Nov. 10, 1964 T. J. SCULLY ETAL 3,156,803

CIRCUIT INTERRUPTER HAVING UNIFORMLY SPACED SPIRAL ARC RUNNERS IN A CONFINED ATMOSPHERE FOR IMPROVED ARC VOLTAGE CONTROL

Filed May 29, 1962 2 Sheets-Sheet 1

FIG. 1.

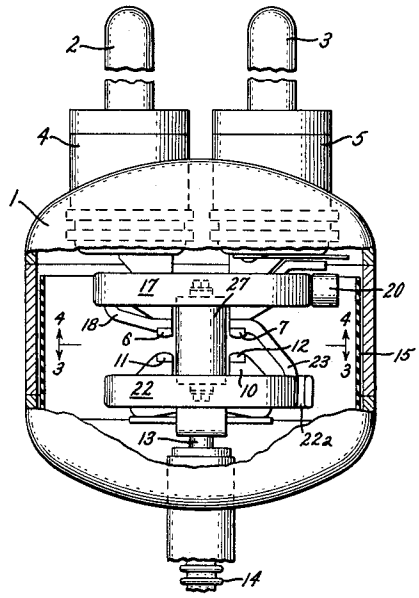


FIG 2.

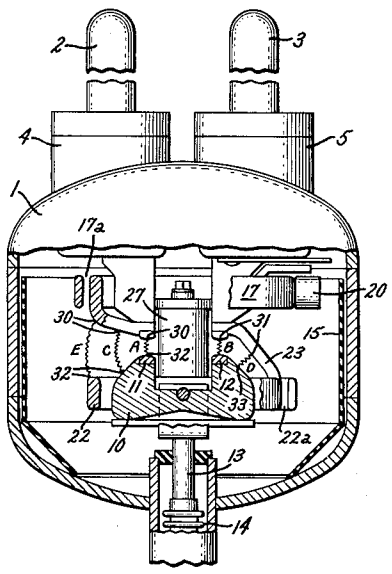


FIG. 3.

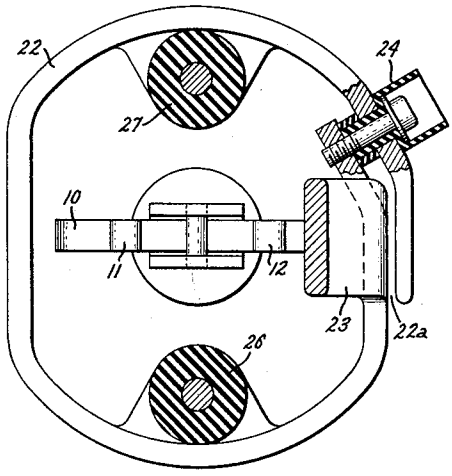
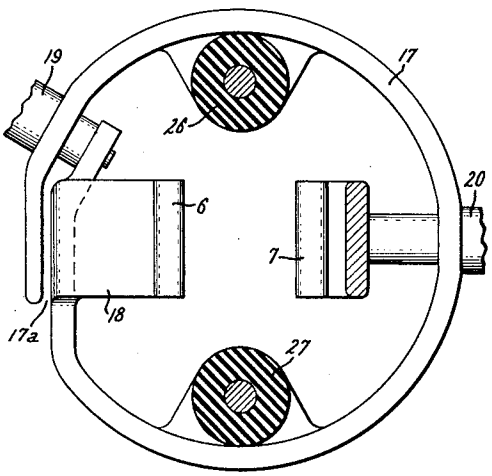


FIG. 4.



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FIG. 5.

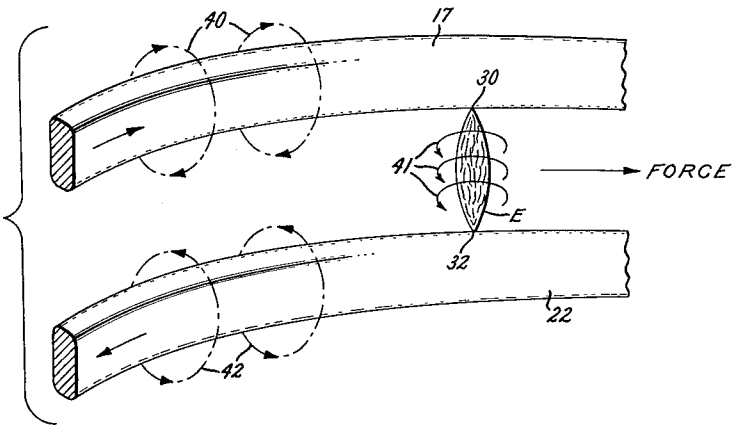


FIG. 7.

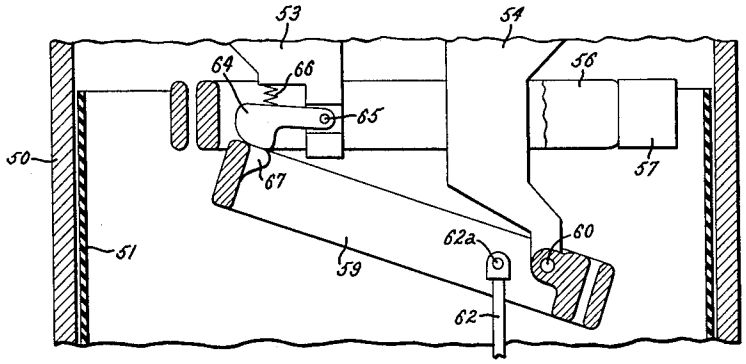


FIG. 6.

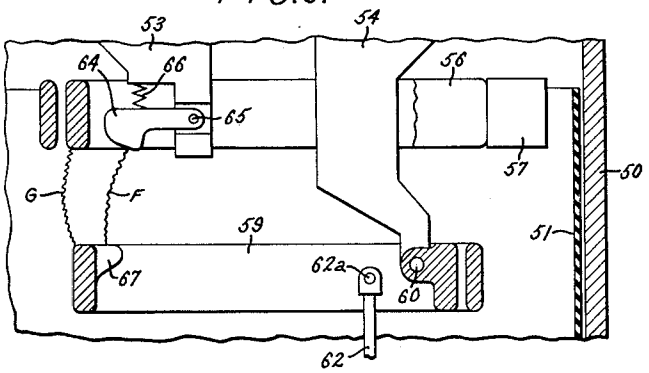
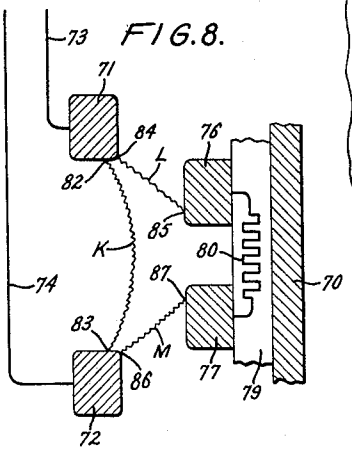


FIG. 8.



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CIRCUIT INTERRUPTER HAVING UNIFORMLY SPACED SPIRAL ARC RUNNERS IN A CONFINED ATMOSPHERE FOR IMPROVED ARC VOLTAGE CONTROL

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19 Claims. (Cl. 200—144)

The present invention relates to a circuit interrupter and more particularly to a circuit interrupter for extinguishing a developed arc wherein the interrupter has switch contacts and arc runner members disposed in a container.

In the past, circuit interrupter switch contacts have been enclosed within a suitable container or envelope having an atmosphere therein, which may be hydrogen gas or the like. The gas within the container may have a pressure less than atmospheric, equal to atmospheric, or greater than atmospheric. Hydrogen gas is particularly desirable because of its high dielectric strength which prevents the reforming of a developed electric arc after the arc has been drawn in the presence of the hydrogen gas and extinguished. The non-oxidizing atmosphere that results from using hydrogen gas substantially reduces deterioration or pitting of the switch contacts and helps maintain the switch contact surfaces in a clean and bright condition, thereby improving performance and life of the circuit interrupter. A further advantage of hydrogen gas atmosphere is that it exhibits good heat conductivity and a high diffusion capacity while at the same time providing for isolation of flash and noise that will develop when the arc is interrupted.

During the circuit interrupting process, the roots or terminals of the arc developed upon separation of the switch contacts are likely to produce extreme local heating and increased ionization if the arc should "stall" or remain immobile. Having only an atmosphere in the enclosure (for example, hydrogen gas) to extinguish the developed arc does not completely solve the existing problem of eliminating hot spots or arc spots on the switch contacts that are caused by the roots or terminals of the developed arc. It is desirable to have the developed arc move continuously in an effort to eliminate these hot spots. In the past this has been done by setting up a magnetic field to exert a force which tends to cause the developed arc to move, and if the magnetic force field is sufficient, the developed arc will be caused to move unhaltingly until extinguished. Such movement of the arc will thus minimize the erosion or deterioration of the contacts. If such a magnetic force field is present to move the developed arc, then suitable arc runner means should be provided adjacent to the switch contacts to receive the developed arc so that the arc may run its course until it is extinguished.

It is desirable to control the developed arc so as to maintain arc voltage, within predetermined maximum and minimum limits. The arc voltage must be high enough so that the system in which the circuit interrupter is utilized cannot sustain the developed arc for a prolonged period of time; if the arc voltage were lower than system voltage, the developed arc might not be extinguished in a reasonably short period of time. Yet the arc voltage must not be so high that the voltage peak exceeds the insulation level of the system. This is especially true at the moment of extinction of the developed arc. Should the arc voltage exceed the insulation level of the system, other electrical apparatus and elements that are connected to the circuit might suffer damage. Obtaining arc voltage control in an enclosed

gas interrupter depends upon a combination of at least three inter-related factors: (1) initial gas pressure, (2) length of the arc, and (3) the amount of stored energy of the system in which the circuit interrupter is utilized. If the path and velocity of the respective roots or terminals of the arc were suitably controlled so as to maintain the arc moving at a substantially constant velocity and with a near constant arc length, not only could undesirable voltage fluctuations be avoided and the enveloping gas be most efficiently utilized, but in addition the deterioration of the switch contacts and the arc runner means could be minimized. This would improve performance and extend the usable life of the circuit interrupter without requiring expensive periodic maintenance or structural repairs or replacements.

Accordingly, it is a principal object of the invention to provide a gas circuit interrupter having improved arc extinguishing means.

Another object of the invention is to provide a gas circuit interrupter having improved arc extinguishing means including means to move the arc being extinguished.

A further object of the invention is to provide a gas circuit interrupter having improved arc extinguishing means adapted to develop a magnetic force field by a structural arrangement that is compact yet effective to continuously move the arc along opposing electrodes or arc runners until the arc is extinguished.

Likewise, it is an object of the invention to provide a new and improved circuit interrupter having an arc extinguishing means that maintains a developed arc at a near constant arc length between predetermined minimum and maximum arc voltage limits while the arc is being moved and extinguished.

An additional object of the invention is to provide an improved and compact circuit interrupter having arc extinguishing means suitable for interrupting either A.C. or D.C. electric power.

Briefly, in accordance with one embodiment of the invention, a circuit interrupter is provided having a pair of separable electrical contacts positioned within a tank containing an atmosphere, which is preferably hydrogen gas. A pair of opposed and equally spaced arc runners of nearly closed spiral configuration are provided, with one of the arc runners being electrically connected to one of the interrupter contacts and other runner being associated with the other contact. An electric arc will be developed upon separation of the contacts, and it is caused to move through the controlled gap between the parallel arc runners by interaction with the magnetic field that is produced by current flowing in the runners. The arc plasma in this field experiences a translational force which propels it orbitally along the runners until it is extinguished by the action of the gas within the tank, and while moving in this manner the arc is confined by the tank wall which is generally concentric with the spiral arc runners.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which may be regarded as the invention, the organization and method of operation together with further objects and advantages thereof may best be understood by reference to the following description which is taken in connection with the accompanying drawings, in which:

FIG. 1 is a front view of the circuit interrupter having a portion of the tank wall broken away to expose the internal components of the interrupter;

FIG. 2 is a view of the circuit interrupter of FIG. 1 having broken away portions of the internal structural components to show the relative positions of the components within the tank;

FIG. 3 is an enlarged fragmentary view of the circuit interrupter inner components on the line 3—3 of FIG. 1 in the direction of the arrows, and showing particularly the structural components of the lower portion of the circuit interrupter;

FIG. 4 is an enlarged fragmentary view of the inner components on the line 4—4 of FIG. 1 in the direction of the arrows and showing particularly the structural components of the upper portion of the circuit interrupter;

FIG. 5 is a schematic view illustrating the relation between a current flow through the pair of arc runners and the direction of movement of a developed arc maintained therebetween;

FIG. 6 is a view of a modification of the circuit interrupter of the invention with broken away portions of the inner structural components to show the relative positions of the modified components within the tank in a circuit breaking position;

FIG. 7 is a view of the modification of FIG. 6 to show the relative positions of the modified components within the tank in a circuit making position; and

FIG. 8 is a fragmentary schematic view of yet another modification of the circuit interrupter of the invention showing the mechanical and electrical arrangement of the inner structural components within the tank.

Referring to the drawings, and particularly to FIG. 1 and FIG. 2, the circuit interrupter of the invention comprises a generally cylindrical container or tank **1** that has an atmosphere therein to extinguish a developed arc. Such an atmosphere as hydrogen gas when confined within the circuit interrupter tank **1** will exhibit an increase in pressure during the extinguishing of a developed arc since the arc heats the gas. Obviously then, the tank **1** has walls of sufficient thickness to safely contain the pressurized gas therein. As indicated, the atmosphere is preferably hydrogen gas but may be any other gas or atmospheric mixture that exhibits desired characteristics for extinguishing a developed arc.

Line terminals **2** and **3**, which are adapted for connection to an external electric power circuit (not shown), enter the tank **1** through its top wall and extend interiorly in parallel, generally axial directions. The line terminals **2** and **3** are electroconductive members and are insulated from the tank **1** by the respective seals and insulator bushings **4** and **5**. Line terminal **2** extends inwardly into the tank **1** and terminates in a fixed or stationary contact **6**. Similarly, line terminal **3** extends inwardly into the tank **1** to terminate in a fixed or stationary contact **7**. The stationary contacts **6** and **7**, in the preferred embodiment of the invention, are positioned in a common plane that is generally perpendicular to the longitudinal axis of the tank **1**.

By reason of the insulator bushings **4** and **5** and the spaced relationship of the stationary contacts **6** and **7**, electrical continuity between the stationary contacts is normally prevented. However, an electrically conductive movable bridging contact **10** is centrally positioned within the tank **1** to be actuated by an operating shaft **13** that extends through a metallic bellows seal **14** having a conventional form. The bridging contact **10** which is fastened to the shaft **13** by means of the pin shown in FIGS. 2 and 3 may be suitably insulated from the operating shaft **13** and the tubular bellows **14** to prevent an undesirable current flow therethrough. The shaft **13** will move the bridging contact **10** normal to the plane of the stationary contacts **6** and **7** into or out of substantially simultaneous engagement with both contacts **6** and **7**. Thus, circuit control of the respective line terminals **2** and **3** is maintained.

A liner member **15** that is formed from suitable insulating material may be inserted in the tank **1** adjacent to an inner wall thereof to encircle the arc runners **17** and **22**. As shown it is disposed in concentric relationship with a circular cross section of the tank. The liner **15** provides electrical insulation between the metallic

wall of the tank and the previously mentioned contacts and any electric arcs that may be developed during operation of the circuit breaker as will be described.

An upper spiral arc runner **17**, most clearly shown by FIGS. 1, 2 and 4, is located within the tank **1** slightly above and adjacent to the stationary contacts **6** and **7**. As is best seen in FIG. 4, the arc runner **17** comprises an elongated, generally circular member whose opposite ends are spaced from each other by a relatively short gap **17***a*. This member and the circular cross section of the tank **1** are substantially concentric with each other. The spiral arc runner is in electrical continuity with the first stationary contact **6** by means of an inclined bar **18** of electrically conductive material that is appended to member **17** at its inner end. The arc runner is suitably supported and insulated from the tank by insulator support assemblies **19** and **20**.

A lower spiral arc runner **22**, best shown by FIGS. 1, 2 and 3, is spaced from and generally surrounds the movable bridging contact **10**. As is best seen in FIG. 3, the arc runner **22** also comprises an elongated, generally circular member having opposite ends spaced from each other by a relatively short gap **22***a*, and it too is disposed in substantially concentric relationship with a circular cross section of the tank **1**. This spiral arc runner is maintained in electrical continuity with the second stationary contact **7** by an inclined bar **23** that is appended to member **22** at its inner end, while it is electrically insulated from the metallic tank **1** by a suitable insulator support assembly **24**.

The upper spiral arc runner **17** and the opposing lower spiral arc runner **22** are fixedly positioned with the tank **1** in spaced-apart parallel planes which are parallel to but on opposite sides of the plane of the stationary contacts **6** and **7**. The arc runners are equidistantly spaced from each other. The desired dimension of this spacing may be determined and maintained by the inclination and length of the respective inclined bars **18** and **23** and by the insulator spacer posts **26** and **27** that are positioned between the upper spiral arc runner **17** and the lower spiral arc runner **22**. The short gaps **17***a* and **22***a* between the overlapping ends of the respective runners are out of register, and in the illustrated structure they are located diametrically opposite one another. Both the upper spiral arc runner **17** and the lower spiral arc runner **22** curl in agreement with each other.

The electrically conductive movable bridging contact **10** as shown by FIGS. 2 and 3 can be formed into a blade element such as shown. However, since it is desired to reduce surface pitting at the points where initial arcs may be developed, upwardly extending contact tips **11** and **12** that are formed from a metal which resists pitting are positioned on the blade element to separably engage the first and second stationary contacts **6** and **7** respectively. Contacts **6** and **7** may be formed from a similar metal which resists pitting.

Operatively, a line current passes through the circuit interrupter of the invention when the movable bridging contact **10** is positioned in the tank **1** to engage the respective contact tips **11** and **12** with the stationary electrical contacts **6** and **7**. The direction of a line current flow through the circuit interrupter is not critical in the invention since the circuit interrupter has applicability to either A.C. or D.C. voltages. This will be subsequently described in more detail. When the movable bridging contact **10** separates from the stationary contacts **6** and **7**, it moves in a plane normal to the plane of the stationary contacts. As a result of this movement, at least two arcs are drawn between the respective contact tips **11** and **12** of the bridging contact **10** and the stationary contacts **6** and **7**. These arcs are indicated in FIG. 2 by the letters A and B. As the movable bridging contact **10** is moved progressively away from the stationary contacts **6** and **7**, the developed arcs at A and B will move radially outwardly to the respective inter-

mediate locations at C and D. The upper roots or terminals **30** and **31** of the developed arcs at the intermediate points C and D are in engagement with the first inclined bar **18** and the second inclined bar **23**. The lower terminals **32** and **33** of the arcs at the intermediate points C and D are in engagement with the peripheral surface of the movable bridging contact **10**.

The arcs at the intermediate points C and D have traveled radially outwardly from the initial positions at A and B since, when the contacts are separated to form the arcs, the magnetic effect of the arcs or loops will impel the arcs radially outwardly toward the arc running surfaces such as the spiral arc runners **17** and **22** of the invention. The speed at which the arcs or loops move radially outwardly toward the arc running surfaces depends upon the magnitude of the arcing current and varies as a function of this arcing current. In other words, arcs of relatively high current magnitude move rapidly outwardly toward the arc running surfaces whereas arcs of relatively low current magnitude move at considerably lesser speeds than the high current arcs. In accordance with the invention, as the arcs continue to move outwardly from the intermediate positions at C and D, arc C eventually reaches a position where it touches the lower spiral arc runner **22**, and the arc designated as E is formed. The arc D will be extinguished at this time since the arc current now reaches the inclined bar member **23** directly through the runner **22** which is conductively connected to the inclined bar **23**. Thus, in the course of a circuit interruption, the developed arcs at initial positions A and B become the single arc at position E that is now located with its upper terminal **30** engaging the upper spiral arc runner **17** and its lower terminal **32** engaging the lower spiral arc runner **22** to maintain current through the circuit interrupter. At this point, in accordance with the structural arrangement of the invention, a magnetic force due to arc current flow is exerted upon the developed arc E to move it along and between the spiral arc runners **17** and **22** in an orbital fashion.

Referring now to FIG. 5, the magnetic forces developed by the flow of current through the internal components of the circuit interrupter of the invention are illustrated. These magnetic forces act to advance or propel the developed arc E in a clockwise direction between the spiral arc runners **17** and **22**. The current flowing in the upper spiral arc runner **17** from the first stationary electrical contact **6** to the upper terminal **30** of the developed arc E produce the magnetic lines of force **40**. The arc current flow in the developed arc E forms the magnetic lines of force **41**. Current returns through the lower spiral arc runner member **22** to the second stationary electrical contact **7** from the lower terminal **32** of the developed arc E and produces magnetic lines of force **42**. It should be noted in FIG. 5 that the magnetic lines of force **40** and **42** act in the same direction between the upper spiral arc runner **17** and the lower spiral arc runner **22**. This additive effect will substantially increase the intensity of the magnetic field between the spiral arc runners **17** and **22** on the left side of the developed arc E which is common to the arc current flow through the spiral arc runners. The magnetic lines of force **41** of the developed arc E also increase the intensity of the magnetic field that is developed between the spiral arc runners **17** and **22**. No arc current flows in the spiral runners **17** and **22** on the right side of the arc E so that the only magnetic field on that side of the arc E is from the previously described magnetic lines of force **41**.

The interaction of these previously described magnetic fields and the arc plasma E produces a net tangential force that acts upon the developed arc and drives the arc E clockwise, i.e., from left to right in FIG. 5. The motion of the arc E during this clockwise circulation exhibits a constant rate of tangential movement and generates a path that defines the lateral area of a cylinder. This constant rate of tangential movement by the arc E drives the arc into fresh or unused areas of atmosphere within the tank **1** to efficiently utilize the extinguishing ability of a particular gas or atmospheric mixture within the tank.

Although not shown, when an arc current flows through the spiral arc runners **17** and **22** in a direction opposite from that shown by FIG. 5, i.e., from runner **22** to runner **17**, the net tangential force that will act upon the developed arc E will still drive the arc in a clockwise direction. The magnetic fields relating to the arc or loop will still develop a net tangential force on the same side of the arc E as previously described and illustrated by FIG. 5. Thus a developed arc E of either A.C. or D.C. current flow will always move in a clockwise direction because of the particular mechanical arrangement of the spiral arc runners **17** and **22** as shown in one embodiment of the invention by FIGS. 1–4. The direction of movement of the developed arc, i.e., clockwise or counterclockwise, is therefore dependent upon the mechanical arrangement of the spiral arc runners **17** and **22** rather than upon the direction of the arc current which flows therethrough. If the direction of spiral curl of the arc runner members **17** and **22** is reversed, a developed arc such as arc E will move in a counterclockwise direction since the magnetic fields would then be on the right side of the arc rather than on the left side such as shown by FIG. 5.

Referring again to FIGS. 2 and 3, the circuit interrupter of the invention provides that the gaps **17***a* and **22***a* in the respective spiral arc runners **17** and **22** are out of register. Therefore, when the developed arc E has moved through a first predetermined portion of its orbit, the constant rate of tangential movement of the arc E will cause the lower terminal **32** to jump the gap **22***a* in the lower arc runner **22**. After the arc E has been propelled in a clockwise direction through the remainder of its orbit, the upper terminal **30** of the arc E reaches the outer end of the upper arc runner **17** whereupon the upper terminal **30** of the arc E jumps gap **17***a*. It can readily be seen that one terminal of the developed arc continues to engage a spiral arc runner whenever the opposite terminal of the arc is jumping a gap in the associated arc runner member. The constant rate of tangential movement of the developed arc in conjunction with the angularly displaced gaps of the spiral arc runners in the circuit interrupter of the invention result in unhalting movement of the arc into fresh gas at a substantially constant rate, whereby the extinguishing ability of the gas is most efficiently utilized. Both of these features as realized by the invention contribute to minimizing the possibility of the developed arc E "stalling" between the opposed spiral arc runner members **17** and **22**. The continuous movement of the arc E prevents significant erosion of arc runner material which would occur at a stalling point. The developed arc E continues to circulate within the tank **1** under the tangential force between the spiral arc runners **17** and **22** for a length of time and for a total distance that are both dependent upon the amount of available energy that must be expended in order to extinguish the arc.

During the clockwise circulation or orbital movement of the developed arc E in the structural arrangement of the invention as shown by FIGS. 1–4, the cylindrical walls of the tank **1** confine the arc and limit its maximum length. The maximum spacing between the spiral arc runners **17** and **22** and the concentric inner wall of the tank **1** is dependent upon the maximum arc voltage permissible. The insulating liner **15** may be provided to prevent the possibility that the developed arc E might jump or arc to the inner wall of the metallic tank **1**. In the embodiment as shown by FIGS. 1 through 4, we contemplate a "dead" tank and such jumping or arcing of the arc E to the inner wall of the metallic tank **1** is not desired. In some applications of the circuit inter-

rupter of the invention, however, the design parameters of the tank and the previously described inner structural components may eliminate the need for the insulating liner 15 while still obtaining the proper functioning of the circuit interrupter.

It may be further pointed out that the development of a singular arc, such as arc E, from a plurality of arcs such as A and B, will produce levels of arc voltage that are generally stable and free of excessive peaks. This arc voltage stability is primarily determined by the opposite and generally parallel spacing of the arc runners 17 and 22, so that in conjunction with the concentric positioning of the tank 1, and the insulating liner 15 when used, the maximum arc length is controlled while the arc is being extinguished. The generally opposed and equally spaced spiral arc runners 17 and 22 are preferably designed to be substantially free from major surface obstructions which might delay the running of the arc terminals, and the short gaps therein are disposed out of register as noted hereinbefore.

The interruption time of the new and improved circuit interrupter of the invention having the generally opposed spiral arc runners has been found to be rapid. For example, in a test conducted to interrupt a D.C. current of 48,500 amperes at 700 volts, and using a tank containing hydrogen gas at a pressure about 20 times greater than atmospheric, the interruption time was .006 second and the developed arc was moved by the magnetic force fields, i.e., by the net tangential force, at an average speed of approximately 425 feet per second through the hydrogen gas.

A modification of the circuit interrupter of the invention is shown in FIG. 6. A partially shown metallic tank 50 and an inner liner 51 are similar to those components of the circuit interrupter previously described. Line terminals 53 and 54 extend generally axially into the tank 50, preferably from the same side of the circuit interrupter as shown. An upper spiral arc runner 56 is fixedly disposed as previously described within the tank 50 slightly above but generally surrounding the inwardly extending line terminals 53 and 54. The upper spiral arc runner 56 is suitably insulated from the tank by an insulator support assembly 57. Additionally, the upper spiral arc runner 56 is maintained in electrical continuity with the inwardly extending line terminal 53. A lower spiral arc runner 59 which is generally concentric with the arc runner 56, is pivotally secured to and maintained in electrical continuity with the inwardly extending line terminal 54 about a pivotal point or rotational axis 60. The lower spiral arc runner 59 is adapted to be actuated about the rotational axis 60 by means of a suitable mechanical linkage represented by the member 62 which is actuated by external means, not shown. The member 62 is pivotally joined to runner 59 at a point 62*a* which is relatively close to the axis 60. The inwardly extending line terminal 53 pivotally secures a radially extending contact bar 64 about a rotational axis or pin 65. A resilient means 66, for example, a spring or the like, is suitably positioned to urge the contact bar 64 to a normal position such as shown by FIG. 6. A cooperating contact 67 is maintained in electrical continuity with the lower spiral arc runner 59 on which it is located, and upon pivotal movement of the lower arc runner about the rotational axis 60 to a circuit making position, as is shown in FIG. 7, the contact 67 will separably engage the contact bar 64. Resilient means 66 assures a firm electrical contact between contact bar 64 and contact 67.

Operatively, a line current will pass through the modification of the circuit interrupter as shown by FIG. 6 when the lower spiral arc runner 59 with the contact 67 thereon is arcuately moved to engage the contact bar 64 as shown by FIG. 7. When the lower spiral arc runner 59 and the contact 67 are moved away from the contact bar 64 toward a normal circuit breaking position as shown by FIG. 6, an F is drawn between the respective contacts 64 and 67. In a manner similar to that previously described, the developed arc will move radially outwardly to a position G where it touches the upper spiral arc runner 56 and is transferred thereto. The previously described tangential force again causes the arc G to move orbitally along the upper and lower spiral arc runners 56 and 59, and the arc is quickly extinguished as before. The proposed modification shown by FIGS. 6 and 7 provides a mechanical arrangement wherein circuit interruption is accomplished upon movement of the actuating member 62 through only a relatively short distance, this distance being much less than the length of the gap formed between the separated contacts 64 and 67.

FIG. 8 shows another modification of the invention having a metallic tank 70, partially shown, similar to the tank previously described and shown by FIGS. 1 and 2. The metallic tank 70 encloses an upper spiral arc runner 71 and a lower spiral arc runner 72 that are centrally positioned within the metallic tank 70 and spaced therefrom in a fashion similar to that previously described and shown by FIGS. 1 through 4. The upper spiral arc runner 71 is maintained in electrical continuity with an incoming line terminal 73, while the lower spiral arc runner 72 is similarly maintained in electrical continuity with line terminal 74.

An annular upper secondary arc runner 76 and an annular secondary arc runner 77 are located in parallel, spaced relationship within the metallic tank 70 on the inner surface sheet or cylinder 79 that is similar to the liner member 15 previously described and shown by FIGS. 1 and 2. These secondary arc runners are interconnected by a plurality of parallel resistance elements embedded in the sheet 79, such as the resistor 80 shown schematically in FIG. 8. The secondary runners 76 and 77, as can be seen in FIG. 8, are separated by a distance less than the spacing between spiral runners 71 and 72 and are disposed medially with respect thereto.

An upper terminal 82 and a lower terminal 83 of a developed arc K, similar to the developed arc E previously described and shown by FIGS. 2 through 5, touch the upper spiral arc runner 71 and the lower spiral arc runner 72 respectively. In the modification of the circuit interrupter shown by FIG. 8, the developed arc K extends radially outwardly under the magnetic effect previously described and is then intercepted by the secondary arc runners 76 and 77. This will divide the arc into two serially related distinct arclets L and M. Arclet L has terminals 84 and 85 on the upper spiral arc runner 71 and the proximate secondary arc runner 76, respectively. In similar fashion, arclet M has terminals 86 and 87 on the lower spiral arc runner 72 and the proximate secondary arc runner 77, respectively.

Operatively, circuit current flowing between line terminals 73 and 74 during the circuit interrupting process will pass in series through the upper spiral arc runner 71, arclet L, upper secondary arc runner 76, resistor 80, lower secondary arc runner 77, arclet M, and the lower spiral arc runner 72. Current flowing through the resistor 80 results in dissipation of system energy without appreciably heating the gas or atmospheric mixture confined within the metallic tank 70, and this tends to reduce the increase in internal pressure within the tank. The resistor 80 is positioned near the metallic tank wall 70 for rapid heat dissipation, thereby minimizing the temperature elevation of the confined gas and the consequent increase of internal pressure due to the heating of this resistor. Thus, the modification of the invention as shown by FIG. 8 enables a thinner metallic tank wall 70 to be used without impairing safety of the overall circuit interrupter.

As will be evidenced from the foregoing description, certain aspects of the invention are not limited to the particular details of the construction illustrated. For example, the optional insulating liner may be omitted,

dependent upon the final design parameters of the metallic tank. Further, it is contemplated that the spiral arc runner members, although shown in planes generally parallel to the plane of the stationary contacts, could be equally spaced from and opposed to each other at something other than a parallel relationship to the plane of the stationary contacts. The primary consideration of the invention is to position the spiral arc runners within the enclosing tank so that the length of a developed arc is maintained relatively constant as it is circulated by the magnetic force field until the arc is extinguished by the atmosphere in the tank.

It is also contemplated that the particular circuit interrupter previously described can function as a device for arcing contacts only. Thus, separate main current carrying contacts may be positioned externally of the interrupter tank so that the main contacts would be protected from any damaging erosion caused by a developed arc. Therefore, while additional modifications and applications will occur to those skilled in the art, it is intended that the appended claims shall cover such modifications and applications that do not depart from the true spirit and scope of the invention.

Having described the invention, what is claimed is:

1. A circuit interrupter comprising:
(*a*) a tank;
(*b*) a pair of line terminals extending into said tank;
(*c*) first and second stationary electric contacts disposed within said tank in spaced relation to each other and insulated from the tank;
(*d*) means for electrically connecting said stationary contacts to said line terminals, respectively;
(*e*) a movable bridging contact disposed separably to engage said stationary contacts within said tank;
(*f*) a first arc runner member located adjacent to said stationary contacts and insulated from said tank;
(*g*) a second arc runner member generally surrounding said bridging contact and insulated from said tank;
(*h*) means for electrically connecting said first and second arc runner members to said first and second stationary contacts, respectively; and
(*i*) actuating means for moving said bridging contact to establish an electric arc in the tank;
(*j*) said arc runner members being positioned in opposition to and spaced from each other for receiving said arc and being so arranged that a magnetic field is developed therebetween in response to current flowing therein for continuously moving the arc along said members while the arc is being extinguished within said tank.

2. The circuit interrupter of claim 1 in which said tank contains hydrogen gas.

3. The circuit interrupter of claim 1 in which said line terminals enter said tank through a common wall thereof and extend interiorly in generally parallel directions.

4. The circuit interrupter of claim 1 in which said arc runner members individually define spiral surfaces.

5. The circuit interrupter of claim 4 in which the spiral surfaces of said members are equidistantly spaced from each other and in which said tank has a circular cross section which is concentric with said members.

6. The circuit interrupter of claim 5 in which the spiral surfaces of said members curl in agreement with each other.

7. The circuit interrupter of claim 6 in which a liner member is disposed adjacent to an inner wall of said tank, said arc runner members being encircled by said liner member which provides electrical insulation between said members and said tank.

8. A circuit interrupter comprising:
(*a*) a tank containing an atmosphere;
(*b*) a pair of line terminals extending into said tank;
(*c*) first and second stationary electrical contacts disposed in a common plane within said tank in spaced relationship to each other and insulated from the tank;
(*d*) means for electrically connecting said stationary contacts to said line terminals, respectively;
(*e*) a movable bridging contact disposed separably to engage said stationary contacts within said tank;
(*f*) actuating means for moving said bridging contacts normal to said plane of the stationary contacts to draw an electric arc in the tank;
(*g*) a first arc runner member located adjacent to said stationary contacts and insulated from said tank;
(*h*) a first bar member appended to said first arc runner member and electrically connected to said first stationary contact;
(*i*) a second arc runner member generally surrounding said bridging contact and insulated from said tank, said second member being disposed in opposition to and equidistantly spaced from said first arc runner member; and
(*j*) a second bar member appended to said second arc runner member and electrically connected to said second stationary contact;
(*k*) said first and second bar members being arranged to position said first and second arc runner members for receiving and limiting the length of said arc.

9. The circuit interrupter of claim 8 in which said arc runner members have spiral configurations, with the opposite ends of each arc runner being spaced from each other by a relatively short gap.

10. The circuit interrupter of claim 9 in which the gap between ends of one of said arc runner members is out of register with the gap between ends of the other arc runner member.

11. The circuit interrupter of claim 9 in which said tank has a circular cross section which is substantially concentric with said arc runner members.

12. The circuit interrupter of claim 11 in which said atmosphere is hydrogen gas.

13. A circuit interrupter comprising:
(*a*) a tank;
(*b*) first and second line terminals extending into said tank;
(*c*) a first spiral arc runner fixedly disposed within said tank and electrically connected to said first line terminals;
(*d*) a first electrical contact associated with said first terminal;
(*e*) a second spiral arc runner pivotally mounted within said tank and electrically connected to said second line terminal, said second arc runner being disposed in substantially concentric relationship with respect to said first arc runner;
(*f*) a second electrical contact located on said second arc runner for separably engaging said first contact upon pivotal movement of the second arc runner; and
(*g*) means for moving said second arc runner to draw an electric arc between said first and second contacts;
(*h*) said first arc runner being so positioned that the arc terminal on said first contact will transfer to said first runner, and said first and second arc runners being so arranged that current flowing therein produces a magnetic field therebetween which interacts with said arc to propel the arc continuously along said runners until the arc is extinguished.

14. The circuit interrupter of claim 13 in which said tank contains hydrogen gas.

15. The circuit interrupter of claim 14 in which said tank has a circular cross section which is substantially concentric with said arc runners.

16. The circuit interrupter of claim 15 in which a liner member is disposed adjacent to an inner wall of said tank to provide electrical insulation between said arc runners and said tank.

17. A circuit interrupter comprising:

(*a*) a tank having a circular cross section;

(*b*) two electroconductive members fixedly disposed within said tank and insulated therefrom, said members being adapted for connection to an external electric circuit;

(*c*) a first pair of elongated, generally circular arc runners disposed centrally within said tank in substantially concentric relationship with said circular cross section, each runner of said first pair being electrically connected at one end thereof to a different one of said electroconductive members and having its opposite end spaced from its one end by a relatively short gap;

(*d*) an insulating liner disposed adjacent to an inner wall of said tank to encircle said first pair of runners;

(*e*) a second pair of annular arc runners located in parallel, spaced relationship adjacent to an inner surface of said liner, said second pair of runners being medially disposed with respect to the runners of said first pair;

(*f*) a plurality of resistance elements supported by said liner and electrically connected in parallel between the runners of said second pair; and

(*g*) contact means within said tank for establishing an electric arc between the runners of said first pair.

18. The circuit interrupter of claim 17 in which said first and second pairs of arc runners are so arranged that said arc will be intercepted by said second pair of runners for division into two serially related arclets between the proximately disposed runners of the respective pairs.

19. The circuit interrupter of claim 18 in which said tank contains hydrogen gas.

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