

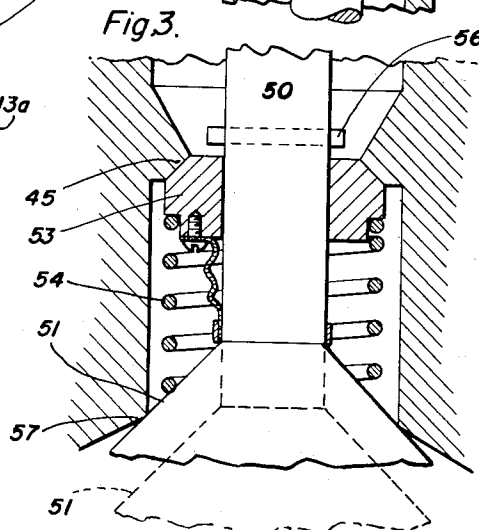
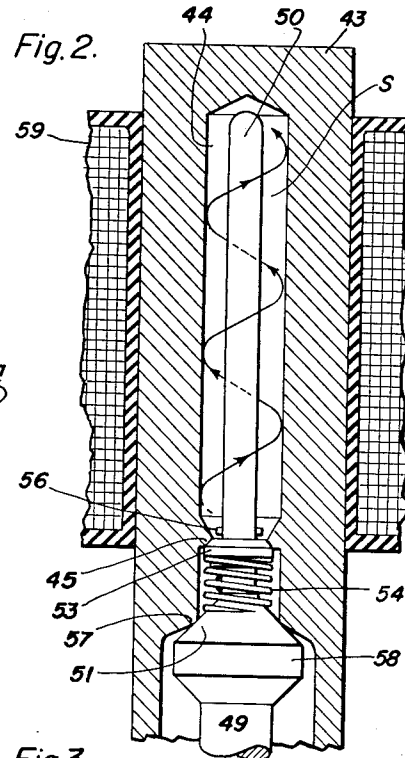
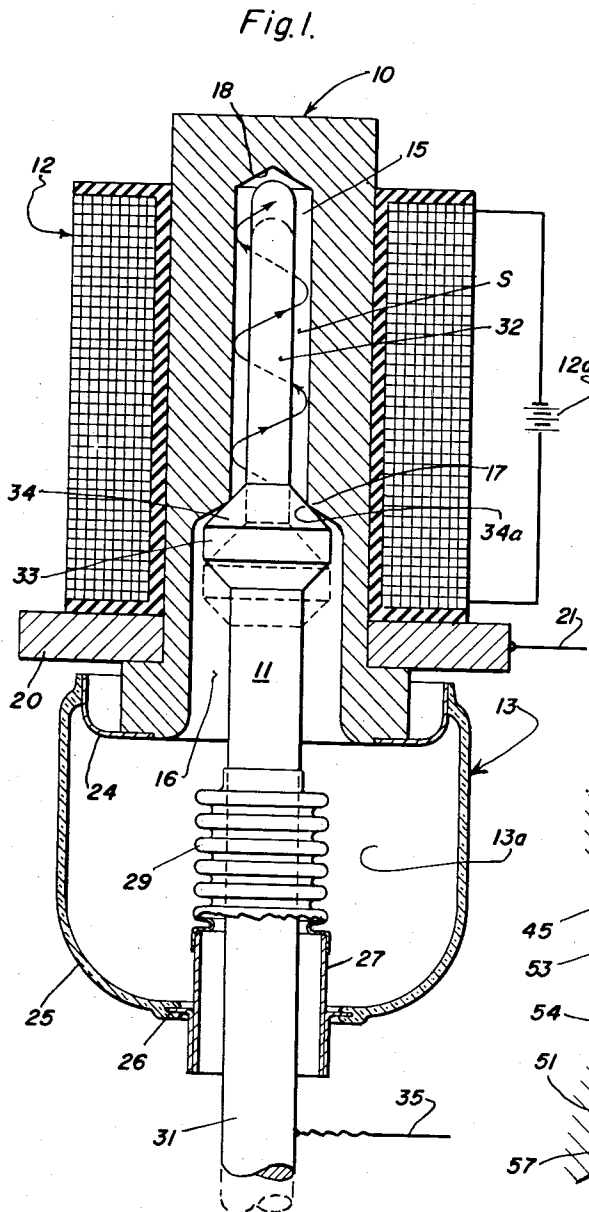
Feb. 14, 1961

KARL-BIRGER PERSSON

2,972,032

VACUUM INTERRUPTER

Filed Jan. 2, 1959



Inventor :
Karl-Birger Persson,

by *Paul A. Frank*
His Attorney.

1

2,972,032

VACUUM INTERRUPTER

Karl-Birger Persson, Ballston Spa, N.Y., assignor to General Electric Company, a corporation of New York

Filed Jan. 2, 1959, Ser. No. 784,769

8 Claims. (Cl. 200-144)

The present invention relates to an improved vacuum switch for alternating currents.

In vacuum type switches, the relatively movable contacting electrodes are located in a vacuum chamber. Upon separation of these conductors, an arc is formed and is ultimately extinguished to provide circuit interruption. When the vacuum is fully effective, the vaporized and ionized electrode material, formed by the arc itself, is the only source of current conduction carriers between the electrodes. In such switches intended for use in alternating current circuits, it is desirable for the switch to maintain current flow until a current zero is reached and then to interrupt the circuit.

In accordance with the apparatus herein described, the electrodes of the vacuum switch which may, for example, be a circuit breaker, define an elongated cylindrical cavity and a cylindrical elongated finger-like member telescopically received in that cavity to define an elongated annular space. The electrodes have cooperating, contact-making surfaces located near the open end of the cylindrical cavity. When the finger-like member is withdrawn slightly from its contact-making position, an arc is struck near the open end of the cavity. Means are provided to create a longitudinal magnetic field within the cavity.

The net effect of the electrode conformations and the magnetic field of the circuit interrupter is to cause the arc to be initially struck adjacent the open end of the cylindrical cavity and thereafter to spiral towards the opposite end of the same. The moving arc is ultimately extinguished as the instantaneous value of the alternating current wave approaches zero. The current is accordingly interrupted at a time when a minimum sudden current change takes place. Undesirable voltage transients are accordingly minimized. Moreover, since the cavity and finger-like member define a somewhat enclosed space, the evaporated electrode material tends to redeposit or condense on the electrode surfaces and to do so in a generally uniform fashion. Undesirable deposit of the conducting electrode material on the insulating walls of the vacuum chamber external to the cavity is thereby minimized and, in addition, the electrodes tend to retain their original shape and size. Since the arc is in continuous motion, there is a minimum tendency for localized pitting or electrode destruction and, in addition, the quantity of vaporized electrode material is relatively small in relation to the electrode material, arc current density, and arc duration.

It is therefore a general object of the present invention to provide an improved vacuum switch for alternating currents.

A further object of the present invention is to provide an improved vacuum switch for alternating currents in which the arc is maintained in motion until the current

2

goes to about zero, at which time interruption takes place with minimum tendency to create voltage transients.

Still another object of the present invention is to provide an improved vacuum circuit interrupter electrode conformation which defines a substantially closed chamber in which the arc is located, thereby minimizing the deposit of vaporized electrode material on the insulating walls defining the vacuum chamber.

Yet another object of the present invention is to provide an improved vacuum circuit interrupter having a cavity-defining electrode in which the arc is initiated and caused to travel in a spiral path away from the open end of the cavity.

Still another object of the present invention is to provide an improved vacuum circuit interrupter having a cavity-defining electrode in which the arc is initiated and in which a magnetic field coacts with the arc to impart a spiral movement to the same causing it to travel in a spiral path away from the open end of the cavity.

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

Fig. 1 is a cross-section taken vertically through a vacuum switch embodying my invention;

Fig. 2 is a similar cross-section in fragmentary form of an alternative embodiment of the present invention in which current conduction normally takes place through a first pair of contact-making surfaces and the arc is initiated between a second pair of contact faces, and

Fig. 3 is an enlarged fragmentary view of the apparatus of Fig. 2.

Referring to Fig. 1, a vacuum switch constructed in accord with the present invention comprises a fixed electrode member, generally 10, a movable electrode, generally 11, a solenoid, generally 12, wound about the fixed electrode 10, and means, generally 13, for mounting the movable electrode 11 and providing a vacuum seal about the space between the two electrodes 10 and 11.

Fixed electrode 10 is circular in shape and the inner portion thereof defines a cylindrical cavity 15. One end of cavity 15 opens into an enlarged cylindrical chamber 16. Chamber 16 communicates with vacuum space 13a defined by vacuum sealing means 13 which may, for example, be a glass envelope. The beveled shoulder of fixed electrode 10 between cavity 15 and chamber 16 mates with and receives beveled shoulder 34 on movable electrode 11. The opposite end of cavity 15 is sealed by the top of electrode 10 forming a base 18 of cavity 15. A mounting plate 20 is secured to fixed electrode 10 and positions the solenoid 12 thereon. One conductor 21 of the circuit to be interrupted is connected to fixed electrode 10 through plate 20.

The insulating envelope, indicated generally at 13, is defined by a cap 24, insulating bulb 25, lower sealing flange 26, and metal sleeve 27. Cap 24 is of metal and at its inboard periphery is secured to the lower annular end of the fixed electrode 10. The insulating bulb 25, which may be of glass, is sealed to the upwardly extending cylindrical face formed by the cap 24 to be sustained thereby. At its lower end, the bulb 25 receives the annular flange 26 which in turn is sealed to the lower metal sleeve 27 through which the movable electrode 11 extends. This sleeve, in conjunction with the bellows 29,

defines the completely sealed chamber which, as herein-after described, is evacuated.

Movable electrode 11 has a finger-like member 32 which is of generally cylindrical configuration and extends into cavity 15, as shown. The axis of finger-like member 32 coincides with the axis of cavity 15 so that these two members define an elongated annular space, indicated at S. At the base of finger 32 the electrode 11 expands in beveled portion 34. This forms a switch contact surface 34a mating with switch contact surface 17 on fixed electrode 10.

The other connection 35 to the circuit to be interrupted is connected to movable electrode 11, as shown. When the movable electrode 11 is in fully inserted position, as shown in Fig. 1, the surfaces 17 and 34a are in engagement to carry the current between conductors 21 and 35. When the movable electrode 11 is slightly withdrawn, as shown by the dotted lines of Fig. 1, an arc is established between surfaces 17 and 34a and the current ultimately interrupted as hereinafter described. This movement is accomplished by suitable well known operating elements (not shown).

The solenoid 12 is at least energized when the circuit interrupter is actuated by moving electrode 11 to separate the surfaces 17 and 34a. This may be done by energizing this solenoid from a separate voltage source, such as the source 12a, Fig. 1. Alternatively, the solenoid 12 may be connected in series with conductor 21 to the circuit to be interrupted, or across the terminals of a transformer in that circuit. Other means to produce a longitudinal magnetic field in the elongated annular space S, as for example, a cylindrical permanent magnet substituted for solenoid 12, may be used if desired.

When current is flowing between conductors 21 and 35 (due to the action of the circuit to be interrupted) and the movable electrode 11 is moved down to the dotted line position of Fig. 1, an arc is struck between the beveled annular surfaces 17 and 34a. With perfect vacuum action, the only source of conducting ions for the arc is the vaporized material of the electrodes 17 and 11, this vaporization taking place because of the heat created by the current flow itself and because of the low vapor pressure space about the electrodes due to the vacuum. The arc thus formed has a component of current flow transverse to the longitudinal or axial magnetic field associated with the action of the solenoid 12 or its equivalent. This component of current flow coacts with the field to rotate the arc itself about the electrode 11, this action being due to the force on the arc which is at right angles to the direction of the arc current and to the magnetic field.

In addition to the rotation of the arc by the action of the solenoid 12, the arc moves away from the open end of the cavity S (adjacent the beveled surface 17) and towards the closed or base end 18. This movement is due to the action of the arc current itself. It will be noted that this current travels from conductor 35 to the electrode 11, and thus creates a strong magnetic field about the electrode 11 up to the point where the arc spans the space S, and only a weak field above that point. The current also travels between the electrode 11 and electrode 10 to span space S in a generally radial direction and thence through the electrode 10 to the conductor 21 (or other point where the electrode 10 is connected to the circuit to be interrupted). Insofar as the arc current travels through the electrode 10, it tends to create a magnetic field that generally reinforces the field of the current flow in electrode 11, although this field is of lesser magnitude. It should be noted in this connection that the current travels through electrode 10 in direction opposite to the flow in electrode 11 and that the current in electrode 10 tends to surround the space S and hence does not exert its full action in creating a magnetic field. The action of the current flow in the electrode 11 (forming a strong magnetic field in the space S up to the arc),

the current flowing in the arc (forming a magnetic field about the radial axis of the arc) and the current in the electrode 10 (forming a magnetic field reinforcing that due to flow in electrode 11) is to drive the arc away from the surfaces 17 and 34 and towards the closed end 18 of the cavity.

The net effect of the foregoing action is to cause the arc to travel in a spiral path towards the closed end 18 of cavity 15, as is shown by the heavy spiral line in Fig. 1. This spiralling action of the arc causes the arc to go a progressively increased distance into the cavity and, in addition, causes it to travel over fresh electrode areas. The former action serves to increase the extent the vaporized electrode material is deposited on the inner wall of the cavity 15 and on the finger-like member 32, rather than on the insulating surfaces of the vacuum space. The latter action minimizes the heating of the electrode material, so that electrode pitting is minimized and, in addition, assures an even action of the arc over all of the electrode area to distribute electrode erosion to a maximum degree.

It will be observed that the circuit interrupter of Fig. 1 defines a pair of separate spaces. One is the annular space S in which the arc is located. The other is the cylindrical space 13a which is surrounded by the insulating wall 25. These two spaces are not only physically separated but, in addition, the enlarged portion of the electrode 11 at the surface 34 defines a restricted passage between these two spaces. Also, the chamber 16 forms a somewhat elongated passage bounded by the relatively cool walls of electrode 10. The net effect of these various spaces is to limit the quantity of vaporized electrode material that passes into chamber 13a and to maximize the quantity of such material that condenses on the surfaces of electrodes 10 and 11. To the extent this vaporized material deposits on electrodes 10 and 11, the deposit tends to maintain the original dimensions of these electrodes and at least does not prejudice the operation of the circuit interrupter. However, vaporized material condensing on the envelope 25 tends to form a current conducting path about the interrupter and ultimately may cause failure. The action of the interrupter of the present invention in tending to suppress deposit of electrode material on the envelope 25 thus contributes to the long life and reliability of the unit. Although insulating wall 25 has been shown as a smooth-surfaced member, convolutions and re-entrant portions may be added to further minimize metallic vapor deposition.

Preferably the cavity 15 of electrode 10 and the finger part 32 of electrode 11 are both of circular cross-section. However, they may be elliptical or other non-circular cross-section so long as they define an annular elongated space S about which the arc can spiral for ultimate circuit interruption as described above.

The electrodes 10 and 11 are made of any suitable conducting material. Preferably they are of metal. Although the metal for this purpose may be a conventional contact metal such as copper or silver, it is preferably chosen in accordance with the principles set forth in the copending application of Lee and Cobine, entitled "Vacuum-Type Circuit Interrupter," Serial Number 750,784, filed July 24, 1958, and assigned to the same assignee as the present invention. Materials such as tin, antimony, lead, zinc, manganese, bismuth, and alloys thereof may, for example, be used. The cavity 15 of electrode 10 and the length of the finger-like member 12 of the electrode 11 are made sufficiently long to assure that by the time the arc approaches the end of the finger portion 32, a current zero is reached. In a sixty cycle circuit, for example, this means that the length of the cavity 15 and the finger portion 12 of electrode 11 is in excess of the axial distance the arc travels in $\frac{1}{2}$ 20 second.

The intensity of the magnetic field produced by the solenoid 12 is chosen to assure arc velocity in its spiral

motion adequate to provide the necessary movement of the arc over the electrode surfaces. The polarity of this field is a matter of indifference as it merely affects the direction of rotation of the spiral path taken by the arc.

Figs. 2 and 3 show an alternative embodiment of the present invention in which the arc-forming surfaces at the open end of the annular space S are spaced from the main contact-making surfaces between the two electrodes. In the structure of these figures, the fixed electrode 43 is provided with an elongated cavity 44 which receives the finger-like member 50 of the movable electrode 49 as shown. The cavity in the electrode 43 defines two beveled surfaces at 45 and 57, respectively, the first serving as an arcing contact surface and the second serving as a normal contact surface. The movable electrode 49 has an enlarged portion 58 which defines a beveled surface 51 which seats against the beveled surface 57 of the fixed contact 43 to form the normal current conducting contact area. The finger-like member 50 of this electrode has a diametral pin 56 which protrudes from both sides and, when the electrode 49 is in the contact-opening position of the dotted lines of Fig. 3, bears against the upper face of the sleeve 53 to break the contact between the beveled surface of that sleeve and the beveled arcing surface 45 of the fixed electrode 43. Spring 54 bears against the bottom surface of the sleeve 53 to hold the same in contact-making relation to the beveled surface 45 of the fixed electrode 43 until disengaged by the action of the pin 56. Pin 56 may, of course, be replaced by a collar or other suitable operative equivalent.

In the structure of Figs. 2 and 3, contact is initially broken between beveled surfaces 51 and 57 as the movable electrode 49 is moved downwardly. The current flow is then confined to the sleeve 53 and the beveled arcing surface 45 of the fixed electrode 43. Further movement of the movable electrode 49 causes the pin 56 to bear against the top surface of the sleeve 53 and draw the sleeve 53 out of contact with the beveled contact surface 45 of the fixed electrode 43. Since members 51 and 53 are electrically connected by flexible conductor 58, the arc is transferred from member 51 to member 53. Metal of the sleeve 53 and the contact surface 45 then vaporizes to form the arc. The arc is moved in a spiral path by the action of the solenoid 59 and the arc current flow and follows a path such as shown in the heavy spiral line of Fig. 2 in the same fashion as is above described in detail with respect to the structure of Fig. 1.

It will be noted that the circuit interrupters shown and described define a radial gap of predetermined length across the space S and it is across this gap that the arc extends as it travels spirally to the base end of the cavity of the fixed electrode. The movable electrode in each instance has two operative positions with respect to the fixed electrode. In the first operative position the movable electrode is in position of maximum insertion. In this position a direct current conducting path is defined between the movable and fixed electrodes by their engaging surfaces. In the second operative position of the movable electrode the contact-making surfaces of the electrodes are spaced by a sufficient distance to cause the arc to travel into the space S.

In the appended claims the term insulating chamber is applied to designate an evacuated chamber, such as 13a, Fig. 1, having walls of insulated material to support one electrode in insulating relation to the other. For most effective circuit interrupter operation and long life it is important that the vaporized electrode material condense on these walls to the minimum possible extent.

While I have shown and described specific embodiments of the present invention it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the invention in its broader aspects. I therefore intend by the appended

claims to cover all changes and modifications falling within the true spirit and scope of the present invention.

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

1. A vacuum interrupter for alternating currents comprising in combination: a pair of relatively movable telescoping inner and outer electrodes defining an elongated annular space, the electrodes in position of maximum insertion having engaging contact-making conformations near one end of said space, and in partially withdrawn contact-breaking position having said conformations spaced while still defining an elongated annular space; means for connecting said electrodes to an alternating current circuit, the circuit connecting means for said outer electrode being displaced from said contact-making conformations in a direction away from the position of maximum insertion of said inner electrode and providing for a generally reentrant current path with current flowing in said electrodes in opposite directions; means defining a vacuum space including said annular space and sustaining said electrodes in insulated relationship whereby withdrawal of the electrodes from said position of maximum insertion to said contact-breaking position creates an arc between said conformations that is propelled by magnetic action into said space; means creating a longitudinal magnetic field in said annular space to cause the arc to spiral about said space as it travels, the length of the annular space when said electrodes are partially withdrawn being sufficient in relation to the frequency of the currents to bring the arc to interruption before it reaches the opposite end of the cavity.

2. A vacuum interrupter for alternating currents comprising in combination: a pair of relatively movable telescoping inner and outer electrodes defining an elongated annular space, the electrodes in position of maximum insertion having engaging contact-making conformations near one end of said space, and in partially withdrawn contact-breaking position having said conformations spaced while still defining an elongated annular space; means for connecting said electrodes to an alternating current circuit, the circuit connecting means for said outer electrode being displaced from said contact-making conformations in a direction away from the position of maximum insertion of said inner electrode and providing a generally reentrant current path with current flowing in said electrodes in opposite directions; means defining a vacuum space including said annular space and sustaining said electrodes in insulated relationship, whereby withdrawal of the electrodes from said position of maximum insertion to said contact-breaking position creates an arc between said conformations that is propelled by magnetic action into said space and away from said end; a solenoid encircling said annular space; and means to cause current flow in said solenoid to cause the arc to spiral about said space as it travels, the length of the annular space when said electrodes are partially withdrawn being sufficient in relation to the frequency of the currents to bring the arc to interruption before it reaches the opposite end of the cavity.

3. A vacuum interrupter for alternating currents comprising in combination: a pair of relatively movable telescoping inner and outer electrodes defining an elongated annular space, the electrodes in position of maximum insertion defining a first set of contact-making conformations near one end of said space and a second set of contact-making conformations outboard said space, the electrodes in initial contact-breaking position of partial withdrawal spacing said second set of contact-making conformations while still defining an elongated annular space; means for connecting said electrodes to an alternating current circuit, the circuit connecting means for said outer electrode being displaced from said contact-making conformations in a direction away from the position of maximum insertion of said inner electrode and providing a generally re-entrant current path with current

flowing in said electrodes in opposite directions; means defining a vacuum space including said annular space and sustaining said electrodes in insulated relationship, whereby withdrawal of the electrodes from said position of maximum insertion through said initial contact-breaking position to said final contact-breaking position creates an arc between said first set of contact-making conformations that is propelled by magnetic action into said space and away from said end; and means creating a magnetic field longitudinally of said space as it travels, the length of the annular space when the electrodes have said final contact-breaking position being sufficient in relation to the frequency of the currents to bring the arc to interruption before it reaches the opposite end of the cavity.

4. A vacuum interrupter for alternating currents comprising in combination: a block of conducting electrode material defining an elongated bore closed at one end and open at the other end, the bore being enlarged to define a shoulder inboard the open end; a pair of terminals for connecting said electrodes to an alternating current circuit, the terminal for the block of electrode material being displaced from the shoulder in a direction toward the open end of said bore and providing for a generally re-entrant current path with current flowing in said electrodes in opposite directions; means defining a vacuum-tight insulating envelope about the open end of the bore; a finger-like member of conducting electrode material movably supported by said envelope, said member extending within said bore to define an elongated annular space in relation thereto, said member further having conformations that engage said shoulder in contact-making engagement when said member is in fully inserted position, and being spaced from said shoulder to break contact when the member is partially withdrawn, whereby the withdrawal of said member from contact-making to contact-breaking engagement draws an arc between said conformations and said shoulder that travels towards the said one end of the bore; and means creating a magnetic field longitudinally of said annular space to cause the arc to spiral about said space as it travels, the length of the annular space when said member is partially withdrawn being sufficient in relation to the frequency of the currents to bring the arc to interruption before it reaches said one end of the bore.

5. A vacuum interrupter for alternating currents comprising in combination: a block of conducting electrode material defining an elongated bore closed at one end and open at the other end, the bore being enlarged to define a shoulder inboard the open end; means contacting said block at a position near the open end of said bore and away from said shoulder for connecting said electrode to an alternating current circuit and providing for a generally re-entrant current path with current flowing in said electrodes in opposite directions; means defining a vacuum-tight insulating envelope about the open end of the bore; and a finger-like member of conducting electrode material movably supported by said envelope, said member extending within said bore to define an elongated annular space in relation thereto, said member further having conformations that engage said shoulder in contact-making engagement when said member is in fully inserted position, and being spaced from said shoulder to break contact when the member is partially withdrawn, whereby the withdrawal of said member from contact-making to contact-breaking engagement draws an arc between said conformations and said shoulder that travels towards the same one end of the bore, the length of the annular space when said member is partially withdrawn being sufficient in relating to the frequency of said alternating currents to bring the arc to interruption before it reaches said one end of the bore.

6. A vacuum interrupter for alternating currents of the type in which the arc is maintained momentarily by conduction through evaporated electrode material prior to interruption comprising in combination: a first electrode

defining a vacuum-tight arcing chamber open at one end; a second electrode movable in relation to the first electrode, extending within said arcing chamber, and having contact-making surfaces in engagement with said first electrode at said one end of the arcing chamber; means for connecting said electrodes to an alternating current circuit, the circuit connecting means for said first electrode being displaced from said contact-making surfaces in a direction toward the open end of said chamber and providing for a generally re-entrant current path; a vacuum-tight envelope spanning the open end of said chamber to define an insulating chamber outboard the first electrode and movably supporting said second electrode in insulating relation to the first electrode, the electrodes defining arcing surfaces within said arcing chamber to break contact at said contact-making surfaces, whereby the electrode material is vaporized by the arc primarily within the arcing chamber and travels into the second chamber only after passage through the restricted space defined by the second electrode and the open end of said arcing chamber.

7. A vacuum interrupter for alternating currents of the type in which the arc is maintained momentarily by conduction through evaporated electrode material prior to interruption comprising in combination: a first electrode defining a vacuum tight arcing chamber open at one end; a second electrode movable in relation to the first electrode, extending within said arcing chamber, and in position of maximum insertion having contact-making surfaces in engagement with said first electrode at said one end of the arcing chamber; means for connecting said electrodes to an alternating current circuit, the circuit connecting means for said first electrode being displaced from said contact-making surfaces in a direction away from the position of maximum insertion of said second electrode and providing for a generally re-entrant current path with current flowing in said electrodes in opposite directions; a vacuum-tight envelope spanning the open end of said chamber to define an insulating chamber outboard the first electrode and movably supporting said second electrode in insulating relation to the first electrode, the electrodes being so conformed as to define arcing surfaces within said arcing chamber when said second electrode is partially withdrawn from said chamber to break contact at said contact-making surfaces and to cause the arc, when formed, to travel away from the open end of said chamber, whereby the electrode material is vaporized by the arc primarily in the arcing chamber at points progressively more remote from the open end thereof and travel into the second chamber only after passage through the restricted space defined by the second electrode and the open end of said arcing chamber.

8. A vacuum interrupter for alternating currents of the type in which the arc is maintained momentarily by conduction through evaporated electrode material prior to interruption comprising in combination: a first electrode having an elongated cylindrical bore open at one end and closed at the other end; a second electrode of finger-like conformation extending into said bore to define an annular space in relation thereto, said second electrode having contact-making conformations that engage the bore of the first electrode adjacent the open end thereof when the second electrode is fully inserted and are spaced therefrom when the second electrode is partially withdrawn; means for connecting said electrodes to an alternating current circuit, the circuit connecting means for said first electrode being displaced from the contact-making conformations in a direction away from the position of full insertion of said second electrode and providing for a generally re-entrant current path with current flowing in said electrodes in opposite directions; a vacuum-tight envelope spanning the open end of said chamber to define an insulating chamber outboard the first electrode and movably supporting said second electrode in insulating relation to the first electrode; and means defining an

external electric circuit from the second electrode at a point outside said bore to the first electrode, whereby on partial withdrawal of said second electrode an arc is formed at said contact-making conformations and is propelled inwardly of said bore and the electrode material is vaporized by the arc within the arcing chamber at points progressively more remote from the open end thereof and can travel into the insulating chamber only after passage through the restricted space defined by the second electrode and the open end of said bore.

References Cited in the file of this patent

UNITED STATES PATENTS

1,929,155	Ullery -----	Oct. 3, 1933
2,027,836	Rankin et al. -----	Jan. 14, 1936

FOREIGN PATENTS

594,282	Germany -----	Mar. 14, 1934
---------	---------------	---------------