Aug. 16, 1960 H. N. SCHNEIDER 2,949,520

CONTACT STRUCTURE FOR AN ELECTRIC CIRCUIT INTERRUPTER

Filed April 23, 1958

Fig. 1.

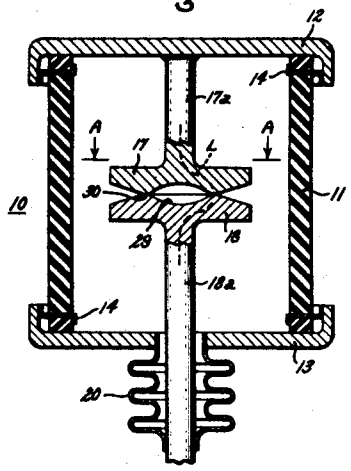


Fig. 2.

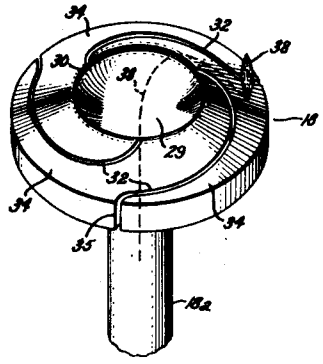


Fig. 4.

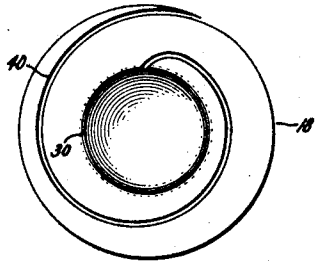


Fig. 3.

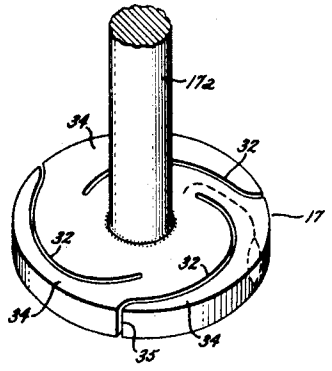
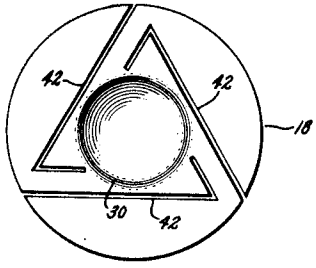


Fig. 5.



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CONTACT STRUCTURE FOR AN ELECTRIC CIRCUIT INTERRUPTER

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18 Claims. (Cl. 200—144)

This invention relates to contact structure for an electric circuit interrupter and, more particularly, to contact structure which is especially, though not exclusively, suited for use in circuit interrupters of the vacuum type.

The usual vacuum type circuit interrupter comprises a pair of separable contacts disposed within a vacuumized chamber. Circuit interruption is initiated by separating these contacts to establish an arc. Assuming that the circuit is an alternating current circuit, the arc maintains itself until about the time a natural current zero is reached, after which the arc is prevented from reigniting by the high dielectric strength of the vacuum.

It has been recognized heretofore that the interrupting capacity of such an interrupter can be materially increased by moving the terminals of the arc at high speed along the surfaces of the contacts or adjacent structure. Such movement tends to minimize the amount of metallic vapors generated from the contacts or adjacent structure by the arc and tends also to increase the degree of diffusion of the vapors that are generated. These factors enable the vacuum to recover its dielectric strength at an increased rate after a current zero and thus render the vacuum more capable of preventing reestablishment of the arc during this critical interval.

In types of interrupters other than those of the vacuum type, high-speed arc movement also facilitates circuit-interruption by cooling the arc column, decreasing contact heating and vaporization and promoting an increased rate of dielectric recovery.

Prior schemes for moving the arc over the contact surfaces have usually relied upon a magnetic field generated by one or more coils connected in circuit with the contacts. These coils must generally be rather massive and bulky and are also difficult to free of adsorbed gases, which are distinct disadvantages, particularly for a vacuum switch construction.

Thus, an object of my invention is to provide structurally-simple and compact means for driving an arc at high speed along the surfaces of a contact or similar structure.

Another object is to incorporate such arc-driving means into the contact structure itself and in such a manner that the arc is moved over surfaces of the contact spaced from the actual contact-making areas of the contact.

In carrying out my invention in one form, at least one of the mating contacts of a circuit interrupter is formed as a conductive disc having a major surface facing the other contact. This major surface is provided with a contact-making area located in a region spaced from the outer periphery of the disc, and the disc is so constructed that the arc established upon contact-separation is driven from the contact-making area across said major surface onto the outer peripheral region of the disc. For carrying current to and from the disc, a conductor is electrically connected to the disc. The disc is slotted from its outer periphery inward in such a manner that the current path extending between the conductor and an arc terminal located at substantially any angular

point on said outer peripheral region has a net component extending generally tangentially with respect to said periphery in the region of the arc. This net tangential component forms with the arc a loop circuit that has a magnetic effect that acts to drive the arc about the peripheral region of the disc. This net tangential component extends from the arc in the same angular direction for substantially all angular positions of the arc on the peripheral region of the disc, and, as a result, the arc is caused to continuously travel in one angular direction along the peripheral region.

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

Fig. 1 is a sectional view of a vacuum circuit interrupter comprising contact structure embodying one form of my invention.

Fig. 2 is an enlarged perspective view of one of the contacts of Fig. 1.

Fig. 3 is an enlarged perspective view of the other contact of Fig. 1.

Fig. 4 is a plan view of a modified form of contact structure for use in connection with the interrupter of Fig. 1.

Fig. 5 is a plan view of another modified form of contact structure for use in connection with the interrupter of Fig. 1.

Referring now to the interrupter of Fig. 1, there is shown a highly-evacuated envelope **10** comprising a casing **11** of suitable insulating material and a pair of metallic end caps **12** and **13** closing off the ends of the casing. Suitable seals **14** are provided between the end caps and the casing to render the envelope **10** vacuum tight.

Located within the envelope **10** is a pair of separable disc-shaped contacts **17** and **18** shown in their engaged or closed-circuit position. The upper contact **17** is a stationary contact suitably secured 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 joined to a conductive operating rod **18***a* which is suitably mounted for vertical movement. The operating rod **18***a* projects through an opening in the lower end cap **13**, and a flexible metallic bellows **20** provides a seal about the rod **18***a* to allow for vertical movement of the rod without impairing the vacuum inside the envelope **10**. As shown in Fig. 1, the bellows **20** is sealingly secured at its respective opposite ends to the operating rod **18***a* and the end cap **13**.

Coupled to the lower end of the operating rod **18***a*, I provide suitable actuating means (not shown) which is capable of driving the contact **18** downwardly out of engagement with the contact **17** so as to open the interrupter and which is also capable of returning the contact **18** to its illustrated position so as to close the interrupter. A circuit-opening operation will soon be explained in greater detail.

Each contact is of a disc shape and has one of its major surfaces facing the other contact. The central region of each contact is formed with a recess **29** in this major surface, and an annular contact-making area **30** surrounds this recess. These annular contact making-areas **30** abut against each other when the contacts are in their closed position of Fig. 1, and are of such a diameter that the current flowing through the closed contacts follows a loop-shaped path L, as is indicated by the dot-dash lines of Fig. 1. This loop-shaped path has a magnetic effect which 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 loop will impel the arc radially outward. The manner in which this action is utilized will soon be explained in greater detail.

Referring to Figs. 2 and 3, it will be noted that each of the contacts **17** and **18** is provided with slots **32** extending from its outer periphery **33** inward. These slots collectively divide each of the contact discs into a series of discrete segments **34** angularly spaced around the contact making region **30**. In the preferred form of my invention illustrated in Figs. 2 and 3, these slots **32** are shown as being of a generally spiral configuration terminating in a mouth **35** at the disc periphery. Each slot extends from its mouth **35** in a generally tangential direction with respect to the periphery and terminates only after extending at least to a point near the angular position of the mouth of an adjacent slot. Preferably, the adjacent slots angularly overlap each other as is shown in Figs. 2 and 3. The importance of the above described slot configuration will soon be pointed out in detail.

Assume now that the circuit is to be interrupted and that, to this end, the contact **18** is driven downwardly to establish a circuit-interrupting arc. The arc is initiated between the projecting areas **30** but is quickly driven in a radial direction toward the periphery **33** by the magnetic effect of the loop circuit L. When the arc has reached the outer peripheral region of the contacts, each of its terminals is located on one of the segments **34**. A typical position of the lower arc terminal is shown for example in Fig. 2, where the arc is designated **38**. Considering first the lower contact **18**, it will be apparent that because of the slots **32**, substantially all of the current flowing between the conductor **18***a* and the arc terminal is concentrated in that particular segment **34** which is then carrying the arc terminal. Because of the generally-spiral configuration of the slots **32**, this current is required to follow a path which is to an effective extent tangential with respect to the periphery **33** in the region of the arc, as is illustrated by the dotted line of Fig. 2. As a result of this tangential configuration of the current path, the magnetic loop has developed a net tangential force component. This net tangential force component drives the arc in an angular, or circumferential, direction about the contact, causing it to move to the end of the segment **34** and to jump across the slot **32** to the next segment **34**. The current flow to the arc is then concentrated in this next segment, and because of the configuration of this segment, there is a new tangentially-acting loop which continues motion of the arc around the contact periphery. For each of the segments **34**, there is a net tangential force component on the arc acting in the same angular direction, and, as a result, circumferential motion of the arc continues at high speed until the arc is finally extinguished. It will be apparent, of course, that if the arc is not extinguished before one revolution is completed, that motion will continue repetitively about the contact periphery until the arc is finally extinguished.

Such movement of the arc is advantageous in that it lessens the amount of contact material that will be vaporized by the arc and also increases the degree of diffusion of the vapors that are generated. This enables the vacuum to recover its dielectric strength at an increased rate and thereby improves its ability to prevent reestablishment of the arc after a current zero, thus increasing the interrupting capacity of the interrupter.

Although I prefer to slot the contact disc in the general manner illustrated in Fig. 2, other slot configurations are also suitable. In any case, however, the disc should be slotted from its outer periphery inward, and the slot configuration should be such that the current path extending between the conductor **18***a* and an arc terminal located at substantially any angular point on the outer peripheral region has a net component extending generally tangentially with respect to the periphery in the vinicity of the arc. In addition, the slot configuration should be such that this net tangential component extends from the arc in the same angular direction for

substantially all angular positions of the arc on the peripheral region of the contact, so that motion of the arc terminal is continued in a single angular direction. By the term angular direction, used hereinabove, is meant a clockwise or counterclockwise direction relative to the central region of the contact.

As an example of another slot configuration which meets these requirements, reference may be had to Fig. 4, which is a plan view of a modified form of contact disc **18**. In this arrangement, a single slot **40** extends from the outer periphery of the disc **18** inwardly toward the center of the disc. This slot **40** has an angular extent of more than 360 degrees, which is much greater than that of the slots **32** of Fig. 2. As a result, this slot **40** is alone sufficient to force all current flowing to an arc terminal located at substantially any angular point on the outer peripheral region to follow a path having a net component extending generally tangentially with respect to the periphery in the vicinity of the arc.

As another example of a slotting arrangement that meets the general requirements set forth hereinabove, reference may be had to Fig. 5, which is a plan view of another modified form of contact disc **18**. Here, the slots **42** are primarily of a straight line configuration, but they nevertheless require the current path through the contact to be of the required tangential configuration.

In all of the above arrangements, the net tangential force component is more pronounced when the arc is located near the outer periphery of the contact, as compared to when the arc is located near the central region of the contact. My contact arrangement effectively utilizes this characteristic by providing a radially-acting force component which continuously biases the arc into this outer peripheral region where the tangential forces are more pronounced. In this connection, because the loop L extends radially outward as well as tangentially, it provides a continuously-acting radial force urging the arc onto the peripheral region.

In the preferred embodiment of my invention, both of the mating contact discs **17** and **18** of a single interrupter are slotted in the same general manner. For example, if the mating contact discs of Figs. 1–3 are viewed along the line A–A of Fig. 1, the slots **32** in the two discs would appear approximately to register, or align. Because of this alignment, the current path in the upper disc **17** has substantially the same configuration as the current path in the lower disc **18**, as is indicated, for example, by the dotted lines of Fig. 3. Accordingly, this current path in the upper disc **17** coacts with the arc to define a tangentially-acting loop circuit having a magnetic effect that impels the upper terminal of arc around the periphery of the contact, thus supplementing the arc-impelling forces previously-described in connection with the lower arc terminal.

If lower speeds of arc motion can be tolerated, only a single one of the discs need be slotted. In such case, the slotted disc alone will provide the tangentially-acting magnetic force for rotating the arc. The other disc though unslotted, will continue to provide a radially-acting loop component which biases the arc onto the peripheral region of the two discs.

As another alternative, the mating discs can be slotted each in a different manner, but yet in such a manner that the two terminals tend to move in the same angular direction. For example, the slot configuration of Fig. 2 could be used for one of the discs and that of Fig. 4 for the other disc. With this combination of discs, the current path through each of the two discs will have a net tangential component extending from the arc in the same angular direction, thus providing forces tending to move both arc terminals in the same angular direction.

In the preferred form of any invention, the slots (**32**) extend entirely through the thickness dimension of the discs, i.e., from one major surface to the other, so as to provide for substantially complete separation of the

segments (34), at least in the outer peripheral region of the discs. As a result, at any particular instant, all current flowing to and from the arc is confined to a single one of the segments 34. With such a construction substantially all of the current is available to provide the tangentially-acting force needed to impel the arc, and, as a result, exceptionally high speeds are obtained. If lower speeds of arc-motion can be tolerated, the slots may be formed in such a manner as to extend only partially through each disc. This allows a portion of the current to flow to the arc along paths having no tangential component or having tangential components acting in the wrong direction, but the predominant portion of the current will flow through a single segment and provide a net tangential force sufficient to impel the arc around the periphery of the disc.

An important advantage of my disclosed contact arrangement is that any substantial arc erosion which does occur occurs in regions which are remote from the actual contact-making areas 30. In this regard, since the arc is quickly driven off of the areas 30 and onto the outer periphery, where it remains until extinguished, no substantial arc erosion occurs in the areas 30. With the contact-making areas 30 thus unimpaired, the usual contact-closing pressures, as well as the current, can be evenly distributed about the contacts to minimize contact-welding, and, in addition, the desired amount of contact wipe can be maintained unimpaired. By "contact wipe" is meant the distance moved by the contact actuating mechanism after the contacts first touch during a closing stroke.

Another advantage of my disclosed contact arrangement is that it readily lends itself to the establishment of a symmetrical electric field in the region of the arcing gap, i.e., a field which is generally symmetrical with respect to a reference plane which bisects the arcing gap between the fully-open contacts and extends perpendicular to the longitudinal axes of the contact rods. This symmetry follows from the fact that the disclosed contacts themselves are of the same general shape and are disposed generally symmetrically with respect to such a reference plane. With regard to this general matter, it should be noted that arcing gaps in general have a lower breakdown strength when subject to voltage of one polarity then when subjected to voltage of an opposite polarity. The more non-symmetrical is the electric field in the region of the gap, the more pronounced is this polarity effect. By providing a symmetrical field, I am able to minimize this polarity effect. As a result, my interrupter is not subject to the unduly prolonged arcing that could result from low dielectric strength during alternate half cycles.

While I have described my invention particularly with regard to a vacuum circuit interrupter, it will be apparent that it also may be advantageously embodied in other types of interrupters. For example, the disclosed contact structure could be used in the type of interrupter that has its contacts disposed in a chamber filled with an arc-extinguishing medium, which may, if desired, be pressurized.

It will be obvious to those skilled in the art that various other 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. In an electric circuit interrupter, a pair of coacting contacts relatively movable from a position of engagement to a position of disengagement to establish a circuit-interrupting arc between said contacts, at least one of said contacts comprising a conductive disk having a major surface facing the other of said contacts, said contacts being constructed to initiate said arc at a point inwardly spaced from the outer peripheral region of said disk and to provide forces for driving said arc across said major surface onto said outer peripheral region, a conductor electrically connected to said disk at a location spaced from the outer periphery of said disk for carrying current to and from said disk, said disk being slotted from its outer periphery inward in such a manner that the current path between said conductor and an arc terminal located at any point on said major surface adjacent the periphery forms with said arc a loop circuit having a magnetic effect exerting a net component of force on the arc generally tangentially with respect to said periphery, said net tangential force component acting in the same angular direction for substantially all angular positions of said arc on said periphery and thereby causing said arc to travel rapidly in one angular direction along the outer peripheral region of said disk, the portions of said outer peripheral region on either side of any peripheral slot being sufficiently close together to enable said tangentially-acting component of force to drive said arc across said slot.

2. The interrupter of claim 1 in which said disk is slotted throughout its entire thickness.

3. In an electric circuit interrupter, a pair of coacting contacts relatively movable from a position of engagement to a position of disengagement to establish a circuit-interrupting arc between said contacts, at least one of said contacts comprising a conductive disk having a major surface facing the other of said contacts, said contacts being constructed to initiate said arc at a point inwardly spaced from the outer peripheral region of said disk and to provide forces for driving said arc across said major surface onto said outer peripheral region, a conductor electrically connected to said disk at a location spaced from the outer periphery of said disk for carrying current to and from said disk, said disk being slotted from its outer periphery inward in such a manner that the current path extending between said conductor and an arc terminal located at substantially any angular point on said outer peripheral region has a net component extending generally tangentially with respect to said periphery in the vicinity of said arc, said net tangential component extending from said arc in the same angular direction for substantially all angular positions of said arc on the peripheral region of said disk, whereby said arc is caused to travel in one angular direction along said peripheral region.

4. The interrupter of claim 3 in which said disk is slotted throughout its entire thickness.

5. In an electric circuit interrupter, a pair of coacting contacts relatively movable from a position of engagement to a position of disengagement to establish a circuit-interrupting arc between said contacts, at least one of said contacts comprising a conductive disk having a major surface facing the other of said contacts, said contacts being constructed to initiate said arc at a point inwardly spaced from the outer peripheral region of said disk and to provide forces for driving said arc across said major surface onto said outer peripheral region, means for producing arc-motion along said peripheral region comprising a plurality of slots formed in said disk, each slot having a mouth located at the outer periphery of said disk and each extending from said outer periphery inward, said slots having portions which extend in a generally tangential direction with respect to the adjacent periphery of said disk, the angular direction followed by the generally tangential portion of each of said slots in departing from the slot mouth being the same for each of said slots.

6. The interrupter of claim 5 in which each of said slots extends generally tangentially at least to a point closely adjacent the annular position of the mouth of an adjacent slot.

7. The interrupter of claim 5 in which at least some

of said slots each extend into angularly overlapping relationship with an adjacent slot.

8. In an electric circuit interrupter, a pair of coacting contact disks each having a major surface facing the other disk and being relatively movable from a position of engagement to a position of disengagement to establish a circuit-interrupting arc between said major surfaces, conductors respectively connected to each of said disks generally centrally thereof for carrying current to and from said disks, said major surfaces each having a generally centrally disposed recess surrounded by a projecting contact-making area that provides a radially-outwardly-acting loop circuit for current flowing through said contact-making areas, each of said major surfaces also including an arc-running portion surrounding said contact-making area and adapted to receive a terminal of an arc driven radially outward by said loop circuit upon contact-engagement, the arc-running portion of at least one of said disks being slotted from the outer periphery of said disk inward, the slot configuration being such that the current path extending between the conductor for said one disk and an arc terminal located at any point on said arc-running surface forms with said arc a loop circuit having a magnetic effect exerting a net component of force on the arc generally tangentially with respect to said periphery, said net tangential force component acting in the same angular direction for substantially all angular positions of said arc on said periphery and thereby causing said arc to travel rapidly in one angular direction along the outer peripheral region of said disk, the portions of said outer peripheral region on either side of any peripheral slot being sufficiently close together to enable said tangentially-acting component of force to drive said arc across said slot.

9. In an electric circuit interrupter, a pair of coacting contact disks each having a major surface facing the other disk and being relatively movable from a position of engagement to a position of disengagement to establish a circuit-interrupting arc between said major surfaces, conductors respectively connected to each of said disks generally centrally thereof for carrying current to and from said disks, said major surfaces each having a generally centrally disposed recess surrounded by a projecting contact-making area that provides a radially-outwardly-acting loop circuit for current flowing through said contact-making areas, each of said major surfaces also including an arc-running portion surrounding said contact-making area and adapted to receive a terminal of an arc driven radially outward by said loop circuit upon contact-disengagement, the arc-running portion of at least one of said disks being slotted from the outer periphery of said disk inward, the slot configuration being such that the current path extending between the conductor for said one disk and an arc terminal located at any point on said arc-running surface has a net component extending generally tangentially with respect to said periphery in the vicinity of said arc, said net tangential component extending from said arc in the same angular direction for substantially all angular positions of said arc on the peripheral region of said disk, whereby said arc is caused to travel in one angular direction along said peripheral region.

10. In an electric circuit interrupter, a pair of coacting contacts relatively movable from a position of engagement to a position of disengagement to establish a circuit interrupting arc between said contacts, at least one of said contacts comprising a conductive disk having a major surface facing the other of said contacts, said contacts being constructed to initiate said arc at a point inwardly spaced from the outer peripheral region of said disk and to provide forces for driving said arc across said major surface onto said outer peripheral region, means for producing arc motion repetitively along said peripheral region comprising at least one slot having a mouth located at the outer periphery of said disk and extending from said outer periphery inward, said slot having a portion which extends in an angular direction relative to the center region of said disk for at least about 360 degrees of said disk.

11. In an electric circuit-interrupter, means for initiating a circuit-interrupting arc in a predetermined region, disk structure providing an annular arc-running surface removed from said predetermined region, means for transferring a terminal of said arc from said predetermined region to the outer peripheral region of said annular arc-running surface, means for producing motion of said arc terminal repetitively along said outer peripheral region comprising slot means extending from the outer periphery of said disk structure inwardly in such a manner that the current path extending through said disk structure to an arc terminal located at substantially any angular point on said outer peripheral region has a net component extending generally tangentially with respect to said periphery in the vicinity of said arc terminal, said net tangential component extending from said arc terminal in the same angular direction for substantially all angular positions of said arc on said peripheral region of said disk structure, whereby said arc is caused to travel in one angular direction along said peripheral region.

12. In an electric circuit-interrupter, means for initiating a circuit-interrupting arc in a predetermined region, disk structure providing an annular arc-running surface removed from said predetermined region, means for transferring a terminal of said arc from said predetermined region to the outer peripheral region of said annular arc-running surface, means for producing motion of said arc terminal repetitively along said outer peripheral region comprising at least one slot having a mouth located at the outer periphery of said disk and extending from said outer periphery inward, said slot having a portion which extends in an annular direction relative to the central region of said disk for at least about 360 degrees of said disk.

13. In an electric circuit-interrupter, means for initiating a circuit-interrupting arc in a predetermined region, disk structure providing an annular arc-running surface removed from said predetermined region, means for transferring a terminal of said arc from said predetermined region to the outer peripheral region of said annular arc-running surface, means for producing motion of said arc terminal along said outer peripheral region comprising a plurality of slots formed in said disk, each slot having a mouth located at the outer periphery of said disk and each extending from said outer periphery inward, said slots having portions which extend in a generally tangential direction with respect to the adjacent periphery of said disk, the angular direction followed by the generally tangential portion of each of said slots in departing from the slot mouth being the same for each of said slots.

14. An arc-impelling electrode arrangement comprising conductive structure including a generally annular peripheral arc-running region along which an arc is adapted to be impelled, a conductor electrically connected to said structure for carrying current to and from said annular peripheral region, means for producing motion of said arc repetitively along said annular peripheral region comprising at least one gap in said annular peripheral region extending from the outermost periphery of said annular arc-running region inwardly in such a manner that the current path between said conductor and an arc terminal located at any point on said annular peripheral region forms with said arc a loop circuit having a magnetic effect exerting a net component of force on the arc generally tangentially with respect to said periphery, said net tangential force component acting in the same angular direction for substantially all angular positions of said arc on said peripheral region and thereby causing said arc to travel rapidly in one angular direction along said annular arc-running region, the portions of said arc-running region on either side of any peripheral gap being sufficiently close together to enable said tangentially-acting component of force to drive said arc across said gap.

15. The electrode arrangement of claim 14 in combination with a second electrode arrangement constructed as defined in claim 14, the annular arc-running regions of the two electrode arrangements being so disposed that the terminals of an arc developed between said two arc-running regions are respectively driven along said two arc-running regions substantially simultaneously, the tangentially-acting net component of force produced by the loop circuit at each electrode arrangement acting in the same angular direction.

16. The structure of claim 1 in which said interrupter is a vacuum-type circuit interrupter comprising an evacuated envelope in which said contacts are disposed.

17. The structure of claim 3 in which said interrupter

is a vacuum-type circuit interrupter comprising an evacuated envelope in which said contacts are disposed.

18. The structure of claim 5 in which said interrupter is a vacuum-type circuit interrupter comprising an evacuated envelope in which said contacts are disposed.

References Cited in the file of this patent

UNITED STATES PATENTS

1,827,516	Greenwood	Oct. 13, 1931
1,834,306	Greenwood	Dec. 1, 1931
2,027,836	Rankin et al.	Jan. 14, 1936
2,051,478	Hampton et al.	Aug. 18, 1936
2,140,378	Biermanns et al.	Dec. 13, 1938
2,443,650	Berkey	June 22, 1948