June 10, 1969 F. KESSELRING 3,449,537

CIRCUIT BREAKER FOR INTERRUPTING AT ZERO CURRENT AND AUTOMATICALLY RECLOSING AFTER UNSUCCESSFUL INTERRUPTION

Original Filed May 14, 1965

FIG. 1.

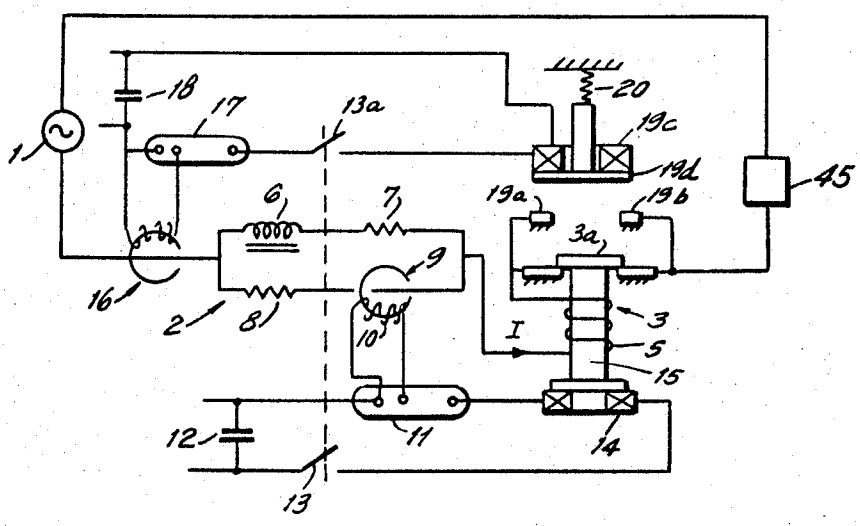


FIG. 3.

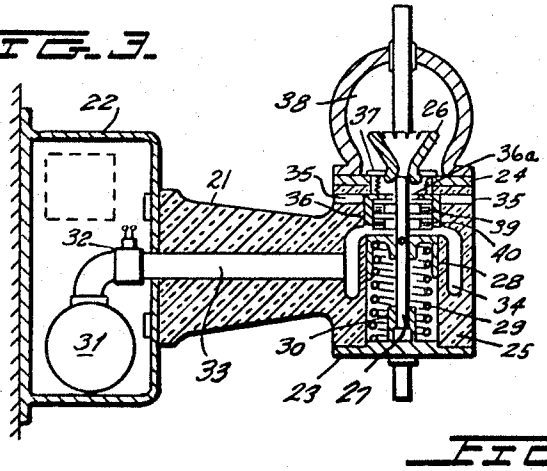


FIG. 2.

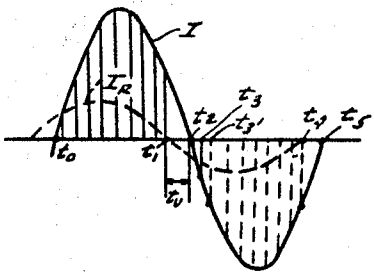


FIG. 1a.

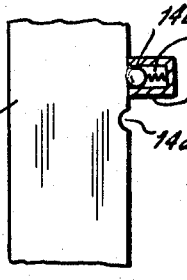


FIG. 5.

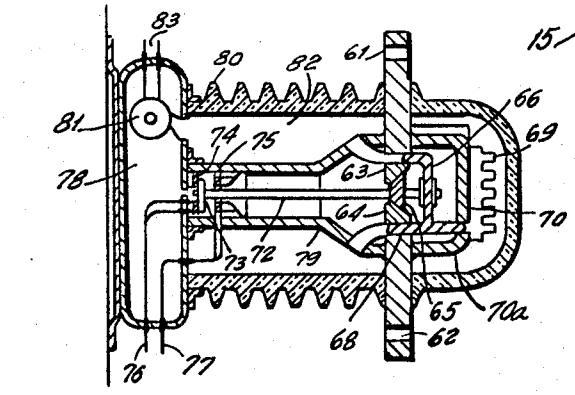
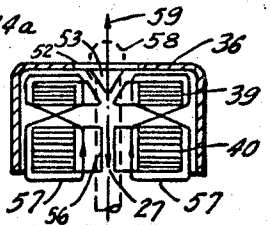


FIG. 4.



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United States Patent Office

3,449,537

Patented June 10, 1969

3,449,537

CIRCUIT BREAKER FOR INTERRUPTING AT ZERO CURRENT AND AUTOMATICALLY RECLOSING AFTER UNSUCCESSFUL INTERRUPTION

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Application May 14, 1965, Ser. No. 455,824, now Patent No. 3,378,727, dated Apr. 16, 1968, which is a continuation-in-part of application Ser. No. 27,437, May 6, 1960. Divided and this application Dec. 12, 1967, Ser. No. 704,205

Int. Cl. H01h *33/82*

U.S. Cl. 200—148

4 Claims

ABSTRACT OF THE DISCLOSURE

A pneumatically operated circuit breaker has a movable contact connected to a pneumatic operating mechanism operated by separate current sensing structures. The first current sensing structure operates to move the contacts to an open position immediately prior to zero current. The second current sensing means is responsive to continued current through the contacts after current zero, which indicates a failure for the contacts to interrupt the current, and immediately closes the contacts before the current can rise to substantial values. The first current sensing means includes a phase shift means which causes a leading relation of the output signal of the current sensing means in relation to the current being measured to permit generation of an output operating signal just prior to current zero.

This application is a division of application Ser. No. 455,824, filed May 14, 1965, in the name of Fritz Kesselring, entitled Circuit Breaker for Interrupting at Zero Current and Automatically Reclosing after Unsuccessful Interruption, now U.S. Patent 3,378,727, which is a continuation-in-part of application Ser. No. 27,437, filed May 6, 1960, in the name of Fritz Kesselring, entitled High Power Synchronous Circuit Breaker, now abandoned. This application relates to a high speed circuit breaker wherein contact disengagement occurs at high speed at a substantially current zero point and is automatically drawn between the disengaged contacts, whereby the circuit breaker disengaging operation is initiated at the next current zero point.

During operation of circuit breakers under high power, circuits of either high or low voltage magnitude are exposed to copious arcing during contact disengagement. In order to properly open the circuit being protected by the circuit breaker, it has, therefore, been necessary to somehow handle the substantial energy in the arc drawn between the disengaging contacts. For example, large air circuit breakers wherein the contacts separate in air are provided with arc chutes and magnetic systems wherein the arc drawn between contacts is moved through a magnetic field which drives the arc into the arc chute where the arc is squeezed and cooled as by notched ceramic arc plates so that the arc may be extinguished. In other applications the arc is exposed to rapidly moving fluid such as compressed air or mixtures of steam and gas which are produced from a liquid dielectric, whereby the arc is blasted through restricted vents in an arc interrupting chamber or ionized arc products are rapidly removed in an attempt to control and subsequently extinguish the arc.

In other applications, the circuit breaker contacts are contained within a vacuum whereby an initial striking of the arc causes metal vapor, and the arc continues to

burn in the metal vapor after the contacts are disengaged so that means must be provided again to control the arc.

The seat of the problem of arcing lies in the fact that the circuit breaker contacts are opened or disengaged at an arbitrary point within the current cycle of the current flowing through the contacts. Therefore, an arc is necessarily drawn when the contacts are opened since a substantial current flows through these contacts in a relatively high power circuit.

It has been found that if the contacts can be opened when the current goes through a zero instantaneous value that an arc will not initially be drawn. Preferably, the contacts should be separated immediately prior to the instantaneous zero value so that if a small arc is drawn, this arc will be extinguished when the zero current value is reached.

This concept, however, has never achieved widespread commercial use with the exception of a few isolated applications since there is always the possibility that when the current passes through zero, the arc will restrike and "hang on" in the next half cycle.

Clearly, if this were to happen in a circuit breaker which is not equipped with devices for controlling an arc, it could destroy the equipment during this next half cycle. Furthermore, the arcing during the half cycle will almost certainly continue even after subsequent zero current values.

The essence of the present invention is to provide a circuit interrupting device of the type which operates initially immediately prior to current zero and is equipped with auxiliary means for measuring or sensing contact current after the contact operation at zero current so that if, after zero current and contact disengagement a current is measured (which would necessarily be an arc current), the circuit breaker is immediately reclosed and is not operated to a disengaged position until a subsequent current zero in the circuit being protected.

By immediately reclosing the circuit breaker contacts after it is found that complete circuit interruption has not occurred at a particular current zero point, the contacts will reclose on a relatively small current and thus are not subjected to substantial closing duty.

With this novel concept I have overcome the heretofore existing danger which has limited the use of current zero interrupting equipment which is that an arc may continue to exist between the cooperating contacts throughout the next half cycle and probably continuously thereafter until back-up equipment is operated. That is to say, in the present invention, when it is found that proper current interruption has not occurred at a current zero, the contacts will reclose until the next current zero at which point it again attempts to interrupt. If the interruption at the next current zero again fails, the circuit again will be reclosed and will continue to operate until at a particular current zero successful current interruption without arcing is achieved.

The concept of the present invention can be applied to many different types of high speed interrupters, such as the electrodynamic type of interrupter shown in copending applications Ser. No. 5,066, filed Jan. 27, 1960, now U.S. Patent 3,128,361, and Ser. No. 5,069, filed Jan. 27, 1960, now abandoned, as well as in pneumatically operated circuit breakers. In each there will be a pair of cooperating contacts which are operatively connected to an operating means which becomes operable only immediately prior to a current zero value after a mechanical or automatic initiation of operation of the contacts. That is to say, once a signal is delivered to the mechanism for causing the circuit breaker to disengage, the operating means will delay contact separation until immediately prior to a current zero value. When the current through the circuit breaker contacts reaches a low value and

is about to go through zero, the circuit breaker contacts are disengaged. A second auxiliary means then comes into play which will operate responsive to current flow through the contacts after the current zero is passed. If there is no current (so that the circuit was successfully interrupted), there will be no further operation. If, however, a current is measured (indicating arcing at the contacts), the circuit breaker contacts will be immediately reclosed before the current can rise to a substatnial value.

As will be seen more fully hereinafter, the means for operating the circuit breaker prior to current zero can comprise a phase shift network for delivering operating current to the contacts wherein the operating current is phase shifted to lead the circuit current by a predetermined amount. When this leading current reaches a predetermined value, it will inherently contain information as to how much later the main current will pass through zero so that accurate control of disengagement of the contacts a predetermined time before current zero can be achieved.

The reclosing of the circuit after a successful interruption can be controlled either by auxiliary contact means whose operating mechanism is activated upon the generation of an opening signal to the circuit breaker or can be controlled by magnetically influencing the position of a valve in a pneumatically operated circuit breaker. In each of these it will be seen that the control system will be influenced by the current which is to be interrupted so that an intial opening operation occurs prior to current zero and a reclosing operation occurs immediately after current zero in the event that there is an unsuccessful interruption.

Accordingly, a primary object of this invention is to provide a novel high power synchronous circuit breaker.

Another object of this invention is to provide a novel circuit breaker which does not require complex arc extinguishing structure.

A further object of this invention is to provide a novel circuit breaker in which the contacts disengage at a current zero value.

A still further object of this invention is to provide a novel synchronous circuit breaker wherein contact interruption occurs at current zero, and if an arc is drawn during contact disengagement, the contacts are immediately reclosed.

These and other objects of the invention will become apparent in the following description when taken in connection with the drawings in which:

FIGURE 1 shows a first embodiment of the invention using a dual electrodynamic type circuit interrupter mechanism.

FIGURE 1*a* shows a detail view of a detent latch used to hold the main contact of FIGURE 1 open.

FIGURE 2 shows current through the circuit breaker contacts of FIGURE 1 as a function of time.

FIGURE 3 illustrates an embodiment of the invention wherein the contacts are pneumatically operated.

FIGURE 4 shows the magnetic control system for pressure control in the embodiment of FIGURE 3.

FIGURE 5 shows a further embodiment of the invention wherein the operating mechanism is a combination of a pneumatic means and an electrodynamic driving means.

Referring now to the drawings and particularly to FIGURE 1, the novel circuit interrupter is operable in a typical circuit to be protected which includes a generator or voltage source **1** which is to supply energy to a load **4** through a measuring circuit **2**, which will be described more fully hereinafter, and a circuit interrupter **3** which includes a movable contact **3***a* which is movable between an engaged and a disengaged position with respect to a relatively stationary contact.

In normal operation, circuit breaker contact **3***a* is held in a closed position by the magnetic field generated in winding **5** which carries the full load current I. That is to say, contact **3***a* may include magnetic material which is responsive to the magnetic field generated by winding **5**. The measuring circuit **2** is provided with a first and second parallel path wherein the upper path includes an inductor **6** and resistor **7**, while the lower path comprises a resistance **8** and a small saturable type reactor **9** which has a primary winding connected in series with resistor **8**. The secondary winding **10** of the reactor is connected in the grid-cathode circuit of a cold cathode tube **11**. The plate cathode circuit of tube **11** is connected in series with a capacitor **12** which is maintained charged to some predetermined D-C voltage by charging means (not shown), a trip switch **13** and the primary winding of an electrodynamic driving coil **14**. Coil **14** is closely coupled to a disc-shaped secondary winding carried by insulating trip rod **15** which is operatively connected to contact **3***a* of the circuit breaker **3**.

This type of electrodynamic operating mechanism of circuit breakers is fully set forth in copending application Ser. No. 5,066, filed Jan. 27, 1960, now U.S. Patent 3,128,361. The operation of such a system is clear to those skilled in the art whereby a rapid rate of change of current forced through coil **14** will induce a substantial current in the disc of conductive material carried by rod **15** and coupled to coil **14** so that an extremely high repelling force will occur between the coupled disc and coil **14** to cause an upward acceleration of the disc, the insulating rod **15** and the contact **3***a*. Any suitable means could be provided to hold the contact **3***a* in its open position against small forces such as those due to gravity. By way of example, FIGURE 1*a* illustrates a ball detent type latch including a housing **14***a* which is fixed with respect to shaft **15**. Housing **14***a* carries a ball **14***b* biased by spring **14***c* which biases ball toward shaft **15**. When contact **3***a* moves to its full open position, detent **14***d* moves under ball **14***b* and the ball seats in detent **14***b* to prevent reclosing of contact **3***a* until a sufficient magnetic field builds up in coil **5** as will be described later. Note that any desired latching type system could be used which is relatively easily released.

A second saturable type reactor **16** has a primary winding which carries the main current I and a secondary winding which is connected to the grid-cathode circuit of cold cathode tube **17**. The plate-cathode circuit of tube **17** is connected in series with a capacitor **18** which may be charged to a predetermined D-C potential by a D-C source (not shown), a tripping switch **13***a* which is ganged to trip switch **13**, and the primary winding of the electrodynamic drive system **19** which has a disc-shaped secondary winding which is movable into bridging engagement with contacts **19***a* and **19***b* against the biasing force of spring **20** which normally extends through the center of primary winding **19***c* and is connected to the movable disc **19***d*.

The operation of the circuit of FIGURE 1 is best understood by reference to FIGURE 2 which shows the main current I plotted against time in solid lines and the current I_r through resistor **8** as a current which leads current I in dotted lines. In order to cause manual circuit interruption, the ganged switches **13** and **13***a* are closed to thereby connect the capacitors **12** and **18** directly in series with tubes **11** and **17**, respectively. The current I_r leads the current I by a time t_Y as shown in FIGURE 2 which, for example, may be 1 millisecond. Therefore, at time t_1 and prior to the time that the current I passes through current zero, the flux of saturable type reactor **9** reverses so that a voltage pulse is applied to the grid-cathode circuit of tube **11**. This causes the tube to fire so that capacitor **12** can discharge through winding **5**.

Accordingly, at time t_1, contact **3***a* will be rapidly moved to its disengaged position and held there by ball **14***b* under relatively low current conditions which very rapidly decrease to zero with the generation of little arcing, if any. Assuming, however, that after current zero at

time t_2 is passed an arc restrikes, then the current I will continue after current zero. Therefore, the flux of reactor **16** will reverse to generate a voltage pulse in the grid-cathode circuit of tube **17** to fire the tube and thus energize winding **19***c* from charged capacitor **18**. This will cause the ring-shaped winding **19***d* to rapidly move downward and into engagement with contacts **19***a* and **19***b* against the force of spring **20**, this happening at time t_3.

This action, in effect, causes a reclosing of the circuit breaker at time t_3 when the make current is still relatively low. As the current increases and reaches a value of, for example, the value at time t'_3, the current through winding **5** will be large enough to generate a strong enough magnetic field to overcome latch **14***b* and reclose contact **3***a* and relieve the relatively small contacts **19***a*, **19***b* and **19***d* from the current carrying duty. After time t'_3 the energy of capacitor **18** will be decreased to a value small enough to permit spring **20** to move contact **19***d* upwardly to its reset position so that the entire system is now ready for a new synchronous disconnection beginning at time t_4 of FIGURE 2 for an attempted arc extinction at current zero at time t_5.

Note that the circuits used in charging capacitors **12** and **18** is such that they will be sufficiently recharged in the time interval t_1 to t_4. If desired, an auxiliary capacitor circuit can be substituted for the original capacitors for the second interruption attempt.

From the foregoing it is seen that an arc can only occur in the relatively short time interval t_1 through t_3 which is approximately equal to 1 millisecond at a relatively small instantaneous current value. Furthermore, the reclosing at time t_3 takes place under very favorable conditions since the current I is still very small. Since a reclosing occurs, in the event that the attempted interruption is not successful, it will be apparent that the circuit eliminates the heretofore required arc extinguishing devices since a substantial arc will never remain on the contacts.

FIGURE 1 illustrates the invention for the case of a combined switch **3** which is magnetically closed and is opened under the influence of electrodynamic forces wherein the contacts remain open when the magnetic closing force does not reappear or the circuit is successfully interrupted. An auxiliary reclosing means is provided in the pure electrodynamic interrupter **19**.

The principle of the invention which is to open the circuit breaker immediately prior to current zero and to thereafter sense the flow of current after current zero indicating the presence of arcing and then reclosing the interrupter may be carried out by other combinations of presently available electrical equipment as well as by new types of equipment specifically designed for this purpose.

In particular, two current responsive means or systems are provided where the first, including measuring circuit **2**, applies an output energy to the energizable operating means **14–15**, while the second, including reactor **16** and tube **17**, applies an output energy to the energizable operating means **19***c*–**19***d*. Note that the first current responsive means operates just prior to current zero, while the second current responsive means operates just following a current zero. Moreover, each of the current responsive means are normally deactivated by switches **13** and **13***a*, and are activated only when these switches are closed.

A further embodiment of the invention utilizing these basic novel principles is shown in FIGURES 3 and 4 wherein the interrupter is essentially of the pneumatically operated type with a novel magnetic control system for achieving the objects of the invention.

Referring to FIGURE 3, a hollow support insulator **21** is fastened to a casing **22** which is carried from some relatively stationary support structure. Insulator **21** is formed of a general T shape and has connection plates **23** and **24** at each respective end of the cross of the T defined by cylinder **25**. A movable contact rod **27** is carried by piston **28** which is movable within cylinder **25** to move contact rod **27** between engaged and disengaged positions with respect to the stationary contact formed by nozzle **26** connected to plate **24**. Contact rod **27** is biased upwardly and into engagement with nozzle **26** by spring **29** which is carried within cylinder **25** and bears against the lower surface of piston **28**. When the movable contact **27** is engaged in the position shown in FIGURE 3, a relatively gas tight connection is formed at the nozzle.

A sliding contact means **30** which can be formed of a plurality of biased contact spring fingers is formed between contact rod **27** and plate **23** so that the contact rod is always electrically connected to plate **23**.

A source of operating pressure such as high pressure air is contained in cylinder **31** and is connectable through the electromagnetically controlled air valve **32**, which may be of any standard type, to the central opening **33** of insulator **21** and opening **34** of cylinder **25**. This pressure may be vented from openings **33** and **34** in a controlled manner through vents **35** which are closed by the distributing slide valve **36**.

The slide valve **36** and its controlling structure are shown in FIGURE 4 in an enlarged view for purposes of clarity, and it is seen that slide valve **36** is formed of a cup-shaped member having a central opening **36***a* for permitting the passage of contact rod **27**. The valve member **36** is normally held in the blocking position shown in FIGURE 3 by springs **37***a* which are distributed around the surface of valve **36**. When the valve **36** moves downwardly, it will cover the upper area of piston **28** to prevent connection of high pressure air thereto and also permits communication of any internal high pressure to the external low pressure through vents **35**. The control system for adjusting the position of valve **36** includes a magnetic control system including members **39** and **40** which will be described more fully hereinafter.

In order to operate the interrupter of FIGURE 3, the valve **32** is operated either manually or in response to signals generated by a fault in the line being protected by the interrupter. This will permit compressed air to flow into areas **33** and **34** and drive piston **28** downwardly in its supporting cylinder. Piston **28** will move downwardly against the biasing force of spring **29** until the end of contact rod **27** reaches the bottom of connection plate **23**. At this moment the distance most favorable for interruption is reached between the opening of nozzle **26** and the top of the movable contact rod. The compressed air within openings **33** and **34** will, when the rod **27** moves downwardly, pass through the opening in the nozzle **26** and into a relatively low pressure area **38** which can be connected to external pressure by valve means (not shown).

Under normal current conditions, the air blast passing nozzle **26** should be sufficient to extinguish a small arc. In the event of heavy short circuit current, however, it is desired that the unit be reclosed and opened only at the next current zero. This operation is achieved through the control of slide valve **36** which under heavy short circuit current conditions will be moved downwardly by the controlling magnet structures **39** and **40** to cut-off the fluid connection between area **34** and nozzle **26** by causing the bottom rim of valve **36** to completely enclose the top of the cylinder receiving piston **28**.

Accordingly, if the arcing current is substantial, the valve **36** will move downwardly and prevent compressed air from acting on piston **28** and thus prevent the opening of the circuit breaker. When, however, the current drops from a high instantaneous value to a substantially zero value, the controlling system including magnetic structures **39** and **40** together with biasing springs **37** will permit slide valve **36** to move upwardly to thereby expose the top of piston **28** to the high pressure in area **34** and thus permit an extremely rapid motion of piston **28** downwardly to disengage contact rod **27** and nozzle **26** under the substantially zero instantaneous current value.

In the event that the fault current is asymmetrical and does not pass through zero after the substantially zero value is achieved prior to zero current passage but rather increases again in the same direction, it will be seen that the valve **36** will rapidly move downwardly to expose discharge openings or vents **35** to thereby relieve the pressure on the top of piston **28** and permit the rapid reclosing of the contacts under the action of spring **29**. Therefore, the circuit breaker will reclose under relatively small instantaneous current valves, and the arc problems associated with asymmetric fault currents are avoided. As soon as the current again approaches the zero current value, the distributing slide valve **36** is pulled upwardly by springs **37***a* so that a synchronous interruption is again started with a correspondingly small circuit breaking load.

The novel magnetic control system for controlling the position of slide valve **36** is best understood from FIGURE 4 which illustrates the first magnetic structure **39** as having a portion of its magnetic circuit including a tapered air gap **52** which cooperates with a wedge-shaped armature **53** which is secured to valve **36**. The second magnetic structure **40** is provided with an air gap **56** in its magnetic circuit. Two windings **57** encircle magnetic cores **39** and **40** to carry current in the direction shown by the arrows, whereby cores **39** and **40** are magnetically linked to one another.

In operation, as current through contact rod **26** which operates as a primary winding for each of cores **39** and **40** decreases, electromotive forces are induced in windings **57**. The E.M.F. generated by the lower magnetic system associated with core **40** is made to be greater as by controlling the iron cross-sectional area and number of turns so that a current will flow in the direction of the arrows in FIGURE 4. If the resistance of winding **57** is greater than its inductance, the total flux of magnetic core **39** can be controlled to lead the current through contact rod **27**. Therefore, armature **53** will be moved downwardly against the biasing force of springs **37** of FIGURE 3 at some predetermined time before the passage of current zero. Thus, the magnetic system of FIGURE 4 operates in the same manner as did the control system of FIGURE 1.

By properly choosing the air gap **52** between magnetic structure **39** and armature **53** and the air gap **56**, no detrimental saturation effects occur so that the time lag will always be approximately the same value for different current conditions. This is because at heavier currents, the rate of rise of current will increase in roughly the same manner.

A further embodiment of the invention is set forth in FIGURE 5. The main contacts of FIGURE 5 are shown as contacts **63** and **64** which are electrically connected to terminals **61** and **62**, respectively. A movable bridging contact **65** is moved between an engaged and disengaged position with respect to contacts **63** and **64**, while a second parallel connected bridge contact **66** is movable between engagement and disengagement with respect to apertures **67** and **68** of contacts **63** and **64**, respectively. A parallel resistor **69** has one end connected to contact **63** and its other end connected to bridge **66** by sliding contact **70** in resistor support member **70***a* in the manner described.

Both main movable contact **65** and member **66** are each operated from an electromagnetic drive system as illustrated in copending application Ser. No. 5,066, now U.S. Patent 3,128,361, and are carried by an insulating rod **72** which carries a conductive ring **73** at the left-hand and thereof and is movable between coupling positions with operating windings **74** and **75**, respectively. Winding **74** is energizable to move disc **73** and insulated rod **72** to the right for a contact disengaged position, while winding **75** is operable to drive disc **73** and insulating rod **72** to the left to achieve the contact engaged position shown in FIGURE 5.

The operating circuit for winding **74** is connected to the winding from an area external of the interrupter as by taking out its leads **76** through appropriate gasket means. In a like manner, leads **77** are energizable for energizing winding **75**. In the embodiment of FIGURE 5 the disc **73** operates both as an inherent part of the electrodynamic drive system as well as a valve member for isolating high pressure chamber **78** and the central portion of insulating housing **79** which is surrounded by a second insulating housing **80**. The volume **82** between housings **79** and **80** is maintained at a low pressure by a pump means **81** which also maintains a relatively high pressure in chamber **78**. Here again, the electrical energy for operation of pump **81** may be derived from an area external of the interrupter through leads **83**.

In operation, when the circuit breaker is in the closed position of FIGURE 5 and it is desired to open the circuit breaker, winding **74** is energized as at time t_1 of FIGURE 2, whereby plate **73** and the insulating rod **72** carried thereby are accelerated to the right to thereby cause high speed disengagement first of brigding contact **65** and then **66**. There is no arcing when main contact **65** disengages, since contact **66** is still engaged. At the same time, and after disc **73** has moved away slightly, there will be communication between the high pressure gas within chamber **78** and the interior of chamber **79**. With the continued motion of insulating rod **72** to the right and as soon as the upper portion of bridge **66** leaves nozzle **67**, a portion of the gas admitted to chamber **79** will flow through nozzle **67** and any arc generated there is quenched at time t_2 of FIGURE 2. This interruption is aided because of the parallel current path provided by resistor **69** which is connected in the circuit when the upper portion of bridge **66** electrically disengages contact **63**. From this point a severely limited current flow continues through resistance **69** until the longer lower portion of bridge **66** clears nozzle **68**. Once the lower portion of bridge **66** clears nozzle **68** in contact **64**, there will be final current interruption at time t_5 of FIGURE 2 with a high pressure gas flow bearing on the nozzle. This relationship between times is controlled by the movement of insulating rod **62** and the relative lengths of the upper and lower extending legs of bridge **66**.

In the event that disconnection fails at time t_2 and an arc is drawn between contacts **63**, **66** and **64**, this failure is sensed as by a suitable sensing circuit such as a reactor **16** of FIGURE 1 (which reseponds to a high rate of change of current) in the external energizing circuit so that winding **75** is energized to thereby drive disc **73** to the left and reclose the circuit breaker. This reclosing operation again is controlled so that it will occur no later than time t_3 of FIGURE 2.

The device of FIGURE 5 is highly desirable since it can be designed to achieve switching periods of the order of 100 microseconds. Furthermore, the structure is particularlly suitable for containing a gas such as sulphur hexafluoride within which contact operation occurs and which gas plays on any arc that may be drawn between contact **65** and stationary contacts **63** and **64** or bridging contact **66** and contacts **63** and **64**.

It is to be further noted that while FIGURE 5 is shown as being used with a gaseous medium, it can also be operated in an oil environment where pressure produced by any arc can, through a differential piston system, be used for arc quenching.

Although I have here described preferred embodiments of my novel invention, many variations and modifications will now be apparent to those skilled in the art, and I, therefore, prefer to be limited, not by the specific disclosure herein, but only by the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows:

1. A high power synchronous circuit breaker comprising a first contact, a second contact, piston means, fluid

connection means, a source of high pressure fluid, and a valve means; said first contact being relatively movable between an engaged and disengaged position with respect to said second contact; said fluid connection means connecting said piston means to said source of high pressure fluid; said piston means being connected to said first contact; said valve positioned within said connection means and being movable between an interposing position between said source of relatively high pressure and said piston and in engagement with a surface of said piston, and a removed position from said surface of said piston; a biasing means connected to said valve for normally biasing said valve means toward said removed position; and a current responsive means connected to said valve means; said valve means being moved to said interposing position responsive to relatively high instantaneous current values of current transferred between said first and second contacts; said valve means being moved toward said removed position at relatively low instantaneous current values; said first contact being movable to said disengaged position by said piston only at low instantaneous current values preceding a zero instantaneous current when said value is moved to said interposing position and said source of relatively high pressure is applied to said piston.

2. The device substantially as set forth in claim 1, wherein said valve is moved to said interposed position responsive to increasing instantaneous current flow after said current zero is passed to disconnect said source of relatively high pressure from said piston to permit reclosing of said first contact at a relatively low instantaneous current.

3. The device substantially as set forth in claim 1 which further includes a movable magnetic member and a stationary magnet structure; said magnetic member being secured to said valve means; said stationary magnetic structure having magnetic flux generated therein by the current transferred between said first and second contacts; said stationary magnet structure attracting said magnetic member to move said valve against the force of the said valve bias when the instantaneous flux in said magnet structure reaches a predetermined value.

4. The device substantially as set forth in claim 3 wherein said valve means is moved to said interposed position responsive to increasing instantaneous current flow after said current zero is passed to disconnect said relatively high pressure from said piston to permit reclosing of said first contact at a relatively low instantaneous current.

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U.S. Cl. X.R.

200—148; 317—11; 335—19