Sept. 26, 1961 J. D. COBINE 3,002,073

ELECTRIC CIRCUIT INTERRUPTION DEVICE AND METHOD

Filed April 16, 1958

Fig. 1.

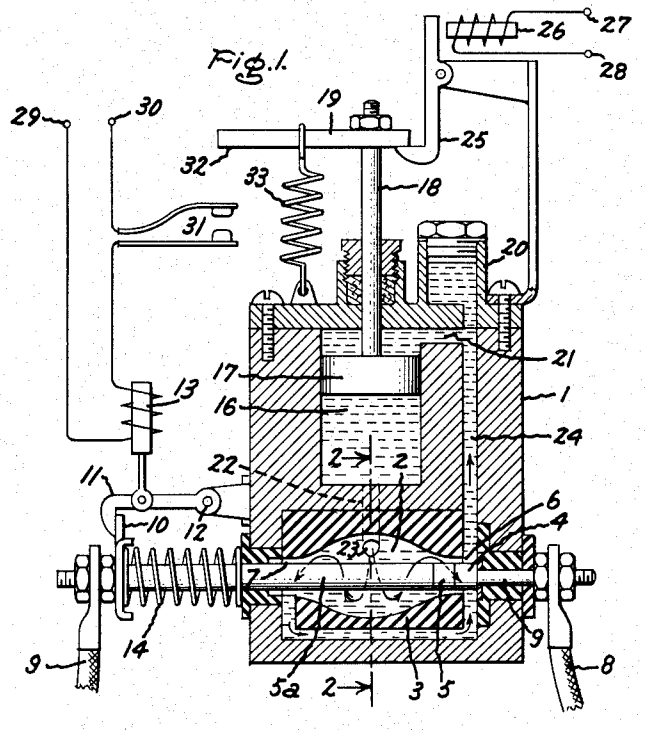


Fig. 3.

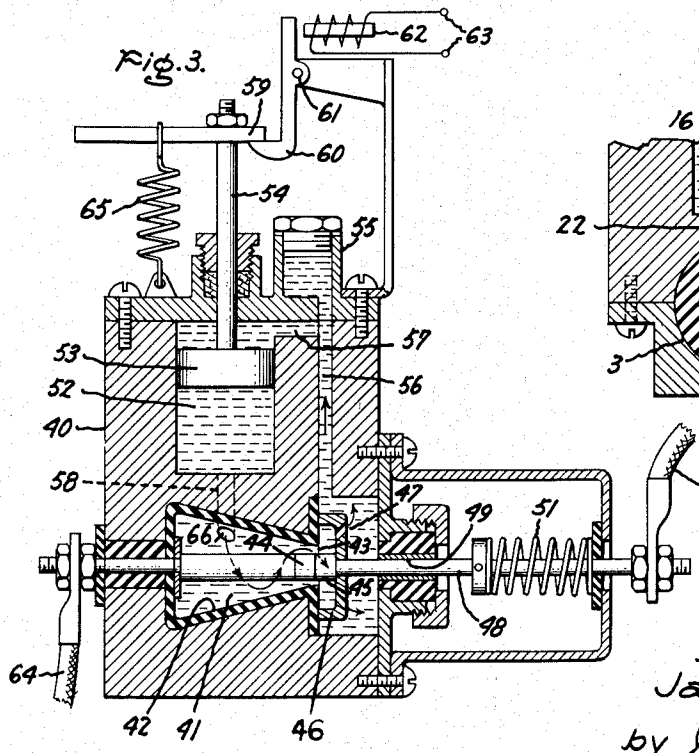
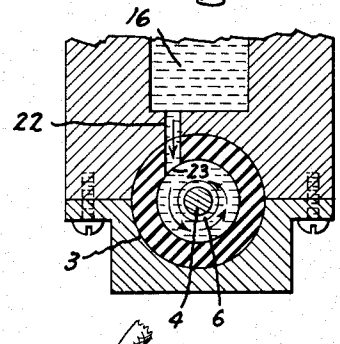


Fig. 2.



Inventor:
James D. Cobine,
by John F. Abel
His Attorney.

United States Patent Office 3,002,073
Patented Sept. 26, 1961

3,002,073

ELECTRIC CIRCUIT INTERRUPTION DEVICE AND METHOD

James D. Cobine, Rexford, N.Y., assignor to General Electric Company, a corporation of New York

Filed Apr. 16, 1958, Ser. No. 728,815
5 Claims. (Cl. 200—150)

The present invention relates to electric circuit interrupting devices and methods and, more particularly, to devices and methods for interrupting high current electric arcs very rapidly without the use of complicated apparatus.

In the electrical generation and transmission arts, it very often becomes necessary to interrupt current in high-voltage high-current circuits, because the circuit becomes overloaded or a particular piece of equipment fails, among other reasons. In these instances, a circuit interrupting device is generally utilized. Such devices generally comprise a pair of arc electrodes which, when mechanically separated, serve as terminal points for a high-current electric arc. The electrical circuit becomes finally interrupted when this arc is extinguished. The efficiency and value of an electric circuit interrupting device is often measured by the time taken to extinguish the arc between the arc electrodes. For many reasons, the more rapidly the arc is interrupted and extinguished, the greater the value and utility of the arc interrupting device. Prior art arc interrupting devices utilize many expedients to interrupt high current arcs. Thus, for example, the arcs are often bent by magnetic fields, blown by high pressure gas blasts, or forced across insulating baffles, among the many means, most of which require the use of complicated and expensive devices.

Accordingly, it is an object of the present invention to provide devices and methods for rapidly interrupting electric currents.

A further object of the present invention is to provide devices and methods for rapidly extinguishing arcs in electric circuit interrupting devices.

A further object of the present invention is to provide a simple, rapidly-acting electric circuit breaker.

In accord with the present invention, an electric circuit interrupting device includes a pair of arc electrodes, at least one of which is movable relative to the other. These electrodes are surrounded by an arc chamber. Means are provided to establish a fluid vortex within the arc chamber and for establishing an electric arc in the arc chamber by separating the arc electrodes. The fluid vortex rapidly and efficiently removes energy from the electric arc, causing the rapid extinction thereof.

The novel features believed characteristic of the present invention are set forth in the appended claims. The invention itself, together with further objects and advantages thereof, may best be understood with reference to the following description taken in connection with the appended drawing in which:

FIG. 1 is a vertical view partially in cross section of one device constructed in accord with the present invention,

FIG. 2 is a vertical cross section along the lines 2—2 in FIG. 1, and

FIG. 3 is a vertical view, partially in cross section of an alternative embodiment of the invention.

In FIG. 1, one arc interrupting device constructed in accord with the present invention includes a breaker housing 1 having therein an arc chamber 2 defined by a double ended tapered arc chamber wall 3 constructed of a suitable electrically insulating material and having the form of a prolate spheroid with open ends. A first fixed arc electrode 4 is located within the wall of breaker housing 1 immediately adjacent one orifice 6 in insulating chamber wall 3. A second movable arc electrode 5 abuts against fixed electrode 4 and is mounted upon electrode rod 5*a* which extends through the opposite end of breaker housing 1, and through a second orifice 7 in insulating chamber wall 3. A first electrical terminal strap 8 is connected to the exterior end of arc electrode 4. A second terminal strap 9 is connected to electrode rod 5*a*.

Electrode rod 5*a* is terminated in a laterally extending member 10 which is latched by pawl 11, pivotably movable about pin 12 and actuated by solenoid 13. When pawl 11 is latched on member 10, the device is in the unactuated or cocked position. Electrode rod 5*a* is spring-biased away from fixed arc electrode 4 by spring 14.

Within breaker housing 1, there is also located a cylinder 16 having therein a fluid driving piston 17 connected to a piston arm 18 having a laterally extending end member 19. A surge tank or reservoir 20, is also located within housing 1. Reservoir 20 is connected with cylinder 16 by means of a fluid conduit 21. Cylinder 16 is connected with arc chamber 2 by means of an off-center fluid conduit 22, terminating in orifice 23. Fluid which passes from arc chamber 2 flows to surge tank 20 by means of fluid conduit 24. The apparatus thus contains a complete fluid flow loop comprising cylinder 16, conduit 22, arc chamber 2, conduit 24, reservoir 20, and conduit 21. In the unactuated or cocked position, piston 17 is maintained in the uppermost portion of cylinder 16, away from fluid conduit 22, and is held latched by pawl 25 which is pivotally rotatable and is latched under laterally extending member 19 on the actuating end of piston rod 18. Pawl 25 may be rotated by actuation of solenoid 26, connected between a pair of terminals 27 and 28. Solenoid 13, which actuates pawl 11, releasing movable arc electrode 5 is connected to a suitable source of electric power connected with terminals 29 and 30 and is connected through a switch 31, actuated by actuating arm 32 connected to the operating end of piston arm 18. Piston arm 18 is spring biased inwardly by means of spring 33 connected between actuating arm 32 and housing 1.

In operation, the interrupting device is cocked, either manually or electrically by means well known to the art, moving piston 17 outwardly within cylinder 16, so that pawl 25 may be locked under member 19 on piston rod 18. At the same time, electrode rod 5*a* is moved inwardly so that movable electrode 5 abuts against fixed electrode 4 and pawl 11 is caught upon member 10.

When it is desired to interrupt the electrical circuit including terminal straps 8 and 9 and electrodes 4 and 5, as for example, upon the exceeding of a particular current value, solenoid 26, which may carry a current proportional to the current passing through the arc electrodes, is actuated. Pawl 24 is rotated, releasing piston 17, which is actuated under the bias of spring 33 inwardly within cylinder 16. The fluid in the lower half of cylinder 16 is urged into arc chamber 2 tangentially, leaving the arc chamber through orifices 6 and 7 which act as nozzles. A fluid vortex is established within arc chamber 2 due to the tangential motion of fluid entering chamber 2 through orifice 23 prior to the separation of terminals 4 and 5. As piston 17 continues to descend within cylinder 16, actuating arm 32 closes switch 31, actuating solenoid 13 and causing pawl 11 to rotate about pin 12. Spring 14 then moves electrode rod 5*a* outwardly, urging movable electrode 5 away from fixed electrodes 4, causing the establishment of a high current electric arc.

As may be noted from FIG. 1, an arc established between movable electrode 5 and fixed electrodes 4 is established within the throat of nozzle 6, defined by insulating material 3, a region of high turbulence. Thus,

there exists a high current arc surrounded by an axial fluid vortex of continuously moving fluid. This vortex rapidly absorbs energy from the arc by direct radiation of thermal energy from the arc to the cooler fluid constituting the vortex, by ambipolar diffusion of electrons and ions into the vortex, thus giving up all of their thermal, kinetic, and potential energy, and by the vaporization of water splashed or otherwise physically urged into the arc column. By these means, the arc column rapidly loses energy to the fluid vortex which, being composed of a fluid in motion, is not appreciably raised in temperature. The fluid of which the vortex is constituted may be any suitable non-conducting fluid, as for example, deionized water or oil.

As the arc column loses energy, the arc voltage between the electrodes of the device rapidly rises to a value above the system sustaining voltage, and the arc is consequently extinguished.

Arc chamber **2** illustrated in the device of FIG. 1, is, in effect, a double-ended device. This means that there are two orifices or nozzles **6** and **7** within which a large amount of energy may be removed from the arc column established between electrodes **6** and **7**. It is possible therefore, to remove movable electrode **5** to such an extent that energy is being extracted from the arc at nozzles **6** and **7**, thus intensifying the energy removal. A double-ended device is not, however, necessary in accord with the invention, and most arcs may be interrupted using only a single ended device, as for example, one including only the nozzle adjacent fixed electrode **4**.

As illustrated in FIG. 1, the device has been shown utilizing a nozzle formed by the smaller end of a substantially conically shaped arc chamber. While, in its preferred embodiment, the present invention contemplates utilizing the added turbulence and added water velocity obtained through the use of a conically shaped arc chamber and a nozzle in the vicinity of the fixed arc electrode, such a structure is not necessary in all cases. Thus, the normal turbulence gained by the establishment of a fluid vortex within a substantially cylindrical arc chamber may be sufficient to extinguish many arcs. Accordingly, while, in its preferred embodiment, my invention contemplates the use of conical arc chambers with nozzles adjacent the fixed electrodes, substantially cylindrical arc chambers may be utilized as well.

In FIG. 2 of the drawing there is shown a partial vertical cross sectional view taken along the lines **2—2** in FIG. 1. As may be seen from FIG. 2, fluid conduit **22** from cylinder **16** enters the arc chamber defined by insulating material **3** tangentially, causing the fluid to rotate in a circular path, forming a vortex, and exit through orifices **6** and **7** in the arc chamber.

In FIG. 3 of the drawing, there is shown an alternative embodiment of the invention. The device of FIG. 3 is a single-ended circuit interrupting device which differs functionally from the device of FIG. 1 primarily in that the operation of the movable arc electrode is controlled by the fluid which forms the vortex, and the arc electrodes are separated by the action of the fluid forming the vortex. In FIG. 3, the arc interrupting device includes a housing **40** having therein an arc chamber **41** surrounded by a conically shaped insulating member **42** and terminating at one end thereof in a nozzle **43**. Meeting within nozzle **43** are a fixed arc-electrode **44** and a movable arc-electrode **45**. Movable arc-electrode **45** is connected with, and mounted upon, an arc actuating plate **46** having outwardly extending orifices **47** therein. Actuating plate **47** is mounted upon electrode shaft **48** which is suitably journaled within bearing **49** and connected to a terminal strap **50**. Electrode actuating plate **46** is urged against insulating member **42** adjacent nozzle **43** by a suitable compression spring **51**.

The device of FIG. 3 also includes a fluid storage cylinder **52** having therein a piston **53** mounted upon a piston rod **54**, a surge tank or reservoir **55** and suitable interconnecting conduits **56**, **57**, and **58** all analogous to like parts in the device of FIG. 1. In the device of FIG. 3, a complete fluid circuit then comprises cylinder **52**, conduit **58**, arc chamber **41**, orifice **43**, orifices **47**, conduit **56**, reservoir **55**, and conduit **57**.

Piston rod **54** terminates in an outwardly extending member **59** which is juxtaposed with a pawl **60** pivotally rotatable about pin **61** and actuated by solenoid **62** connected between terminals **63**. A fixed terminal strap **64** is connected to the outwardly extending end of fixed arc electrode **44**.

To cock the device of FIG. 3, piston rod **54** is pulled upwardly until pawl **60** engages member **59**. Movable electrode **45** is automatically urged into abutment with fixed electrode **44** by the action of compression spring **51**. In operation, let it be assumed that the device is to be actuated by a current overload through conductors **50** and **64** and arc electrodes **44** and **45**. A current representative, and proportional to, the main current flows through solenoid **62**, actuates pawl **60** allowing piston **53** to be urged into cylinder **52** by means of tension spring **65**. Fluid contained within cylinder **52** is urged tangentially into arc chamber **41** through orifice **66**. A vortex is established therein, the portion of greatest turbulence existing at orifice **43**. The fluid forced into arc chamber **41** through orifice **66** escapes therefrom through orifices **47** in electrode actuation plate **45**, both of which are insufficient to allow all of the fluid to escape therethrough. Under these conditions, fluid pressure builds up within arc chamber **41** and electrode actuation plate **45** is lifted from its seat, against the pressure of compression spring **51**, allowing fluid to flow through conduit **56** to reservoir **55**. As electrode actuation plate **45** leaves its seat, movable arc electrode **45** is separated from fixed arc electrode **44**, and an electric arc is established therebetween. This electric arc rapidly loses energy to the fluid vortex, particularly to the turbulent portion existing at nozzle **43** in the same fashion as in the device of FIG. 1, and the arc is readily extinguished.

In the embodiments of both FIGS. 1 and 3 of the drawings, the means which is responsive to energization to force fluid into the arc chamber to establish a fluid vortex therein is shown to be a reciprocating piston. This means is not, however, unique and could equally as well be any other means for forcing fluid from a storage chamber into the arc chamber before an arc is struck. Such means include a rotating eccentric pump or other similar means.

While the invention has been set forth hereinbefore, with respect to particular embodiments thereof, many modifications and changes will readily occur to those skilled in the art. Accordingly, I intend by the appended claims to cover all such modifications and changes as fall within the true spirit and scope of the invention.

What I claim is:

1. An electric circuit interrupting device comprising: a pair of arc-electrodes, at least one of which is movable to separate said electrodes and cause the initiation of an electric arc therebetween; an arc chamber surrounding said electrodes and having an orifice within the wall thereof; means associated with said orifice for causing a fluid flow therethrough and tangentially within said chamber to establish therein an arc-extinguishing fluid vortex, the walls of said arc chamber tapering in the region thereof laterally surrounding said arc-electrodes in circuit-closed position to create thereat a nozzle in which fluid is forced past said electrodes when in circuit opened position at high velocity creating a region of high fluid turbulence to rapidly extract energy from said arc; and means responsive to a flow of fluid within said chamber for separating said arc-electrodes to initiate said arc after the establishment of said vortex.

2. An electric circuit interrupting device comprising: a pair of arc-electrodes at least one of which is movable to separate said electrodes and cause the initiation of an electric arc therebetween, a tapered arc chamber having

an orifice in the wall thereof surrounding said electrodes and forming a minimal diameter region adjacent to the intersection of said electrodes to define thereat, a nozzle, said nozzle approximately surrounding the junction between said electrodes when in contact-making position; and means associated with said orifice for causing a stream of fluid to flow therethrough and tangentially within said chamber to establish therein an arc-extinguishing fluid vortex, said vortex creating at said nozzle a region of high velocity fluid flow and high fluid turbulence to rapidly extract energy from said arc due to the restricted diameter of said nozzle, the axis of said vortex corresponding substantially with the line of motion of said movable electrode.

3. An electric circuit interrupting device comprising: a pair of electrodes, at least one of which is movable to separate said electrodes and cause the initiation of an electric arc therebetween; a substantially conical arc chamber having an orifice in the wall thereof surrounding said electrodes and defining in the region of the intersection of said electrodes, a nozzle, said nozzle approximately surrounding the junction between said electrodes when in contact-making position; means associated with said orifice for causing a fluid flow therethrough and tangentially into said chamber to establish therein an arc-extinguishing fluid vortex having a restricted diameter portion in said nozzle, causing fluid to be forced past the arc at high velocity establishing a region of high fluid turbulence surrounding said arc which rapidly extracts energy therefrom; and means responsive to a flow of fluid within said chamber for separating said arc electrodes to initiate the arc after the establishment of said vortex.

4. An electric circuit interrupting device comprising: a pair of arc-electrodes at least one of which is movable to separate said electrodes and cause the initiation of an electric arc therebetween, a substantially conical arc chamber having an orifice in the wall thereof surrounding said electrodes and defining, in the region of the intersection of said electrodes, a nozzle; means associated with said movable arc electrode for substantially closing the throat of said nozzle; and means associated with said orifice for causing a fluid flow therethrough and tangentially within said chamber to establish therein a fluid vortex; said means for closing said nozzle being responsive to a flow of fluid within said chamber to open the throat of said nozzle and concurrently therewith separate said electrodes to establish said arc.

5. An electric circuit-interrupting device comprising: a pair of arc-electrodes at least one of which is movable to separate said electrodes and cause the initiation of an electric arc between, a tapered arc chamber having an orifice in the wall thereof surrounding said electrodes and forming a minimal diameter region laterally surrounding the intersection of said electrodes to define thereat a nozzle, and means for establishing within said tapered arc chamber an arc-extinguishing fluid vortex having a restricted diameter portion in said nozzle, causing fluid to be forced past said arc at high velocity establishing a region of high fluid turbulence surrounding said arc to rapidly extract energy therefrom, said means including an orifice in the wall of said chamber and means for causing a stream of fluid to flow therethrough and tangentially in said chamber thereby establishing said vortex, the axis of said vortex corresponding substantially with the line of motion of said movable electrode.

References Cited in the file of this patent

UNITED STATES PATENTS

1,820,928	Whitney et al.	Sept. 1, 1931
2,061,945	Koppelmann et al.	Nov. 24, 1936
2,109,685	Ainsworth	Mar. 1, 1938
2,279,040	Grosse	Apr. 7, 1942
2,310,093	Korndorfer	Feb. 2, 1943
2,391,826	Flurscheim	Dec. 25, 1945
2,517,136	Schneider	Aug. 1, 1950
2,533,545	Ainsworth et al.	Dec. 12, 1950

FOREIGN PATENTS

319,019	Great Britain	Dec. 11, 1930
638,145	Germany	Nov. 10, 1936
477,231	Great Britain	Dec. 24, 1937
679,327	Germany	Aug. 5, 1939
723,076	Germany	July 30, 1942
960,111	Germany	Mar. 14, 1957