June 21, 1966 W. M. LEEDS 3,257,533

FLUID-BLAST CIRCUIT INTERRUPTERS WITH TWO SELECTIVELY-OPERATED FLUID-BLAST SOURCES

Filed April 23, 1965 3 Sheets-Sheet 1

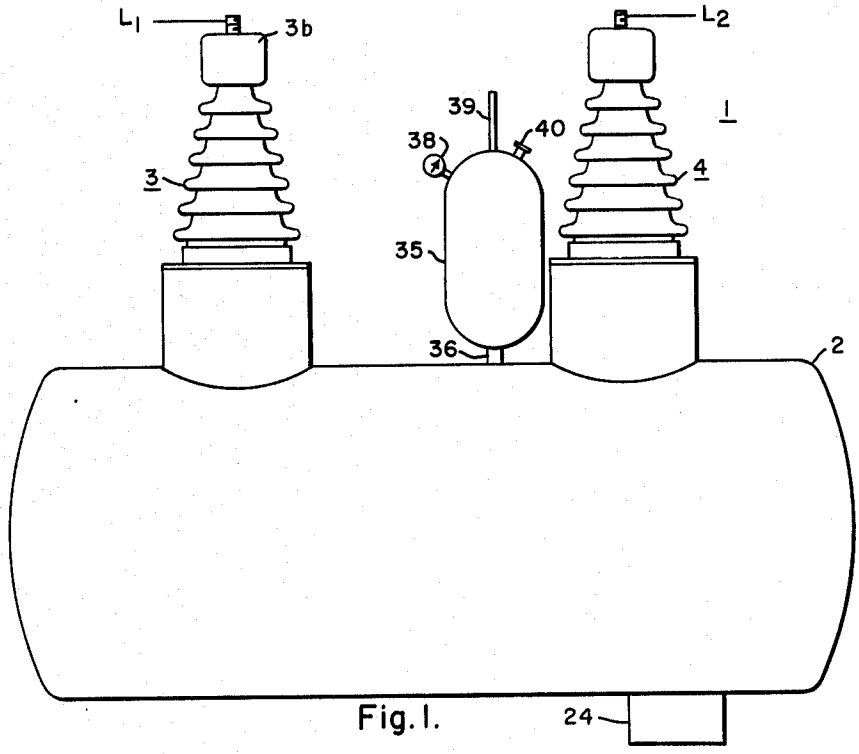

Fig. 1.

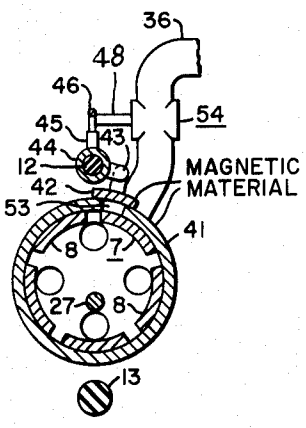

Fig. 3.

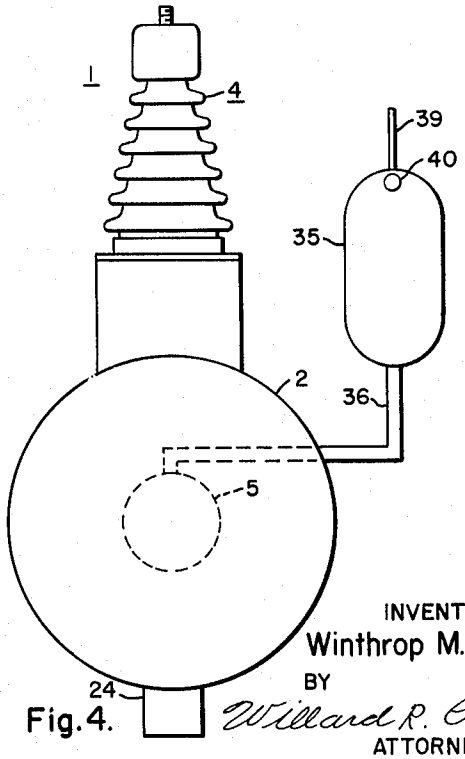

Fig. 4.

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FLUID-BLAST CIRCUIT INTERRUPTERS WITH TWO SELECTIVELY-OPERATED FLUID-BLAST SOURCES

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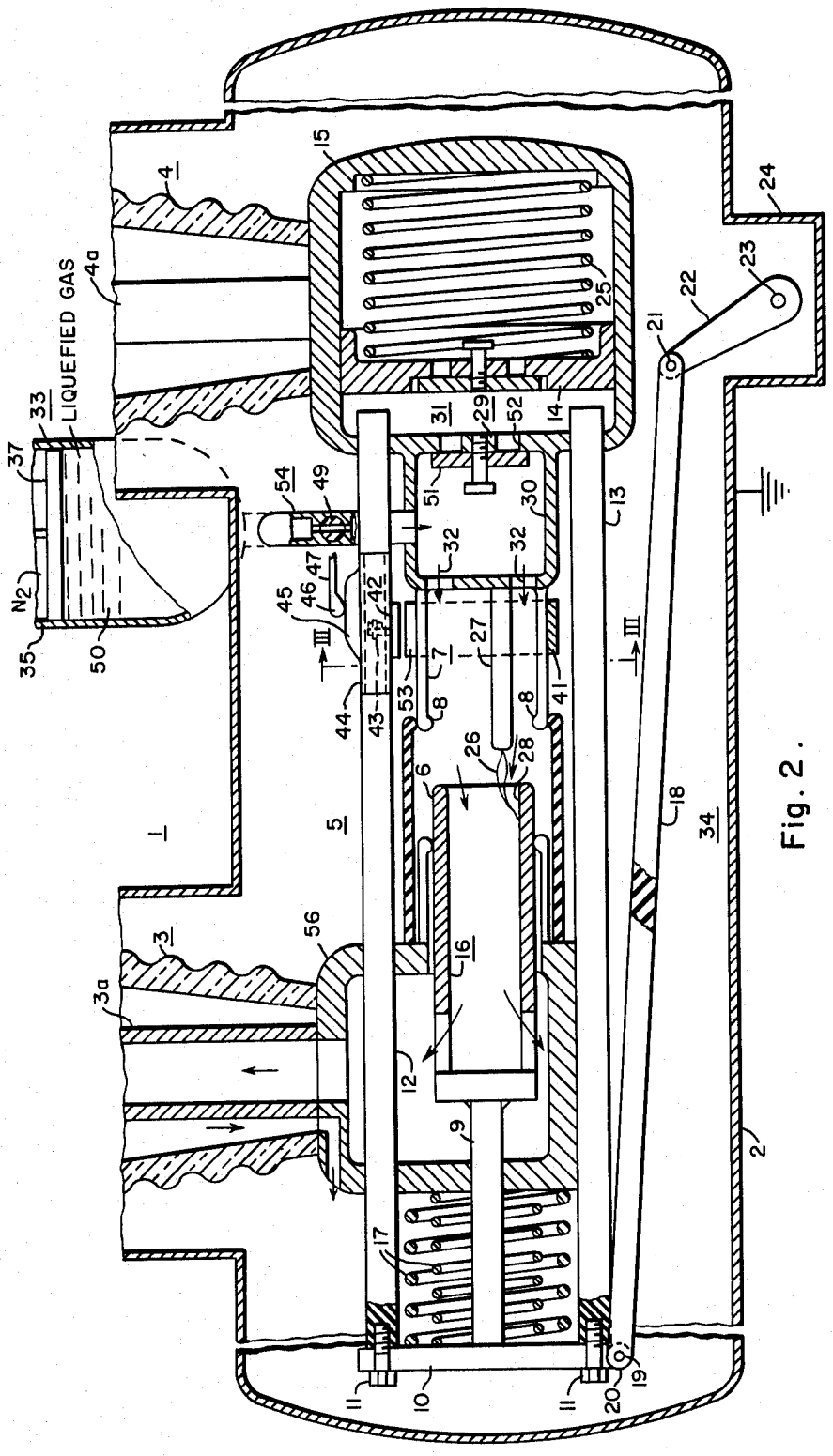

Fig. 2.

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FIG. 5.

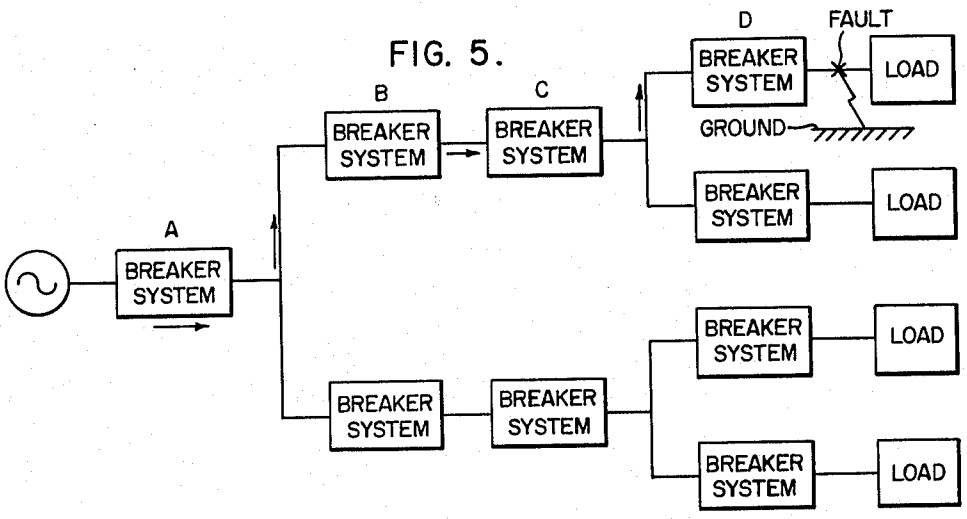
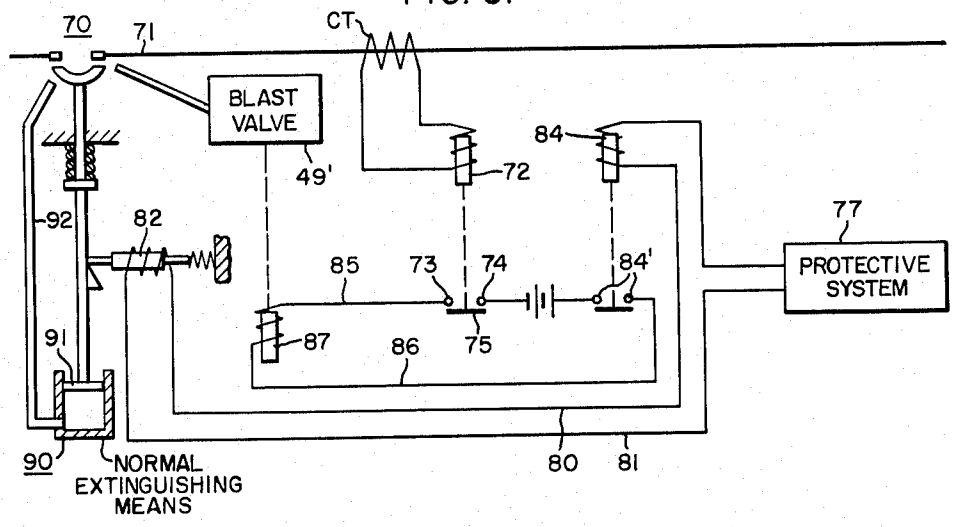


FIG. 6.



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3,257,533

FLUID-BLAST CIRCUIT INTERRUPTERS WITH TWO SELECTIVELY-OPERATED FLUID-BLAST SOURCES

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Filed Apr. 23, 1965, Ser. No. 452,451
7 Claims. (Cl. 200—148)

This application is a continuation-in-part of my copending application filed July 20, 1961, Serial No. 125,506.

This invention relates to circuit interrupters in general, and, more particularly, to circuit interrupters adaptable for interrupting medium-value and also relatively high-power circuits.

A general object of the present invention is to provide a highly effective and economical circuit interrupter suitable for the interruption of currents over a wide range of values.

A more specific object of the present invention is to provide an improved circuit interrupter of the "puffer" type, that is one injecting a quantity of arc-extinguishing gas into the contact structure by the operation of a piston structure; and preferably, supplementary means are additionally provided, selectively operated only during high-current interruptions, to force the injection of a liquefied gas into the arc region to assist in the interruption of high-amperage fault currents.

In puffer-types of circuit interrupters, such as those set forth in United States patent application filed March 24, 1961, Serial No. 98,135, now U.S. Patent 3,214,544, issued October 26, 1965, to Winthrop M. Leeds, and assigned to the assignee of the instant application, the advantage is obtained that the device is relatively cheap to manufacture, and reliance need not be placed upon an associated compressor for providing a dual-pressure operating system. As a result, the operation of such puffer-type circuit interrupters is relatively simple and is entirely satisfactory for moderate-value currents. However, as the interrupting currents increase in magnitude, the puffer-type breakers require unreasonably high operating forces. Another form of circuit interrupter, not using a puffer, which has been tested successfully interrupting over 40,000 amperes is a liquid sulfur-hexafluoride (SF_6) injector type, such as set forth in United States patent application filed September 13, 1957, Serial No. 683,760, now U.S. Patent 3,150,245 issued September 22, 1964 to Winthrop M. Leeds and Benjamin P. Baker, and assigned to the assignee of the instant application. However, this latter-mentioned circuit interrupter requires a high-cost compressor to take the low-pressure exhaust gas and recompress it into a liquid, and force it back into the accumulator.

Accordingly, it is a further object of the present invention to provide an improved circuit interrupter utilizing a puffer-type of interrupter for normal operations, and only during the high short-circuit current interrupting operations is there brought into play a selectively-operated valve device which will function to inject an additional quantity of a liquefied gas, such as liquefied sulfur hexafluoride (SF_6) gas, into the arcing region to quickly bring about the interruption of such high-value short-circuit currents.

It is an additional object of the present invention to provide an improved circuit interrupter of the type set forth in the immediately preceding paragraph, in which the operation of the normally-functioning piston is rendered inoperable during such high short-circuit current interruptions, and an associated valve structure is employed to prevent dissipation of the liquefied gas pressure by preventing the compressed gas from entering the piston chamber.

The circuit interrupter described in this invention shows two sources of gas blast to accomplish arc quenching. One of these, for instance a puffer piston, provides gas flow, preferably of SF_6, sufficient to extinguish arcs in a range up to moderate current values of several thousand amperes. A second source, consisting of a reservoir containing fluid under high pressure in either the gaseous or liquid state, is selectively controlled to come into action only when high currents above the range handled by the first source are to be interrupted.

Prior art, such as Ruppel Patent Re. 21,125, broadly covers the above-described selective action interrupter. However, the Ruppel structure, and other devices providing interrupting action initiated directly by overload current magnitude, suffer from the disadvantage that the high pressure blast is released whenever high overload current flows through the breaker regardless of whether or not the protective system has called for this particular breaker to be tripped.

My invention specifically avoids this undesirable situation by using a current-responsive element which does not produce a gas blast directly as by opening a valve, but rather sets up conditions under overload that will cause the high pressure fluid blast to be activated if and only if the breaker is actually tripped. The construction shown involves current-initiated magnetic means for aligning a cam-operating surface with the cam line of action so that the opening movement of the breaker will operate the auxiliary blast valve on high current overload conditions only. If the breaker is not tripped, no blast occurs even though high current actuates the cam alignment device.

Other arrangements will suggest themselves to those skilled in the art for producing similar results of energizing a second source of fluid blast only when a condition of high current overload exists together with opening movement of the breaker contacts as a result of a tripping signal being applied during the overload condition.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings, in which:

FIG. 1 is a side elevational view of a circuit interrupter embodying features of the present invention;

FIG. 2 is a longitudinal vertical sectional view taken through the tank structure of the circuit interrupter of FIG. 1 with the contact structure illustrated at an intermediate point in the opening operation, the puffer structure shown rendered inoperable, and the liquefied gas injector being illustrated in its operable position;

FIG. 3 is a fragmentary sectional view taken substantially along the line III—III of FIG. 2;

FIG. 4 is an end elevational view of the circuit interrupter;

FIG. 5 illustrates diagrammatically a radial type distribution system; and,

FIG. 6 illustrates a modified type circuit interrupting arrangement.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral **1** generally designates a circuit interrupter particularly adaptable for interrupting a wide range of currents. As shown, the circuit interrupter **1** generally comprises a tank structure **2** into which downwardly extend a pair of terminal bushings **3**, **4**. As viewed in FIG. 2, the lower ends of the downwardly-extending terminal bushings **3**, **4** support, in a fixed position, an interrupting assembly generally designated by the reference numeral **5**.

The interrupting assembly **5** generally includes a perforated tubular movable contact **6** cooperable with a relatively stationary contact structure **7** comprising a

plurality of finger contacts **8**. As shown more clearly in FIG. 3, the finger contacts **8** are circumferentially disposed and engage the outer surface of the movable contact **6** in the closed-circuit position.

As shown in FIG. 2, the movable contact **6** is secured to an operating rod **9** fixedly secured to a yoke member **10** of generally T-shaped configuration. Secured by bolts **11** to the yoke member **10** is a pair of insulating operating rods **12**, **13** which abut at their right-hand ends a movable piston **14**, operable within a piston cylinder **15** secured to the lower extremity **4***a* of the right-hand terminal bushing structure **4**.

Preferably, the movable contact structure, generally designated by the reference numeral **16**, and comprising the movable contact **6** and operating rods **12**, **13**, is biased in a leftward opening direction by a contact accelerating spring **17**. To effect rightward closing movement of the movable contact structure **16** and consequent compression of the contact accelerating spring **17**, there is provided an insulating operating rod **18** pivotally connected, as at **19**, to a lower portion **20** of the yoke member **10**. The insulating operating rod **18** is pivotally connected, as at **21**, to a rotatable crank-arm **22** keyed to an operating shaft **23**, which passes through a sealed opening provided in a depending operating crank housing **24** associated with the tank structure **2**. The seal provided along the operating shaft **23** may be of the type set forth in United States Patent 2,889,434 issued June 2, 1959, to Harry J. Lingal, and assigned to the assignee of the instant application.

From the foregoing description it will be apparent that clockwise rotative movement of the crank-arm **22**, as effected by an external operating mechanism, not shown, providing motive power through the operating shaft **23**, will effect rightward closing movement of the movable contact structure **16** effecting thereby contact closing engagement between the movable tubular contact **6** and the relatively stationary contact structure **7** compressing the accelerating spring **17** and driving the puffer piston **14** toward the right, meanwhile effecting compression of the piston driving spring **25**. The breaker will then be in the closed-circuit position and is preferably latched in this position by the externally-situated operating mechanism.

To effect an opening operation of the circuit interrupter **1**, the external mechanism, not shown, is unlatched, and the contact accelerating spring **17** is immediately effective to quickly cause leftward opening movement of the movable contact **6** away from the relatively stationary contact structure **7**, drawing an arc **26** therebetween, which quickly moves by virtue of the gas blast, to the arcing horn **27** and along the inner surface **28** of the movable tubular contact **6** as shown in FIG. 2. The manner of interruption is more fully set forth in United States patent application filed October 7, 1960, Serial No. 61,284, now U.S. Patent 3,154,658 issued October 27, 1964, to Robert G. Colclaser, Jr., and Russell N. Yeckley, and assigned to the assignee of the instant application.

Simultaneously, with leftward opening movement of the movable contact **6**, there occurs leftward driving motion of the puffer piston **14**, biased by the piston driving spring **25**, and a consequent blast of compressed gas, such as sulfur-hexafluoride (SF_6) gas, through a valve structure **29** associated with a mixing chamber **30**. In other words, the driving spring **25** will force the puffer piston **14** to the left compressing thereby gas within the region **31** and opening the valve structure **29** thereby causing the ejection of gas under pressure into the mixing chamber **30** and along the drawn arc **26** in the manner illustrated by the arrows **32** in FIG. 2.

The foregoing interrupting structure utilizing the puffer piston **14** is suitable for moderate value currents, say up to 10,000 amperes. However, at infrequent intervals, there occurs the existence of a heavy short-circuit current on the line, and fault currents over 10,000 amperes may be encountered. Thus, currents for high interrupting power, say above 20,000 amperes, may come into existence. To provide a puffer action which would be adequate to effect the interruption of these high-amperage currents would require excessive spring pressure for the piston driving spring **25**. It is, therefore, an additional purpose of the present invention to provide a supplementary interrupting device **33** comprising a quantity of liquefied gas under pressure. When sulfur hexafluoride (SF_6) gas is used under a pressure of say 30 to 45 p.s.i. within the interior **34** of the tank structure **2**, supplementary means consisting preferably of liquefied sulfur hexafluoride (SF_6) gas is contained within a pressure bottle **35** disposed externally of the tank structure **2** and connected therewith by means of an insulating conduit **36**.

With reference to FIG. 2, it will be noted that disposed withinn the pressurized bottle **35** is a piston **37** forced downwardly by nitrogen (N_2) gas under pressure, say of the order of 800 to 1000 p.s.i. The liquid SF_6 accumulator **35** with nitrogen above the piston separator compressed to about 800 p.s.i. (well above the SF_6 vapor pressure to prevent "vapor lock") would be located outside the breaker tank, as shown in FIGS. 1 and 4 to make the pressure gauge **38** and liquid-level indicator **39** visible. In addition, the refilling plug **40** would be readily accessible.

With reference to FIGS. 2 and 3, it will be noted that encompassing the relatively stationary contact structure **7** is a split magnetic ring **41** having associated therewith an armature **42**. The armature **42** is pivotally connected, as at **43**, to a cam sleeve **44**, which is biased by a helical spring, not shown, in a counterclockwise direction, as viewed in FIG. 3. Associated with the cam sleeve **44** is a cam lug **45** which, at times, makes abutting engagement with a valve cam follower **46**, constituting one end of a valve actuating lever **47**. With reference to FIG. 2, it will be noted that clockwise rotation of the valve actuating lever **47** about its pivot **48** will effect opening of the valve **49** associated with the accumulator **35** and permit an injection of liquefied gas **50** into the mixing chamber **30**. The injection of the liquefied gas **50** into the mixing chamber **30** will quickly effect closure of the piston valve structure **29**, thereby moving the valve plate **51** over the associated apertures **52** and prevent the entrance of the gas into the piston cylinder region **31** of the operating cylinder **15**. If this were allowed to occur, there would result some loss of effective pressure of the injected liquefied gas.

The armature **42**, which causes the cam lug **45** to align with the cam follower **46**, is so arranged as to be attracted and operable when current magnitudes, say of 10,000 amperes or over, flow through the contact structure **6**, **7**. As well known by those skilled in the art, the passage of current through the relatively stationary contact structure **7** will cause an encompassing magnetic flux to flow through the split magnetic ring **41**. Due to the air gap at **53**, the armature **42** will be attracted, and will cause rotation of the cam sleeve **44** into an aligned position so that the cam lug **45** and valve cam follower **46** will make abutting engagement.

It will be apparent that following an interrupting operation the cessation of current through the contact structure **6**, **7** will immediately permit the helical cam sleeve spring, not shown, to effect a retraction of the armature **42** and a consequent non-alignment position of the cam sleeve **44** relative to the valve cam follower **46**. As a result, during a subsequent closing operation, there will be no opening of the valve structure **54** associated with the accumulator **35**.

Puffer-type circuit interrupters utilizing sulfur-hexafluoride (SF_6) gas are self-contained, that is, contain no compressor and high-pressure reservoir, and therefore are preferred as economical design for moderate power high-voltage breakers. For high interrupting power (above 20,000 amperes, for example), puffer breakers require unreasonably high operating forces. Another form of inter-

rupter, not utilizing a puffer, which has been tested successfully interrupting over 40,000 amperes is a liquid SF_6 injector type. However, this requires a high-cost compressor to take the low-pressure exhaust gas and recompress it into a liquid and force it back into the accumulator.

The present invention is particularly concerned with a puffer-type breaker for normal load-switching duty, which is provided with a liquid sulfur-hexafluoride SF_6 accumulator tank **35** and a valve arrangement **54**, whereby liquid SF_6 is injected into the interrupting chamber **30** only when short-circuit current flows through the breaker contacts **6, 7** during a tripping operation. Since short-circuit conditions only occur at rare intervals, the amount of liquid SF_6 stored is sufficient for many years service, and it may be replenished as needed at normal maintenance periods.

The interrupting device **1** illustrated in FIG. 2, shows an embodiment of the invention in which the interrupter assemblage **5** is suspended from a pair of bushing terminals **3, 4** inside a grounded steel tank **2**. An insulating operating rod **18** is used to close the breaker by moving a tubular moving contact **6** into contacting engagement with a stationary finger cluster **7**. At the same time, an accelerating spring **17** at the left-hand end of the assembly **5** is compressed, while on the right the puffer piston **14** is moved back compressing its driving spring **25**. For normal low-power switching duty, when the breaker is tripped, the accelerating spring **17** drives the moving contact **6** to the left, and an arc **26** appears at the separating contacts **6, 7**. The puffer piston **14** is also driven to the left, displacing SF_6 gas through the check valve **29** and deionizing the arc **26**, which has moved to the arcing horn **27** and the inside **28** of the tubular moving contact **6**. The gas exhausts to a chamber **56** on the left terminal **3**, then passes up the hollow conductor **3***a* to the bushing cap **3***b*, where it is filtered and return to the tank **2**. This filtering feature is set forth and claimed in United States patent application field March 27, 1961, Serial No. 98,632, now U.S. Patent 3,214,553, issued October 26, 1965, to Winthrop M. Leeds, and assigned to the assignee of the instant application.

The liquid SF_6 accumulator **35** with nitrogen (N_2) gas, above a piston separator **37**, compressed to about 800 p.s.i. (well above the SF_6 vapor pressure to prevent "vapor lock") would actually be located outside the breaker tank **2**, as shown in FIG. 1, to make the pressure gauge **38**, liquid-level indicator **39** and refilling plug **40** accessible. A strong glass-reinforced insulating tube **36** would bring the liquid SF_6 to the cam-operated valve **54** on the interrupter assembly **5**.

The cam **45** is attached to a cylindrical sleeve **44** free to rotate about operating rod **12**, but retained lengthwise to move with the piston-retrieving operating rod **12**. A helical spring (not shown) keeps the cam **45** normally at such an angular position that reciprocating movement of the operating rod **12** will not operate the valve **54**. A split ring **41** of magnetic material surrounds the stationary finger cluster **7**. When current above a predetermined value, say 10,000 amperes, flows through the contacts **6, 7**, the flux across the air gap **53** pulls the armature **42** down. The armature **42** is coupled to the cam sleeve **44** so that it will rotate the cam lug **45** in line with the follower **46** attached to the liquid SF_6 valve **54** and still not impede longitudinal movement of the operating rod **12** and the cam sleeve **44**. Thus, if short-circuit current exceeding the predetermined value flows through the contacts **6, 7** at the time the breaker **1** is tripped, the cam **45** becomes magnetically positioned so that, as the contacts are opened, the cam follower **46** is actuated, opening the valve **54** momentarily to admit a quantity of liquid SF_6 into the mixing chamber **30**. Vaporization of this liquefied SF_6 produces sufficient gas pressure and flow that even high-current arcs are easily extinguished. Alternate arrangements for directing liquid spray into the arc **26** are possible to speed up vaporization and intensify the cooling and deionization of the arc **26**. The high pressure developed by the liquid SF_6 closes the check valve **29** to prevent wasteful flow into the puffer cylinder **15** and possibly forcing back the puffer piston **14**.

As soon as the current is interrupted, the cam-retrieving spring, not shown, moves back the cam surface **45** so that on the closing stroke, the liquid SF_6 valve **54** will not be operated.

FIG. 5 diagrammatically illustrates a radial distribution system. It will be noted that fault current flows through all four breakers A, B, C, and D, but only breaker D should be tripped, so that only the faulted section of the system would be disconnected, leaving power flowing to all the other sections. Thus, there is no need for over-current responsive valves in breakers A, B, and C to be turned on, since these three breakers should not have to be tripped.

If the fault were between breakers B and C, only breaker B should open, but not breaker A. In this case, only half of the system would have to be disconnected, with power left on the other half. Breaker A should trip only if the fault were on the bus section between breakers A and B.

In connection with the radial distribution system of FIG. 5, and the desirability of selective tripping of breakers, reference may be had to Chapter 7 and Fig. 74 of the book entitled, "Silent Sentinels," published by the Westinghouse Electric Corporation, copyright 1940, and the accompanying descriptive matter.

It will be noted that in accordance with the present invention, the circuit interrupter uses two sources of gas blast to accomplish arc quenching. One of these, for instance, a puffer piston, provides gas flow, preferably of sulfur-hexafluoride (SF_6) gas, sufficient to extinguish arcs in a range up to moderate current values of several thousand amperes. A second source, consisting of a reservoir containing fluid under high pressure in either the gaseous or liquid state, is selectively controlled to come into action only when high currents above the range handled by the first source are to be interrupted. An important disadvantage of breakers of the prior art, such as set forth in Ruppel Reissue Patent 21,125, is that interrupting action is initiated directly by the overload current magnitude, and the high-pressure blast is released whenever high overload current flows through the breaker, regardless of whether or not the protective system has been called for this particular breaker to be tripped.

My invention specifically avoids this undesirable situation by using a current-responsive element, which does not produce a gas blast directly, as by opening a valve, but rather sets up conditions under overload that will cause the high-pressure fluid blast to be activated if, and only if, the breaker is actually tripped. The construction shown in FIG. 2 involves current-initiated magnetic means for aligning a cam-operating surface with the cam line of action, so that the opening movement of the breaker will operate the auxiliary blast valve on high-current overload conditions only. However, if the breaker is not tripped, no blast occurs even though high-current actuates the cam alignment device.

Other arrangements will suggest themselves to those skilled in the art for producing similar results of energizing a second source of fluid blast only when a condition of high-current overload exists, together with opening movement of the breaker contacts, as a result of a tripping signal being applied during the overload condition.

In the construction set forth in FIG. 2 it will be noted that the overload current magnetically aligns the cam plate **45** with the cam follower **46** to actuate the blast valve **49** upon the circuit interrupter being tripped open. Other arrangements for providing the same result will be apparent to those skilled in the art. For example, in the modified-type circuit interrupter **70** of FIG. 6 of the drawings, it will be noted that the fault current passing through the transmission line **71** will actuate the current transformer CT and energize the solenoid device **72** to effect

closure of the contacts 73, 74 by the movable bridging contact 75. This will condition the interrupter 70 so that should the protective system 77 call upon the circuit interrupter 70 to open, the energization of the circuit 80, 81, will energize not only the tripping solenoid 82, but, in addition, energize the actuating solenoid 84 closing contacts 84' to thereby effect through the circuit connections 85, 86, energization of the blast-value solenoid 87 and thereby open the blast valve 49' releasing a blast of the second auxiliary fluid source, which is only brought into play on the existence of overload or fault current conditions.

It will be noted in FIG. 6 that a normal, relatively low-current extinguishing means 90, including a piston device 91, sends a normal relatively low-current fluid flow through a blast pipe 92. This is analogous to the puffer device 14, 15 of FIG. 2, which is normally used for load-carrying operation of the breaker.

It will, from the foregoing, be apparent that the improved circuit-interrupting arrangements of the present invention condition the breaker in response to overload or fault conditions to cause the flow of fluid from the second auxiliary overload current source only when the breaker is actually tripped open. The mere passage of overload current through the breaker does not in and of itself effect opening of the overload current blast valve 49, 49'. The arrangement is such as to merely condition the circuit interrupter so that only during an actual tripping operation is there brought into play the supplementary source of arc-extinguishing fluid.

From the foregoing description of the invention, it will be apparent that there is provided an improved economical puffer-type or other type circuit interrupter in which auxiliary liquefied gas injector means 33, 49' are employed selectively operated only on currents above a predetermined magnitude. Since the auxiliary liquefied gas interrupter device 33 is employed only infrequently, it need not be replaced except at relatively long intervals of time when normal maintenance operations would take place.

Although there has been illustrated and described particular embodiments of the invention, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art without departing from the spirit and scope of the invention.

I claim as my invention:

1. The combination in a puffer-type circuit interrupter of a substantially closed metallic grounded tank, a pair of terminal bushings extending into said grounded metallic tank, an interrupting assembly supported at least in part by said pair of terminal bushings, the interrupting assembly including a movable contact, a relatively stationary contact and a pair of spaced insulating operating rods for effecting separation of the same, a driving operating rod for effecting reciprocal movement of said pair of spaced insulating operating rods, a puffer cylinder supported by one of said terminal bushings and having a puffer piston movable therein, means biasing said puffer piston in a direction to force a blast of gas into the arc established between said relatively stationary and movable contacts, the ends of the spaced insulating operating rods abutting said puffer piston to charge the same during the closing operation of the interrupter, an accumulator containing a liquefied gas, valve structure associated with said accumulator to release a blast of liquefied gas therefrom, check valve means associated with said puffer cylinder, and magnetic structure including a rotatable cam sleeve having a cam lug for effecting operation of said valve structure for selectively operating said valve structure only at currents above a predetermined value.

2. A selective magnetically-actuated valve structure for a fluid-blast circuit interrupter including contact structure separable to establish an arc, a split magnetic ring surrounding said contact structure, a movable armature, a cam sleeve carrying a cam lug and pivotally connected to said movable armature, blast-valve releasing means, a blast valve lever carrying a cam lug, whereby currents above a predetermined magnitude passing through said contact structure will effect movement of the armature to bring the cam lug and the valve cam follower into alignment to effect releasing of said blast means.

3. A fluid-blast circuit interrupter including contact means for establishing an arc, a first normal fluid-extinguishing means for interrupting said arc under normal load-carrying operation of the interrupter, a second auxiliary fluid-extinguishing means for interrupting said arc only under predetermined fault-current interrupting conditions including a fluid control valve therefor, current-responsive conditioning means responsive to the current flow through said contact means and operable only at current values above a predetermined current magnitude for conditioning said control valve to render the latter capable of opening and thereby releasing a blast of fluid from said second auxiliary fluid-extinguishing means, operating means for mechanically opening said contact means, means for initiating operation of said operating means, and means responsive only to the activation of said last-mentioned means to effect actual opening of the conditioned control valve for obtaining fluid flow from said second auxiliary fluid-extinguishing means for fault-current interruption.

4. The combination of claim 3, wherein the initiating means is a protective device individually associated with the particular circuit interrupter and only at selected times operated.

5. The combination according to claim 3, wherein the first normal fluid-extinguishing means is a puffer piston, and the second auxiliary fluid-extinguishing means includes a liquefied gas accumulator.

6. The combination of claim 5, wherein the current-responsive conditioning means includes a split magnetic ring surrounding the contact means and a movable armature selectively responsive to currents above a predetermined current magnitude.

7. The combination according to claim 5, wherein the current-responsive conditioning means includes magnetic structure associated with the contact structure for selective action.

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ROBERT S. MACON, *Acting Primary Examiner.*