

[54] **CONTACT STRUCTURES FOR
VACUUM-TYPE CIRCUIT BREAKERS**

[72] Inventor: **Howard C. Ludwig**, Pittsburgh, Pa.

[73] Assignee: **Westinghouse Electric Corporation**,
Pittsburgh, Pa.

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[51] Int. Cl. **H01h 33/66**

[58] Field of Search **200/144 B, 166 BI, 166 BH,
200/166 BA**

[56] **References Cited**

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Primary Examiner—Robert S. Macon

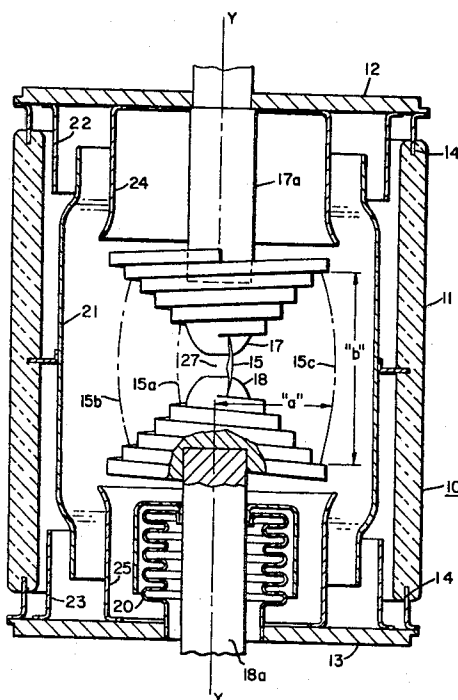
Attorney—A. T. Stratton, Clement L. McHale and
Willard R. Crout

[57] **ABSTRACT**

A vacuum-type circuit breaker is provided having two cooperable generally conically shaped separable contacts, in which each of the contacts has continuous spiral-shaped shoulders forming a progressively greater length for the established arc as it is rotated about the separated contacts.

As the arc is magnetically rotated around the two contacts with its terminals at the continuous spiral-shaped shoulders, the arc progressively assumes a greater length caused by the progressive movement of the terminals of the arc upon the spirally arranged stepped shoulders, which not only increase in diameter, but, additionally, attain a greater distance from the tip portion of the respective contact.

4 Claims, 10 Drawing Figures



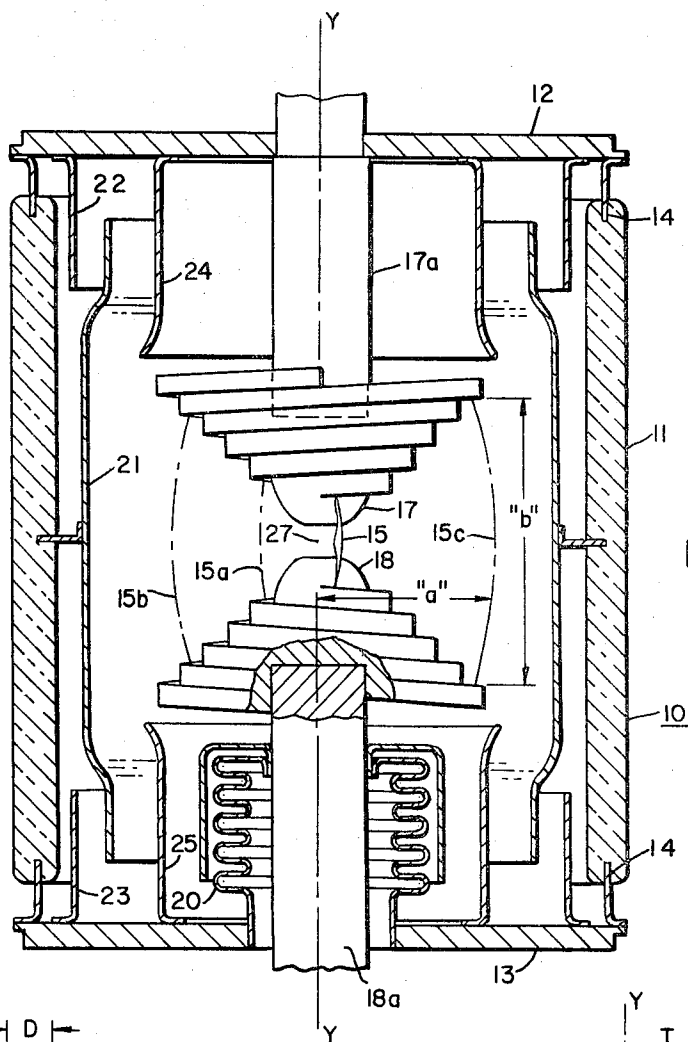


FIG. 1

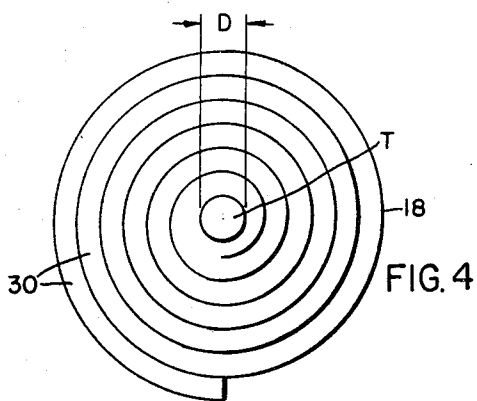


FIG. 4

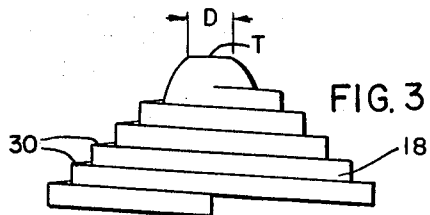


FIG. 3

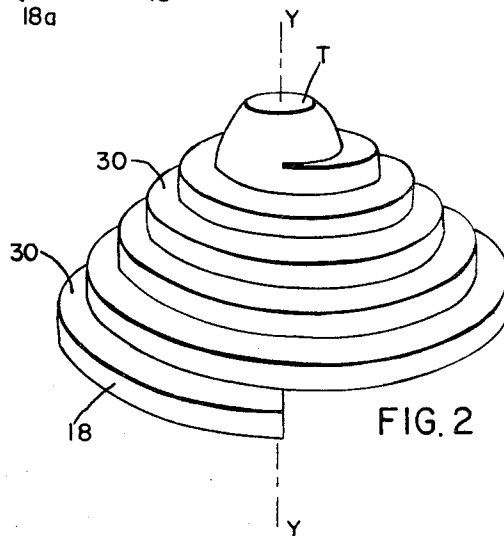
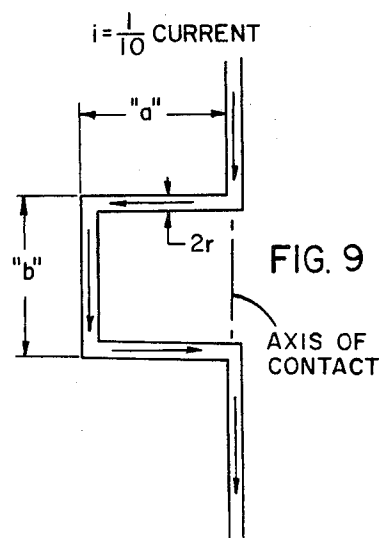
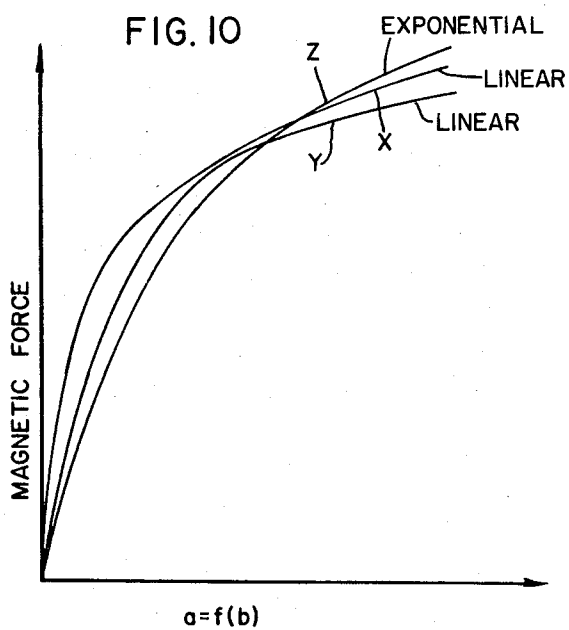
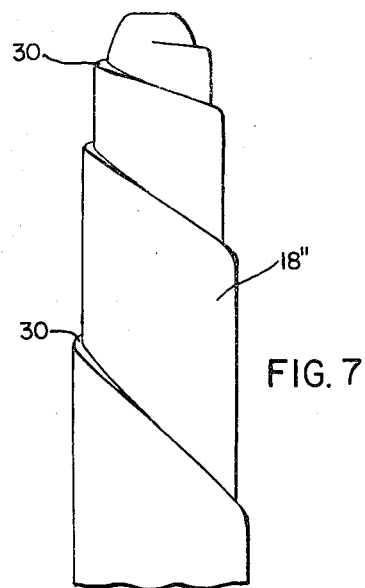
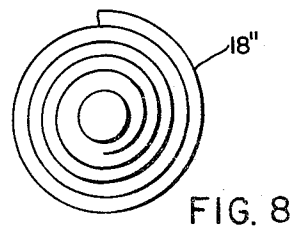
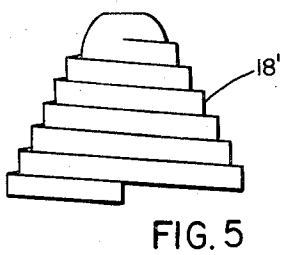
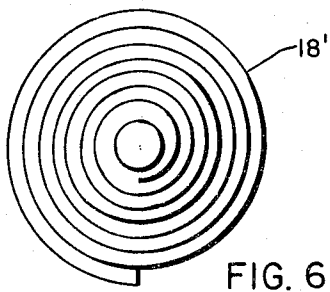


FIG. 2

INVENTOR
Howard C. Ludwig

Willard R. Crow
ATTORNEY



CONTACT STRUCTURES FOR VACUUM-TYPE CIRCUIT BREAKERS

CROSS-REFERENCES TO RELATED APPLICATIONS

Applicant does not know of any related patent application pertinent to the present invention.

BACKGROUND OF THE INVENTION

The present invention refers to vacuum-type circuit interrupters in which an arc is established within an evacuated enclosure. One of the contacts, may be secured to a metallic bellows and may be the movable contact engaging and disengaging the other cooperable contact, which is generally the stationary contact. In the closed-circuit position of the device, the separable contacts make contacting engagement for carrying the line current. During the opening operation, suitable means effects separating motion of the movable contact away from the other contact, thereby establishing an arc within the evacuated enclosure.

As well known by those skilled in the art, it is very desirable to keep the arc terminal moving to avoid erosion of the established contact structure. By causing continuous movement of the arc terminals upon the cooperable contact structure, there additionally results the maintenance of the contacts in a relatively cool state, as contrasted with the situation which results where the arc terminals do not move and excessive heating occurs at the arc-terminal regions. In the latter case, considerable vaporized metal is ejected into the arcing region, together with electrons and ionized particles. It is, therefore, desirable to maintain the arc in continuous motion to maintain the contacts relatively cool and also to minimize erosive effects. In the past, magnetic coils or slots in the confronting faces of the contacts have created a rotating action of the arc.

SUMMARY OF THE INVENTION

According to a preferred embodiment of the present invention, preferably both of the separable contacts of a vacuum-type circuit interrupter are generally conically shaped, and are provided with continuous spirally shaped shoulders, which progressively assume a greater diameter and, additionally, attain a greater distance from the tip of the particular contact. As a result, the rotation of the arc about the two separated contacts causes the arc length to assume a considerably greater length, and also by the induced magnetic effects causes the arc terminals to progressively move along the continuous spiral-shaped shoulders and thereby to constantly increase the arc length.

Accordingly, it is a general object of the present invention to provide an improved contact structure for a vacuum-type circuit breaker.

A more specific object of the present invention is the provision of a pair of separable contacts, which by their configuration cause the arc to assume a greater and greater length during the rotation of the arc about the contact structures.

A more specific object of the present invention is the provision of an improved separable contact structure for a vacuum-type circuit interrupter in which each contact is of generally conical shape with continuous spiral-shaped shoulders to provide thereby a spirally-

arranged arc-terminal surface of progressively greater diameter, and additionally having a greater length from the extremity tip of the particular contact.

Further objects and advantages will readily become apparent upon reading the following specification taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 2 is a considerably enlarged perspective view of one of the contact structures illustrated in FIG. 1;

FIGS. 3 and 4 illustrate respectively side elevational and top plan views of the contact construction shown in FIG. 1;

FIGS. 5 and 6 illustrate, respectively, side elevational and top plan views of another contact configuration embodying the principles of the present invention;

FIGS. 7 and 8 illustrate still a further contact configuration embodying the principles of the present invention;

FIG. 9 is a diagrammatic view illustrating the theoretical principles involved in my invention; and,

FIG. 10 is a graph illustrating the induced magnetic forces involved as a function of the particular continuous spiral-shaped shoulder configuration.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

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 10 comprises a tubular casing 11 of insulating material and metallic 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-circuit position. The upper contact 17 is a stationary contact suitably attached to a conductive rod 17a, 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 18a, 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, draws an arc 15, and opens the vacuum-type circuit interrupter.

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

For condensing the metallic vapors that are generated by the arc, I provide vapor condensing metallic shields 21, 22, 23, 24, and 25. The shielding comprises a tubular main shield 21 surrounding the arcing gap 27 and located between the insulating casing 11 and the arcing gap. This main shield 21 extends lon-

gitudinally of casing 11 for substantial distances on opposite sides of the arcing gap 27. Preferably, the tubular main condensing shield 21 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 is suitably supported on the insulating casing 11 and is maintained at a voltage approximately midway that of the contacts 17 and 18 when the interrupter is opened.

Surrounding the main shield 21 at its respective opposite ends are auxiliary shields 22, 23. These auxiliary shields 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.

Located radially inwardly of the main shield 21 at its opposite ends are additional auxiliary shields 24, 25. These additional shields 24, 25 are also of a generally tubular form and are electrically connected to end caps 12 and 13, respectively. Thus, the upper auxiliary shield 24 is at the same potential as upper contact 17, and the lower shield 25 is at the same potential as lower contact 18.

The present invention is particularly concerned with the contact structure 17, 18 for a vacuum-type circuit interrupter 10, such as illustrated in FIG. 1. A study of prior art reveals the importance of contact configuration with respect to the dissipation and distribution of the vacuum arc energy as a function of the current flowing in the arc-forming cycle of an alternating current circuit and self-magnetic field forces, which develop as a consequence. It is also common knowledge that a loop form of current conducting lines occurring when the cathode spots move radially outwardly from the axis develops magnetic field forces, which tend to lengthen the current-conducting loop initiated.

In the prior art, however, the spreading or wider distribution of current-flow lines is inhibited by the attraction between current flow lines which tend to bundle (magnetic pinch) as current increases. It is known that with the use of prior art configurations of contacts, a mode transition in arc-conducting form begins as the current reaches a value of roughly about 3,000 amperes. As a result, it would appear that the contact surface would be severely damaged, shortening the operating life of the interrupter. A criterion of interrupter service life would be the accumulative current interrupted by the device.

I believe that this accumulative current value for useful service would be increased with the use of the contact-configuration described in my invention. In view of the foregoing discussion concerning the self-magnetic field forces and the following remarks concerning the behavioral motion of cathode spots, my invention provides a submissive track or path for cathode spots, which causes a lengthening path for current conduction and inhibits the pinch effect from developing to concentrate the current flow through the contact surface.

From an examination of surfaces over which cathode spots have operated it is observed that they tend to follow paths having no discontinuities, i.e., the cathode spots do not favor to cross splits, crevices, scratches or move over the edge of a contact.

In the case of a rising current which exceeds 3,000 amperes, cathode spots which have not been permitted by contact dimensions and surface structure to spread out over a larger area will be subject to the pinch effect causing a mode change in the arc and a damaging effect on the contact surfaces. The configuration of contacts suggested to alleviate this problem consists of a "Tower of Babel" spiral, as shown in more detail in FIGS. 2-8 of the drawings. This type of contact configuration provides a continuous path for cathode spot motion 15 of an ever-increasing radius and length of the arc 15a, 15b, 15c. The shape of contacts, as shown, provides a submissive path for the cathode spots to travel which develops an ever-lengthening current loop 15, 15a, 15b, 15c to keep the cathode spots spreading outwardly, preventing the formation of the high current mode of the arc. In the drawing views of FIGS. 2-8, consider the contribution to the lengthening of the arc as (b), and the distance from the axis as (a), as diagrammatically indicated in FIG. 9. When calculating the magnetic force exerted to increase the conducting loop, as in FIG. 9, one can vary (a) and (b) to optimize these dimensions to produce the largest magnetic forces for a given current flow. For calculations, the following equation was used:

$$F = \frac{I^2}{100} \left[1n \frac{b}{r} + \frac{1}{3} \frac{b}{a} + \frac{1}{4} \frac{b^2}{a^2} + \frac{3r^2}{20a^2} - \frac{b^4}{32a^4} \right] \text{ dynes}$$

where r is the radius of conductor along (a), assumed to be 0.1 cm. and (I) is the practical current (200 amp., the assumed max. current in one cathode spot). If (a) is considered to vary linearly with (b), i.e., $b = a - 1.25$ where 1.25 cm is the closed contact surface radius and where $0.5 b = a - 1.25$ cm, the curves X and Y respectively are found, as shown in FIG. 10. If an exponential relation between (a) and (b) are considered $b = e^a - 1.25$ cm. then curve Z results, (FIG. 10). It becomes apparent then that a linear relationship between (a) and (b) gives the largest forces at the lower values of (a) and (b) and then gives way to an exponential relationship at higher values of (a) and (b). In the calculations, the contribution to the (b) values did not include the separation distance of contacts 17, 18 of the contribution due to the increase given by a similarly constructed anode contact. Further calculations, possibly computerized, to develop optimum practical values of (a) and (b) are needed. However, the characteristic form of the contact configuration 17, 18 described here is intended as the concept of the invention.

With further reference to FIG. 2, it will be noted that the generally conically-shaped movable contact 18 has continuous spirally-arranged arc-terminal shoulders 30. The shoulder 30 assumes a progressively greater distance a from the axis Y—Y of the contact, and also contributes to the increase of axial length of the arc b by the steady increase from the extremity tip T of contact 18.

The various proportions of Δa as a function of Δb are indicated in the drawings.

For example, dimension of the contacts 17, 18 which might be used are, $D = 1$ inch; a typical dimension of Δb would be one-fourth inch, and Δa would be one-fourth inch.

In FIG. 7, Δa would be, for example, one-fourth inch and Δb would, for example, be 1 inch.

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From the foregoing description, it will be apparent that by the particular cooperable relationship of the two generally conically shaped contacts 17, 18 that the rotative effect exerted upon the arc 15 by its self-induced magnetic action causes it to assume a greater and greater length 15a, 15b, 15c with a greater intensification of the magnetic field. The continuous spiral-shaped shoulders 30 provide termination points for the ends of the established arc 15 and by its rotation causes the end terminals thereof to assume a greater and greater looping effect. Not only are the arc-terminal surfaces 30 kept much cooler than would otherwise be the case, but, additionally, the greater length of the arc 15 itself tends to bring about extinction of the arc 15.

Although there have been illustrated and described specific structures, it is to be clearly understood that the same was merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A vacuum-type circuit interrupter comprising, in combination, means defining an evacuated enclosure, a pair of separable contacts disposed within said evacuated enclosure engageable and disengageable to establish an arc, each of said separable contacts being

6

generally conically shaped with continuous spirally arranged shoulders (30) so that rotative movement of the arc will cause it to attain a greater and greater length for interruption.

2. The circuit interrupter combination of claim 1, wherein if b is the axial length of the arc and a is the radial distance from the shoulder to the axis of the contact, the configuration is such that the following relationship holds:

$$\Delta a = \Delta b.$$

3. The circuit interrupter combination of claim 1, wherein if b is the axial length of the arc and a is the radial distance from the shoulder to the axis of the contact, the configuration is such that the following relationship holds:

$$\Delta a = \Delta .5b.$$

4. The circuit interrupter combination of claim 1, wherein if b is the axial length of the arc and a is the radial distance from the shoulder to the axis of the contact, the configuration is such that the following relationship holds:

$$\Delta b = \Delta e^a.$$

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