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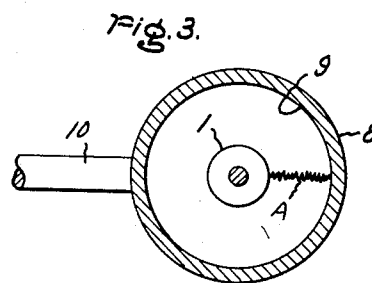
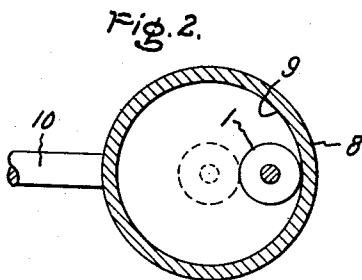
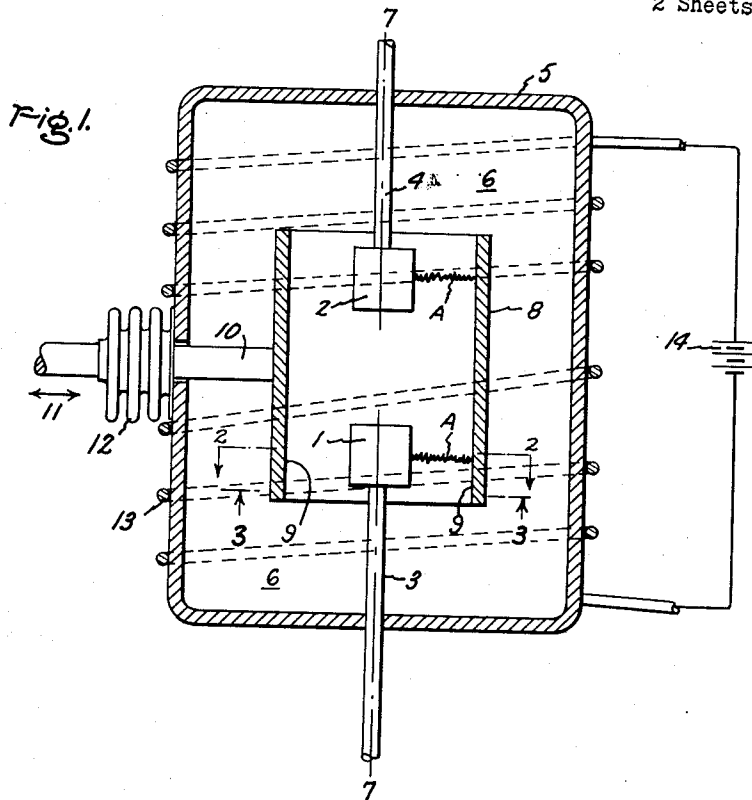
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3,014,109

ALTERNATING CURRENT VACUUM SWITCH

Filed Oct. 23, 1959

2 Sheets-Sheet 1



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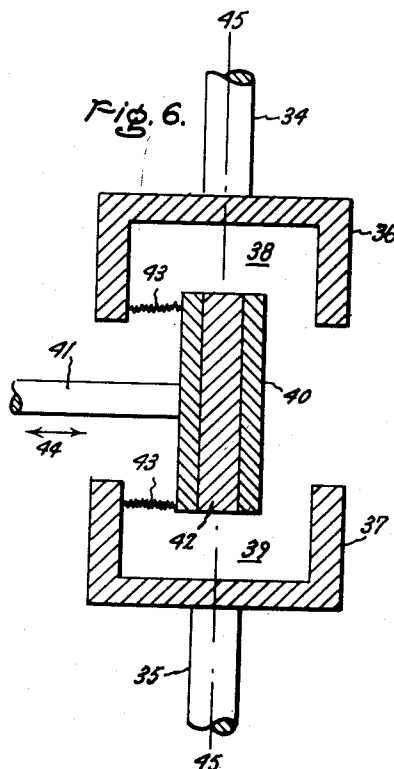
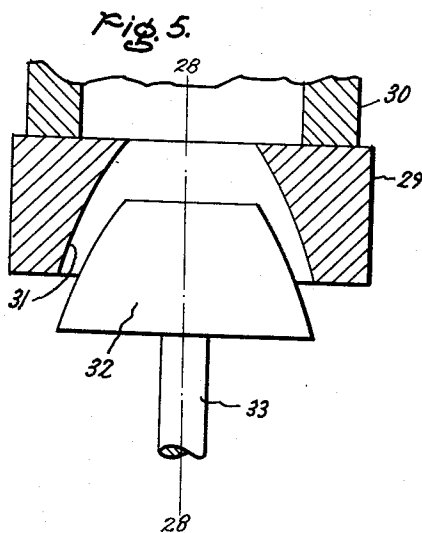
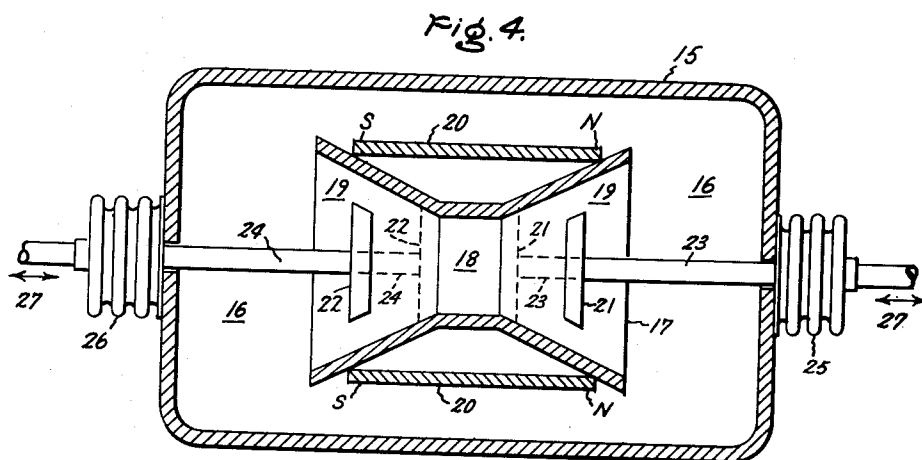
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ALTERNATING CURRENT VACUUM SWITCH

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2 Sheets-Sheet 2



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3,014,109

ALTERNATING CURRENT VACUUM SWITCH
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Filed Oct. 23, 1959, Ser. No. 848,460
8 Claims. (Cl. 200-144)

The present invention relates to an improved vacuum switch having relatively movable electrodes that, in one position, engage each other to define a conducting path and, in a second position, define an annular space across which an arc is formed and rotates until substantially current zero.

Vacuum type switches utilize a vacuum space to provide high dielectric strength, rapid dielectric strength recovery, and high current interrupting capacity. Such switches are preferably so designed that, in an alternating current circuit, they continue to conduct current until substantially current zero is reached. This minimizes "chopping," the sudden current decay that otherwise produces transient overvoltages or surges in inductive circuit components. In one form of such switch, the arc is maintained by the ions and other conduction carriers formed by action of the arc upon the electrodes until substantially current zero, after which time the arc disappears and the conduction carriers disperse and disappear to provide dielectric strength recovery.

It is important in vacuum switches of this kind to avoid undue electrode erosion, and to minimize the tendency of vaporized electrode material to condense on insulating portions of the switch structure. In accordance with the present invention these objectives are accomplished by providing in the switch at least one inner or cylindrical electrode with a beveled or cylindrical outer face and a cooperating outer or hollow electrode with a mating beveled or cylindrical cavity telescoping over the first electrode. In the circuit-opening or interrupting position, the two electrodes are located with their axes substantially coincident and in axially spaced relation to define an annular space. A magnetic field in the direction of the axis (formed by flow of circuit current through a winding, by permanent magnet elements, or otherwise) extends through at least this annular space and coacts with the magnetic field of the arc to generate a circumferential force on the arc causing the same to rotate around the annular space. This rotating movement—of speed determined by the strength of the magnetic field and the arc current value—serves to sweep the arc over the electrode surfaces in a uniform motion that prevents pocking or erosion at any one point on the electrodes and continually presents fresh electrode surfaces to the arc. In addition, the telescoping relationship of the electrodes minimizes the tendency of evaporated electrode material to escape into the vacuum space and deposit on insulating surfaces. By "telescoping relationship," as used herein, I mean to express a configuration of electrodes wherein one or more electrode is located wholly or partially within another electrode.

In the preferred form of the invention herein described, two cylindrical electrodes coact with a shiftable hollow electrode having a substantially cylindrical cavity. In an alternative form of the present invention at least one cylindrical electrode of a beveled conformation is provided and coacts with a hollow electrode having a mating beveled cavity which telescopes thereover. In the circuit closing positions the beveled electrodes nest to provide a large annular area of contact with each other. Opening is effected by withdrawing the electrodes from each other, thereby forming a conical space of annular cross-section across which the arc is formed and rotates under the influence of the magnetic field.

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It is a general object of the present invention to provide an improved vacuum switch in which an arc is rotated about an annular space until substantially current zero.

Another object of the present invention is to provide a vacuum circuit interrupter in which the circuit-interrupting arc is perpendicular to the axis of the switch.

Still another object of the invention is to provide a vacuum circuit interrupter in which a longitudinal magnetic field is utilized to rotate a circuit interrupting arc along the arc-electrodes to prevent undue electrode erosion.

Yet another object of the present invention is to provide a vacuum circuit interrupter in which a longitudinal arc-rotating magnetic field may be provided by the current to be interrupted.

A further object of the present invention is to provide a vacuum arc-interrupter in which circuit interruption is effectuated by removing an intermediate cylindrical electrode from contact with a pair of primary fixed electrodes to cause the establishment of a pair of arcs and rotating the arcs in an annular space between the fixed electrodes and the cylindrical intermediate electrode.

The novel features which I believe to be characteristic of the present invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a view in axial cross-section with parts in elevation of a vacuum switch constructed in accordance with the present invention and utilizing a pair of fixed cylindrical electrodes and a cooperating movable hollow electrode having a cylindrical bore;

FIGURE 2 is a fragmentary cross-sectional view through axis 2-2, FIGURE 1 with the electrodes in circuit-making position;

FIGURE 3 is a fragmentary cross-sectional view through axis 2-2, FIGURE 1 with the electrodes in circuit-breaking position;

FIGURE 4 is a view in axial cross-section with parts in elevation of a vacuum switch constructed in accordance with the present invention and utilizing a fixed hollow electrode with a pair of opposed conical bores and cooperating movable electrodes with like beveled faces;

FIGURE 5 is a fragmentary view of another embodiment of the present invention in which a single electrode member with a bore in the form of a curved surface of revolution coacts with a single electrode having its outer surface of like conformation; and,

FIGURE 6 is a fragmentary view in axial cross-section with parts in elevation of still another embodiment of the present invention, using a single movable electrode in conjunction with a pair of fixed hollow electrodes.

Referring now to FIGURE 1, there are shown at 1 and 2 a pair of axially spaced coaxial cylindrical electrodes. These are supported, respectively, by the conducting support arms 3 and 4 which are in turn imbedded in the vacuum tight envelope 5 which defines a vacuum chamber indicated generally at 6. The electrodes 1 and 2 and their supporting rods 3 and 4 are held in insulating relationship to each other by the envelope 5. This envelope may be wholly of an insulating material, such as glass, or in the alternative it may be primarily of a non-insulating material with insulating portions located to provide the requisite non-conducting support for the electrodes.

It will be observed that the electrodes 1 and 2 are located on a common axis 7-7 and, as seen in FIGURE 2, they are of cylindrical conformation about axis 7-7.

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A hollow electrode 8 with an inner cylindrical cavity 9 telescopes over the spaced electrodes 1 and 2, as shown. Electrode 8 is carried by the operating arm 10 which is supported for shifting movement in the direction indicated by the arrow 11, this support being derived from a suitable operating member (not shown). The bellows 12 is secured at its open end to the envelope 5, preferably by being embedded therein, as shown. At its disc or closed end, the bellows 12 embraces the arm 10 in a gas, tight seal, thereby providing a seal between the arm 10 and the envelope 5 without interfering with the vacuum-tight character of the envelope 5.

A helix 13 surrounds the envelope 5, with its axis in the direction of the axis 7-7 of the electrodes 1 and 2. A source of current, symbolized by the battery 14, is provided to cause current flow through the helix 13 and hence to develop a longitudinal magnetic field within the envelope and in the direction of the axis 7-7.

In the circuit-making position the cavity 9 of the hollow electrode 8 seats in contact-making relationship against the electrodes 1 and 2, as shown in detail in FIGURE 2. The circuit then may be traced from the conducting support rod 4 (which is connected to the external circuit) to the electrode 2 and thence to the electrode 3. The circuit can further be traced from the electrode 3 to the electrode 1, which is also in contact with the cavity 9 of electrode 8 and thence to the conducting support rod 3 and to the external circuit.

When it is desired to open the circuit between the conducting rods 3 and 4, the operating arm 10 (and hence the electrode 3) is shifted from the circuit-making position of FIGURE 2 to the circuit-breaking position of FIGURE 3. This is accomplished by suitable operating mechanism (not shown) to which the arm 10 is attached. As the electrode begins this movement, arcs are drawn between the previously engaging portions of the electrodes 1 and 2 and the cavity 9 of the electrode 8, (assuming the movement did not commence at the instant of a current zero). These arcs are maintained until substantially current zero by the conduction carriers formed by the evaporating electrode materials under the heat and electric field conditions associated with the arcs.

It will be noted that the arcs formed as the electrode 8 moves towards its concentric position in relation to the axis 7-7 are radial in relation to the axis 7-7. This is seen best at A, FIGURE 3, where the position of such arc is shown. Moreover, as shown at A, FIGURE 1, the arcs tend to extend in planes normal to the axis 7-7, or at least to have their principal component in such planes. The arcs are accordingly in directions generally at right angles to the field caused by the winding 13 (which is in the direction of the axis 7-7), so that the magnetic field interacting with the field surrounding the arc gives rise to a force effective on the arc. This force, being at right angles to both the direction of current flow and the direction of the magnetic field, drives the arcs A circularly in relation to the axis 7. The arcs A accordingly rotate about the axis 7 at velocities determined by the arc current flow and the intensity of the magnetic field created by current flow in the winding 13.

In the final circuit-opening position of FIGURE 3, the cavity of the movable electrode 9 is centered in relation to the axis 7-7 and the electrodes 1 and 2. The annular space traversed by the arc under this condition is of like length, regardless of the circumferential position of the arcs. This assures that any resistance to circumferential movement of the arcs that might otherwise result from unsymmetrical electrode configurations is eliminated and the arcs rotate freely about the annular space defined by the electrodes 1 and 2 and the cavity 9 of the electrode 8.

The rotational movement of the arcs A continues until the alternating current falls substantially to zero. At this time, the arcs discontinue and the evaporated

electrode material in the arc paths has an opportunity to disperse, to deionize, and otherwise form a space of progressively increased dielectric strength. The dielectric strength of the spaces thus formed increases more rapidly than the voltage increase between the electrodes 1 and 2 and the movable electrode 3, resulting in a final circuit interruption that serves to disconnect the electrodes 1 and 2 and thus bring current flow therebetween to an end.

The winding or coil 13 is shown for purposes of illustration as energized by the unidirectional voltage source 14. Other current sources may be used, if desired. One particularly appropriate source of energizing current for the winding 13 is the secondary winding of a current transformer located in the circuit of the electrode support arms 3 and 4. In this instance the magnetic field associated with the winding 13 is alternating, but since the particular direction of orbital movement of the arcs 14 is not important, the alternating field is as effective as a unidirectional field in imparting the desired orbital movement to the arcs. Alternatively the leads to support arms 3 and 4 may form helices to directly establish a longitudinal magnetic field.

Since the arcs A are at all times within the confines of the bore 9 of hollow electrode 8, the evaporated electrode material tends to condense onto the electrodes 1, 2, and 3 rather than on the insulating interior surfaces of the envelope 5. In particular, there is a minimum tendency for the vaporized electrode material to condense on that portion of the envelope 5 that lies radially outward of, and is shielded by, hollow electrode 8. For this reason, the insulating character of the envelope 5 is preserved over a long succession of circuit interruptions.

FIGURE 4 is an axial cross-sectional view, with parts in elevation, of a modified form of the present invention. In the interrupter of this figure, the envelope 15 defines a space 16 which is evacuated to form a vacuum chamber and hence provide vacuum interrupter action. A fixed hollow electrode 17 is supported within the vacuum chamber 16 by suitable support elements (not shown). This electrode has a central cylindrical bore 18 bounded by a pair of opposed like conical flaring bores 19. A permanent magnet sleeve 20 surrounds the electrode 17, as shown. This magnet is permanently magnetized along its length (as indicated by the pole symbols N and S) thereby defining a magnetic field along the longitudinal axis of the electrode 17 and within the bore thereof.

A pair of movable electrodes 21 and 22 are located within the opposed conical portions 19 of electrode 17. These movable electrodes are carried by the support arms 23 and 24, respectively. The support arms 23 and 24 (and hence the movable electrodes 21 and 22) are carried by suitable operating mechanism (not shown) for shifting movements towards and away from each other as indicated by the arrows 27. The bellows 25 and 26 are in vacuum tight sealing engagement with the respective support arms 23 and 24, and are likewise in vacuum tight sealing engagement with the envelope 15, thus forming a tight seal about the vacuum space 16.

In the switch or interrupter of FIGURE 4 the alternating current circuit to be interrupted is connected to the protruding portions of the support arms 23 and 24, respectively. In the circuit-closing positions, these arms are positioned to bring the beveled electrodes 21 and 22 to seating engagements with the conical bore portions 19 of the fixed electrode 17. The resulting positions of the movable electrodes and support arms are shown by the dotted lines of FIGURE 4. With the electrodes so positioned, a circuit is established from the conducting support arm 23 through the beveled electrode 21 to the mating beveled surface of the fixed hollow electrode 17. The circuit can be traced through the electrode 17 to the beveled surface mating with electrode 22, through

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electrode 22, and to the conducting support arm 24. It will be noted that, by reason of the large areas of bevel contact between the electrodes, this circuit is highly effective in providing a low resistance conducting path.

When it is desired to open or interrupt the circuit between the support arms 23 and 24, the support arms 23 and 24 are retracted in unison by the operating mechanism (not shown). This brings these arms, and the respective movable electrodes 21 and 22, to the solid line positions of FIGURE 4. At the initiation of such movement, arcs are drawn between the electrodes 21 and 22, respectively, and the interior beveled faces 19 of the fixed electrode 17 (unless the movement happens to commence at a current zero). The arcs so drawn vaporize some of the electrode materials, and the resultant heat and electric field within the arc gives rise to ions and other electrically conducting carriers between each movable electrode and the fixed hollow electrode 17. These arcs are maintained until the current flow is substantially zero. Since each such arc has at least a component of current flow in the radial direction between the fixed electrode 17 and the movable electrode, each arc is at least, to some extent, at right angles to the field within the electrode 17 due to the action of the permanent magnet 20. The longitudinal magnetic field and the magnetic field associated with each arc coact to give rise to a circumferential force component on the arc, driving the arc in rotational travel about the movable electrode in action similar to that above described with reference to FIGURE 1. The arcs continue to rotate as above described until the instantaneous current value falls approximately to zero, at which time the arcs extinguish. Thereafter the metal vapor in the arcing space disperses and deionizes, giving rise to a buildup of dielectric strength that precludes a restrike of the arc upon the subsequent voltage buildup across the electrodes.

FIGURE 5 shows, in fragmentary form, still another embodiment of the present invention. In this form an electrode support arm 30 carries a hollow electrode 29 with a cavity 31, in the form of a flaring surface of revolution about the axis 28. The cooperating electrode support arm 33 carries a solid electrode 32 having its exterior surface in the shape of a like surface of revolution about the axis 28. Means (not shown) is provided to define a magnetic field traversing the electrodes along the axis 28—28, such means being in the form of a winding such as that of FIGURE 1, or in the form of a permanent magnet such as 20, FIGURE 4.

With the switch or interrupter of FIGURE 5, either or both of electrode support arms 30 and 33 is movably supported for translation along the axis 28—28. In the circuit-closing position, the headed solid electrode 32 fits in a snug engagement with the cavity 31 of the hollow electrode 29, thus forming a large-area effective current conducting path. When it is desired to open or interrupt the circuit, one or both of the electrode support arms 30 and 33 are moved to position the electrodes in the solid line positions of FIGURE 5. As this movement takes place, an arc is formed between electrodes 29 and 32, with at least a component of its direction radial in relation to the axis 28. The arc thus formed is thus driven in circumferential orbital travel about the axis 28—28 and continues to orbit until substantially zero current flow takes place.

In the embodiment of FIGURE 6 electrodes 36 and 37 are respectively supported by and connected to the conducting support arms 34 and 35. Arms 34 and 35 are connected to the external circuit to be switched (not shown) and are mechanically supported by a vacuum envelope (not shown), through which they protrude. As shown, the hollow electrodes 36 and 37 each have a cylindrical cavity, 38 and 39, respectively. The cylindrical electrode 40 is of cylindrical outer conformation and is of length to extend into the respective cavities

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38 and 39 of the hollow electrodes. Electrode 40 is carried by support arm 41 which extends laterally of electrode 40 and through the vacuum envelope (not shown) to a suitable switch operating mechanism. The latter is capable of shifting the arm 41, and hence the electrode 40 in circuit-making and circuit-breaking movements in the direction of the arrow 44 as hereinafter described.

A bar magnet, preferably of cylindrical conformation, is embedded in electrode 40, as shown at 42. One end of this magnet is magnetized to form a north pole and the other end is magnetized to form a south pole. The magnetic flux in the respective annular spaces between electrode 40 and electrodes 36 and 37 (when the electrodes are positioned as shown in FIGURE 6 is accordingly in the general direction of the axis 45—45.

In the circuit closing condition of the switch of FIGURE 6, electrode 40 is shifted to the position so as to contact and connect fixed electrodes 36 and 37. In this position the cylindrical outer surface of electrode 40 defines a line of contact with the cylindrical cavity of each of the fixed electrodes 36 and 37, thus forming a conducting path between electrodes 36 and 37 and hence between the support arms 34 and 35 and the terminals (not shown) of the external circuit. The switch of FIGURE 6 is opened by shifting the electrode 40 from the circuit-making position to the circuit-breaking position illustrated in FIGURE 6. In the centered or circuit-breaking position, the axis of the electrode 40 is coincident with the axis 45—45, which is also the axis of the cavities 38 and 39 of the fixed electrodes 36 and 37, thus defining annular spaces between the electrode 40 and the electrode cavities 38 and 39, respectively. As this movement takes place any current between the electrodes at the moment of contact separation gives rise to a pair of arcs 43. These arcs are driven in rotational movement about the axis of electrode 40 by the interaction between the magnetic field of magnet 42 and the magnetic field of the arc. In the circuit-breaking position, the annular space in which this rotational movement takes place is of uniform radial extent, thus assuring that there is a maximum freedom for the arc to rotate in response to the magnetic field interaction.

Through the above action, the arcs 43 are continually playing upon fresh surfaces of the electrodes, thereby providing uniform erosion over the electrode surfaces and a maximum rate of voltage recovery when the current goes to zero and the arcs extinguish. Moreover, electrodes 36 and 37 provide shielding surfaces onto which the vaporized electrode metal tends to condense in preference to the otherwise insulating surfaces of the vacuum envelope.

It will be noted that in all of the above-described embodiments of the present invention, an arc is formed with at least a component of direction radially related to the axis of the magnetic longitudinal field. This arc is rotated about the annular space defined by the cooperating electrodes and thus does not tend to dwell at any particular electrode point. The result is that the eroding action of the arc is distributed over the electrode surfaces and the quantity of vaporized electrode material is limited by the constant presentation of fresh electrode surface to the arcs. The result is a vacuum switch or interrupter that is capable of many high current interrupting operations without undue electrode disintegration and in which the voltage recovery following arc interruption is at a favorable rate. Moreover, in each of the above-described embodiments of the present invention the hollow electrode serves as a baffle or shield minimizing the condensation of vaporized electrode materials on the insulating faces of the envelope.

While I have shown and described particular embodiments of the present invention it will be understood that various embodiments and alternative constructions may be employed without departing from the true spirit and scope thereof. By way of example (and not by way of

limitation) the magnetic fields used with any form of the present invention may be created by permanent magnets, by windings, or by some other means, and either the hollow or the cylindrical electrode (or electrodes) may be made movable, all without departing from the principles of the invention. I therefore intend by the appended claims to cover all such modifications and alternative constructions as fall within their true spirit and scope.

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

1. A vacuum circuit interrupter comprising in combination: means defining an evacuated space; a pair of longitudinally spaced primary electrodes in said space, each having an outer face; an intermediate electrode in said space having a cavity portion telescoping each of said primary electrodes, the end of each said cavity portions into which said primary electrodes telescope having at least as large a radius when seen in axial cross-section as any other portion thereof; means producing a longitudinal magnetic field in said space along the direction of the axis of said primary electrodes; and means operable to move said electrodes in relation to each other between a circuit closing position in which the outer faces of said primary electrodes seat in contacting relation on the cavity portion of said intermediate electrode, and a circuit opening position in which said primary and said intermediate electrodes are radially spaced to define annular spaces across which arcs extend and rotate under the influence of said magnetic field.

2. A vacuum circuit interrupter comprising in combination: means defining an evacuated space; a pair of spaced substantially co-linear primary electrodes in said space; an intermediate electrode in said space having internal portions telescoping each of said primary electrodes respectively, and portions defining a conducting path between said internal portions; means establishing a longitudinal magnetic field along the axis of said primary electrodes; and means operable to cause relative motion between said pair of primary electrodes and said intermediate electrode, said motion being between a circuit closing position in which the internal portions of said intermediate electrode are in contact with an element of each of said primary electrodes to define a conducting path therebetween, and a circuit opening position in which said cavity portions of said intermediate electrode are substantially co-axial with the axis of said primary electrodes to define annular spaces surrounding said primary electrodes across each of which an arc extends and rotates under the influence of said magnetic field.

3. A vacuum switch comprising in combination: means defining an evacuated space; a first electrode in said space having its outer face of beveled conformation about a predetermined axis in said space; a second electrode in said space having a cavity portion of complementary beveled conformation in relation to the beveled conformation of the first electrode, and about the same axis, whereby in one position along said axis the electrodes nest in surface-to-surface contact and as the electrodes are axially spaced they define a space of annular cross-section and of extent determined by the amount of separation; means operable to produce a magnetic field in said space in the direction of said axis; and means operable to move said electrodes in relation to each other between a circuit closing nested position of surface-to-surface contact and a circuit opening spaced position defining a space of annular cross-section in said axis, across which an arc extends and rotates under the influence of said magnetic field.

4. A vacuum circuit interrupter comprising in combination: means defining an evacuated space; a first electrode in said space having an arcing surface defined by rotation of a line about an axis through said first electrode; a second electrode in said space having a cavity

defined by the rotation of a second line of substantial length about said axis through said electrode; means supporting said electrodes with said axes in parallel relationship and with said surface of said first electrode extending into the confines of the cavity of said second electrode; means for moving said electrodes in relation to one another between a first circuit-making position in which said arcing surface of said first electrode is in contact with the interior surface of said cavity and said second electrode to define a conducting circuit, and a second circuit-breaking position in which the electrodes are co-axial and define an annular space between the arcing surface of said first electrode and the interior surface of the cavity of said second electrode and the first electrode extends within said cavity; and means operable to produce a magnetic field about said first electrode in the direction of the axis thereof to rotate an arc located within said cavity and extending across said annular space between said electrode until the extinction thereof.

5. A vacuum circuit interrupter comprising in combination: means defining an evacuated space; a pair of longitudinally spaced primary electrodes in said space each having a surface defined by the rotation of a line about an axis through said primary electrodes; an intermediate electrode in said space having a cavity defined by the rotation of a line about an axis through said intermediate electrode; magnetic means located along the axis of said electrodes defining a longitudinal magnetic field parallel with said axes; means supporting said electrodes with the surfaces of said primary electrodes located within the confines of the cavity of said intermediate electrodes and permitting movement of the electrodes in relation to each other between a first position in which the surfaces of said primary electrodes rest against the cavity of said intermediate electrode to define a conducting circuit, and a second position in which the surfaces of said primary electrodes are centrally located in spaced relation to said intermediate electrodes to define an annular arc space about said first axis across which an arc extends and rotates until extinction thereof.

6. A vacuum circuit interrupter comprising in combination: means defining an evacuated space; a pair of first spaced hollow electrodes within said space, said electrodes having facing cavities of cylindrical conformation about an axis extending along the longitudinal axis of said space; a cylindrical electrode in said space with its axis in parallel relation to the axis of the cavities of said hollow electrodes and extending into each of said cavities; means establishing a longitudinal magnetic field along the axis of said electrodes; and means operable to move said hollow and said cylindrical electrodes in relation to each other between an eccentric circuit closing position in which the surface of said cylindrical electrode rests in line contact with the cavities of said hollow electrodes to define a conducting path therebetween, and a circuit opening position in which the axis of said cylindrical electrode is coincident with the axis of the cavities of said hollow electrodes to define annular spaces about the ends of said cylindrical electrode across each of which an arc extends and rotates under the influence of said magnetic field.

7. A vacuum circuit interrupter comprising in combination: means defining in an evacuated space; a hollow electrode in said space having a cavity defined by the rotation of a line about the longitudinal axis thereof; a cylindrical electrode in said space having an exterior arcing surface defined by a rotation of like line about an axis through said cylindrical electrode; said cylindrical electrode including therein permanent magnetic means magnetized in the direction of the axis through said cylindrical electrode to define a magnetic field extending longitudinally along the axis thereof; means supporting said electrodes with said axes in parallel relation and with the surface of said cylindrical electrode extending into the confines of the cavity of said hollow electrode; and means for moving said electrodes in relation to each other

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between a first position in which the exterior surface of said cylindrical electrode rests against the cavity in said hollow electrode to define a conducting circuit, and a second position in which the electrodes are coaxial and define an annular space between the exterior surface of said cylindrical electrode and the cavity of said hollow electrode in which an arc drawn between said electrodes upon the motion thereof from said first to said second position is rotated by the magnetic field until extinction thereof.

8. A vacuum circuit interrupter comprising in combination: means defining in an evacuated space; a hollow electrode in said space having a cavity defined by the rotation of a line about the longitudinal axis thereof; a cylindrical electrode in said space having an exterior arcing surface defined by a rotation of a like line about an axis through said cylindrical electrode; magnetic means to define a magnetic field extending longitudinally along the axis of said cylindrical electrode; means supporting said electrodes with said axes in parallel relation and with the surface of said cylindrical electrode extending into the confines of the cavity of said hollow electrode; and

means for moving said electrodes in relation to each other between a first position in which the exterior surface of said cylindrical electrode rests against the cavity in said hollow electrode to define a conducting circuit, and a second position in which the electrodes are co-axial and define an annular space between the exterior surface of said cylindrical electrode and the cavity of said hollow electrode in which an arc drawn between said electrodes upon the motion thereof from said first to said second position is rotated by the magnetic field until extinction thereof.

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