

Jan. 22, 1963

A. P. STROM
CIRCUIT INTERRUPTERS

3,075,060

Filed Oct. 30, 1957

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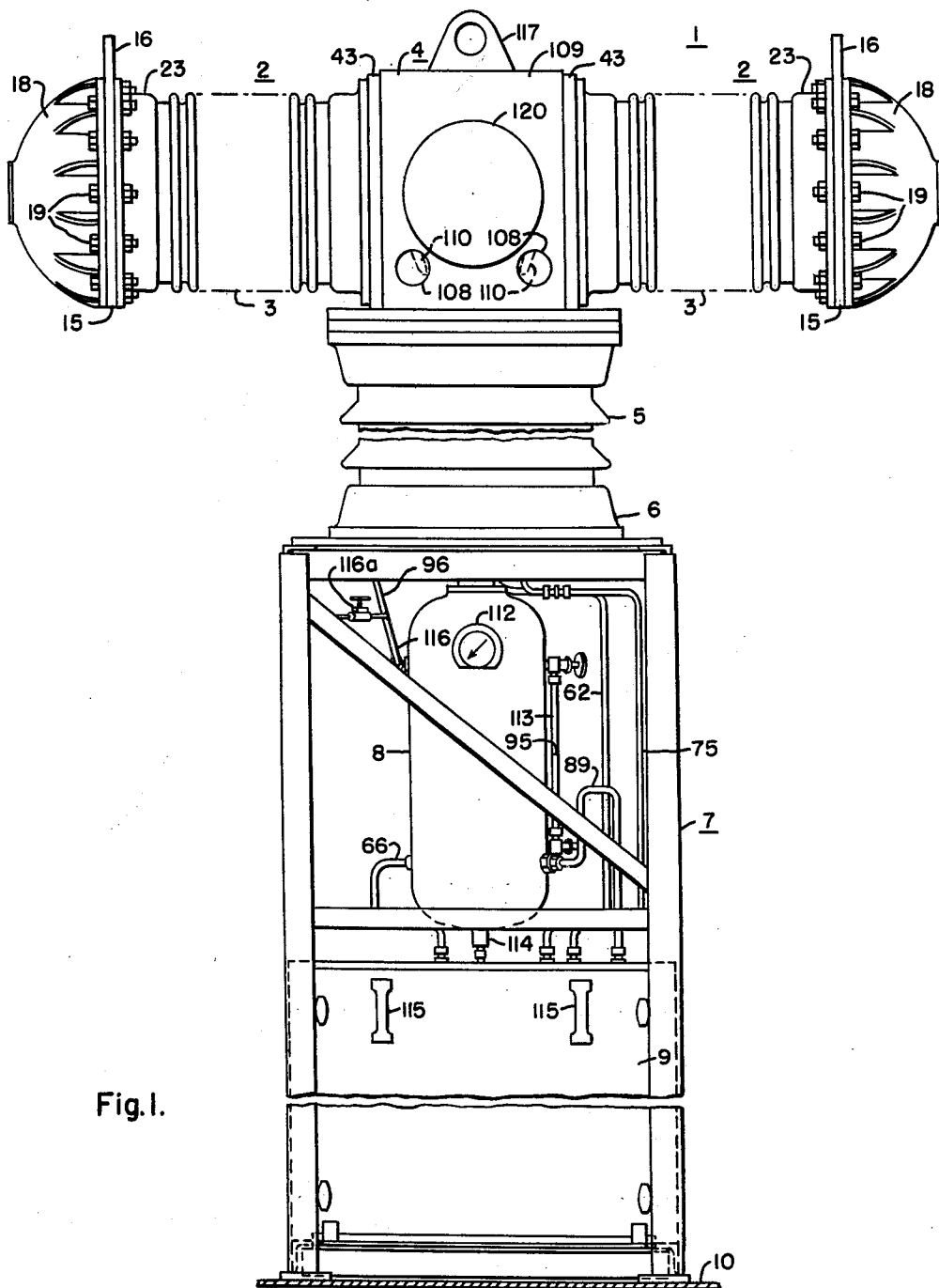


Fig. 1.

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Fig. 2.

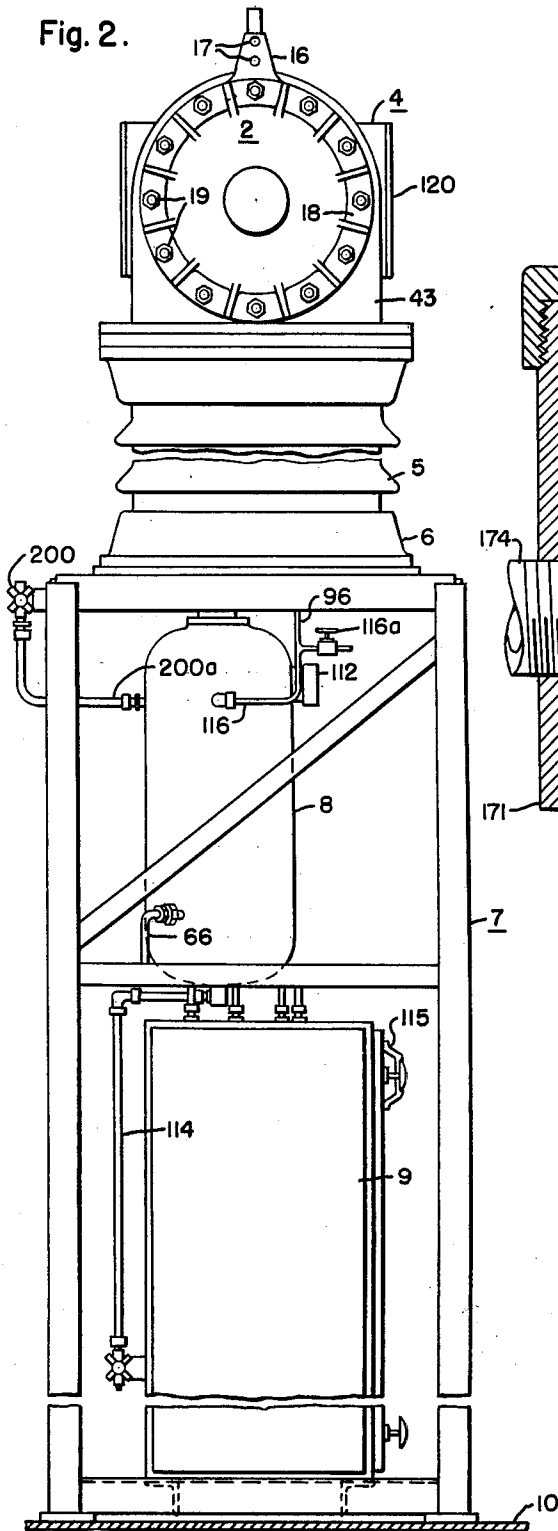
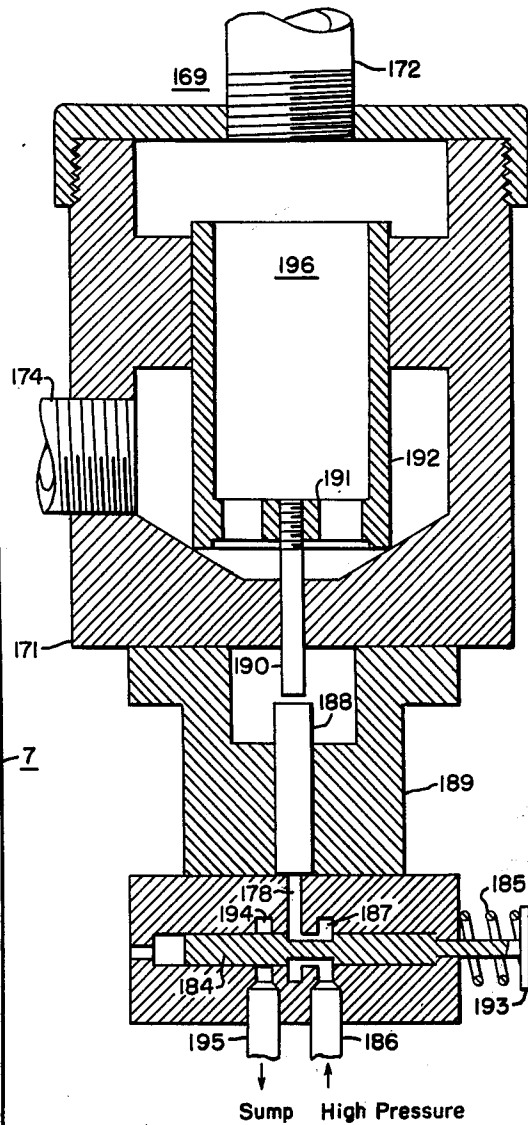


Fig. 6.



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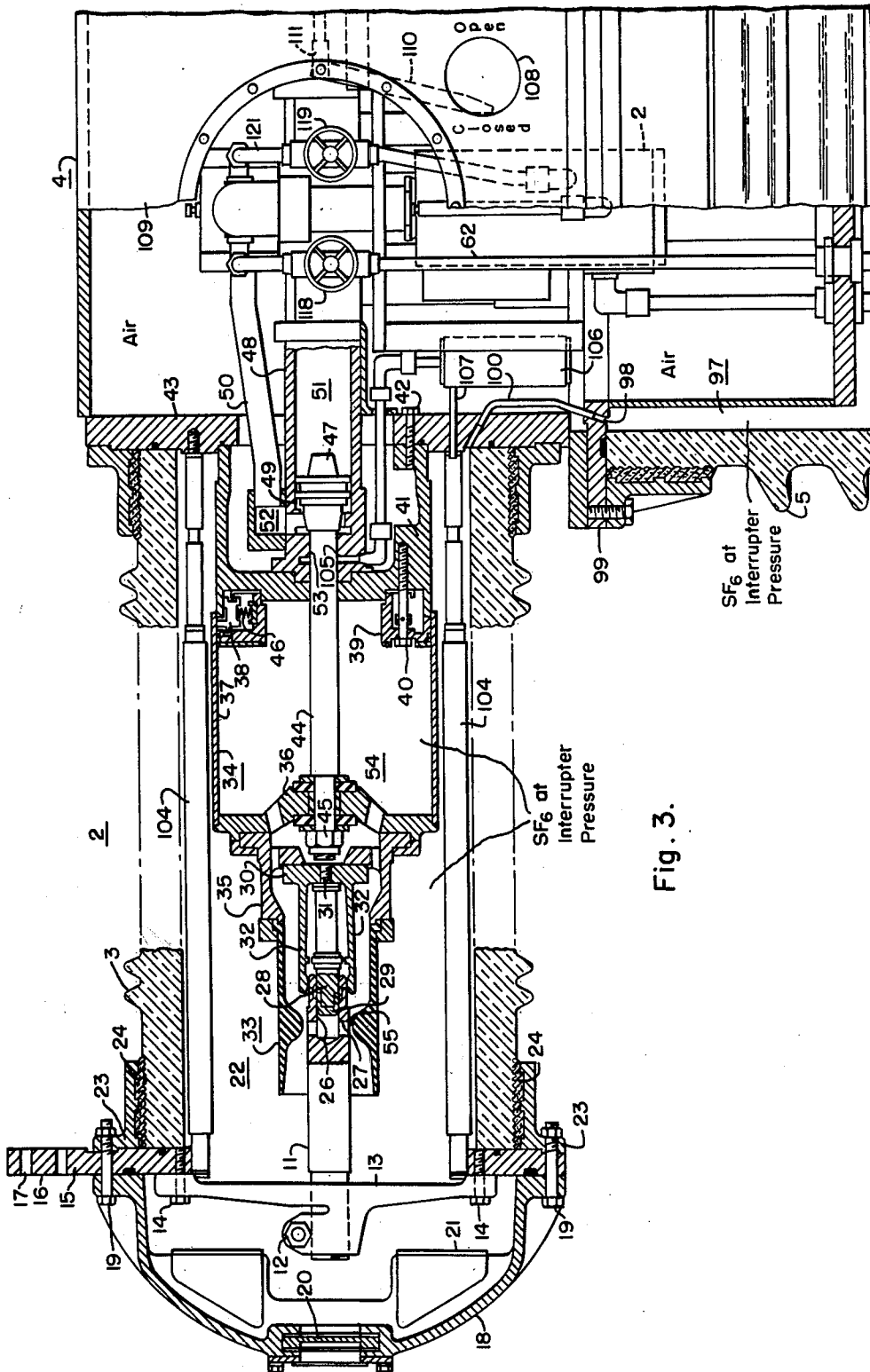
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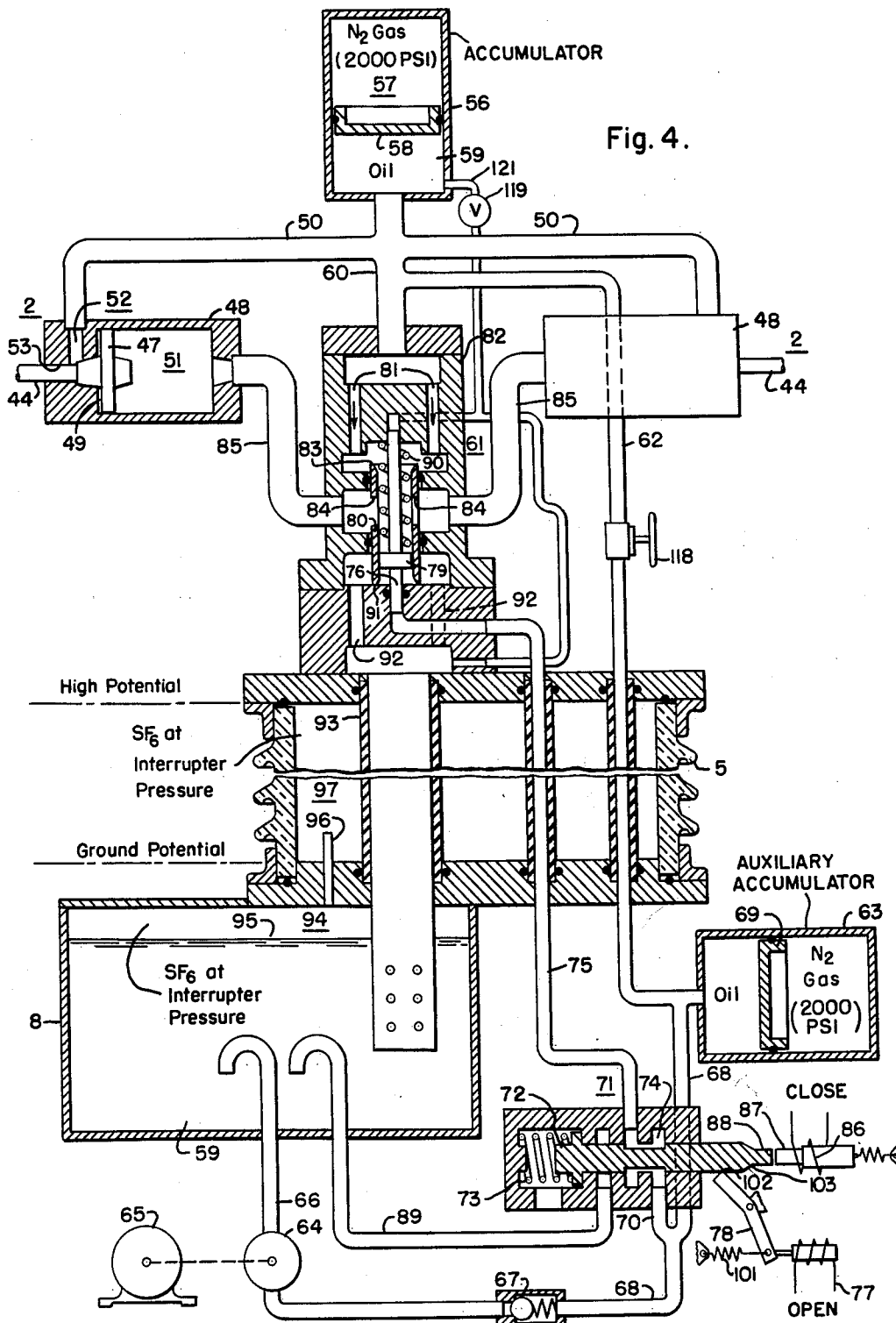
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3,075,060

CIRCUIT INTERRUPTERS

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15 Claims. (Cl. 200-143)

This invention relates to circuit interrupters in general and, more particularly, to circuit interrupters utilizing a hydraulic operating mechanism.

A general object of the present invention is to provide an improved circuit interrupter, which will more effectively and rapidly interrupt the circuit therethrough, than has been achieved heretofore.

Another object of the present invention is to provide an improved hydraulic operating mechanism for a circuit interrupter, which will function efficiently and rapidly to bring about quick separation of the contact structure. In this connection, the invention has particular advantage, when puffer-type interrupters are employed, which create considerable variable back-pressure forces.

Another object of the invention is to provide an improved gas-blast circuit interrupter employing a hydraulic operating mechanism to forcibly effect contact separation and piston movement, regardless of the back-pressure forces, which may be created during the interrupting operation by the arc-heated gases.

Yet a further object of the present invention is to provide a circuit interrupter particularly adaptable for high-voltage application, in which the accumulator for the hydraulic operating mechanism may be disposed at high potential, and preferably immediately adjacent to the operating cylinders, the latter in conjunction with pistons effecting contact separating movement.

A further object of the invention is to provide an improved gas-blast circuit interrupter utilizing an effective arc-extinguishing gas, such as sulfur hexafluoride SF_6 , or selenium hexafluoride SeF_6 , which gases have a high-dielectric strength, in which the arc-extinguishing gas is fed from ground potential up through a hollow, upstanding, insulating pedestal, the latter being employed to vertically support the arc-extinguishing assembly for the circuit interrupter.

In gas-blast circuit interrupters, particularly those employing "puffer-type" interrupters, it is very desirable to have a powerful mechanism, that can start to open the breaker without delay, when a short circuit occurs, and has sufficient power to carry the mechanism through the opening stroke at essentially constant velocity, even though high-stopping forces are generated by the rapidly expanding gases in the arc. The present invention is particularly concerned with a hydraulic type of mechanism, which can be used in a sulfur hexafluoride SF_6 breaker, or breakers employing other gases, to obtain breaker operation with minimum delay and essentially constant velocity.

An important feature of the present invention is the mounting of the hydraulic cylinders, accumulator and valves at high potential, adjacent to the interrupting chambers themselves, so that the operating cylinders can thus be connected directly to the breaker contacts, or the puffer piston (if such is used), and operated through the pipe connections from the accumulator so as to give maximum speed of operation.

Another important feature of the present invention is the utilization of a high-pressure pump at ground potential, with a hydraulic connection by means of a small-bore insulating tube extending upwardly through the hollow supporting porcelain insulator from the pump to the accumulator at high potential. The hydraulic fluid such as oil may then be discharged from the operating cylinders,

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and carried down, by means of a relatively large-bore insulating tube at low pressure, to the pump sump. As a result, operation of the breaker contacts and "puffer" pistons (when they are used) may be achieved from ground potential by means of an insulating rod actuated from the ground end by a solenoid spring, or other means, such as a hydraulic fluid forced through a pilot duct may be used. In the latter case a high-pressure hydraulic control pipe of insulating material extends down to a pilot valve at ground potential from an elevated master valve, and is employed to effect the operation of the master control valve at high potential adjacent the accumulator and operating cylinders.

Yet a further object of the invention is to provide an improved impedance shunting contact assembly, having separable contacts for high-power circuit interruption, which shunting impedance assembly may be hydraulically actuated in a similar manner to the actuation of the main movable contact assembly.

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

FIGURE 1 is a fragmentary, side elevational view of a hydraulically actuated compressed-gas circuit interrupter, with a portion broken away to reduce the vertical height, and embodying the principles of the present invention, with the contact structure being indicated in the closed-circuit position;

FIG. 2 is a fragmentary, end elevational view of the complete circuit interrupter assembly of FIG. 1;

FIG. 3 is a considerably enlarged, vertical sectional view taken through the left-hand arc-extinguishing unit of the circuit interrupter of FIG. 1, showing the hydraulic actuating mechanism therefor, and the contact structure being illustrated in the closed-circuit position;

FIG. 4 is a diagrammatic view, considerably simplified, of the general hydraulic operating mechanism illustrated in FIGS. 1-3, with the contact structure being shown fragmentarily in the closed-circuit position;

FIG. 5 is a fragmentary, vertical sectional view taken through a modified type of circuit interrupter employing a shunting impedance assembly having movable contact structure, with the modified type of circuit interrupter being illustrated in the closed-circuit position; and

FIG. 6 is a considerably enlarged view, in vertical section, of one of the valve assemblies utilized in the modified type of circuit interrupter of FIG. 5.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral 1 generally designates a circuit interrupter assembly particularly suitable for high-voltage and high-current applications. Although for purposes of illustration the present invention will be described as applied to a high-voltage, high-power circuit interrupter, such as one suitable for interrupting 10,000,000 kva. at 138 kv., it is to be understood that certain features of the invention are suitable for use on circuit interrupters of lower voltage and current rating, or, indeed, for circuit interrupters of considerably higher rating.

The 138 kv. circuit interrupter illustrated in FIG. 1 includes a pair of laterally projecting, arc-extinguishing structures 2, enclosed within porcelain, weatherproof, hollow casings 3 and secured to the opposite sides of a mechanism compartment or housing 4. The mechanism housing 4 may consist of heavy, high-strength, steel plates welded together and forming a rugged support for carrying the laterally jutting arc-extinguishing structures 2, as well as supporting internally thereof suitable hydraulic operating cylinders and an accumulator, more particularly described hereinafter.

The mechanism housing 4 is supported at the upper end of an upstanding insulating pedestal 5, which, in this

particular instance, may be formed of porcelain. The upstanding pedestal 5 is shown broken in FIGS. 1 and 2, but in practice may extend a considerable distance upwardly depending upon the voltage encountered.

The lower end 6 of the insulating pedestal 5 is supported, in turn, upon an angle-iron framework, generally designated by the reference numeral 7 and serving to support a reservoir or sump 8 and a lower control compartment 9. The framework 7 itself may rest upon a suitable base 10, say formed from structural concrete.

With particular reference to FIG. 3, it will be noted that the arc-extinguishing structure 2 includes a relatively stationary, rod-shaped contact 11, which may be threadedly secured and clamped, as at 12, to a spider-shaped conducting support 13. The spider support 13 may be secured, as by mounting bolts 14, to a ring-shaped terminal plate 15 having a terminal pad 16. The terminal pad 16 may have apertures 17 therethrough to accommodate bolts for making a fixed connection to a high-voltage transmission line, not shown.

Extending over the spider support 13 is an end cap 18. The end enclosing cap 18 may be secured by a plurality of bolts 19 to the ring-shaped terminal plate 15. The end cap 18 may carry a rupture disc 20 (FIG. 3) adaptable to break, upon the occurrence of excessive pressure, and a basket 21 containing a material, such as activated alumina, to absorb products of decomposition from the arced gas.

It is to be noted that there is provided within the region 22 within porcelain casing 3 a suitable arc-extinguishing, and high-dielectric strength gas, such as sulfur hexafluoride SF_6 at a pressure, say of 60 p.s.i. Although SF_6 is mentioned, by way of example, it will be obvious from the following description that other gases, or even compressed air may be employed to advantage.

As shown in FIG. 3, the hollow porcelain casing 3 has a ring-shaped flange 23 secured thereto, as by cement 24, and the ring-shaped mounting flange 23 may be secured, as by bolts 19, to the terminal plate 15.

It will be observed that the contacting end of rod-shaped stationary contact 11 is bored out, as at 26, with side apertures, as at 27, to accommodate the entrance of a movable rod contact 28, the latter having an arc-resisting tip 29 composed of any suitable arc-resisting material, such as a tungsten-silver alloy.

The movable contact 28 is secured to a finger support 30, as by a threaded connection 31. The finger support 30 has a plurality of spaced fingers 32, which engage the external surface of the stationary contact 11, as shown in FIG. 3, in the closed-circuit position of the interrupter.

Surrounding the contacts 11, 28 is an insulating orifice structure, generally designated by the reference numeral 33, and, in this particular instance, being composed of polytetrafluoroethylene. This material has been found especially suitable for resisting the action of arced sulfur hexafluoride gas, as set out more in detail in U.S. Patent 2,757,261, issued July 31, 1956, to Harry J. Lingal, Thomas E. Browne, Jr. and Albert P. Strom and assigned to the assignee of the instant application.

Clamping the orifice structure 33 to a movable puffer cylinder, generally designated by the reference numeral 34, is a support 35, the latter being secured to a cylinder end 36 by any suitable means, not shown. The puffer cylinder 34 includes the cylinder end 36 and a hollow puffer cylinder section 37, the latter sliding over resilient contact fingers 38, mounted in a ring-shaped contact support 39 constituting part of a stationary piston. The contact support 39 is secured, as by bolts 40, to a support casting 41, which is secured, by bolts 42, to a heavy end plate 43 formed from steel plate and constituting a portion of the mechanism housing 4.

A piston rod 44 is clamped, by a nut 45, to the cylinder end 36 and effects the actuation thereof, carrying with it the entire movable orifice structure 33, movable contact 28, finger support 30 and the fingers 32 thereof, all con-

stituting a movable contact assemblage, back over the support casting 41 in a manner, which will be obvious upon an inspection of FIG. 3. The flexible contact fingers 38, biased radially outwardly by compression springs 46, maintain good contacting engagement with the conducting cylinder 37 during this movement.

The right-hand end of the piston rod 44 is fixedly secured to a piston 47, movable within an operating cylinder 48. As noted in FIG. 3, there is always present high-pressure hydraulic fluid acting upon the left-hand, opening face 49 of the piston 47, as fed by a high-pressure conduit 50, tending to move the movable contact 28 toward the right, into the open-circuit position. It is one of the important features of the invention that his high pressure exists at all times tending to force the hydraulic piston 47 open, and only by a reduction of the pressure within the region 51 within operating cylinder 48 it is possible to permit such opening action to occur. It will be noted that if the pressure within region 51 is the same as the pressure within region 52, to the left of piston 47, then the piston will nevertheless move to its closed position because of the fact that the cross-sectional area of piston rod 44 moves through opening 53 out of the operating cylinder 48. Equalization of pressure, therefore, within regions 51, 52 will effect closing of the interrupter, whereas a reduction of pressure within region 51, as more fully described hereinafter, will permit the constant high pressure within region 52 to effect a rapid opening stroke of the movable contact 28 and orifice structure 33, compressing the sulfur hexafluoride gas within region 54, within puffer cylinder 37, and forcing it to flow out through the orifice 55, provided by orifice structure 33, to effect extinction of the arc drawn there-through.

FIG. 4 shows more clearly, in diagrammatic form, the essential parts of the hydraulic operating mechanism of the present invention. The high-pressure conduit 50, which leads to the region 52 on the opening side of the piston 47, also communicates with a high-pressure accumulator 56, disposed at high potential within the mechanism housing 4. As shown in FIG. 4, nitrogen gas at, say 2,000 p.s.i., is disposed in the region 57 above a movable piston or diaphragm 58, movable within the accumulator 56 and maintaining the hydraulic fluid, such as oil 59, under the same high pressure. The high-pressure oil 59 not only communicates by means of high-pressure conduits 50 to the two operating cylinders 48 of both arc-extinguishing structures 2, but also it connects by way of a conduit 60 to a master control valve, generally designated by the reference numeral 61 in FIG. 4. Further, the conduit 60 has a branch connection 62, which passes down through the hollow pedestal 5 to an auxiliary accumulator, designated by the reference numeral 63, and disposed at ground potential within the control compartment 9 (FIG. 1). Naturally the portion of the conduit 62 passing downwardly through insulating pedestal 5 is formed of insulating tubing.

A hydraulic pump 64, driven by a motor 65, is employed to draw hydraulic fluid 59 from the reservoir or sump 8 (FIG. 4) through a feed pipe 66 and force it under high pressure through a check valve 67 and through a conduit 68 into the auxiliary accumulator 63 at ground potential. A suitable gas, such as nitrogen N_2 , may be employed within auxiliary accumulator 63 to the right of piston or diaphragm 69 therein under a suitable pressure, such as 2,000 p.s.i. A branch conduit 70, leading from feed conduit 68, enters a port of a pilot valve, generally designated by the reference numeral 71. A valve spindle 72, movable within pilot valve 71, is biased by a compression spring 73 in a direction to permit high-pressure oil to pass through a region 74 of pilot valve 71 and upwardly through a control conduit 75 to the lower side of a piston 76, reciprocally movable within master control valve 61. Thus, as shown in FIG. 4, the pilot valve 71 has just been tripped by energization of a tripping sole-

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noid 77 to effect unlatching of a latch 78, to permit the compression spring 73 to move the valve control spindle 72 of pilot valve 71 to the right, thereby permitting flow of high-pressure oil upwardly through control pipe 75 to act upon the lower side of piston 76. FIG. 4 shows piston 76 of master valve 61 in the breaker closed position prior to its being moved upwardly to a breaker open position by the aforesaid tripping of pilot valve 71.

The piston 76 of master control valve 61 has a spider-shaped connection 79 with a sleeve valve 80, the latter moving with piston 76 and controlling the flow of high-pressure oil 59 downwardly through passages 81 within valve casing 82. As shown in FIG. 4, the master control valve 61 is in the breaker closed position, allowing high-pressure oil 59 to pass across the upper edge 83 of sleeve valve 80, and through ports 84 provided therein, to communicate through conduits 85 to the closing sides of hydraulic pistons 47.

Upon energization of a closing solenoid 86, the armature 87 thereof will strike a protruding end 88 of control spindle 72, forcing the latter to the left, as viewed in FIG. 4, compressing spring 73, effecting the relatching of tripping latch 78, and placing the control pipe 75 in communication with an exhaust pipe 89 to the sump 8. This will permit compression spring 90 to move sleeve valve 80 downwardly, opening up the passages 81 and closing the lower end 91 of sleeve valve. This will effect closing of the pistons 47 and hence closing of the movable contact structure 11, 28 in an obvious manner.

The lower end of the master control valve 61 communicates by means of a passage 92 to an insulating exhaust pipe 93 leading to the reservoir, or sump 8. Preferably the region 94 above the liquid level 95 of sump 8 is filled with sulfur hexafluoride SF_6 gas at the aforesaid 60 p.s.i., that is, at the same pressure as exists within the region 22 within hollow casings 3. It will be observed that a pipe 96 interconnects the region 94 within sump 8 with the region 97 within hollow upstanding pedestal support 5 to increase the voltage withstanding ability of the pedestal support 5. This has the further advantage that an opening 98 is provided in support plate 99 (FIG. 3) at the upper end of porcelain casing 5 to communicate by way of a pipe connection 100 with the region 22 within casing 3, as shown in FIG. 3.

It will be apparent that in the closed-circuit position of the interrupter 1, as shown in FIG. 3, the electrical circuit therethrough includes terminal pad 16, ring-shaped terminal plate 15, spider support 13, stationary contact 11, movable contact 28, conducting cylinder head 36, conducting puffer cylinder 37, finger contacts 38, support casting 41, through the conducting mechanism housing 4, and through the right-hand arc-extinguishing structure 2 of FIG. 1 in a similar manner to the right-hand terminal pad 16 (FIG. 1).

In this closed-circuit position, the hydraulic mechanism will be in the position as shown in FIG. 3, and as shown in FIG. 4, with the exception that in FIG. 4 the pilot valve spindle 72 will be latched by the tripping latch 78 and will not be in the tripped position, as actually shown in FIG. 4.

When it is desired to effect the opening of the circuit interrupter 1, suitable means, not shown, effects the energization of tripping solenoid 77. This action unlatches the tripping latch 78, against the tension spring 101, and rotates the nose 102 of the tripping latch 78 from under the shoulder 103 of pilot valve spindle 72.

The pilot valve spindle 72 (FIG. 4) will immediately be moved to the right, as actually shown in FIG. 4, by the compression spring 73, so that high-pressure oil will move through region 74 of pilot valve 71, through control pipe 75 to act upwardly upon the lower face of piston 76 of master control valve 61.

This will move sleeve valve 80 upwardly to close off the passages 81, and to open up the passages 92 to pipes 85, so that the latter may exhaust high-pressure oil from

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regions 51 within cylinders 48 down through the exhaust pipe 93 to the sump 8.

Since high-pressure oil 59 continues to exist within the regions 52 of operating cylinders 48, the pistons 47 will move toward each other in an opening direction, causing separation of the contacts 11, 28, and effecting compression of gas within regions 54 within cylinders 37 (FIG. 3). This forces compressed gas out through orifices 55 to effect extinction of the two serially related arcs drawn within the arc-extinguishing structures 2.

To obtain substantially equal voltage division between the two breaks during this interrupting operation, preferably impedance tubes 104 are employed shunting the contacts 11, 28 and providing substantially equal voltage division between the two extinguishing structures 2.

In the fully open circuit position of the interrupter, the pistons 47 (FIG. 4) will be disposed at the inner ends of the operating cylinders 48, close to each other, and valve sleeve 80 will be in its upper closed position, with the pilot valve assembly 71 in the position as it is actually shown in FIG. 4.

To effect the closing operation of the interrupter 1, suitable means, not shown, effects the energization of the closing solenoid 86. This will move armature 87 thereof to the left, as viewed in FIG. 4, moving pilot valve spindle 72 to the left, and relieving the oil pressure in control pipe 75. The nose 102 of tripping latch 78 will latch under the shoulder 103 of spindle 72, and valve sleeve 80 of master control valve 61 will be moved downwardly by the compression spring 90. High-pressure oil will pass from accumulator 56 through passages 81 over the top 83 of valve sleeve 80, through ports 84 and through conduits 85 to act within regions 51, thereby moving actuating pistons 47 outwardly, away from each other, in the closing direction. This will effect closing of the contact structure 11, 28 (FIG. 3) in an obvious manner.

To prevent the leakage of high pressure oil along the opening 53, as shown in FIG. 3, a drain connection 105 is provided leading to a collecting can 106, with the upper end of the can having a gas connection, through a pipe 107, to the region 22 within hollow casing 3. This structure is set out and claimed in U.S. patent application filed October 30, 1957, Serial No. 693,306 by Winthrop M. Leeds, and assigned to the assignee of the instant application. This application also covers the use of gas, such as SF_6 , within hollow pedestal 5.

Preferably a pair of windows 108 (FIG. 1) are provided in a side plate 109 of mechanism housing 4 to permit observation of a pair of indicating pointers 110, which are pivotally mounted, and are spring-biased to the closed position by suitable biasing means not shown. The upper ends of the indicating pointers 110 (FIG. 3) have abutments 111 secured thereto, which are struck by the pistons 47 when the latter reach the extremity of their opening stroke. Thus, an accurate indication is provided, as to the contact condition, of each arc-extinguishing structure 2, since the indicator pointer 110 will constantly indicate the closed position, unless and until it is actually struck by a portion of the operating piston 47.

With attention being directed to FIG. 1, it will be observed that a gauge 112 indicates the pressure of the SF_6 above the liquid level 95 (FIG. 4) within sump 8. Also a glass-tube gauge 113 is employed to note the level 95 of the hydraulic oil 59 within the sump 8. A drain pipe 114 is connected to the bottom of the sump 8 for drainage purposes. The control pipe 75 and the feed pipe 62 to the upper accumulator 56 are indicated in FIG. 1, as is also the pipe 89 leading from the pilot valve 71 within compartment 9 to the sump 8. Handles 115 are provided to open the doors of compartment 9, permitting access to the various pressure switches and to the control panel therein. A manually operable valve 200 for filling the sump 8 with oil through a line 200a is shown in FIG. 2.

With further reference to FIGS. 1 and 2, it will be noted that a pipe 116 is provided, connected to the upper end of sump 8 and permitting SF_6 gas to be fed from an external supply tank, not shown, through hand valve 116a to the region 94 (FIG. 4) within the upper end of sump 8. The connection 96, leading from pipe 116, connects the region 94 within sump 8 to the region 97 (FIG. 3) within casing 5. A lifting eye 117 may be welded to the mechanism housing 4 for enabling transportation of the entire interrupter 1.

The hand operation for inching of the breaker contacts by the use of the control valves 118, 119 will now be described. This is done for maintenance purposes with power removed from the interrupter 1 by opening suitable disconnect switches, not shown. Hand operation may be accomplished by means of two valves 118, 119 just inside of a front metallic cover plate 120 (FIG. 1). The left-hand valve 118, as viewed in FIG. 3, is in the conduit 62 leading from the lower accumulator 63 to the upper accumulator 56, and this hand valve 118 is normally open. The right-hand valve 119 is in a line 121 that connects the upper accumulator 56 to the sump 8 by way of the master control valve 61, and is normally closed. For hand operation, with the power off the breaker, it is merely necessary to close the left-hand valve 118, shutting off lower accumulator 63 and open the right-hand valve 119 to reduce the upper accumulator pressure to zero. Valve 119 is then reclosed. If the breaker 1 is now closed, and it is decided to open it, the pilot valve 71 is actuated to the open position. This puts pressure from the lower accumulator 63 on the small piston 76 under the large operating sleeve valve 80, moving it to the breaker open position. However, since there is no pressure on the opening faces 49 of pistons 47 within the contact operating cylinders 48, the movable contacts 28 will not move open until the left-hand valve 118 (FIG. 3) is cracked open, thereby admitting oil at a slow rate from the lower accumulator 63. By this means the movable contacts 28 may be inched open and stopped at any point during such an inspecting operation.

Similarly, to inch the movable contacts 28 closed, it is merely necessary to reset the pilot valve 71 to the closed position, allowing the large valve 61 to move to closing position. Then the movable contacts 28 may be inched closed by cracking the left-hand valve 118 open.

There is a particular advantage of pressurizing the sump 8, as was disclosed and claimed in the aforesaid Leeds application. If the sump 8 is not pressurized, the sump return line 93 (FIG. 4) at the bottom of the large master valve 61 is at a pressure below atmospheric, by the pressure of the column of oil from this point to the sump 8. This is also true of the line 75 leading to the small piston 76 that opens the main master control valve 61 when this valve 61 is closed. This small differential pressure is more likely to leak at the O ring seal about these lines than a higher pressure, and if it does, an air bubble would enter the sump lines 75, 93. This would be particularly bad in the line 75 leading to the small piston 76 that operates the master control valve 61, since this line 75 alternates between sump pressure and high pressure. If air got into this line 75, it would have to be compressed before the valve would open, which might cause a delay of several times normal operating time.

With the sump 8 at a positive pressure, as provided by the SF_6 at 60 p.s.i. in region 94 (FIG. 4), the air cannot leak in the sump lines 75, 93, and such leakage troubles cannot occur.

With particular reference to FIG. 5 of the drawings, it will be observed that there is illustrated a modified type of circuit interrupter, generally designated by the reference numeral 122 and comprising a generally Y-shaped structure. The Y-shaped structure includes an upstanding, hollow, insulating pedestal 123, which is analogous to the pedestal 5 of the interrupter 1 of FIG. 1.

Supported upon the top of the hollow supporting ped-

estal 123 is a mechanism housing, generally designated by the reference numeral 124. A mounting flange ring 125 is secured, by cement 126, to the upper end of the pedestal 123. The ring-shaped mounting flange 125 may be fixedly secured to the mechanism housing 124 by a plurality of mounting bolts 127. The mechanism housing 124 includes a pair of operating cylinders 128, enclosing a pair of hydraulically actuated pistons 129. Secured, in threaded manner, to the actuating pistons 129 is a tubular piston rod 130, to the outer end of which is fixedly secured a movable contact 131, which makes contacting engagement with a relatively stationary contact 132.

The separable contacts 131, 132 are disposed within a surrounding weatherproof casing 133, which is preferably formed from porcelain. The porcelain casing 133 has secured thereto at its lower end, by cement 134, a ring-shaped mounting flange 135, the latter being secured, as by bolts 136, to the upper slanting surface 143 of the mechanism housing 124, as shown in FIG. 5.

Secured, as by cement 137, to the outer end of the weatherproof casing 133 is a closure cap 138 having a line terminal connection 139, as shown. Gaskets 140, 141 may be employed to effect a gas-tight seal, since sulfur hexafluoride gas is disposed within the region 142 at a pressure of, say 60 p.s.i. Secured, by suitable means, not shown, to the slanting surface 143 of the mechanism housing 124 is an operating cylinder 144. Slidable within the operating cylinder 144 is a piston 145, the latter being secured to and movable with the movable contact 131. Also movable with the movable contact 131 is an insulating orifice member 146, the latter having an orifice restriction 147. As in the arrangement of FIG. 1, retraction of the piston 145 within operating cylinder 144 causes fluid, such as SF_6 , to pass through the openings 148 in piston 145, through the orifice 147 and adjacent the established arc drawn between contacts 132, 131 to effect the extinction of the latter.

Extending into the tubular piston rod 130 is a flexible rod-shaped contact 149, which is secured to the lower end of the operating cylinder 128. During the opening movement the flexible rod contact 149 carries the current from the movable contact 131 to the conducting mechanism housing 124, and hence to the other arc-extinguishing unit 150 of the circuit interrupter 122.

Shunting each of the two identical arc-extinguishing units 150 is an impedance interrupter, generally designated by the reference numeral 151 and comprising a relatively stationary contact 152 cooperable with a movable contact 153. The movable contact 153 is fixedly secured to a piston 154 movable within an operating cylinder 155, being hydraulically actuated.

The contacts 152, 153 separate within an orifice structure 155, movable with the movable contact 153 and with a piston 156. Thus sulfur hexafluoride gas is compressed within the region 157 and is forced to flow through openings 158 through the orifice 159 and adjacent the impedance arc drawn between contacts 152, 153.

The contacts 152, 153 are separable within an enclosing, weatherproof casing, designated by the reference numeral 160 and preferably formed of porcelain. A closure cap 161 is secured by any suitable means to the outer end of the weatherproof casing 160 and is electrically connected by a connector 162 to the line-terminal connection 139 of closure cap 138.

In the closed-circuit position of the interrupter 122, the electrical circuit therethrough includes line terminal 139, conducting cap 138, spider support 163, stationary contact 132, movable contact 131, conducting tubular piston rod 130, flexible rod contact 149, operating cylinder 128, through the mechanism housing frame 124 to the right-hand operating cylinder 128, as viewed in FIG. 5, and through the right-hand arc-extinguishing unit 150 in an identical manner.

Naturally a shunt circuit exists about each of the arc-extinguishing units 150 through the impedance interrupter 151 by way of the connector 162, conducting cap 161, resistance blocks 164, stationary contact 152, movable contact 153, piston 154, operating cylinder 155, and to the mechanism housing 124.

The hydraulic operating mechanism, generally designated by the reference numeral 165, will now be described. As in the construction of the interrupter 1 of FIG. 1, an accumulator 166 at high potential is employed. This accumulator 166 may have a construction identical to the accumulator 56 of FIG. 4, having nitrogen gas therein at 2000 p.s.i. acting upon a diaphragm separating the nitrogen N_2 and the oil 59. A high-pressure pipe 167 constantly connects the high-pressure end of the accumulator 166 to the upper opening face of each operating piston 129, thereby tending to bias the movable contacts 131 to their open-circuit position. Additional conduits 168 connect the high-pressure accumulator 166 to the opening side of the pistons 154, within operating cylinders 155, also tending to bias the movable impedance contacts 153 to the open-circuit position. The construction is such that a suitable restriction is provided in conduit 199 dumping high-pressure oil out of cylinders 155, so that in fact, the movable contact 153 opens subsequently to the opening of the main movable contact 131.

As shown in FIG. 5, the hydraulic mechanism 165 includes a closing hydraulic valve 169 and an opening hydraulic valve 170. Each of the hydraulic valves 169, 170 has a construction, as shown in FIG. 6 of the drawings. FIG. 6 shows, to an enlarged scale, the closing valve 169, but, as will be obvious hereinafter, the opening valve 170 may have a similar construction, the only difference being in the types of conduits leading into the valve casing 171. Features of the opening valve 170 are set forth and claimed in United States patent application filed March 15, 1961, Serial No. 95,933, by Albert P. Strom and William H. Fischer and assigned to the assignee of the instant application.

In the case of the closing valve 169, the upper conduit 172 leads directly from the high-pressure accumulator 166, whereas in the case of the opening valve 170, the upper conduit 173 is connected to the lower side of the operating pistons 129 through a common manifold 175. The outlet conduit 174 leading from the closing hydraulic valve 169 leads to the common manifold 175, which in turn is connected to the lower end of each operating cylinder 128 by a pipe connection 176. The outlet conduit 177 of the opening valve 170 leads through an insulating tube 179 to a lower sump 8 (FIG. 4). An insulating operating rod 180 extends upwardly through the weatherproof pedestal 123, and through a bellows 181 to a double-armed bell-crank lever 182. The double-armed bell-crank lever 182 is pivotally mounted about a fixed axis 183 and is rotated thereabout by the operating rod 180. The operating rod 180 may be manually or electromagnetically actuated from ground potential by any suitable means, not shown.

With attention again directed to FIG. 6, it will be observed that each of the hydraulic valves 169, 170 has a pilot-valve spindle 184, biased by a spring 185, so that high-pressure oil 59 tends to pass from a pipe 186 into a region 187 to act upwardly upon a piston 188 movable within a piston casing 189. The piston 188, in turn, strikes a stem 190, secured through a spider support 191 to the lower end of a main sleeve valve 192. The sleeve valve 192 reciprocally moves within the valve casing 171 and controls the flow of oil 59 through the valve.

The double-armed bell crank lever 182 is so arranged as to depress either one button 193 of the closing valve 169 or the button 193 of the opening valve 170. When the button 193 is depressed, this moves the pilot valve spindle 184 to the left, as viewed in FIG. 6, closing off the high-pressure oil inlet 186, and dumping the region 178 below

piston 188 to the low sump pressure, through region 194 and low pressure outlet 195, leading to the sump 8.

Thus, when the button 193 of either valve 169, 170 is untouched, the arrangement is such that high-pressure oil maintains the piston 188 and hence the sleeve valve 192 in its upper raised open position. On the other hand, when the button 193 is depressed, the converse situation arises, and the sleeve valve 192 is maintained at its lower closed position by the pressure of the oil within region 196.

The operation of the modified type of interrupter 122 will now be explained. To effect the opening of the interrupter, from the closed-circuit position illustrated in FIG. 5, the operating rod 180 is moved upwardly so as to release the button 193 of opening valve 170 and to depress the button 193 of closing valve 169. As heretofore explained, the pilot valve spindles 184 of both valves will move to positions wherein the sleeve valve 192 of closing valve 169 will be closed, thereby shutting off high-pressure oil from accumulator 166 to the region 197 within operating cylinder 128, whereas the sleeve valve 192 of opening valve 170 will be raised to permit a dumping of high-pressure oil out of the region 197 of operating cylinders 128 through the manifold 175 and through the exhaust pipe 179 to the sump 8 (FIG. 4).

Since there exists high-pressure oil at all times on the upper surfaces of the pistons 129, and since the lower sides of the pistons 129 are now exposed to a reduced pressure, these pistons 129 will now move down, causing the opening of the movable contacts 131 away from the stationary contacts 132, drawing two serially related arcs within the orifices 147. The blast of gas passing through the orifices 147 in the manner previously described, will effect extinction of the main-current arcs drawn between contacts 131, 132.

At the same time, that the pressure is reduced within regions 197 of operating cylinders 128, the pressure will likewise be reduced in the regions 198 within operating cylinders 155 back of the pistons 154 in the impedance current interrupters 151. Because of the provision of suitable restrictions in the conduits 199, the opening of the impedance contacts 153 will be slightly delayed. This will give the main current arc a chance to be interrupted at the main gaps 131, 132 so that only a small residual current arc needs to be subsequently interrupted at the impedance contacts 152, 153.

Since the resistance blocks 164 reduce the current, and improve the power factor, the residual current arc passing between the contacts 152, 153 will quickly be extinguished by the puff of SF_6 gas out of the region 157 by retraction of the pistons 156. In the fully open-circuit position, the pistons 145, 156 are in their fully open positions, the movable contact structures 131, 153 are opened, and current has therefore ceased to flow through the interrupter 122.

To effect the closing of the interrupter, the operating rod 180 is moved downwardly, releasing the button 193 of closing valve 169 and engaging the button 193 of opening valve 170. In the manner heretofore explained, the sleeve valve 192 of closing valve 169 will be raised to its open position, thereby effecting intercommunication between the accumulator 166 and the manifold 175 and hence regions 197 in back of the pistons 129. The depression of the button 193 of opening valve 170 will effect the closing of the sleeve valve 192 associated therewith, thereby closing the connection between manifold 175 and the lower sump 8. Since the cross-sectional area of the tubular portion of tubular piston rod 130 moves out of the operating cylinder 128, this unbalanced pressure acting upon piston 129 effects the rapid closing of contact structure 131, 132. A similar action takes place in each impedance interrupter 151 and these close likewise. The interrupter is hence closed and current passes therethrough.

From the foregoing description of the two circuit interrupters 1, 122, it will be observed that there has been

provided an improved hydraulically actuated circuit interrupter in which the accumulator 56, 166 is at high potential and closely adjacent the operating cylinders 48, 128. The pipe connections are therefore short, and since the operating cylinders 48, 128 are immediately adjacent the movable contact structures 28, 131, high-speed motion results with no delay whatsoever. Not only are the accumulators 56, 166 at high potential immediately adjacent the contact structures, but also they need be of relatively small size because of the replenishment of high-pressure hydraulic fluid therein by the feed pipes 62, 202. The sulfur hexafluoride gas at the lower pressure can be fed upwardly through the pedestal 5 or upwardly through a pipe 201 (FIG. 5) to maintain the proper pressure within the arc-extinguishing structures.

In both interrupters the tripping operation is initiated at ground potential, the tripping impulse being sent through the weatherproof pedestal 5, 123.

By having the accumulator at high potential and the hydraulic mechanism also at high potential, a high-speed circuit interrupter results in which no time delay whatsoever is encountered between the initiation of the tripping impulse and the initiation of the opening operation of the movable contact structure.

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 for interrupting high-voltage circuits of considerable power including an arc-extinguishing unit, insulating support means for supporting said arc-extinguishing unit an adequate distance from ground potential, said arc-extinguishing unit including a relatively stationary contact, a cooperable movable contact separable from the relatively stationary contact to establish an arc, hydraulic operating means disposed in immediate proximity to the contacts for actuating said movable contact including a hydraulic operating cylinder and a high-pressure accumulator, a master control valve for controlling the flow of hydraulic liquid into said cylinder, a hydraulic piston movable within said hydraulic operating cylinder, means connecting said hydraulic piston to said movable contact for the actuation thereof, and the hydraulic operating cylinder accumulator, master control valve and piston all being at the same high potential as the movable contact.

2. The combination in a high-voltage circuit interrupter of insulating support means for supporting a pair of serially related arc-extinguishing units a sufficient distance from ground potential, said pair of serially-related supported arc-extinguishing units including two pairs of serially related contacts separable to establish at least two serially related arcs, said pairs of contacts including two movable contacts movable toward each other during the opening stroke, a pair of hydraulic operating cylinders having hydraulic pistons therein coupled to said movable contacts, a high-pressure accumulator positioned generally between said units for feeding hydraulic fluid into said hydraulic operating cylinders, and the two movable contacts, hydraulic operating cylinders, accumulator and pistons all being at substantially the same voltage.

3. A high-voltage circuit interrupter including a pair of separable main contacts and a pair of separable shunting impedance contacts, an impedance in series with said pair of impedance contacts, hydraulic operating means for sequentially opening first a movable main contact and subsequently a movable impedance contact, separate hydraulic operating cylinders and separate pistons for effecting the opening movement of said movable contacts, and the hydraulic operating cylinders being at substantially the same high voltage as the movable contacts.

4. A high-voltage circuit interrupter including a pair of separable main contacts and a pair of separable shunting impedance contacts, an impedance in series with said pair of impedance contacts, hydraulic operating means for sequentially opening first a movable main contact and subsequently a movable impedance contact, hydraulic operating cylinders and pistons for effecting the opening movement of said movable contacts, a high-pressure accumulator for feeding hydraulic fluid into said hydraulic operating cylinders, and the hydraulic operating cylinders and accumulator being at substantially the same high voltage as the movable contacts.

5. A high-voltage circuit interrupter including an upstanding hollow insulating pedestal, an arc-extinguishing unit supported at the upper end of said upstanding pedestal an adequate distance above ground potential, said elevated arc-extinguishing unit including a pair of separable cooperable contacts, a hydraulic operating cylinder and a piston therein coupled to one of said contacts, means including a high-pressure accumulator for feeding hydraulic fluid to the opening side of said piston for constantly maintaining high-pressure hydraulic operating fluid on the opening side of said hydraulic piston, hydraulic means including a master control valve for governing the hydraulic pressure on the closing side of said piston to effect opening and closing movement of said one contact, the accumulator and the hydraulic operating cylinder being at substantially the same high potential as said one contact, an auxiliary accumulator disposed at ground potential, and a feed conduit extending upwardly through said hollow pedestal and interconnecting the two accumulators.

6. A high-voltage circuit interrupter including an arc-extinguishing unit, an insulating pedestal for supporting said arc-extinguishing unit up in the air above ground potential, said unit having a movable contact associated therewith, a hydraulic operating cylinder and a piston for moving said movable contact, a high-pressure accumulator at high potential supported by said pedestal, an auxiliary accumulator at ground potential, and an insulating feed conduit extending through said insulating pedestal and hydraulically interconnecting said two accumulators.

7. The combination in a high-voltage circuit interrupter of an elevated arc-extinguishing unit, an insulating hollow pedestal for supporting said elevated arc-extinguishing unit up in the air above ground potential, said unit including a movable contact, a hydraulic operating mechanism for moving said movable contact including a hydraulic operating cylinder, piston, master control valve, and accumulator all at high potential supported on said insulating pedestal, an auxiliary accumulator at ground potential, insulating conduit means interconnecting said two accumulators, and means extending upwardly through said hollow insulating pedestal for operating said master control valve at high potential.

8. A high-voltage circuit interrupter including an arc-extinguishing unit, an insulating pedestal for supporting said arc-extinguishing unit up in the air above ground potential, said unit having a movable contact associated therewith, a hydraulic operating cylinder and a piston for moving said movable contact, a high-pressure accumulator at high potential supported by said pedestal, an auxiliary accumulator at ground potential, an insulating feed conduit extending through said insulating pedestal and hydraulically interconnecting said two accumulators, a master control valve at high potential, a manual inching valve in said feed conduit, a sump at ground potential, a second manual inching valve in a hydraulic connection from said high potential accumulator to said sump, whereby said manual inching valves may be used to inch the movable contact slowly for inspection purposes.

9. A circuit interrupter of the gas-blast type for interrupting high-potential circuits including an upstanding hollow insulating support pedestal for supporting an arc-extinguishing unit an adequate distance above ground

potential, said supported arc-extinguishing unit including a relatively stationary contact, a cooperable movable contact cooperable with said relatively stationary contact to establish an arc, a relatively stationary operating cylinder, a movable puffer piston movable within said relatively stationary operating cylinder to blast gas through said arc to effect the extinction thereof, a piston rod for said movable puffer piston, hydraulic operating means at high potential and also supported by said hollow pedestal for effecting opening motion of both said movable puffer piston and said movable contact including a hydraulic operating cylinder and a high-pressure accumulator, a hydraulic piston movable within said hydraulic operating cylinder, means connecting said hydraulic piston to said piston rod for effecting opening and closing motion of said puffer piston, an auxiliary accumulator at ground potential, feed-pipe means interconnecting the two accumulators and extending through said hollow support pedestal, and the hydraulic operating cylinder, high-pressure accumulator and piston being at the same high potential as the movable contact.

10. The combination in a high-voltage gas-blast circuit interrupter for interrupting high-potential circuits of a generally T-shaped interrupting structure, a pair of relatively stationary contacts disposed adjacent the outer ends of the lateral arms of the generally T-shaped interrupting structure, a pair of relatively stationary operating cylinders in the arms of the generally T-shaped structure, a pair of puffer pistons carrying movable contacts movable within said pair of relatively stationary operating cylinders toward each other during the opening operation, a hydraulic operating mechanism at high potential including at least one hydraulic operating cylinder and a pair of hydraulic pistons connected to said pair of puffer pistons, the hydraulic operating mechanism also including a high-pressure accumulator at high potential, an auxiliary accumulator at ground potential, and an insulating supply line extending through the central support of the generally T-shaped interrupting structure interconnecting the two accumulators.

11. A high-power gas-blast circuit interrupter including a pair of separable main contacts and a pair of separable shunting impedance contacts, an impedance in series with said pair of impedance contacts, a pair of gas-blast puffer structures associated with said two pairs of separable contacts to effect the extinction of the main current arc and the residual current arc, a hydraulic operating mechanism for said puffer structures including a pair of hydraulic operating cylinders and a pair of hydraulic pistons movable therein, means for delaying the motion of the hydraulic piston associated with the impedance contacts relative to the motion of the hydraulic piston associated with the main contacts, and the hydraulic operating mechanism causing said puffer structures to sequentially extinguish the main and residual current arcs.

12. A high-power gas-blast circuit interrupter including a pair of separable main contacts and a pair of separable shunting impedance contacts, an impedance in series with said pair of impedance contacts, a pair of gas-blast puffer structures associated with said two pairs of separable contacts to effect the extinction of the main current arc and the residual current arc, a hydraulic operating mechanism at the same potential as the movable contacts for said puffer structures including a pair of hydraulic operating cylinders and a pair of hydraulic pistons movable therein, means for delaying the motion of the hydraulic piston associated with the impedance contacts relative to the motion of the hydraulic piston associated with the main contacts, and the hydraulic operating mechanism causing said puffer structures to sequentially extinguish the main and residual current arcs.

13. A high-voltage fluid-blast circuit interrupter adaptable for interrupting high-potential circuits including an upstanding generally T-shaped interrupting structure having a hollow upstanding portion, a pair of line terminals

disposed at the outer extremities of the laterally extending arms of the generally T-shaped interrupting structure, each arm including a laterally extending insulating casing, a pair of relatively stationary contacts disposed adjacent the outer ends of the lateral arms of the generally T-shaped interrupting structure and interiorly of the casings, a pair of movable contacts cooperable with said pair of relatively stationary contacts and movable toward each other during the opening operation, a fluid-blast puffer structure associated with each movable contact and movable therewith during the opening operation, a mechanism housing disposed at the upper end of the supporting column of the generally T-shaped interrupting structure and interposed between the two insulating casings, a hydraulic operating mechanism at high potential disposed at least partly within said mechanism housing, said mechanism housing being at high potential and at the potential of the movable contacts, said hydraulic operating mechanism including a pair of hydraulically operated pistons connected to the pair of movable contacts to effect the actuation thereof and a high-potential accumulator, an auxiliary accumulator at ground potential, and a feed conduit at least partly of insulating material interconnecting said two accumulators and extending through said hollow upstanding portion.

14. The high-voltage fluid-blast circuit interrupter according to claim 13, wherein a master control valve is at high potential and a hydraulic pilot line also extends upwardly through said hollow upstanding portion.

15. A high-voltage fluid-blast circuit interrupter including an upstanding generally Y-shaped interrupting structure, a pair of line terminals disposed at the outer ends of the outwardly extending arms of the generally Y-shaped interrupting structure, main contact means disposed within said outwardly extending arms of the generally Y-shaped interrupting structure, additional outwardly extending arms containing shunting impedance contacts, hydraulic means at high potential disposed at the upper end of the supporting column of the generally Y-shaped interrupting structure, means delaying opening of the impedance contacts until after arc extinction at the main contact means including said hydraulic means for sequentially operating the main contact means and the impedance contact means, and connecting means interconnecting the outer ends of the impedance arms with the outer ends of the first-mentioned arms.

References Cited in the file of this patent

UNITED STATES PATENTS

1,653,086	Christensen et al.	Dec. 20, 1927
2,239,554	Duffing	Apr. 22, 1941
2,290,320	Duffing	July 21, 1942
2,445,529	Leeds	July 20, 1948
2,459,599	Strom	Jan. 18, 1949
2,604,562	Paul	July 22, 1952
2,662,133	Burmeister	Dec. 8, 1953
2,665,351	Forwald	Jan. 5, 1954
2,730,589	Perry et al.	Jan. 10, 1956
2,745,952	Cabanes et al.	May 15, 1956
2,748,226	MacNeill et al.	May 29, 1956
2,781,435	Heilmann et al.	Feb. 12, 1957
2,813,177	Eberhard et al.	Nov. 12, 1957
2,816,978	Lindell	Dec. 17, 1957
2,933,575	Baker	Apr. 19, 1960

FOREIGN PATENTS

72,321	Switzerland	May 1, 1916
479,069	Great Britain	Jan. 31, 1938
117,076	Australia	June 4, 1943
599,966	Great Britain	Mar. 25, 1948
60,645	France	May 12, 1954
509,879	Italy	Jan. 18, 1955
760,146	Great Britain	Oct. 31, 1956
765,524	Great Britain	Jan. 9, 1957