Aug. 18, 1970 R. E. FRINK 3,524,958

FLUID-BLAST CIRCUIT INTERRUPTERS HAVING ELECTROMAGNETIC PISTON-DRIVING MEANS

Filed Sept. 1, 1966 3 Sheets-Sheet 1

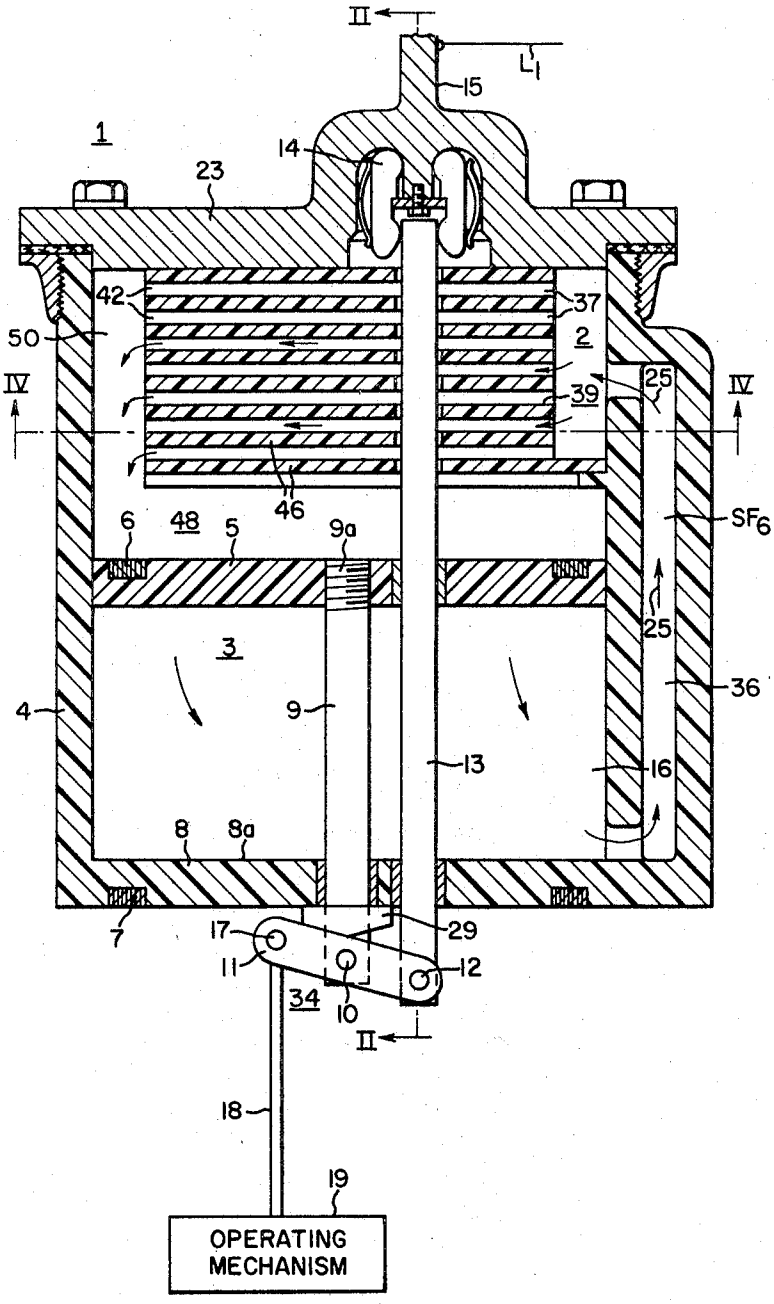
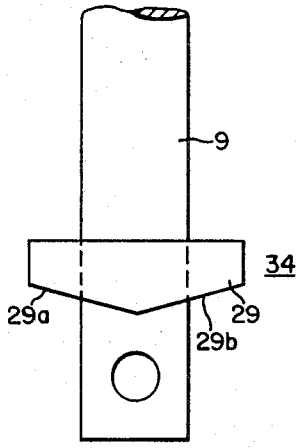


FIG.1.

FIG.5.



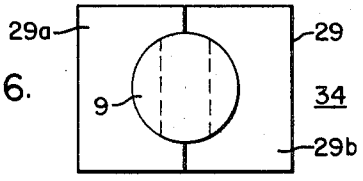


FIG.6.

WITNESSES

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FLUID-BLAST CIRCUIT INTERRUPTERS HAVING ELECTROMAGNETIC FISTON-DRIVING MEANS

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FIG.2.

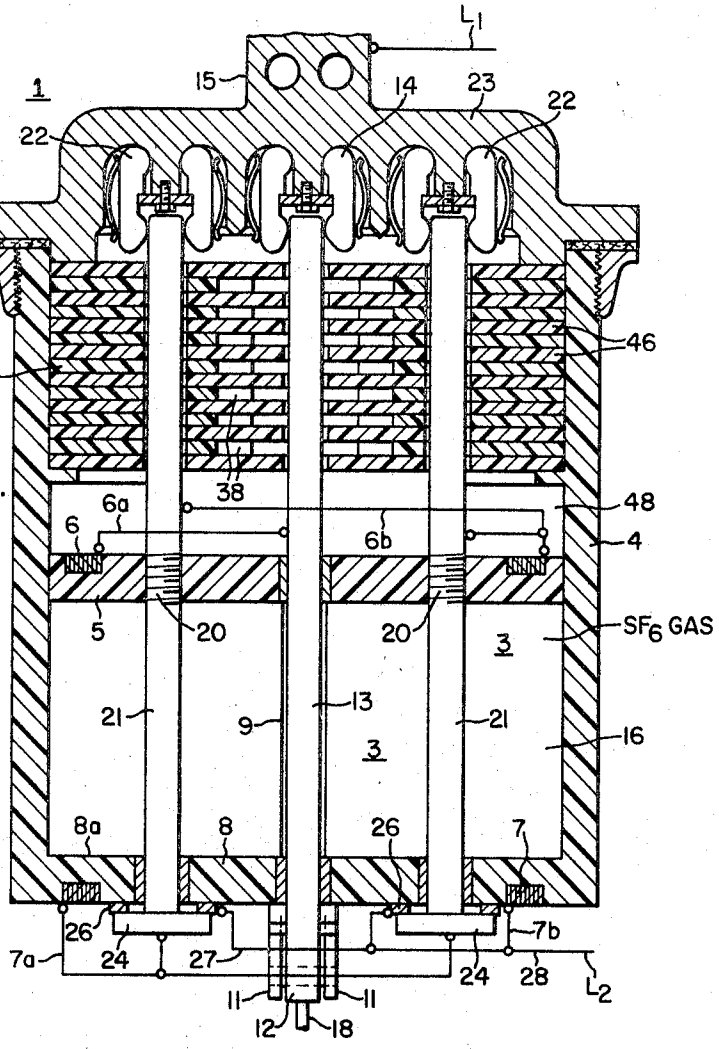


FIG.7.

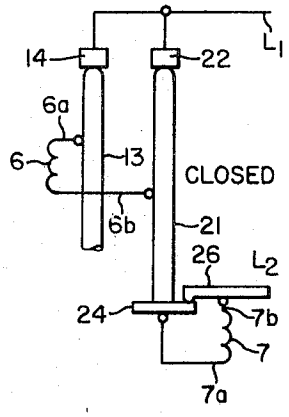


FIG.8.

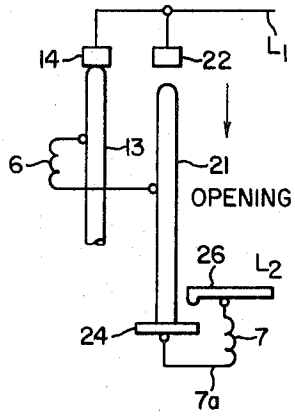


FIG.12.

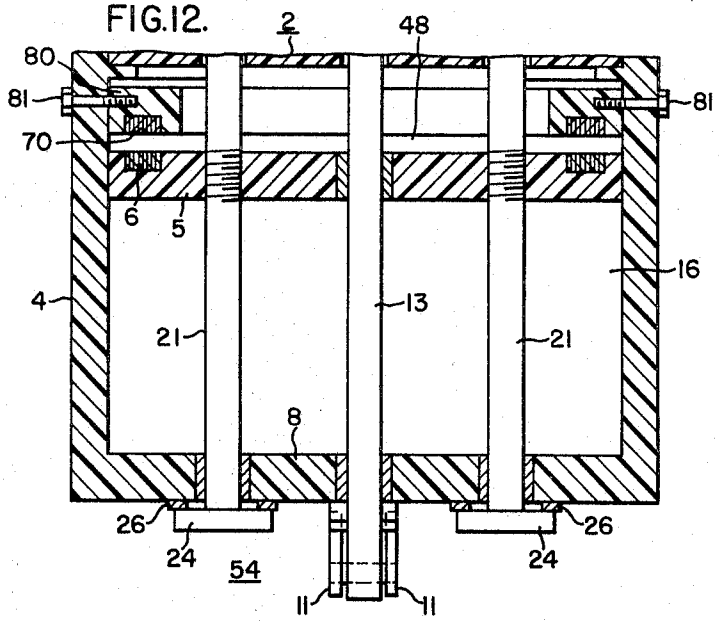
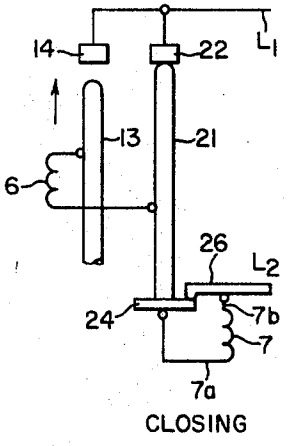


FIG.9.



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FLUID-BLAST CIRCUIT INTERRUPTERS HAVING ELECTROMAGNETIC PISTON-DRIVING MEANS
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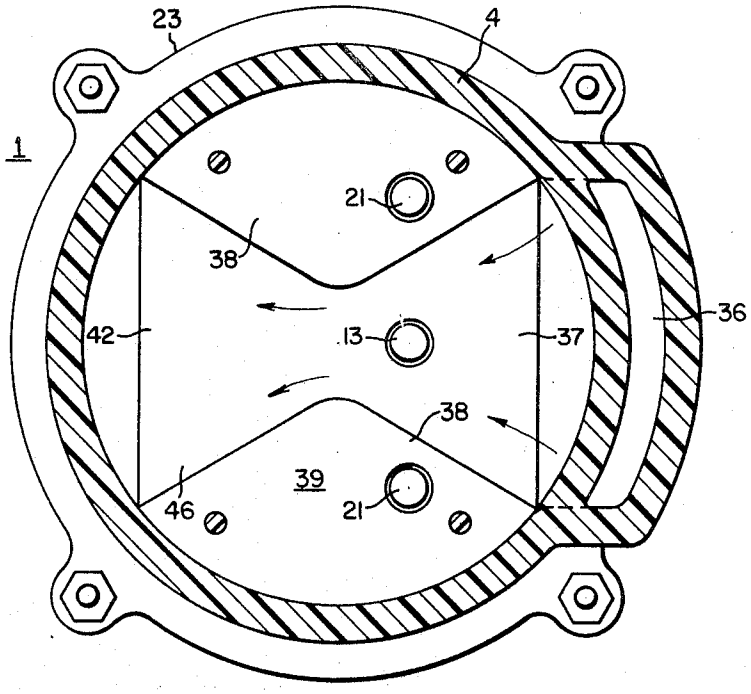
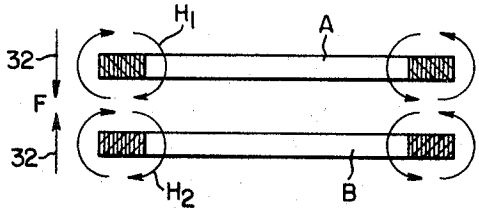


FIG. 4.

FIG. 10.



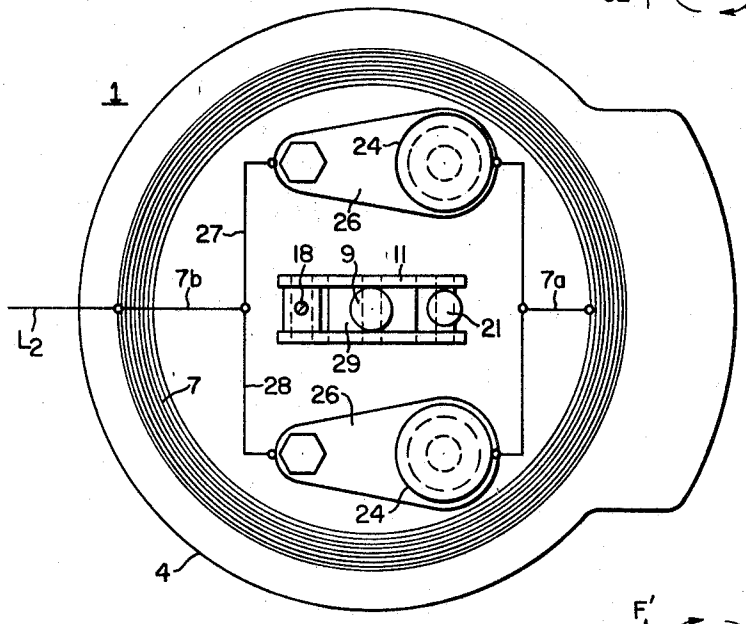
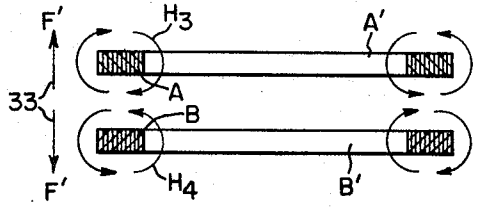


FIG. 3.

FIG. 11.



United States Patent Office 3,524,958 Patented Aug. 18, 1970

3,524,958

FLUID-BLAST CIRCUIT INTERRUPTERS HAVING ELECTROMAGNETIC PISTON-DRIVING MEANS

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Filed Sept. 1, 1966, Ser. No. 576,616
Int. Cl. H01h 33/90
U.S. Cl. 200—148 11 Claims

ABSTRACT OF THE DISCLOSURE

A fluid-blast circuit interrupter is provided having piston means for generating pressurized fluid flow into the established arc. An accelerating coil is carried by the movable piston, and is magnetically repelled, or attracted to a stationary accelerating coil located at one end or the other of the operating cylinder accommodating the reciprocally-movable piston.

The two accelerating coils are inserted electrically into the circuit upon separation of the main contact structure, and they carry the main line current at this time. The magnetic repulsion or attraction between the accelerating coils augments the driving force of the operating mechanism, which initially moves the piston mechanically, and additionally takes care of low-current interruption. The interruption of fault currents, however, is particularly assisted in this electromagnetic action, when otherwise the back pressure forces would be excessive to thereby impair the interruption effort.

The accelerating coils are out of the circuit on the closing stroke, at which time initial contact is made at the main contacts.

An interrupting structure is provided by spaced apertured plates with intervening laterally spaced flow plates, so that a transverse cross blast of fluid flow at spaced points is achieved through the established arc to effect its interruption. The outlet side of the interrupting structure is pneumatically connected to the back side of the driving piston so that advantage may be taken of cavitation effects.

This invention relates generally to fluid-blast circuit interrupters and, more particularly, to fluid-blast circuit interrupters utilizing electromagnetic piston-driving means to effect fluid motion toward the arc.

A general object of the present invention is to provide an improved fluid-blast circuit interrupter which will avoid the necessity of utilizing heavy driving springs to effect fluid motion. As well known by those skilled in the art, in fluid-blast circuit interrupters, particularly those of the piston, or "puffer" type, it has heretofore been necessary to employ strong accelerating springs which are charged in the closed-circuit position of the interrupter, and which are released to drive the associated piston member to effect fluid flow toward the arc during the opening operation. Since the magnitude of the fault current may approach the order of many thousands of amperes, for example, 25,000 to 50,000 amperes, it is necessary to have sufficient pressure to permit the fluid flow to forceably pass into and through the arc to effect the latter's interruption. This necessarily results in there being adequate spring pressure which will have the sufficient energy output to force the fluid into the arc even under extremely high arc pressures.

Accordingly, it is a further object of the present invention to eliminate the necessity of having strong accelerating driving springs to effect fluid motion toward the arc, and instead to rely upon electromagnetic piston driving means to augment the fluid force during heavy fault current interruption.

Another object of the invention is to provide an improved "puffer" type circuit interrupter in which the energy in the fault current being interrupted is used to drive the puffer piston, thus permitting breaker operation with a conventional mechanism.

Still a further object of the present invention is to employ a conventional operating mechanism to effect piston, or pumped fluid motion during relatively low, or load-current operation, and to utilize in cooperation therewith electromagnetic means including a pair of accelerating coils, which may be either attracted or repelled to facilitate fluid motion during heavy fault-current interruption.

Yet a further object of the present invention is to utilize improved electromagnetic means, including two or more accelerating coils, to assist in the piston-driving effort during the opening operation of a fluid-blast circuit interrupter.

Another object of the present invention is to provide an improved interrupting passage structure for quickly effecting the extinction of an established arc in a circuit interrupter.

Still a further object is to employ an improved interrupting section, as described in the immediately preceding paragraph, taken in conjunction with a piston-driving member so that back-pressure forces will tend to be eliminated.

Still a further object of the present invention is to provide an improved linkage system for a circuit interrupter of the type having main contacts and arcing contacts associated with a piston member for effecting fluid motion.

Another object of the present invention is to provide an improved fluid-blast circuit interrupter having an improved piston member for effecting fluid motion, in which an accelerated coil is movable with the piston member and is attracted, or repelled by an associated accelerating coil member.

Still a further object of the present invention is to provide stationary and movable accelerating coils associated with a piston structure for a fluid-blast type of circuit interrupter.

In accordance with one embodiment of the present invention, there is provided an operating cylinder for a fluid-blast type of circuit interrupter, within which is reciprocally movable a piston member carrying an accelerating coil. A conventional mechanism is utilized to effect motion of the aforesaid piston member, which additionally carries a movable main contact member. An arcing contact member slides through the piston and operating cylinder members and is actuated by the externally-disposed operating mechanism. A stationary accelerating coil is utilized, which, together with the aforesaid movable accelerating coil, is inserted into series circuit during the opening operation by a suitable linkage arrangement, which insures the opening of the main contact members prior to the subsequent opening of the arcing contact members. The arrangement is such that the piston member is assisted in its fluid-driving motion by the movable accelerating coil, which is attracted to the stationary accelerating coil, so that during the interruption of fault currents, the piston-driving effort is increased by utilizing energy passing through the circuit interrupter.

In an alternative embodiment, instead of using accelerating coils which attract, a varient is provided in having accelerating coils which repel each other so that one of the aforesaid repelling coils assists the fluid-driving motion of the piston member.

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 vertical sectional view taken through a fluid-blast type of circuit interrupter having electromagnetic piston-driving means in the form of two attracting accelerating coils, the contact structure being illustrated in the closed-circuit position;

FIG. 2 is a vertical sectional view taken generally transversely to the view of FIG. 1, substantially along the line II—II of FIG. 1, again the contact structure being illustrated in the closed-circuit position;

FIG. 3 is a bottom plan view of the circuit interrupting structure of FIG. 1;

FIG. 4 is a sectional plan view taken through the interrupting structure of the circuit interrupter of FIG. 1, the view being taken substantially along the line IV—IV of FIG. 1;

FIG. 5 is a fragmentary enlarged view of a portion of the operating linkage;

FIG. 6 is a plan view of the operating linkage of FIG. 5;

FIGS. 7–9 are diagrammatic views indicating the accelerating coil connections in the respective closed, opening and closing positions of the circuit interrupter;

FIGS. 10 and 11 are diagrammatic views illustrating the broad electromagnetic principles incorporated in the present invention to effect fluid motion; and,

FIG. 12 is a sectional view taken through a modified-type of circuit interrupter of the fluid-blast type, generally similar to the circuit interrupter of FIG. 1, but utilizing repelling accelerating coils in place of attracting accelerating coils.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral **1** generally designates a fluid-blast type of circuit interrupter. The fluid may be any suitable arc-extinguishing fluid, such as sulfurhexafluoride (SF_6) gas, for example. Generally, the fluid-blast circuit interrupter **1** comprises an apertured interrupting section or structure **2** and a fluid-driving section **3**. As shown in FIG. 1, there is provided an operating cylinder **4**, within which is reciprocally movable a fluid-driving piston **5** carrying an accelerating coil **6**. The accelerating coil **6** is attracted to a second stationary accelerating coil **7**, which is supported within the base end **8** of the operating cylinder **4**.

An operating rod **9** is secured, as at *9a*, to the piston member **5**, and has its lower end pivotally connected, as at **10**, to a pair of parallel-disposed operating links **11**. The operating links **11** are pivotally connected, as at **12**, to a movable arcing contact **13** which is adapted to engage and separate from a stationary arcing contact **14**.

As shown in FIG. 1, the stationary arcing contact **14** is electrically connected by a terminal connector **15** to one line terminal L_1 of the circuit interrupter **1**.

The left-hand ends of the pair of parallel-disposed operating links **11**, as viewed in FIG. 1, are pivotally connected, as at **17**, to an operating rod **18**, which may be operated by any suitable operating mechanism, generally designated by the reference numeral **19**.

Fixedly secured to the movable piston member **5**, as by a threaded connection **20**, is a pair of movable main contact rods **21**, which make contact with a pair of main stationary contacts **22**, the latter being electrically connected through the top terminal closure plate **23** to the terminal connector **15** of the circuit interrupter **1**.

The lower ends of the two main movable contact rods **21** are enlarged, as at **24**, to form movable contacts cooperable with a pair of stationary contacts **26** more clearly shown in FIG. 3 of the drawings. The two stationary contact plates **26** are electrically connected by connectors **27**, **28** to a lower terminal connection L_2 of the circuit interrupter **1**.

It will, therefore, be evident that in the closed-circuit position of the circuit interrupter **1**, as illustrated in FIGS. 1, 2 and 7 of the drawings, the electrical circuit traverses the path from the terminal L_1, connector **15**, terminal plate **23**, main stationary contact **22**, the two main

movable contact rods **21**, lower contacts **24**, stationary contacts **26** and line connectors **27**, **28** to lower main line terminal L_2. As will more fully be brought out hereinafter, in this closed-circuit electrical condition of the circuit interrupter **1**, the two accelerating coils **6**, **7** are short-circuited.

The electromagnetic driving means, generally designated by the reference numeral **3**, will now be described. As mentioned, there is provided a movable accelerating coil **6** and a stationary accelerating coil **7**, which tend to attract during their insertion into the series electrical circuit during the opening operation. More particularly, the upper movable accelerating coil **6**, carried by the piston member **5**, has its terminal connections *6a*, *6b* respectively connected to the movable arcing contact rod **13** and the movable main contact rod **21**. The lower stationary accelerating coil **7** has one of its terminal connections *7a* electrically connected to one of the movable lower terminals **24** of the movable main contact rod **21**. The other terminal connection *7b* is connected to one of the stationary contact plates **26** affixed to the bottom plate **8** of the operating cylinder **4**. Reference may be had to the diagrammatic view of FIG. 7 for an understanding of the coil connections for the two accelerating coils **6**, **7** comprising the electromagnetic driving means **3**.

With reference to FIG. 10 of the drawings, it will be apparent that depending upon the direction of the winding of the two coils A, B and the direction of the resulting magnetic field H_1, H_2, the coils will be attracted by a force F, as illustrated by the arrows **32** of FIG. 10, or repelled by a force F′ as indicated by the arrows **33** of FIG. 11. The principles pertaining to the magnetic interaction, creating an attractive force F, as illustrated by the arrows **32** of FIG. 10, are applicable to the electromagnetic driving means **3**, comprising the accelerating coils **6**, **7**, as applied to the circuit interrupter **1** of FIGS. 1–4 of the drawings.

During the opening operation of the circuit interrupter **1**, as effected by the operating mechanism **19**, either in response to manual operation, or in response to an overload condition existing on the line L_1–L_2 connected by the circuit interrupter **1**, as well as understood by those skilled in the art, a downward driving force, or tensile force is exerted upon the operating rod **18**, which is transmitted through the linkage means **34** to effect a counterclockwise rotation of the pair of operating links **11** about the pivot pin **10** to initially effect downward opening movement of the piston rod **9** to thereby force the piston **5** to move downwardly. Since the two main movable contact rods **21** are fixedly secured, as at **20**, to the piston **5**, there will immediately occur a separation between the movable and stationary main contacts **21**, **22**, thus forcing the current to flow through the separable arcing contacts **13**, **14**, which are yet closed. Reference may be had to diagrammatic view of FIG. 8 of the drawings in this connection. In addition, not only is there provided a separation at the main stationary and movable contacts, **21**, **22**, but also there occurs simultaneous separation at the main contacts **24**, **26** at the lower end **8** of the circuit interrupter **1**.

With reference to FIG. 8 of the drawings, it will be observed that the two accelerating coils **6**, **7** are now inserted into the series circuit passing through the circuit interrupter **1** through the closed arcing contacts **13**, **14**. The passage of the series line current through the accelerating coils **6**, **7** will cause them to be attracted together so as to assist the downward fluid-driving motion of the movable piston **5** to force fluid, such as SF_6 gas, for example, through the side conduit passage **36** and up into the interrupting section **2** of the circuit interrupter **1** in a manner indicated by the arrows **25** of FIG. 1.

The fluid flow will pass upwardly through the bypass channel **36** and will flow through the passages **37** provided by the laterally-spaced plate portions **38** (FIG. 4)

constituting the inlet plate sections **39** of the interrupting section **2** of the circuit interrupter **1**.

The arc (not shown), which is established between the separable arcing contacts **14, 13**, will be subjected to a transverse flow of fluid, which, after contacting the arc, will be exhausted through the lateral exhaust passages **42** provided by the flow-plate section **39** of the interrupting section **2**. The intervening apertured insulating plates **46** assist in the transverse flow of the fluid **16** passing through the arc.

It will be observed that the downward opening movement of the piston **5** tends to create a cavitation in the region **48** below the apertured interrupting section **2** of the interrupter, so as to induce an exhausting flow of fluid downwardly through the exhaust passage **50**. In a circuit breaker interrupting a high-current arc, the arc temperature may be of the order of 10,000° K. This produces a very large increase of pressure in the arcing region. In many "puffer type" interrupters of previous design this pressure is transmitted back to the compressing side of the piston, tending to stop its motion, or even reverse it. In the device described in this invention, the pressure resulting from arc temperature travels in both directions from the arcing region and is applied substantially equally to both sides of the piston. The forces counterbalance each other, and the piston is much more easily moved than would be the case if it were not for this counterbalancing effect. This tends to eliminate backpressure and facilitates a lateral inward flow of fluid into the established arc. The operating linkage **34**, piston **5** and movable contact rods **13, 21** continues to more fully-open position wherein the piston **5** may abut the upper surface **8***a* of the operating cylinder head **8** to limit the opening travel of the piston **5** and contact structure.

During the closing operation of the circuit interrupter **1**, the operating mechanism **19** provides a compressive force exerted upwardly along the operating rod **18** to thereby effect a clockwise rotative motion of the pair of operating links **11** about the pivot shaft **10** to effect downward travel of the arcing contact rod **13** relative to the two main movable contact rods **21**. This rotative action of the links **11** of the linkage system **34** continues until the upper side surfaces of the links **11** contact the inclined portion **29***a* of the stop member **29** secured to the operating rod **9** (FIG. 5). In this connection it is to be noted that the driving links can rotate through a small arc about the pin **10** through rod **18**, but are restrained from large rotation by the stops **29***a*, **29***b*. When this occurs, the entire linkage system **34** and the movable contact rods **13, 21** move upwardly as a unit thus causing the two main movable contact rods **21** to make engagement with the stationary main contacts **22** before the engagement of the arcing contacts **13, 14**. As a result, the accelerating coils **6, 7** are not in the electrical circuit during the closing operation. This state of affairs is illustrated in the diagrammatic view of FIG. 9 of the drawngs showing the beginning of the closing operation.

FIG. 12 illustrates a modified-type of circuit interrupter, generally designated by the reference numeral **54**. It will be noted that instead of utilizing a stationary accelerating coil **7** disposed within the cylinder head **8**, instead a stationary accelerating coil **70** is provided being embedded in a ring-shaped plate **80** affixed by bolts **81** to the side wall of the operating cylinder **4**. The coil connections may be identical to those utilized in connection with the circuit interrupter **1** of FIGS. 1–4 of the drawings. The coil winding is so arranged as to follow the principles set forth in FIG. 11 to result in a repelling force F^1 between the accelerating coils so as to again cause a downward opening driving movement of the movable piston member **5** within the operating cylinder **4**. The contact operating sequence and the passage of the fluid flow occurs in a manner identical to that of the interrupter **1** of FIG. 1; consequently, it is believed that a further discussion thereof is unnecessary.

Calculations show that with two ten-turn coils **6, 7** having a mean diameter of 10 inches and separated 7 inches apart, the force of attraction between them is 5,000 pounds for 25,000 amperes and 13,000 pounds for 40,000 amperes. This is of the order of magnitude of the forces found necessary for operation of fluid-blast circuit interrupters at currents of this order.

It will be understood that the electromagnetic driving means **3**, involving the accelerating coils **6, 7**, or repelling coils **6, 70**, may be used to operate any piston-type of circuit interrupter which needs a blast of fluid under pressure directed at the established arc. As set out hereinbefore, the piston **5** can be made to operate in either direction depending upon whether the coils are wound to attract or to repel. An essential fundamental concept involved in the present invention is a piston driven by magnetic forces between two coaxial coils, the power for movement of the piston being supplied by the fault current being interrupted in the circuit breaker. For the lower current values being interrupted, reliance may be placed merely upon the power supplied by the operating mechanism **19**.

Although there has been illustrated and described specific structures, 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 by those skilled in the art without departing from the spirit and scope of the invention.

I claim as my invention:

1. A fluid-blast type of circuit interrupter including a pair of separable main contacts and a shunting pair of separable arcing contacts, an operating cylinder having a movable piston reciprocally movably therein; passage means for directing a flow of fluid under pressure from said movable piston toward the established arc, a piston rod (**9**) carrying a movable stop member (**29**), at least one driving link (**11**) pivotally connected to said piston rod and also connected at one end thereof to one of the arcing contacts, one of the main contacts being carried by said movable piston, operating means (**19**) connected to the other end of said driving link, said driving link having partial arcuate rotation by striking two stop portions of said movable stop member (**29**), whereby upon opening movement of the circuit interrupter the partial rotation of said driving link effects opening motion of the movable piston and separation of the main contacts while maintaining the arcing contacts closed.

2. The fluid-blast type of circuit interrupter of claim **1**, wherein an accelerating coil is carried by the movable piston.

3. The combination of claim **2**, wherein an attracting coil is stationarily disposed adjacent one end of the operating cylinder.

4. The combination of claim **2**, wherein said one main contact is extended through said one end of the operating cylinder and serves to conduct current to said stationarily disposed attracting coil.

5. The fluid-blast type of circuit interrupter of claim **1**, wherein a repulsion coil is carried by the movable piston.

6. The combination of claim **5**, wherein a repulsion coil is stationarily disposed intermediate the ends of the operating cylinder.

7. The combination of claim **1**, wherein an apertured interrupting structure is provided to extinguish the arc.

8. A fluid-blast circuit interrupter including separable main contact means, said main contact means including a movable main contact, separable arcing contact means separable to establish an arc and in electrical parallel with the main contact means, piston means including an operating cylinder and a reciprocally-movable piston movable therein, said movable piston carrying the movable main contact and being movable within the operating cylinder

to force fluid under pressure against an established arc, electromagnetic means for assisting in the movement of said movable piston, said electromagnetic means being connected in series electrical circuit with the separable arcing contacts on opening of the main contacts, operating means for initially moving the piston and the movable main contact at the beginning of a circuit-opening operation to open the main current path and to thereby insert in the series circuit the electromagnetic means, said operating means subsequently functioning to open the separable arcing contacts to thereby establish the arc; whereby the piston forces fluid toward the arc to effect its extinction.

9. The combination of claim **8**, wherein the movable main contact is extended through a closed end of the operating cylinder and serves to conduct to said electromagnetic means.

10. The combination of claim **8**, wherein an apertured interrupting structure is provided to extinguish the arc.

11. The combination of claim **8**, wherein the electromagnetic means comprises a spaced pair of coils relatively movable with respect to each other.

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ROBERT S. MACON, Primary Examiner

U.S. Cl. X.R.

200—150; 335—201