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VACUUM-TYPE CRCUIT INTERRUPTER WITH CONTACTS HAVING PARTICULARLY SHAPED CIRCUMFERENTIALLY SPACED SLOTS

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Fig. 1.

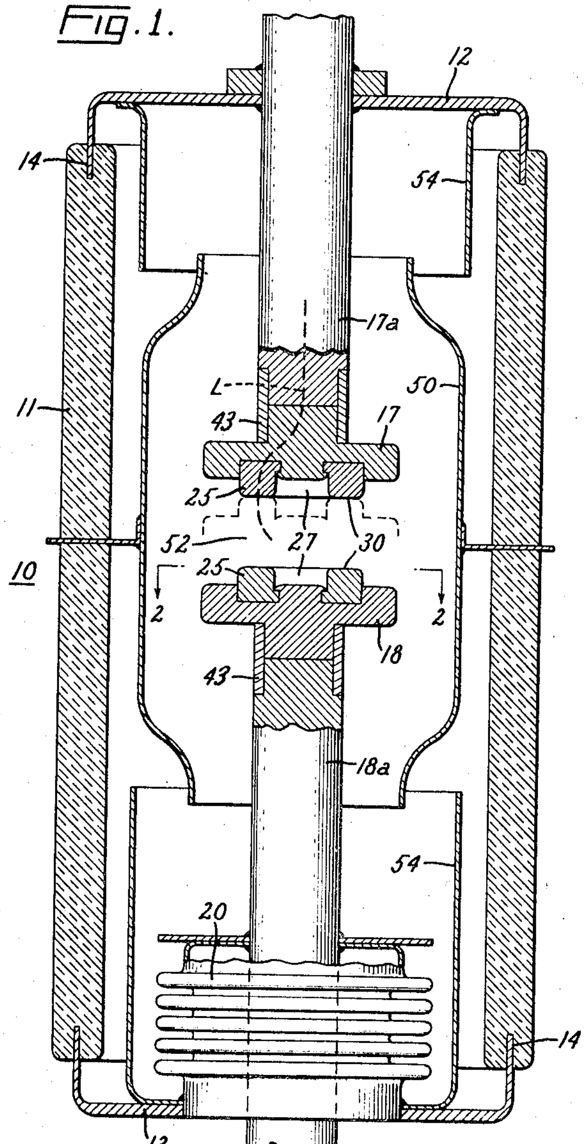


Fig. 2.

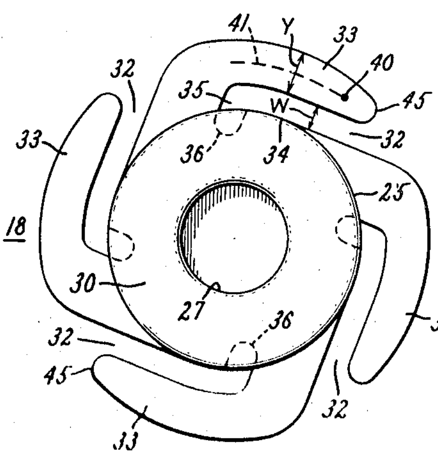
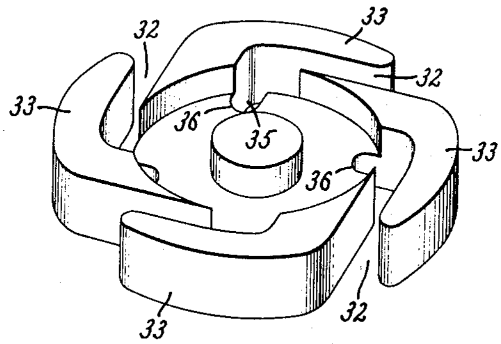


Fig. 3.



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VACUUM-TYPE CIRCUIT INTERRUPTER WITH CONTACTS HAVING PARTICULARLY SHAPED CIRCUMFERENTIALLY SPACED SLOTS

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ABSTRACT OF THE DISCLOSURE

Contact structure for a vacuum-type circuit interrupter comprising a disc-shaped contact having circumferentially spaced slots formed therein for producing arc-rotation. The slots extend substantially tangential to a large centrally-located contact-making button having an outer periphery concentric with the outer contact periphery. The slots are relatively wide, having an average width over half that of the circumferentially-extending fingers formed between the slots and the outer contact periphery.

This invention relates to a vacuum-type circuit interrupter and, more particularly, to contact structure for such an interrupter that is capable of interrupting very high currents for a small diameter of contact.

The invention is concerned with the general type of contact structure shown and claimed in U.S. Patent 2,949,520—Schneider, assigned to the assignee of the present invention. The contact of the Schneider patent comprises a disc-shaped member having a plurality of slots therein extending both radially and circumferentially of the disc member. These slots are used to produce an arc-rotating effect that forces arcs having a terminal located on the slotted potrion of the disc member to revolve about the central axis of the disc member. Centrally of the disc member there is a contact-making region where arcs are initiated during circuit interrupting operations. Such an arc is magnetically driven radially outward off of the contact-making region; and as it approaches the outer periphery of the disc member, it is rotated by the arc-rotating action produced by the slots in the disc member.

While the slot configuration disclosed in the Schneider patent has been found effective in increasing the amount of current that can be interrupted by contacts of a given diameter, there is an upper current limit beyond which these contacts will not successfully interrupt.

An object of my invention is to construct the contacts in such a manner that currents above this current limit can be successfully interrupted with a contact of equal diameter.

In carrying out my invention in one form, I provide a pair of disc-shaped contacts having a substantially circular outer periphery and a pair of contact-making buttons respectively secured to said contacts, each having a substantially circular outer periphery concentric with the outer periphery of its associated contact. The contact-making buttons have a diameter greater than one-half that of the disc-shaped contacts. Each contact is provided with circumferentially-spaced slots extending from a starting point at the outer periphery of the contact substantially tangent to the outer periphery of the button to provide circumferentially-extending finger portions between the slots and the outer contact periphery. The slots have an average width of at least substantially half of the average widht of the fingers. Each slot extends away from its starting point at the outer periphery of the contact for a substantial distance past the point at which the slot first touches the outer periphery of the button.

At its innermost end, the slot has a portion extending transversely of the tangential portion of the slot past the outer periphery of said button to a point spaced radially-inwardly from said button periphery.

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 sectional side elevational view of vacuum interrupter embodying one form of the invention.

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

FIG. 3 is a perspective view of the contact structure of FIG. 2 with a portion thereof removed for clarity.

Referring now to FIG. 1, there is shown a vacuum-type circuit interrupter comprising a sealed envelope **10** evacuated to a pressure of 10^{-4} millimeters of mercury or lower. This envelope comprises a tubular casing **11** of insulating material and a pair of end caps **12** and **13** joined to opposite ends of the casing **11** 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, portion. 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**.

Each of the contacts **17** and **18** is of a substantially circular 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 the 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 the 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 dotted 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. To make the loop in the loop-shaped path sufficiently pronounced so as to provide the desired high radially-outwardly acting force, the outer diameter of the contact-making button **25** is made greater than half that of the disc-shaped contact.

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**. Each slot **32** extends from a starting point at the outer periphery of its disc **17** or **18** substantially tangent to the outer periphery of the button **25**, first touching the outer periphery of the button at a point **34**, and continuing tangentially of the button periphery for a substantial distance past point **34**. At its innermost end, each slot has an inwardly-extending portion **35** that is substantially perpendicular to the tangential portion of the slot. This inwardly extending portion **35** extends from the outer periphery of the button to a point **36** spaced radially inward from the outer periphery of the button. As seen in FIG. 2, the button extends across, or bridges, the inwardly-extending slot portion **35**.

These slots **32** force the current flowing to or from an arc terminal on a finger **33** to follow a path through the finger that extends circumferentially of the disc in the vicinity of the arc. For example, if the arc terminal is at a position **40** in FIG. 2, the effective path of the current flowing through the finger **33** to the arc will be as shown at **41**, extending circumferentially of the disc. This circumferential component of the current path causes the current flowing through the loop L to develop a net circumferentially-acting force component which revolves 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** at the free end of fingers **33**, thus producing a continuous rotational movement of the arc on the contact surface. It is now generally recognized that such continuous rotational movement of the arc enables higher currents to be interrupted, apparently because it reduces the quantity of metal vapors generated by the arc, thus permitting more complete condensation of the metal vapor at current zero.

Heretofore, the slot configuration most widely used for effecting arc-rotation in vacuum interrupters is substantially that shown in FIG. 2 of the aforesaid Schneider patent. While that slot configuration is quite effective, I have been able with the slot configuration disclosed and claimed in the present application to interrupt considerably higher currents with contacts of a given diameter. For example, with contacts having a diameter of 1⅜ inches, I have been able under corresponding voltage conditions to interrupt 10,000 amperes R.M.S., as compared to 7500 R.M.S. with contacts of the same diameter slotted in substantially the same manner as illustrated in FIG. 2 of the aforesaid Schneider patent. For larger diameter contacts, an increase in interrupting capacity by approximately ⅓ was also noted.

One feature which contributes to the improved performance of my slotted construction is the relatively great width of the slots **32** in comparison to the width of fingers **33**. In this regard, I make the average width W of the slots at least substantially one-half the average width Y of fingers **33**, considered in the region where the fingers extend parallel to the circumference of the disc. This will be apparent from FIG. 2, where these widths in contact **17** are shown as they would be viewed from the other contact. This enlarged slot width contributes to a number of important advantages. First of all, it results in reduced width of the fingers and thus confines the current path through the finger to a direction more effectively circumferential in the vicinity of the arc terminal. By concentrating the current path in this manner, the magnetic force on the arc is directed more effectively circumferential and is thus more effective in rotating the arc about the disc periphery. Secondly, the enlarged slot width reduces the chance that molten metal resulting from high current arcs will fill the slots and thus decrease their effectiveness by forming metal bridges thereacross. Such metal bridges are undesirable in that they form current paths across the slots which interfere with confining the current to the desired circumferentially-extending path.

Another feature which contributes to improved performance of my slot configuration is that the finger **33** formed by each slot between the outer edge of the slot and the contact-periphery extends over most of its length substantially parallel to the disc periphery. This contributes to making the current path **41** more effectively circumferential than would be the case with a slot that was more effectively radial. My slot, over its entire length except at its innermost end **35**, extends approximately parallel to the outer periphery of the disc. This is a result of making the slot substantially tangential to the periphery of contact-making button **25**, which has a diameter greater than half the disc diameter.

It appears that the arc terminal, in moving radially-outward from the contact-making button after its initiation, frequently jumps across a slot **32**. This immediately places the arc terminal on finger **33** in a position where there is a strong circumferential acting force on it, thus commencing rotation of the arc at an exceptionally early point following its initiation. The position of the slot immediately adjacent the periphery of contact-making button and extending tangential thereto encourages the arc terminal to follow this short path onto a portion of finger **33** where there is a high circumferentially-acting force on the arc.

Another feature which contributes to improved performance is that the end of each finger is rounded, being radiused or arcuate over its entire width, as indicated at **45**. Previous contact designs have had sharp points at the end of the fingers, and there seems to have been a tendency for the arc terminal to hang on such points, hesitatoing before moving across the solt **32**. By removing these sharp points, this tendency for the arc to hang at the end of a finger is reduced and the arc moves more freely across slot **32**.

It is to be noted that my slot **32**, except for its inner end portions **35**, is of a substantially straight-line configuration. This straight-line configuration permits the slots to be easily formed by a milling process. A rotating milling-tool, driven about an axis perpendicular to the disc **17** and having a diameter equal to the slot width, is simply fed from the outer periphery of the disc into a position near the inner end of the slot along a straight line path. Thereafter, the direction of feed is changed by approximately 90 degrees to form the short inwardly-extending portion **35** of the slot.

The inwardly extending portion **35** of each of the slots **32**, which is bridged by contact-making button **25**, serves to discourage the arc from stalling near the inner end of a slot, as is explained in application Ser. No. 583,808, now Pat. No. 3,462,572—Sofianek, filed Oct. 3, 1966, and assigned to the assignee of the present invention.

For accentuating the radially-outward bow in the current path L, a sleeve **43** of high resistance metal such as stainless steel is provided about each of the contact rods **17*a*** and **18*a*** where it is joined to the contact structure. The presence of the sleeve forces most of the current to enter the contact through its central region, thus forcing it to flow radially outward to reach the contact-making area **30**.

In a preferred form of the invention, the button **25** is made of material that has a high resistance to contact welding, e.g., the copper-bismuth or copper-lead alloys disclosed and claimed in Pat. 3,246,979—Lafferty et al., assigned to the assignee of the present invention. The remainder of the contact is preferably made of a dissimilar metal which is easy to process, e.g., pure copper. Although it is preferred to make the button of a different material from the rest of the contact, it is satisfactory in certain applications to use the same material for the entire contact so that the button is integral with the remainder of the contact.

In a preferred form of the invention, the slots **32**, in the region outside button **25**, extend through the entire thickness of their associated discs and also extend to the outermost periphery of the discs, thereby rendering the fingers almost completely separate from each other. This separateness results in a stronger arc-rotating force being available since the current flowing to an arc terminal is confined to a path especially shaped to produce arc-rotation.

For condensing the metallic vapors generated by arcing, suitable vapor-condensing shields **50** and **54** are provided. The main shield comprises a tubular member **50** surrounding the arcing gap **52** and located between the insulating casing **11** and the arcing gap. This shield is preferably maintained at a potential substantially midway that of the two electrodes when the circuit interrupter is opened. Auxiliary sihelds **54** of tubular form connected to the end caps **12** and **13**, respectively, surround opposite ends of the main shield **50**.

While I have shown and described a particular embodiment of my invention, it will be obivous 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,

(b) a pair of relatively movable disc-shaped contacts within said envelope having a generally circular outer periphery,

(c) contact-making buttons respectively secured to said disc-shaped contacts and each having a substantially circular outer periphery substantially concentric with the outer periphery of its associated disc-shaped contact, the diameter of said button being greater than half the diameter of said disc,

(d) each of said contacts having circumferentially-spaced slots therein extending from a starting point at the outer periphery of said contact substantially tangent to the outer periphery of said button to provide circumferentially-extending finger portions between said slots and the outer periphery of said contact,

(e) each of said slots having an average width of at least substantially half of the average width of the circumferentially-extending finger portion bounding its outer edge, said widths in each contact being measured as viewed from the other contact,

(f) each of said slots extending away from its starting point at the outer periphery of said contact for a substantial distance past the point at which the slot first touches the outer periphery of said button,

(g) said slot having a portion at its innermost end extending transversely of the tangential portion of said slot across the outer periphery of said button to a point spaced radially inwardly of the button periphery.

2. The structure of claim **1** in which the portion of said slot at the innermost end thereof extends beneath said button and is bridged by said button.

3. The structure of claim **1** in which each of said finger portions has a rounded free end, being arcuate over its entire width.

4. The structure of claim **1** in which each of said slots follows a substantially straight line path from the outer contact periphery to said portion at its innermost end.

5. The structure of claim **4** in which said slot portion at the innermost end of each slot follows a straight line path.

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