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[54] **FLUID-BLAST CIRCUIT INTERRUPTERS WITH PISTON-DRIVING MEANS AND COOPERABLE FLOATING PISTON WITH ACCELERATING COIL**
 11 Claims, 6 Drawing Figs.

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 195, 148, 149, 18, 186; 317/75, 152, 11, 137,
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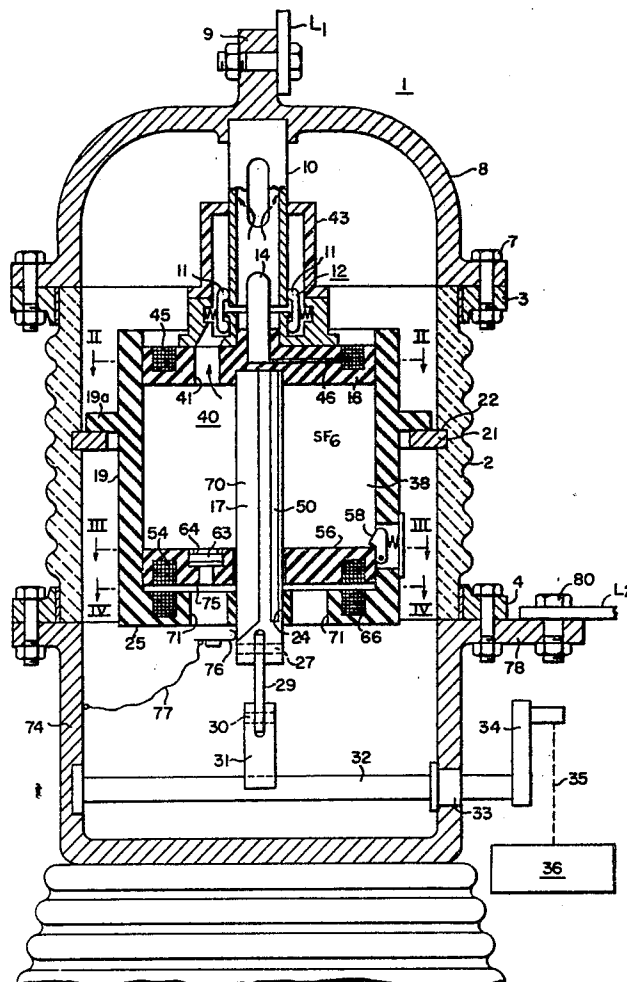
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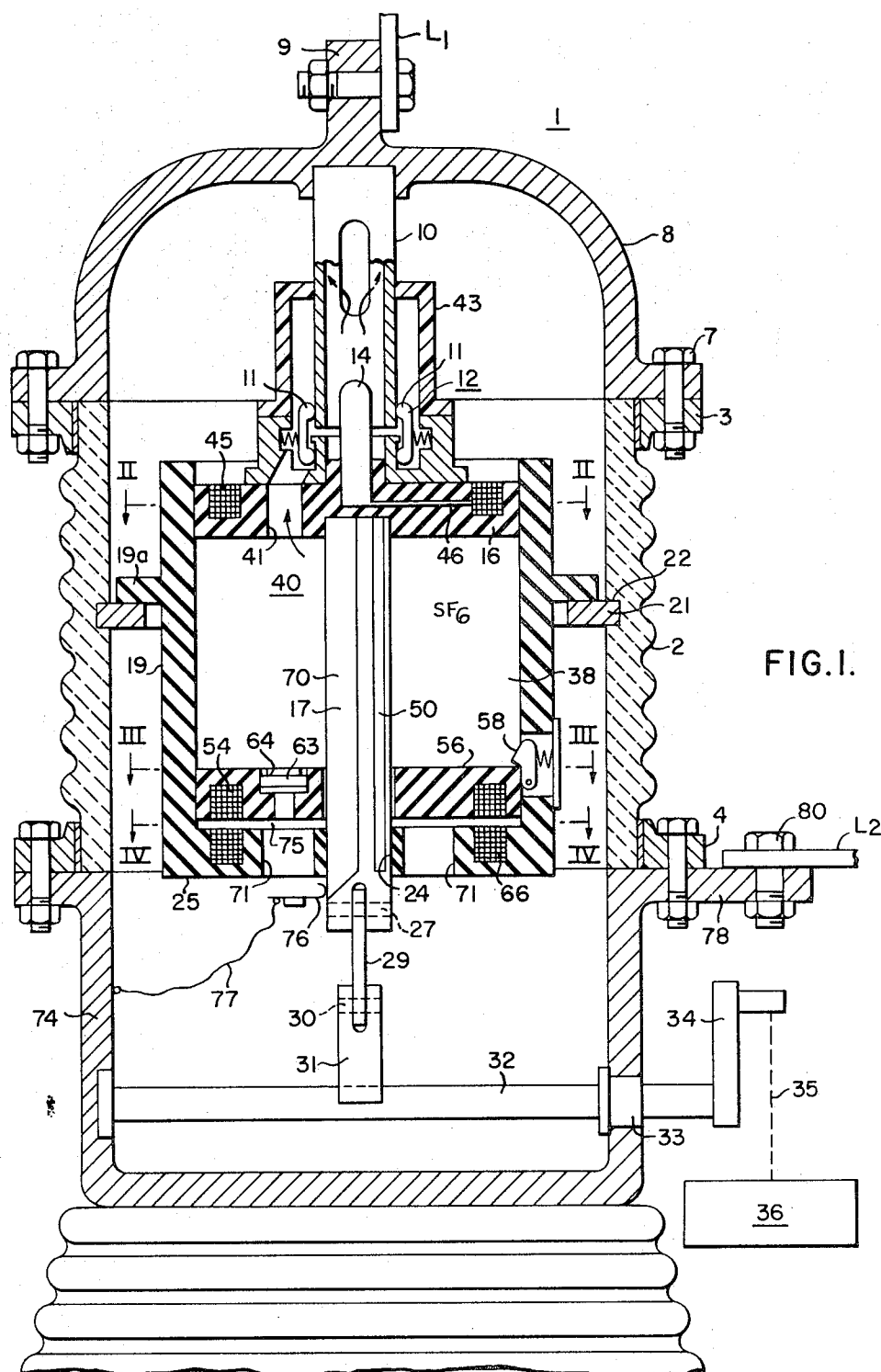
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ABSTRACT: A fluid-blast circuit interrupter is provided having a movable fluid-driving piston carrying the movable contact structure and, additionally, a movable accelerating coil. An operating mechanism causes motion of this piston. The movable piston moves within an operating cylinder having a stationary second accelerating coil in the base portion thereof. A floating piston, carrying a movable third accelerating coil, is also reciprocally movable within the operating cylinder, and is magnetically repelled by the stationary accelerating coil when the three accelerating coils are inserted serially into the circuit during the opening operation.

The movable piston also carries an arcing horn to which the moving terminal of the established arc is transferred by fluid flow during initial motion of the moving piston. This transfer of the arc terminal effects the series insertion of all three accelerating coils into the circuit to reduce the force requirements imposed upon the operating mechanism.





WITNESSES

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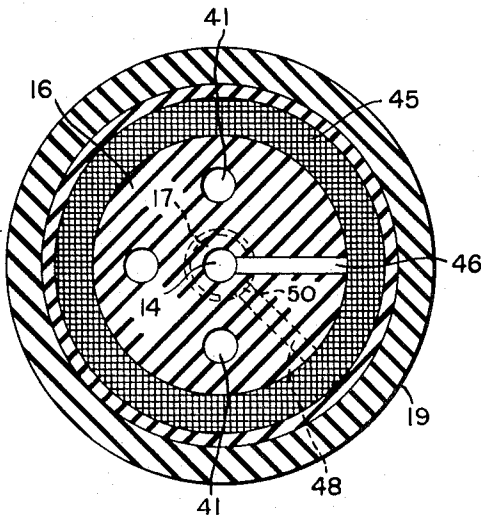


FIG. 2.

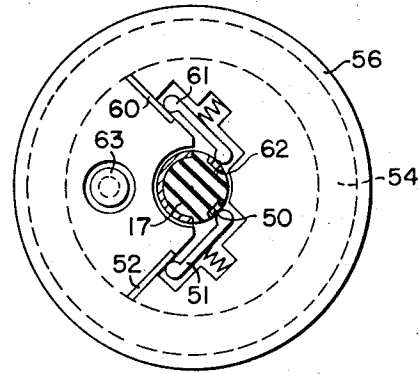


FIG. 3.

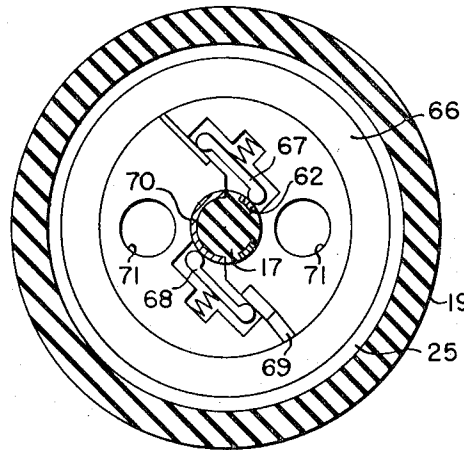


FIG. 4.

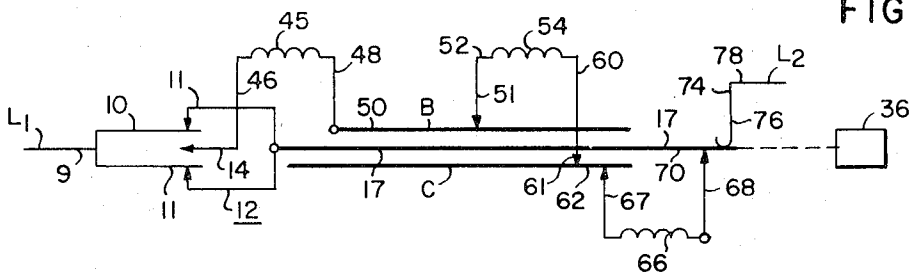


FIG. 5.

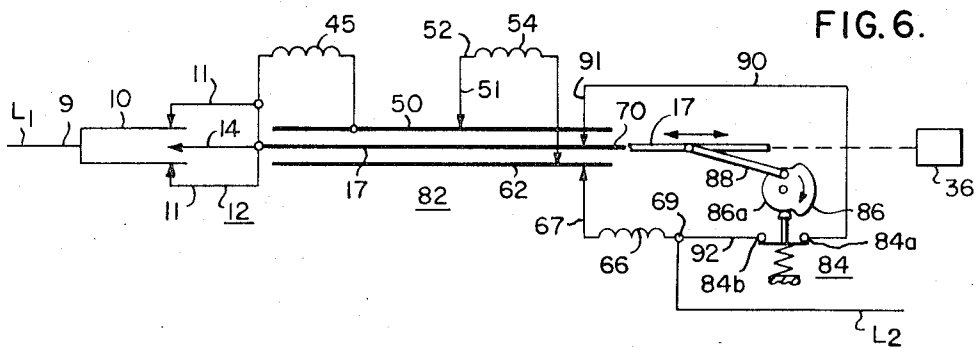


FIG. 6.

FLUID-BLAST CIRCUIT INTERRUPTERS WITH PISTON-DRIVING MEANS AND COOPERABLE FLOATING PISTON WITH ACCELERATING COIL

This invention relates, generally, to fluid-blast circuit interrupters, and, more particularly, to fluid-blast circuit interrupters in which piston means, incorporating electromagnetic means, are utilized for forcing fluid under pressure toward the established arc to effect the extinction thereof.

A general object of the present invention is to provide an improved fluid-blast circuit interrupter in which piston means, incorporating a floating piston having an accelerating coil carried therewith, is utilized for very rapidly compressing the fluid within the operating cylinder chamber and sending the same toward the established arc to effect the extinction thereof.

In U.S. Pat. application, filed Sept. 1, 1966, Ser. No. 576,616, now U.S. Pat. No. 3,524,958 by Russell E. Frink, and assigned to the assignee of the instant application, there is illustrated and described a novel fluid-blast circuit interrupter utilizing electromagnetic means connected serially into the circuit during the opening operation to assist the operating mechanism driving the associated piston structure. It is, accordingly, a further object of the present invention to improve upon the principles set forth in the aforesaid application to provide an improved high-speed fluid-blast circuit interrupter incorporating a floating piston having an accelerating coil associated with the fluid piston-driving means.

In application, filed Sept. 1, 1966, Ser. No. 576,739, now U.S. Pat. No. 3,524,959 by Russel E. Frink, and assigned to the assignee of the instant application, there is illustrated and described a fluid-blast circuit interrupter in which arc transfer means is utilized to connect the electromagnetic means serially into the circuit during the opening operation to assist the mechanical effort provided by the associated operating mechanism. It is still a further object of the present invention to improve upon the general type of circuit interrupter set forth in the last-mentioned Frink application to speed up the fluid-pressure providing means.

Still a further object of the present invention is the provision of an improved fluid-blast circuit interrupter in which a movable piston, having an accelerating coil, is mechanically driven by the associated operating mechanism within an operating cylinder, the latter having a second accelerating coil associated therewith, and in which a floating piston having a third accelerating coil is also movable within said operating cylinder to considerably speed up the compressing of the fluid for ejection into the established arc.

In accordance with a preferred embodiment of the present invention, there is provided a stationary operating cylinder having an accelerating coil in the base portion thereof. A movable piston member, mechanically driven by the operating mechanism, carries movable main and insulated arcing horn means, together with an accelerating coil, the movable contact means separating from an associated stationary contact means to establish a main current arc. By the mechanical movement of the piston by the associated operating mechanism, a fluid blast causes a transfer of the main current arc to the arcing horn means, which is connected in series with the accelerating coil carried by the movable piston member. In addition, a floating piston is movable within the operating cylinder, and it carries a second movable accelerating coil, which is repelled by the stationary accelerating coil disposed at the base of the operating cylinder. By suitable sliding contact means and movable conductor bars, embedded longitudinally in the contact operating rod, the three accelerating coils are in electrical circuit with said arcing horn means, so that upon transfer of the main current arc to the arcing horn means, the three accelerating coils are inserted into the series circuit to thereby very rapidly cause fluid-driving movement of the floating piston in conjunction with the mechanically driven piston member.

In accordance with a further embodiment of the invention, a separate normally closed switch is provided to force the current to flow through the three accelerating coils, and, in this

instance the arcing horn means is electrically connected to the main movable contact structure.

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 circuit interrupter incorporating the principles of the present invention, the contact structure being illustrated in the closed-circuit position;

FIG. 2-4 are sectional views taken, respectively, along the lines II-II, III-III and IV-IV of FIG. 1;

FIG. 5 is a diagrammatic view illustrating the accelerating coil connections for the circuit interrupter of FIG. 1; and,

FIG. 6 illustrates diagrammatically a further modified type of fluid-blast circuit interrupter in which a separate switch is employed to force the current flow through the accelerating coils, the structure, with the exception of the circuit connections, being identical to that set forth in FIG. 1, again the contact structure being illustrated in the closed-circuit position.

Referring to the drawings, and more particularly, to FIG. 1 thereof, the reference numeral 1 generally designates a fluid-blast circuit interrupter. As shown in FIG. 1, generally, the fluid-blast circuit interrupter 1 comprises an upstanding insulating casing 2 formed of a suitable weatherproof material, such as porcelain, for example, having a pair of flange rings 3, 4 cemented to the upper and lower ends thereof. Secured, as by a plurality of bolts 7, is an upper conducting line terminal cap 8 having a line connection 9, which is connected to the external lead L₁.

Extending downwardly centrally within the top metallic casting 8 is a stationary tubular vented contact, designated by the reference numeral 10, and making closed contacting engagement with a plurality of main movable contact fingers 11, which constitute a part of a movable contact structure, generally designated by the reference numeral 12.

The movable contact structure 12, in addition, comprises an arcing horn means 14, which, together with the movable contact structure 12, is carried by a movable piston 16 secured to a piston rod 17, the latter being mechanically driven by a suitable operating mechanism, more fully described hereinafter.

It will be noted that the movable piston member 16 reciprocally operates within a stationary operating cylinder 19 having a radially outwardly extending flange ring 19a (FIG. 1), which is secured, as by bolts (not shown), to a metallic support ring 21, which is stationarily supported within a recess 22 provided on the inner face of the upstanding porcelain casing 2, as shown in FIG. 1.

It will be observed that the piston rod 17 extends through an opening 24 provided in the base portion 25 of the operating cylinder 19, and is pivotally connected, as at 27, adjacent its lower end, through a floating link 29, which, in turn, is pivotally connected, as at 30, to a rotating crank arm 31 movable with a rotatable crankshaft 32.

The crankshaft 32 extends through a seal 33, and has an external crank arm 34 provided at its outer extremity, which is mechanically connected, by linkage means 35, to a suitable operating mechanism, generally designated by the reference numeral 36. From the foregoing description, it will be apparent that functioning of the operating mechanism 36 will effect closing and opening rotative movement of the rotatable crankshaft 32, and hence vertical opening and closing movement of the piston rod 17 and movable contact structure 12 with respect to the stationary contact 10.

It will also be obvious that downward opening movement of the piston 16, as effected by the operating mechanism 36, will compress a suitable arc-extinguishing fluid 38, such as sulfur hexafluoride (SF₆) gas, within the region 40 below the movable piston 16, and force this compressed arc-extinguishing gas 38 upwardly through suitably provided apertures 41 and through a nozzle insulating member 43 adjacent the established arc (not shown).

It will be observed that the movable piston member 16 carries therewith a movable accelerating coil 45, which has an electrical connection 46 to the arcing horn 14. The movable accelerating coil 45 has its other terminal connected, by a conductor 48 (FIG. 2), to a vertical movable conducting bar 50 extending lengthwise of the operating piston rod 17 and movable therewith.

A contact finger 51 (FIG. 3) bears in sliding relationship with the longitudinal movable contact bar 50 to electrically connect the contact bar 50 with one terminal 52 (FIG. 3) of a movable accelerating coil 54, which is embedded in a floating piston member 56 reciprocally movable within the operating cylinder 19, and latched in the position shown in FIG. 1 by a spring-biased latching element 58.

The other terminal 60 (FIG. 3) of the movable accelerating coil 54 is electrically connected to a contact finger 61 (FIG. 3), which slides relevant to a longitudinal movable contact bar 62, more clearly shown in FIGS. 3 and 4 of the drawings.

The movable floating piston member 56, carrying the accelerating coil 54, in addition, has a unidirectional valve 63 associated therewith to permit fluid to flow only upwardly through the aperture 64, and not downwardly therethrough, the purpose for which will be more fully understood from the following description.

The stationary accelerating coil 66, disposed in the base portion 25 of the operating cylinder 19, also has a pair of contact fingers 67, 68 connected to the terminals thereof, as shown more clearly in FIG. 4 of the drawings. The contact finger 67 permits sliding engagement with the longitudinal movable contact bar 62, and the stationary contact finger 68 makes sliding connection with a longitudinal movable contact bar 70, also supported on the insulating operation piston rod 17 and electrically connected to main contacts 11.

The base 25 has a pair of apertures 71 provided therethrough to permit fluid to flow from the lower base container 74 upwardly into the region 75 below the floating piston member 56.

As shown in FIG. 1, a stationary contact finger 76 bears in sliding relationship with the longitudinal movable contact bar 70, and provides a connection to the base casting 74 of the circuit interrupter 1, which has a line terminal connection 78. A line terminal L_2 may be connected, by a bolt 80, to the terminal 78 and hence, through the connection 77, to the longitudinal movable contact bar 70. Reference may be had to the diagrammatic view of FIG. 5 to more clearly understand the accelerating coil connections to the longitudinal movable contact bars 50, 62 and 70 carried by the insulating operating piston rod 70.

A gas-filled "puffer" breaker has features which the dual-pressure breakers lack. Filled to a low pressure, such as 45 p.s.i.g., for example, the puffer or piston-operated breaker does not require heaters to prevent liquefaction of the arc-extinguishing gas. The pressure required for interruption is produced, when needed, by the motion of a piston within an operating cylinder, thus eliminating expensive gas-handling system with its attendant gauges, compressor, reservoirs, filters, etc. The chief disadvantage of the puffer, or piston-type circuit interrupter, is the large mechanical forces required to produce the needed gas flow. By incorporating accelerating coils, as shown, in the piston and cylinder assembly, it is possible to obtain additional energy from the fault current to compress the gas from the magnetic field produced by the short circuit current.

In the circuit interrupter 1, as illustrated in FIG. 1, downward opening movement of the piston rod 17, as effected by the operating mechanism 36, causes corresponding downward movement of the movable piston member 16 within the operating cylinder 19. This compresses the arc-extinguishing gas 38 within the region 40, and forces it upwardly through a plurality of apertures 41 (FIG. 2) and through the orifice, or nozzle member 43, and through the vented stationary contact 10 to transfer the arc to the movable arcing horn 14. When this occurs, the three accelerating coils

45, 54, 66 are all inserted into the series electrical circuit, as indicated by the diagrammatic view of FIG. 5.

Since the coils 54, 66 repel, and since the coils 45, 54 attract, the floating piston member 56 will move upwardly, being attracted to the movable piston member 16.

The coils 45, 54 are wound so that the magnetic forces attract, while the coils 54, 66 are wound to provide a repelling force. The buildup of pressure within the region 40 closes the check valve 63 in the auxiliary piston 56. When the current is transferred into the coils 45, 54, 66, the floating piston 56 is moved upwardly to overcome the holding force exerted by the latch 58 when large magnetic forces are produced. For high currents, the large magnetic forces acting upon the piston 56 will produce a corresponding large rise in pressure within the volume 40. One feature of the novel design of the circuit interrupter of FIG. 1 is that, although high gas pressures can be obtained, the load imposed upon the operating mechanism 36 is virtually unaffected except for the additional mass of the piston 56. For example, if the interrupter 1 clogs, the piston 56 will move until the magnetic forces equal the force exerted by the gas 38, when the piston 56 will stop motion. Independent of the pressure, the entire system, consisting of the piston 16, the volume 40 and piston 56, will continue to move downwardly toward the open position under the influence of the operating mechanism 36. When the current is interrupted, the piston 56 is returned to the open position by the expansion of the gas within the region 40, and also by the continued downward opening motion of the piston 16. The latch 58 holds the piston 56 in position when the breaker is closed. Check valve 63 permits cool gas from behind the interrupter to mix with warm gas drawn in through the interrupter contacts. It is anticipated that the interrupter 1 would be designed to handle half rating without the magnetic boost, thus greatly minimizing the energy requirements of the operating mechanism 36.

FIG. 6 illustrates diagrammatically a modified connection diagram for the three accelerating coils. In the modified type of circuit interrupter 82, illustrated in FIG. 6, the arcing horn 14 is electrically connected to the main contact fingers 11. The three accelerating coils are cut in by a separate switch 84, which is operated by the piston rod 17. This may be a small high-speed puffer type of interrupter, but for purposes of illustration, is shown to be a simple normally closed switch 84 to divert the fault current into the accelerating coils 45, 54 and 66 by the action of rotating cam 86 and a driving link 88. The cam 86 in rotating during the opening operation will open the switch 84. The switch 84 has one contact 84a electrically connected by a connection 90 to a sliding finger contact 91 sliding on the conductor bar surface 70. The other contact 84b is connected by a connector 92 with the terminal 69 of coil 66. As shown in FIG. 6, the line connection L_2 may be directly connected with this coil terminal 69.

The switch operation could be made sensitive to the exact instant of time at which fault-current magnitude, so that positive control of the exact instant of time at which the coils will be used, can be obtained. The switch 84 will be closed immediately after the main contacts 10, 12 reach the fully open position and the low portion 86a of the cam is reached, thus eliminating any possibility of the three accelerating coils 45, 54 and 66 cutting in on the closing stroke.

From the foregoing description of two embodiments of the present invention, it will be observed that we have provided an improved puffer-type interrupter with a floating piston 56, which is driven by magnetic forces between coils 45, 54 embedded in the piston faces. High gas pressures can be obtained without high energy outputs required of the operating mechanism 36. Interrupter contact travel is relatively unaffected. Unlike designs with only one moving piston, contact motion is not dependent upon the magnetic forces produced. Predictable interrupting performance is therefore obtained. High stresses upon the mechanical system 36 are not produced because of the magnetic forces. The number of auxiliary parts is kept to a minimum, and, since lower mechanism

forces are required, a reliable and economical design is obtained. Faster interrupting times can be obtained with the steep pressure rise produced by two pistons 16, 56 moving toward each other.

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 therein by those skilled in the art without departing from the spirit and scope of the invention.

We claim:

1. A fluid-blast circuit interrupter including contact means separable to establish an arc, fluid-driving means including a piston and an operating cylinder relatively movable with respect to each other for forcing fluid into the established arc to effect the extinction thereof, electromagnetic means for augmenting the relative motion between said piston and said operating cylinder comprising three accelerating coils one in the piston, one in the operating cylinder and a third coil in a floating piston movable within the operating cylinder, and means for transferring the series line current through said three coils in series to thereby bring about the existence of repulsive and attractive magnetic forces between the coils and thereby achieve such augmented piston action.

2. The combination according to claim 1, wherein the transferring means comprises a movable arcing horn means insulated from the contact means and movable with a movable piston, and said movable piston reciprocally operating within a relatively stationary operating cylinder.

3. The combination according to claim 1, wherein the floating piston is latched in an operative position remote from the piston.

4. The combination according to claim 1, wherein the floating piston has a unidirectional valve associated therewith.

5. The combination according to claim 1, wherein the piston is movable and reciprocally operated within a relatively stationary operating cylinder.

6. The combination according to claim 1, wherein the trans-

ferring means comprises a switch, and the operating rod for the piston actuates said switch.

7. The combination according to claim 1, wherein the piston is movable, the separable contact means comprises a movable contact, and the movable piston carries the movable contact therewith.

8. The combination according to claim 1, wherein the piston is movable and is actuated by a movable piston rod, and the transferring means comprises movable contact bars carried by the movable piston rod.

9. A fluid-blast circuit interrupter including casing means, a relatively stationary operating cylinder disposed interiorly within said casing means and having an apertured end head, a movable piston reciprocally operable within said operating cylinder, an operating rod for actuating said movable piston and extending out of said apertured end head, a separable contact means including a movable contact carried by the movable piston, arcing horn means carried by said movable piston and insulated from said movable contact, a first accelerating coil carried by said movable piston and electrically connected to said movable arcing horn means, a floating piston disposed interiorly within said operating cylinder and carrying a second accelerating coil, a third accelerating coil stationarily supported in said apertured end head, conducting means for electrically connecting the three accelerating coils in series, nozzle means carried by said movable piston for directing fluid under pressure compressed within said operating cylinder into the arc established between the separable contact means, and the transfer of the series line current to said arcing horn means and into the three accelerating coils in series bringing about the existence of repulsive and attractive magnetic forces between the coils and thus speeding up the piston movement especially during fault current interruption.

10. The combination of claim 9, wherein the conducting means comprises conducting bars extending lengthwise along the operating rod.

11. The combination of claim 9, wherein the floating piston has a unidirectional valve associated therewith.

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