refractory metal matrix and an alloy filling the pores of said matrix consisting essentially of copper-aluminum-bismuth, or silver-aluminum-bismuth, or nickel-aluminum-bismuth,
 - e. the aluminum being present in a quantity of: between 9 and 15 percent by weight of the copper-aluminum in the case of copper-aluminum-bismuth, between 5 and 10 percent by weight of the silver-aluminum in the case of silver-aluminum-bismuth, and between 8 and 13 percent by weight of the nickel-aluminum in the case of nickel-aluminum-bismuth,
 - f. the bismuth being present in a quantity of less than about 5 percent by weight of the total alloy and in a quantity sufficient to inhibit contact-welding, and being distributed throughout said alloy.
7. A vacuum-type electric circuit interrupter comprising:
 - a. an envelope evacuated to a pressure of 10^{-4} mm. of mercury or less,
 - b. a pair of contacts within said envelope relatively movable into and out of engagement,
 - c. said contacts being substantially free of absorbed gases and surface contaminants,
 - d. at least one of said contacts having its circuit-making and breaking regions formed of a refractory metal matrix and an alloy filling the pores of said matrix consisting essentially of: (1) copper-aluminum containing 9 to 15 percent by weight of aluminum, or (2) silver-aluminum containing 5 to 10 percent by weight of aluminum, or (3) nickel-aluminum containing 8 to 13 percent by weight of aluminum, and a weld-inhibiting metal,
 - e. said weld-inhibiting metal having substantially no solid-state solubility in the primary metal of the alloy or aluminum and having an effective freezing temperature below that of the primary metal-aluminum alloy,
 - f. said weld-inhibiting metal being present in a quantity less than about 5 percent by weight of the total alloy and in a quantity sufficient to inhibit contact welding, and being distributed throughout said total alloy.
8. A vacuum-type electric circuit interrupter comprising:
 - a. an envelope evacuated to a pressure of 10^{-4} mm. of mercury or less,
 - b. a pair of contacts within said envelope relatively movable into and out of engagement,
 - c. said contacts being substantially free of absorbed gases and surface contaminants,
 - d. at least one of said contacts having its circuit-making and breaking regions formed of a porous refractory metal matrix and an alloy filling the pores of said matrix consisting essentially of (1) copper-aluminum containing 9 to 15 percent by weight of aluminum, or (2) silver-aluminum containing 5 to 10 percent by weight of aluminum, or (3) nickel-aluminum containing 8 to 13 percent by weight of aluminum.
9. The vacuum-type circuit interrupter of claim 8 in which said alloy consists essentially of copper-aluminum.
10. The vacuum-type circuit interrupter of claim 8 in which said alloy consists essentially of silver-aluminum.
11. The vacuum-type circuit interrupter of claim 8 in which said alloy consists essentially of nickel-aluminum.