April 29, 1969 J. C. SOFIANEK 3,441,698

VACUUM-TYPE CIRCUIT INTERRUPTER

Filed Oct. 3, 1966

FIG. 1.

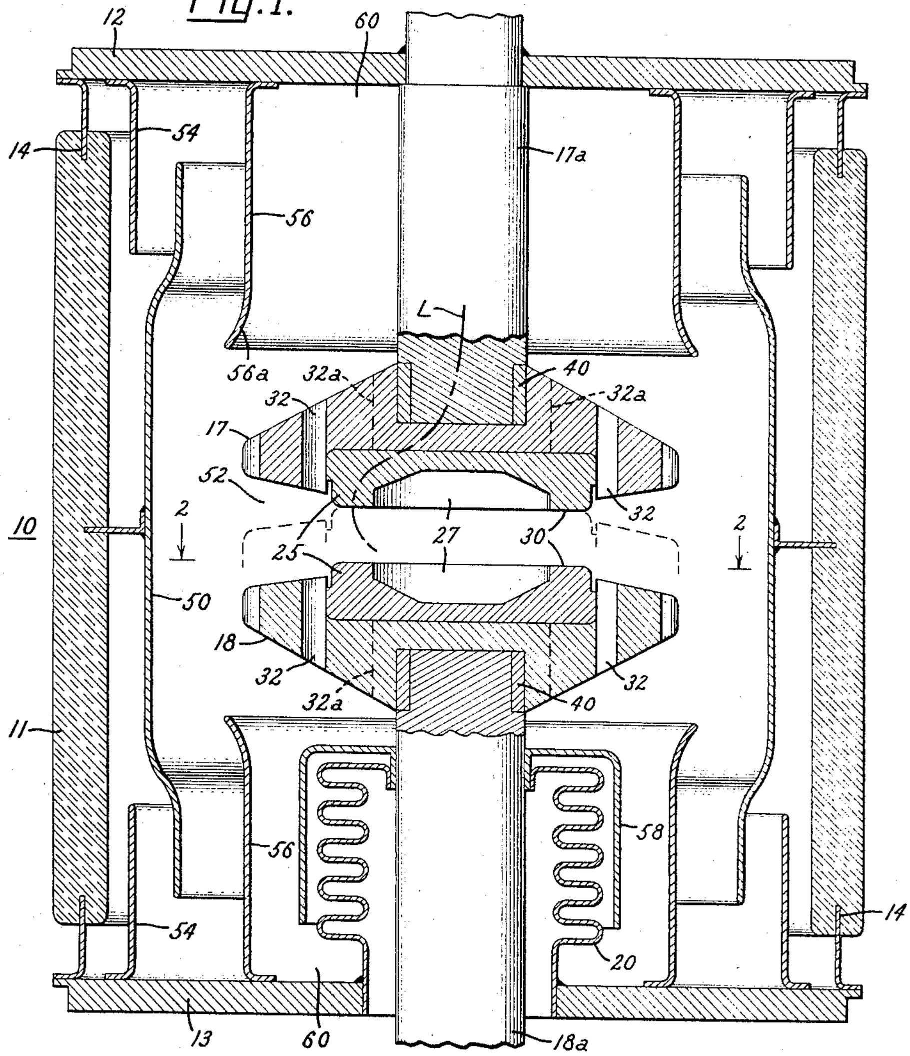
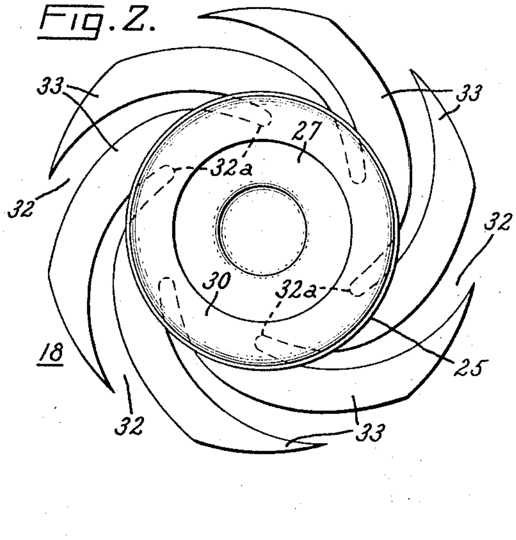


FIG. 2.



INVENTOR:
JOSEPH C. SOFIANEK,

BY William Freedman
ATTORNEY

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VACUUM-TYPE CIRCUIT INTERRUPTER

Joseph C. Sofianek, Broomall, Pa., assignor to General Electric Company, a corporation of New York

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U.S. Cl. 200—144 6 Claims

This invention relates to a vacuum-type circuit interrupter and, more particularly, relates to improved shielding structure for protecting the insulation of such an interrupter from being impaired by the condensation thereon of arc-generated metallic vapors.

It is customary to protect the tubular insulating housing of a vacuum-type circuit interrupter from such vapor-condensation by providing some form of shielding, preferably of metal, located between the insulating housing and the arcing gap of the interrupter. This shielding is intended to intercept and condense arc-generated vapors before they can reach the insulating housing, thus preventing the vapors from condensing on and coating the insulation with metallic particles. The present invention is especially concerned with vapor-condensing shielding of the general type disclosed and claimed in U.S. Patent 2,892,912, Greenwood et al., assigned to the assignee of the present invention. This shielding comprises (1) a main shield of tubular form surrounding the arcing gap and maintained at a potential intermediate that of the electrodes of the interrupter and (2) a pair of auxiliary shields of tubular form respectively surrounding the opposite ends of the main shield and electrically connected to the electrodes. The auxiliary shields act to intercept metal vapors that might otherwise bypass the main shield and also provide a desired distribution of the electric field at the ends of the interrupter.

When the above-described shielding is employed in interrupters that are used for extreme high currents it has been found that small amounts of metal have still reached the insulating envelope despite the shielding. The quantity of such metal is minute, but even this minute quantity seems to detrimentally affect the interrupting ability of the interrupter.

An object of the present invention is to improve the ability of the shielding to condense metal vapors that tend to bypass the main shield.

Another object is to force any sparkover between the main shield and adjacent structure to occur in a location where there is a reduced chance for coating the insulating envelope with metal particles generated by the spark.

Another object is to condense a large portion of the arc-generated vapors projected toward the ends of the main shield in a region that is essentially free of electrical stress.

In carrying out the invention in one form, I provide a main vapor-condensing metal shield of tubular form surrounding the usual arcing gap of the interrupter. This main shield extends longitudinally of the tubular insulating casing of the interrupter for substantial distances on opposite sides of the arcing gap and is maintained at a potential intermediate that of the interrupter's electrodes following interruption. A first pair of auxiliary metal shields of generally tubular form respectively surround the ends of the main shield and are spaced radially outward therefrom. These auxiliary shields are respectively connected to the electrodes of the interrupter. In combination with this shielding, I provide additional auxiliary metal shields of generally tubular form that are respectively surrounded by said main shield at its opposite ends. These additional auxiliary shields are spaced radially inwardly from said main shield and are electrically connected to said electrodes.

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In a preferred form of the invention, the additional shields are so shaped that higher electrical stresses are present in the regions between these additional auxiliary shields and the main shield than are present between said first auxiliary shields and the main shield.

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

FIG. 1 is a side elevational view in section of a vacuum-type interrupter embodying one form of the present invention.

FIG. 2 is a plan view taken along the line 2—2 of FIG. 1.

Referring now to FIG. 1, there is shown a vacuum-type circuit interrupter comprising an envelope **10** evacuated to a pressure of 10^{-4} mm. of mercury or lower. The envelope comprises a tubular casing **11** of insulating material and metal end caps **12** and **13** joined to the tubular casing **11** at its opposite ends by suitable vacuum-tight seals **14**.

Located within the envelope **10** is a pair of relatively movable contacts **17** and **18**, shown by the solid lines of FIG. 1 in their disengaged or open position. The upper contact **17** is a stationary contact suitably attached to a conductive rod **17***a*, which at its upper end is united to the upper end cap **12**. The lower contact **18** is a movable contact attached to a conductive operating rod **18***a*, which is suitably mounted for vertical movement. Upward movement of the contact **18** from its solid line position to its dotted line position engages the contacts and thus closes the interrupter, whereas return movement in a downward direction separates the contacts and opens the interrupter.

The operating rod **18***a* projects freely through an opening in the lower end cap **13**, and a flexible metallic bellows **20** provides a seal about rod **18***a* to allow for vertical movement of the rod without impairing the vacuum inside envelope **10**. As shown in FIG. 1, the bellows is secured in sealed relationship at its respective opposite ends to the operating rod **18***a* and the lower end cap **13**.

Although the present invention is applicable to interrupters having various types of contacts, I have illustrated it in connection with an interrupter having contacts of the type disclosed and claimed in my copending application Ser. No. 583,808, filed Oct. 3, 1966, and assigned to the assignee of the present invention. Accordingly, each of the illustrated contacts **17** and **18** is of a disc-shape and has one major surface facing the other contact. Each contact comprises a centrally located contact-making button **25** suitably brazed to the remainder of the contact. Each of these contact-making buttons is provided with a centrally located recess **27** so that contact between the buttons occurs on an annular contact-making area **30** when then contacts are in their dotted-line engaged position of FIG. 1. These annular contact-making regions **30** are of such a diameter that current flowing through the closed contacts follows a radially outwardly bowing loop-shaped path L, as is indicated by the dot-dash line of FIG. 1. The magnetic effect of current flowing through this loop-shaped path L tends in a well-known manner to lengthen the loop. As a result, when the contacts are separated to form an arc between the areas **30**, the magnetic effect of the current through the loop will impel the arc radially outward.

As the terminals of the arc move toward the outer periphery of the discs **17** and **18**, the arc is subjected to a circumferentially acting magnetic force that rotates the arc about the central axis of the discs. This circumferentially acting magnetic force is produced by a plurality of slots **32** provided in each of the discs and dividing the discs into a plurality of fingers **33** bounded by adjacent pairs of slots. The slots extend from the outer periphery of the discs radially inward by paths that extend both circumferentially and radially of the discs, as is shown in FIG. 2. These slots **32** correspond to similarly designated slots in the U.S. Patent 2,949,520 Schneider and, thus, force the current flowing to or from an arc terminal on the slotted portion of the contact to follow a path that has a component extending circumferentially of the disc in the vicinity of the arc. This circumferential component of the current path causes current flowing through the loop L to develop a net circumferentially acting force component which tends to rotate the arc about the central axis of the disc.

This circumferentially acting force component is high enough to drive each terminal of the arc across slots **32**, thus producing a continuous rotational movement of the arc on the contact surface. This continuous rotational movement of the arc enables higher currents to be interrupted, apparently because it reduces contact-erosion by the arc, thus reducing the quantity of metal vapors generated and thereby permitting more complete condensation of the metal vapors at current zero.

For condensing the metal vapors that are generated by the arc, I provide vapor-condensing metal shielding **50, 54, 56** and **58**. This shielding comprises a tubular main shield **50** surrounding the arcing gap **52** and located between the insulating casing **11** and the arcing gap. This main shield **50** extends longitudinally of casing **11** for substantial distances on opposite sides of the arcing gap **52**. Preferably, the tubular main shield **50** has an enlarged diameter in the region around the contacts **17** and **18**, as compared to its diameter near its ends, so as to give added clearance between the shield and the contacts **17, 18**. The main shield **50** is suitably supported on the insulating casing **12** and is maintained at a voltage approximately midway that of the contact **17** and **18** when the interrupter is opened. In the illustrated form of the invention, this midpotential relationship is provided by relying upon the substantially equal capacitances present between the shield and opposite ends of the interrupter.

Surrounding the main shield **50** at its respective opposite ends are auxiliary shields **54** of the general type shown in the aforesaid Greenwood et al. patent. These auxiliary shields **54** are electrically connected to the end caps **12** and **13**, respectively, and therefore are at the same potential as the contacts **17** and **18**, respectively. Each of these auxiliary shields **54** is of a generally tubular form and surrounds the end of the main shield **50** in radially-spaced relationship. These auxiliary shields **54** serve to intercept and condense metal vapors that might bypass the primary shield **50** at its ends. The auxiliary shields **54** also serve to relieve the seals **14** of voltage stresses.

Located radially inwardly of the main shield **50** at its opposite ends are additional auxiliary shields **56**. These additional shields **56** are also of a generally tubular form and are electrically connected to end caps **12** and **13**, respectively. Thus, the upper auxiliary shield **56** is at the same potential as upper contact **17**, and the lower shield at the same potential as lower contact **18**.

Each of the auxiliary shields **56** surrounds a space **60** that has one end open, i.e., the end facing the contacts, and its other end closed off by an end wall of the interrupter. At each end of the interrupter, the auxiliary shields **54** and **56** are both spaced from the main shield.

An additional shield **58** of cup-shaped form is provided about the bellows **20** to protect the bellows from the arc-generated products.

When an arc is formed across the gap **52** during interruption, most of the metallic vapors generated by the arc are projected radially outward from the arcing gap and are condensed on the inner surface of the main shield **50**. In the illustrated interrupter, however, a relatively large quantity of metal vapors is also projected from gap **52** through the slots **32** in directions longitudinal of insulating casing **12**. A high percentage of these longitudinally directed vapors are trapped within the spaces **60** surrounded by the two auxiliary shields **56**. In the case of the upwardly directed vapors, most of these trapped vapors are intercepted and condensed either by the inner surface of the upper auxiliary shield **56** or by the lower surface of end cap **12**. This trapping and condensation precludes these vapors from finding a path around the upper end of main shield **50**, thus preventing them from reaching insulating casing **12**. In the case of the downwardly directed vapors, the vapors trapped within lower space **60** are condensed either on the inner surface of lower auxiliary shield **56**, the upper surface of end cap **13**, or the outer surface of the shield **58** for the bellows. This condensation prevents these vapors form finding a path around the lower end of main shield **50**.

It is to be noted that each of the spaces **60** is a region of very low, virtually zero, electric stress since it is bounded on substantially all sides, except the open side facing the contacts, by metal parts at the same potential. Even on the open side of space **60**, the contact thereadjacent is at the same potential as the auxiliary shield **56**, thereby precluding the entry into space **60** of a significant electric field. This very low electric stress greatly reduces the tendency for a sparkover to develop between the surface of the metal condensate on the walls of space **60** and an adjacent part such as main shield **50**. Such sparkovers, even though they are usually self-extinguishing, seem to detract from the interrupting ability of the interrupter. Without the auxiliary shields **56**, there is a significant chance for such a sparkover since the condensate has a rather rough surface that is conducive to the initiation of sparkover.

If a sparkover does occur between the main shield **50** and an adjacent part, it is most desirable that it be located within the space bounded by the main shield **50** rather than outside this space. This is the case because the sparkover, even though it usually quickly extinguishes itself, generates some metallic vapors which are more likely to reach the casing **11** if the spark is outside the main shield **50**. To encourage any sparkover involving main shield **50** to be located inside the main shield **50**, I shape each of the inner auxiliary shields **56** so that the maximum electric stress between the main shield **50** and inner auxiliary shields **56** is greater than that between main shield **50** and the outer auxiliary shields **54**. To this end, I provide each auxiliary shield **56** with a flared portion **56*a*** at its free end that forms a region thereadjacent where the electrical stress is higher than in any region located between shields **50** and **54**. The relatively small diameter of the auxiliary shield **56** compared to that of auxiliary shield **54** also contributes to the higher stress adjacent portion **56*a*** of the inner shield **54**.

While I have shown and described a particular embodiment 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. A vacuum-type circuit interrupter comprising:

(a) a highly evacuated envelope comprising a tubular casing primarily of insulating material,

(b) a pair of electrodes within said casing defining an arcing gap therebetween across which arcs are established during a circuit-interrupting operation,

(c) a main vapor-condensing metal shield of tubular form surrounding said arcing gap and extending longitudinally of said tubular casing for substantial distances on opposite sides of said gap,

(d) means for maintaining said main shield at a potential intermediate that of said electrodes following interruption,

(e) a first pair of auxiliary metal shields of generally tubular form respectively surrounding the ends of said main shield and spaced radially outward therefrom,

(f) means for respectively electrically connecting said auxiliary shields to said electrodes,

(g) a pair of additional auxiliary metal shields of generally tubular form respectively surrounded by said main shield at its opposite ends,

(h) said additional auxiliary shields being spaced radially inward from said main shield and being electrically connected to said electrodes.

2. A vacuum-type circuit interrupter as defined in claim **1** in which each of said electrodes has openings therein through which metallic vapors are expelled from said arcing gap longitudinally of said tubular casing during an interrupting operation.

3. The circuit interrupter of claim **1** in which the space bounded by each of said additional auxiliary shields has one end facing said electrodes that is open and another end remote from said electrodes that is substantially closed off by metallic structure extending thereacross.

4. A vacuum-type circuit interrupter as defined in claim **3** in which each of said electrodes has openings therein through which metallic vapors are expelled from said arcing gap longitudinally of said tubular casing during an interrupting operation.

5. A vacuum-type circuit interrupter as defined in claim **1** in which said auxiliary shields are so shaped that when said interrupter is open, higher electrical stresses are present in the regions between said main shield and said additional auxiliary shields than in any region between said main shield and said first pair of auxiliary shields.

6. The vacuum type circuit interrupter of claim **5** in which at least one of said additional auxiliary shields has a flared portion at its free end surrounded by said main shield, where the highest electric stress is present between said main shield and said one additional auxiliary shield.

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ROBERT S. MACON, *Primary Examiner.*

U.S. Cl. X.R.

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