Nov. 17, 1959 C. F. CROMER 2,913,559

FLUID-BLAST CIRCUIT INTERRUPTER

Filed Jan. 30, 1958 2 Sheets-Sheet 1

Fig. 1

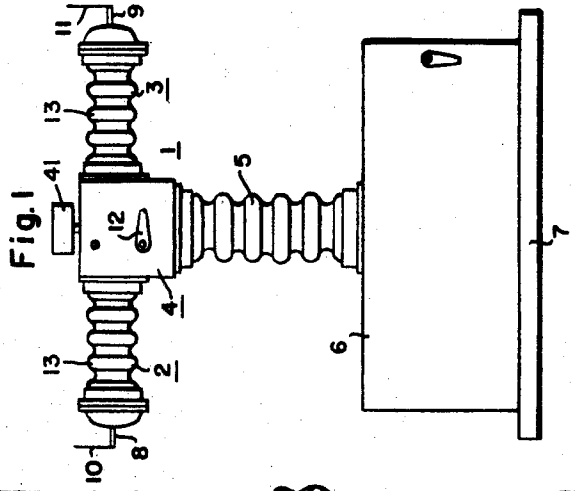
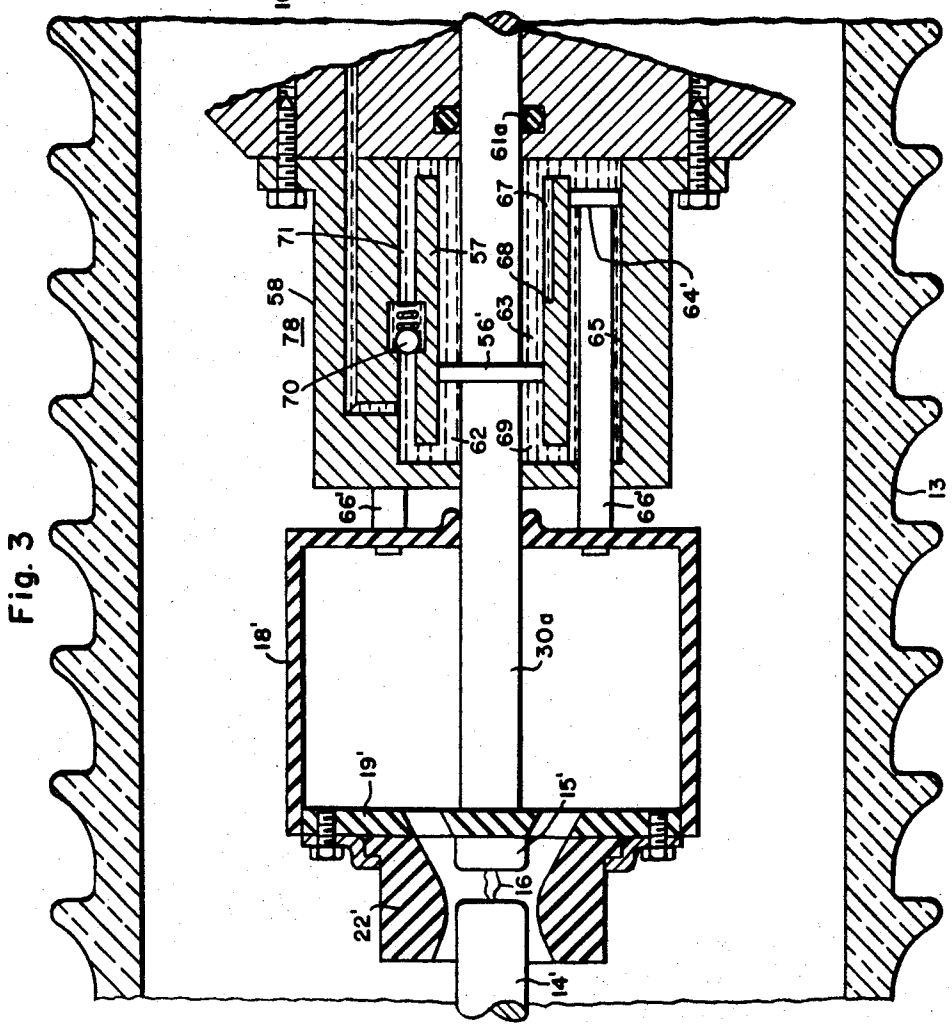


Fig. 3



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FLUID-BLAST CIRCUIT INTERRUPTER

Filed Jan. 30, 1958 2 Sheets-Sheet 2

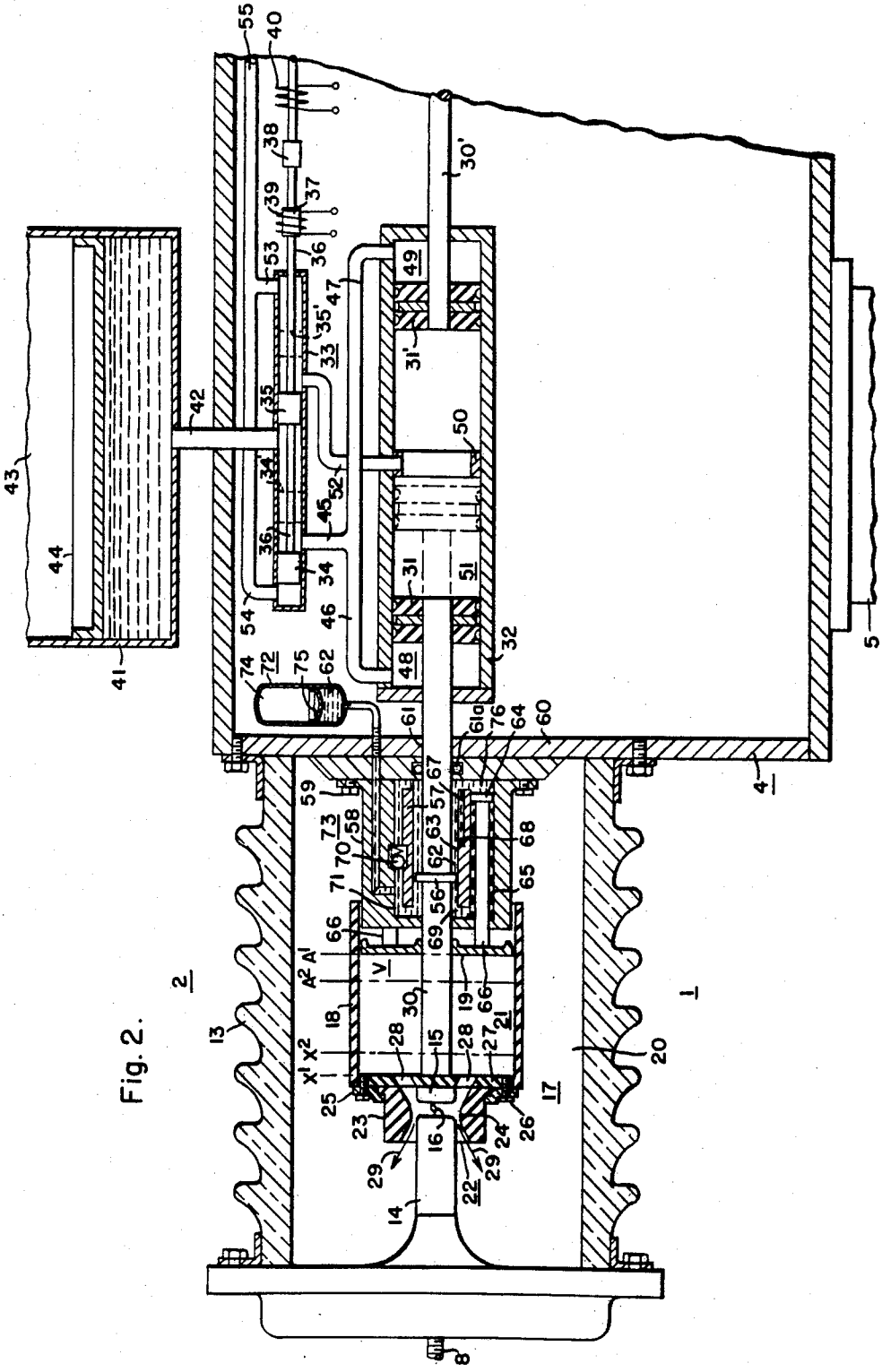

Fig. 2.

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FLUID-BLAST CIRCUIT INTERRUPTER

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Application January 30, 1958, Serial No. 712,166

10 Claims. (Cl. 200—148)

This invention relates to circuit interrupters in general, and, more particularly, to arc-extinguishing structures for circuit interrupters of the fluid-blast type.

In United States patent applications, Serial Nos. 693,309 and 693,306, entitled "Circuit Interrupters" and filed October 30, 1957, respectively by Albert P. Strom and Winthrop M. Leeds, both applications being assigned to the assignee of the instant application, there are shown and described circuit interrupters of the type which employ a blast of fluid, such as gas, for example, sulfur hexafluoride (SF_6) against the established arc to effect the extinction thereof. As illustrated and claimed in the aforesaid applications, a hydraulic operating mechanism, utilizing a hydraulic fluid, such as oil, is employed to rapidly effect contact separation and movement of a piston structure to bring about compression of the arc-extinguishing gas. This compressed gas is directed through an orifice structure movable with the movable contact and into the lengthening arc to bring about its extinction.

It is a general object of the present invention to improve, and render more effective, circuit interrupters of the fluid-blast type, such as exemplified in the foregoing applications.

Another object of the present invention is to provide an improved fluid-driving means to rapidly effect compression of an arc-extinguishing fluid and to force it into the arc stream to bring about the latter's extinction.

Another object of the invention is to provide an improved circuit interrupter of the fluid-blast type in which a movable operating cylinder is movable with the movable contact over a piston, to effect compression of fluid therein, and, simultaneously, movement of the piston in the opposite direction is achieved to very quickly bring about compression of the fluid suitable for arc extinction.

Another object of the invention is to provide an improved fluid-driving means, which will cause an operating cylinder and a piston disposed therein to move in opposite directions during the opening operation of the interrupter, to thereby very rapidly effect compression of the fluid disposed within the operating cylinder, and to provide orifice means employed in conjunction therewith to direct the compressed fluid into the established arc to effect the extinction thereof.

Still a further object of the invention is to provide an improved fluid-compression means employed in a fluid-blast circuit interrupter, in which the length of the established arc is maintained at a minimum length and, in addition, the mass of the movable operating cylinder is maintained at a minimum and the volume thereof is also maintained at a minimum size.

A further object of the present invention is to provide an improved fluid-compressing means in a circuit interrupter of the type in which an operating cylinder moves with the movable contact, in which a substantially enclosed hydraulic system is associated with the operating cylinder, so that during the opening operation, an interiorly disposed piston is operated by the substantially

enclosed hydraulic system to very rapidly effect compression of the fluid for arc-extinguishing purposes.

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 fluid-blast circuit interrupter embodying the principles of the present invention, and the contact structure being illustrated in the closed-circuit position;

Fig. 2 is a considerably enlarged, vertical sectional view through one of the arc-extinguishing units of the interrupter of Fig. 1, with a portion of the operating mechanism broken away to illustrate the operation thereof, the contact structure being illustrated in the partially open-circuit position; and

Fig. 3 illustrates a modified fluid-driving means in which a piston carrying the orifice and movable contact moves interiorly of an initially relatively stationary operating cylinder.

Referring to the drawings, and more particularly to Fig. 1 thereof, the reference numeral **1** generally designates a circuit interrupter of the fluid-blast type. Briefly, the circuit interrupter **1** includes a pair of serially related arc-extinguishing units **2**, **3** extending horizontally laterally away from an intermediately disposed mechanism housing **4**. The mechanism housing **4** is positioned at the upper end of an insulator column **5**, the latter being supported upon a lower mechanism compartment **6**. The mechanism compartment **6**, in turn, is fixedly positioned in place upon a concrete base **7**. Line terminal connections **8**, **9** serve to connect the circuit interrupter **1** to transmission lines **10**, **11**. As will be obvious, the electrical circuit passing through the interrupter **1** extends through the two arc-extinguishing units **2**, **3** in series.

Positioned externally of the mechanism housing **4** is an indicator pointer **12**, which indicates the open and closed-circuit positions of the interrupter **1**. Preferably, the indicator pointer **12** is of the type set out in Leeds application Serial No. 693,306. As shown in Fig. 1, the interrupter **1** is indicated as being in the closed-circuit position.

Referring more particularly to Fig. 2 of the drawings, which illustrates a cross-sectional view through the left-hand arc-extinguishing unit **2**, it will be observed that disposed interiorly within a weatherproof casing **13**, preferably formed of porcelain, is a relatively stationary contact **14** cooperable with a movable contact **15**. The relatively movable contacts **14**, **15** are separable, during the opening operation, to establish an arc **16** therebetween.

To effect the extinction of the established arc **16**, a fluid-driving means, generally designated by the reference numeral **17**, and including a movable operating cylinder **18** and an interiorly disposed movable annular piston **19** are provided. Preferably, the construction is such, during the opening operation of the interrupter **1**, that the movable operating cylinder **18** and the ring-shaped interiorly disposed piston **19** move in opposite directions, to thereby very rapidly effect the compression of fluid **20** within the space **21** interiorly of the operating cylinder **18**. This fluid **20** may be either a gas or a liquid, but for purposes of illustration, it is assumed to be a heavy gas, such as sulfur hexafluoride (SF_6) or selenium hexafluoride (SeF_6) or admixtures of one or both of the aforesaid gases with argon, helium, carbon dioxide, nitrogen, or air. The reason for using one of these heavy gases is that their arc-extinguishing performance is remarkable, and, in addition, they have very good dielectric strength to hold the voltage in the open-circuit position of the interrupter.

Associated with the movable operating cylinder **18** is an orifice structure, generally designated by the reference

numeral 22, and including a ring-shaped orifice member 23 having an orifice 24 therein. As shown in Fig. 2, the established arc 16 is preferably established within the orifice 24 of orifice member 23. As shown, the ring-shaped orifice member 23 is fixedly secured to, and movable with, the operating cylinder 18, being attached thereto by a flanged ring 25, the latter being secured by bolts 26 to the head 27 of the operating cylinder 18. The head 27 of operating cylinder 18 contains a plurality of apertures 28 to permit a flow of gas 20, in a compressed state, from the region 21 through the apertures 28, and through the orifice 24 of orifice member 23 to effect extinction of the established arc 16. The arrows 29 indicate the direction of gas flow.

For effecting the movement of the operating cylinder 18 over the piston 19, there is provided a piston rod 30. As shown, the right-hand end of the piston rod 30 has a piston 31 secured thereto and operable within an operating cylinder 32. To effect the movement of the piston 31 within operating cylinder 32, there is provided a spool-type control valve, generally designated by the reference numeral 33, and including a pair of valve spools 34, 35 interconnected by a valve rod 36. The right-hand end of the valve rod 36 has a pair of spaced armatures 37, 38 secured thereto, which are attracted by solenoid coils 39, 40, when the latter are energized. The particular circuits for effecting the energization of the opening solenoid 39 and the closing solenoid 40 are not illustrated, as they may be of any suitable type and form no part of the present invention.

A hydraulic accumulator, designated by the reference numeral 41, is disposed above the mechanism housing 4 and has a hydraulic conduit 42 leading into the spool control valve 33. Preferably, the hydraulic fluid is oil, which is under a high pressure, such as 2,000 p.s.i. Compressed nitrogen gas is disposed within the upper region 43 of the accumulator 41, a movable diaphragm piston 44 maintaining the separation between the compressed nitrogen gas and the hydraulic oil under high pressure. Any suitable means may be employed to feed additional hydraulic fluid under pressure into the accumulator 41, such as set out in either of the aforesaid patent applications to Winthrop M. Leeds or Albert P. Strom. Replenishing means has been omitted from the drawing for clarity.

As noted above, two arc-extinguishing units 2, 3, are serially related and associated with the circuit interrupter 1. An actuating piston 31' is fixedly secured to the left-hand end of the piston rod 30', which actuates the movable contact for the right-hand arc-extinguishing unit 3, not shown. As will be obvious, however, both arc-extinguishing units 2, 3 are arranged to open and to close simultaneously, both units 2, 3 being controlled by the same control spool valve 33. Since the right-hand arc-extinguishing unit 3 is a duplicate of the left-hand arc-extinguishing unit 2, its omission in Fig. 2 was deemed desirable for simplicity.

To effect the opening of the movable contact 15 away from the relatively stationary contact 14, the opening solenoid 39 is energized by any suitable means, not shown. This will attract the armature 37 secured to the valve rod 36 to the position shown in Fig. 2, where the hydraulic inlet 42 is connected to a conduit 45. The conduit 45 branches into two conduits 46, 47, both leading to the extremities of the operating cylinder 32. Since high pressure now exists in the regions 48, 49 in front of both pistons 31, 31', both pistons will move toward each other into engagement with a ring-shaped flexible stop 50 to the completely open-circuit position. During this time, it will be observed that the region 51 between both pistons 31, 31' is connected, by means of a conduit 52, to a low-pressure exhaust conduit 53. Consequently, the movable contact 15, orifice structure 22 and operating cylinder 18 will quickly move to the fully open-circuit position.

When it is desired to effect the closing of the interrupter 1, the closing solenoid 40 will be energized by suitable means, not disclosed. As well known by those skilled in the art, the energization of the closing solenoid 40 will be simultaneously accomplished by the deenergization of opening solenoid 39, so that no conflict arises. Thus, the energization of closing solenoid 40 will attract armature 38, and effect the rightward movement of control valve rod 36 so that spool valves 34, 35 will reach the dotted line positions 34', 35'. It will be apparent that in this position of spool valves 34, 35 in positions 34', 35' that high-pressure conduit 42 from accumulator 41 will interconnect with conduit 52, which leads into the region 51 between both pistons 31, 31'.

The increase of pressure within the region 51 between both pistons 31, 31' will effect their separating movement in opposite directions away from each other. During this time, it will be noted that the regions 48, 49 in front of the pistons 31, 31', respectively, interconnect through conduits 46, 47 and 45 with the low-pressure conduit 54. As shown in Fig. 2, low-pressure conduit 54 is connected with low-pressure conduit 53 and leads through the header conduit 55 to a suitable sump at low pressure, not shown.

It will be obvious that during the opening operation, the operating cylinder 18 is connected with the movable contact 15 and moves to the right, as viewed in Fig. 2, to effect compression of gas within the space 21. As mentioned, this compressed gas, in space 21, is ejected through the spider openings 28 in cylinder head 27, and through orifice 24 to effect extinction of arc 16. It is an important feature of the invention that, simultaneously with rightward movement of operating cylinder 18, during the opening operation, that leftward movement of annular piston 19 also simultaneously takes place. The consequence of both these movements of operating cylinder 18 and annular piston 19 is a very quick compression of the gas 20 within region 21, thereby very quickly creating a considerable pressure differential across the orifice 24.

It will be observed that movable with the piston rod 30 is a hydraulic piston 56, movable within a stationary operating cylinder 57, the latter being integrally formed with a casting 58 secured by bolts 59 to a side plate 60 forming a portion of the mechanism housing 4. The side plate 60 has an opening 61, through which the piston rod 30 extends with a close fit, having a liquid-tight seal 61a associated therewith.

Thus, the movement of the hydraulic piston 56, during the opening operation acts to compress the hydraulic liquid 62 within the space 63, and forces this hydraulic liquid 62 to act upon a plurality of actuating pistons 64, one of which is shown, to effect leftward movement of such actuating pistons 64 within operating cylinders 65. The actuating pistons 64 are connected, through piston rods 66, to the annular piston 19 of the fluid-driving means 17. When the hydraulic piston 56 reaches enlarged spaces 67, the hydraulic liquid 62 behind the hydraulic piston 56 will move around the piston 56, through the spaces 67, to the front side of the hydraulic piston 56; consequently, further driving movement of the actuating pistons 64 ceases. This enables the head 27 of operating cylinder 18 to pick up the annnular piston 19, and to return the latter to its closed position, shown in full lines in Fig. 2, thus increasing the isolating gap distance between the separated contacts 14, 15 in the fully open circuit position of the interrupter.

During the closing operation, the piston rod 30 moves to the left, as effected by piston 31, and hydraulic piston 56 moves therewith. This movement of hydraulic piston 56, carried by piston rod 30, has no driving effect upon the hydraulic liquid 62 during the time that the hydraulic piston 56 is moving through the enlarged spaces 67. During this time, of course, hydraulic liquid 62 merely moves from the front, outer surface of hydraulic piston 56 through the spaces 67 to the rear face of the hydraulic

piston 56, so no actuation of parts is caused thereby. However, when hydraulic piston 56 arrives at the point 68 at the extremity of the enlarged spaces 67, further closing movement of piston rod 30 and hydraulic piston 56 effects a compression of hydraulic liquid 62 within space 69. This pressure within space 69 soon rises sufficiently to open one or more ball check-valves 70, only one being shown, to permit the return of hydraulic liquid 62 through return passages 71 to the space 63 in back of hydraulic piston 56. Thus, during the entire closing operation, the annular piston 19 remains substantially stationary in its retrieved position shown in Fig. 2.

To cushion the shock of the hydraulic liquid 62 during opening and closing operations, it is preferable to provide an auxiliary accumulator, generally designated by the reference numeral 72, and associated with the closed hydraulic system 73 associated with annular piston 19. The auxiliary accumulator 72 is of conventional structure including compressed nitrogen gas, within a space 74 at the upper end of auxiliary accumulator 72, a flexible diaphragm 75 being employed to separate the compressed nitrogen gas from the hydraulic liquid 62 therein.

Fig. 3 illustrates a modified fluid-driving means, generally designated by the reference numeral 78, in which there is a reversal of parts, as compared to the piston construction of Fig. 2. In Fig. 3, the piston 19′ carries an orifice structure 22′ and is fixedly secured to the movable contact 15′. The piston 19′ is actuated by a piston rod 30*a* having a hydraulic piston 56′.

The piston 19′ moves interiorly of a movable operating cylinder 18′, the latter being actuated by operating rods 66′, which, in turn, are fixedly secured to actuating pistons 64′. The method of operation of the modified fluid-driving means 78 is identical to the previous construction illustrated in Fig. 2, there being involved merely a reversal of parts, that is, the annular piston 19 of Fig. 2 takes the place of the operating cylinder in the construction of Fig. 3. The operating cylinder 18 of Fig. 2, employed in the construction of Fig. 3, is actuated by the piston rods 66′ in the same manner as was previously described in connection with Fig. 2. For certain applications it may be desirable to utilize such a reversal of fluid-driving parts.

It will be noted that since the operating cylinder 18′ of Fig. 3 is not retracted to the right in the fully open-circuit position of the interrupter, as was the case in Fig. 2, it is therefore, desirable in connection with maintaining an adequate gap distance in the fully open-circuit position, to have the operating cylinder 18′ and the piston 19′ composed of insulating material. For certain applications, however, the use of such insulating material may not be required, and the piston 19′ and the operating cylinder 18′ could, in such applications, be formed of metallic material.

From the foregoing description, it will be apparent that there is provided an improved puffer-type interrupter 1. Generally, puffer-type interrupters employ either a movable piston and a stationary cylinder, or a movable cylinder and a stationary piston, as a means of compressing a gas confined in the cylinder. The present invention concerns such a puffer-type circuit interrupter in which a movable cylinder 18 is withdrawn by a rod 30 over a fixed piston 19. The gas compressed within volume 21 is expelled through the ports 28, and thence through the orifice 24 performing its interrupting function.

It has been found that for a fixed current to be interrupted, a particular pressure differential must exist across the orifice 24 before interruption can be accomplished. This pressure differential is then, in the puffer-type device, dependent upon the decrease in volume V. The more rapidly volume V is decreased, the shorter will be the arcing time reducing the total interrupting time accordingly.

In accordance with the present invention, an extremely high rate of compression of gas within space 21 can be accomplished. During the opening stroke, assume that the operating cylinder 18 is withdrawn by the piston rod 30 from position X^1 to some intermediate position X^2. A volume of oil 62 is displaced by hydraulic piston 56. This volume of oil is forced into a plurality of chambers 76, forcing pistons 64 outwardly. The pistons 64 being attached to the annular piston 19, in turn, drive the large piston 19 from an initially retracted position A^1 to some other position A^2, toward the face of the retracting cylinder 18, thus providing an additional compression of the gas in the space 21. The displacement of the piston 19 from position A^1 to position A^2 can be made equal to, less than, or more than the displacement of the operating cylinder 18 from X^1 to X^2 by varying the relative or effective areas of pistons 56 and 64.

As the operating cylinder 18 is further withdrawn in the opening direction, it continues to drive the piston 19 toward the face of the cylinder 18 until the hydraulic piston 56 enters the region of openings 67. Thereafter, the oil is merely circulated through the openings 67 around the two faces of the hydraulic piston 56; and the annular piston 19 is retrieved to its initial position (shown in full lines) by the operating cylinder 18.

During the closing stroke, the oil is circulated from the front face of the hydraulic piston 56 through the openings 67 to the other face of the piston 56. Upon reaching the limit of the openings 67, as at point 68, the oil 62 within space 69 is raised to a sufficient pressure to open the check valves 70, which permits oil passage through the return system 71 to the chamber 76.

From the foregoing, it is apparent that the invention provides for a relatively large initial volume of gas, and a higher pressure is generated in a shorter time interval at a shorter gap between the interrupting contacts 14—15 than in conventional type interrupters. In addition, the invention provides for a long isolating gap distance in the open-circuit position of the interrupter.

In addition to other advantages possessed by the invention, there are two particular points of advantage:

(1) Restriction of the arc column to a minimum length.

(2) Reduction in size, in accelerated mass, and in the reaction force on the mechanism.

Generally, in puffer-type gas interrupters, arc energy serves no useful mechanical purpose; consequently, it is advantageous to hold the length of the arc column to a minimum. This result is provided for in the double-acting compressor arrangement described in the present invention, inasmuch as the contacts will only have parted a relatively small distance before the attaining of sufficient pressure differential across the orifice 24 for efficient arc extinction.

The same short arc length could be obtained with the same pressure differential and with the same initial volume with prior art structures, in which the piston is fixed at all times and with only the operating cylinder movable. However, this requires a considerably larger diameter operating cylinder which, in turn, requires a larger housing for the assembly. In addition, the additional size of such an operating cylinder would increase the total mass to be accelerated by the mechanism, besides the additional reaction force against the mechanism caused by the internal pressure acting on a larger cylinder-head area.

It is, therefore, apparent that in the present invention the pressure differential across the orifice 24 is quickly attained, while the length of the established arc is kept at a minimum. Moreover, the mass of the parts is kept to a minimum, so that the mechanism may be of relatively light construction.

Although there have been shown 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.

I claim as my invention:

1. A circuit interrupter of the fluid-blast type including means for establishing an arc, fluid-driving means including an operating cylinder having a cylinder head and a piston movable therein, means for moving the operating cylinder over the piston to compress fluid therein, means utilizing said compressed fluid to assist in extinction of said arc, and means operable to move said piston during the opening operation of the interrupter toward the cylinder head to augment the compression of the fluid.

2. The combination in a fluid-blast circuit interrupter of means for establishing an arc, a movable operating cylinder and a movable piston positioned therein, means for causing the simultaneous movement of said operating cylinder and said piston in opposite directions to effect thereby a very rapid compression of fluid within said cylinder, and means utilizing the compressed fluid to effect extinction of said arc.

3. A circuit interrupter of the fluid-blast type including a movable contact separable from a relatively stationary contact to establish an arc, an operating cylinder having a head movable with said movable contact, an orifice structure carried by the head of said operating cylinder, a movable piston located within said movable operating cylinder, means for simultaneously moving said operating cylinder and said movable piston in opposite directions to rapidly effect compression of fluid within said operating cylinder, and the compressed fluid passing through the orifice structure to effect extinction of said arc.

4. A circuit interrupter of the fluid-blast type including a movable contact separable from a relatively stationary contact to establish an arc, an operating cylinder having a head movable with said movable contact, an orifice structure carried by the head of said operating cylinder, a movable piston located within said movable operating cylinder, an operating rod secured to said operating cylinder and having a hydraulic piston secured thereto, hydraulic means actuated by movement of said hydraulic piston for effecting movement of said movable piston toward the operating cylinder head to augment the compression of fluid within the operating cylinder, and the compressed fluid passing through the orifice structure to effect extinction of said arc.

5. The combination in a fluid-blast circuit interrupter of means for establishing an arc, fluid compression means including a movable operating cylinder and a movable piston movable therein, a substantially closed hydraulic system for actuating said movable piston, means responsive to movement of said operating cylinder to move hydraulic liquid within said substantially closed hydraulic system to effect movement of said movable piston, said piston and operating cylinder moving in opposite directions to compress fluid within said operating cylinder, and means utilizing said compressed fluid to effect extinction of said arc.

6. The combination in a fluid-blast circuit interrupter of means for establishing an arc, fluid compression means including a movable operating cylinder and a movable piston movable therein, a substantially closed hydraulic system for actuating said movable piston, means responsive to movement of said operating cylinder to move hydraulic liquid within said substantially closed hydraulic system to effect movement of said movable piston, said piston and operating cylinder moving in opposite directions to compress fluid within said operating cylinder, means utilizing said compressed fluid to effect extinction of said arc, and means operable near the end of the opening operation to render ineffective said responsive means to permit thereby independent travel of said operating cylinder to pick up the piston so that both may move together to the fully open isolated open circuit position.

7. A circuit interrupter of the fluid-blast type including a movable contact separable from a relatively stationary contact to establish an arc, a piston and an orifice structure movable with said movable contact, a movable operating cylinder, said piston being movable within said movable operating cylinder, means for causing simultaneous movement of both said movable piston and said movable operating cylinder in opposite directions during the opening operation to effect thereby very fast compression of fluid within said operating cylinder, and the compressed fluid within said movable operating cylinder being ejected out of said orifice structure into engagement with said arc.

8. A circuit interrupter of the fluid-blast type including a movable contact separable from a relatively stationary contact to establish an arc, a piston and an orifice structure movable with said movable contact, a movable operating cylinder, said piston being movable within said movable operating cylinder, means including a substantially closed hydraulic system for causing simultaneous movement of both said movable piston and said movable operating cylinder in opposite directions during the opening operation to effect thereby very fast compression of fluid within said operating cylinder, and the compressed fluid within said movable operating cylinder being ejected out of said orifice structure into engagement with said arc.

9. A circuit interrupter of the fluid-blast type including a movable contact separable from a relatively stationary contact to establish an arc, a piston and an orifice structure movable with said movable contact, a movable operating cylinder, said piston being movable within said movable operating cylinder, a piston rod for actuating said movable contact and piston and having a hydraulic piston secured thereto, a substantially closed hydraulic system, said hydraulic piston effecting movement of hydraulic fluid within said substantially closed hydraulic system, piston means responsive to the movement of hydraulic fluid within said hydraulic system to effect movement of said movable operating cylinder in the direction of said relatively stationary contact to effect thereby very fast compression of fluid within said operating cylinder, and the compressed fluid within said movable operating cylinder being ejected out of said orifice structure into engagement with said arc.

10. A circuit interrupter of the fluid-blast type including a pair of contacts separable to establish an arc, fluid-blast means including a movable operating cylinder part and a movable piston part movable therein, a movable orifice structure carried by one of said movable parts, means for simultaneously moving said movable operating cylinder part and said movable piston part in opposite directions to effect thereby very rapid compression of fluid within said movable operating cylinder part, and the compressed fluid being exhausted out of said movable operating cylinder part through said movable orifice structure to effect extinction of said arc.

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