June 15, 1965 SHOTARO TOMINAGA 3,189,717

COMPRESSED-GAS CIRCUIT INTERRUPTER HAVING COOPERABLE ARCING AND DISCONNECTING CONTACTS WITH DOWNSTREAM BLAST VALVE

Filed March 24, 1961 2 Sheets-Sheet 1

Fig. 1.

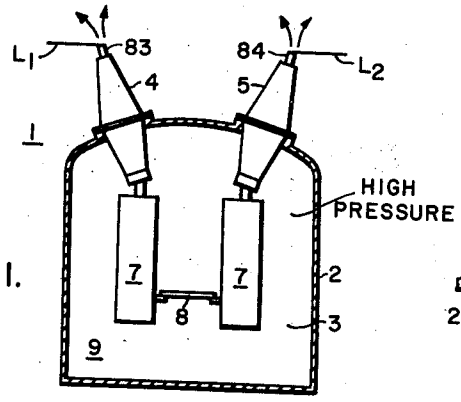


Fig. 3.

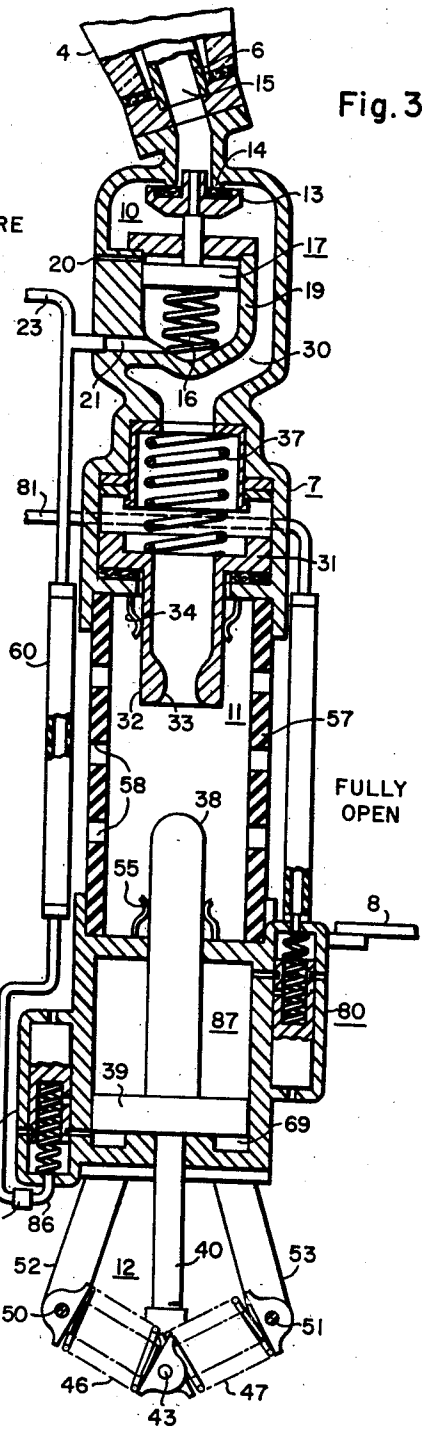


Fig. 4.

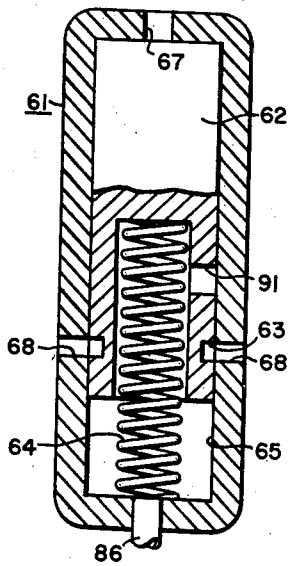
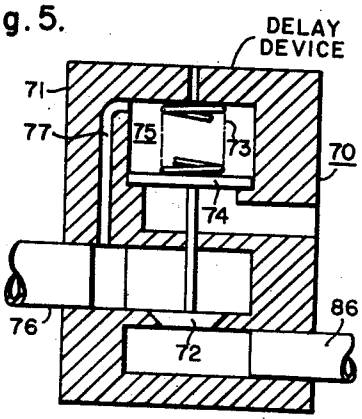


Fig. 5.



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COMPRESSED-GAS CIRCUIT INTERRUPTER HAVING COOPERABLE ARCING AND DISCONNECTING CONTACTS WITH DOWNSTREAM BLAST VALVE

Filed March 24, 1961 2 Sheets-Sheet 2

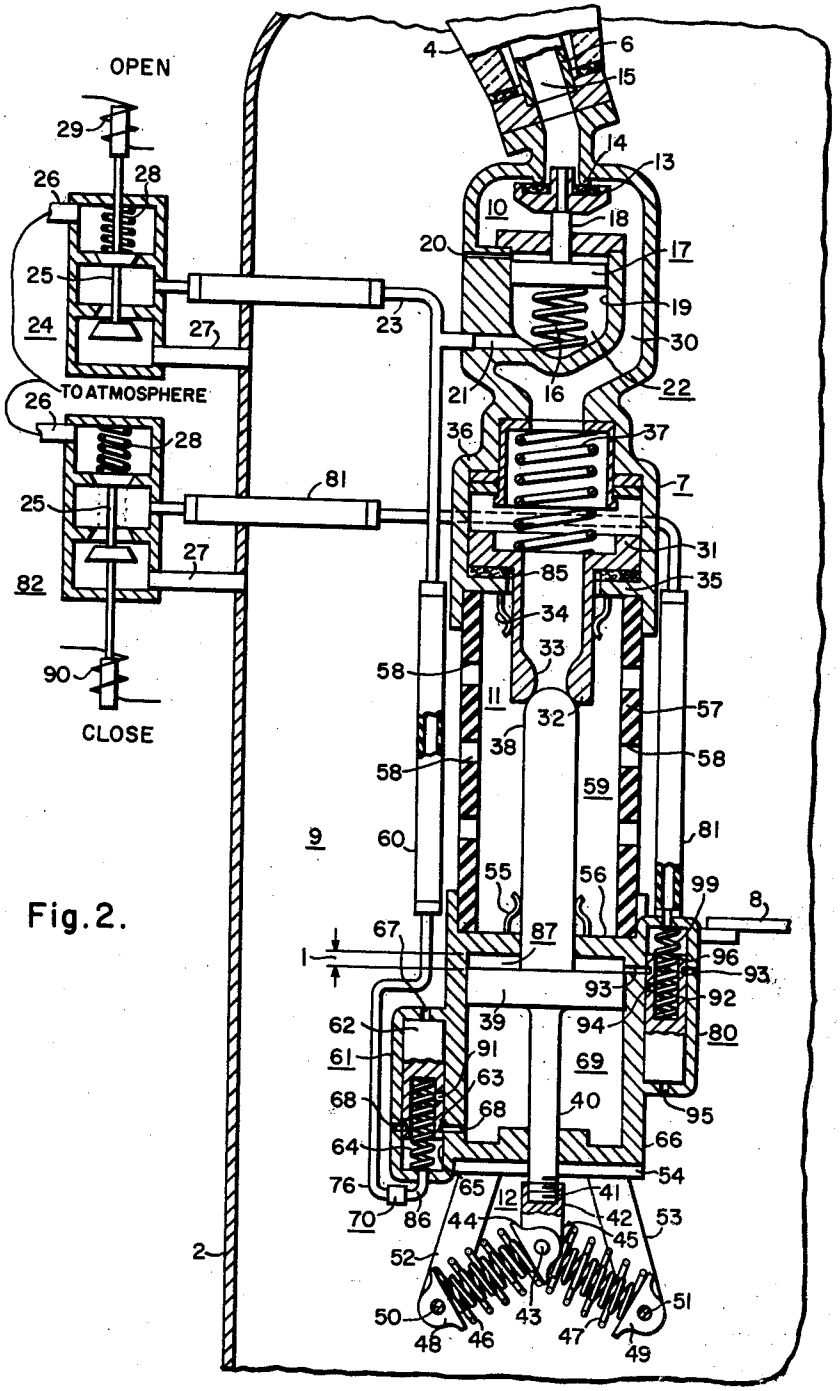

Fig. 2.

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COMPRESSED-GAS CIRCUIT INTERRUPTER HAVING COOPERABLE ARCING AND DISCONNECTING CONTACTS WITH DOWNSTREAM BLAST VALVE

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5 Claims. (Cl. 200—148)

This invention relates to compressed-gas circuit interrupters, and, more particularly, to compressed-gas circuit interrupters suitable for interrupting relatively heavy-power circuits.

A general object of the present invention is to provide an improved compressed-gas circuit interrupter in which improved and simplified operation is obtained over a wide current range.

A more specific object of the present invention is the provision of an improved compressed-gas circuit interrupter in which a movable disconnecting contact directly coacts with the movable arcing contact of the interrupter.

Another object of the present invention is the provision of an improved compressed-gas circuit interrupter in which overcenter-spring means are associated with the movable disconnecting contact, the latter preferably coacting with the movable arcing contact of the circuit interrupter.

Still a further object of the present invention is the provision of an improved compressed-gas circuit interrupter in which a pair of cooperable contacts separate during the opening operation, both of said contacts being piston actuated, and preferably one of the contacts being suitable for performance as a disconnecting contact.

Yet a further object of the present invention is an improved pneumatic control for a compressed-gas circuit interrupter.

Another object of the present invention is the provision of an improved compressed-gas circuit interrupter involving a pressurized metallic tank, and in which the interrupter is adaptable for use with a highly-efficient dielectric and arc-extinguishing medium, such as sulfur hexafluoride (SF_6) gas.

Another object of the present invention is the provision of an improved compressed-gas circuit interrupter embodying a grounded pressurized tank in which only a pair of control lines are necessary for emergence from the tank to control the opening and closing operations of the circuit interrupter.

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 somewhat diagrammatic view illustrating an application of the present invention to a relatively high-power circuit-interrupting construction;

FIGURE 2 is a fragmentary vertical sectional view taken through a portion of the tank structure of the interrupter of FIG. 1, illustrating one of the two arc-extinguishing assemblages, and the contact structure being illustrated in the closed-circuit position;

FIGURE 3 is a view somewhat similar to that of FIG. 2 but illustrating the position of the several parts in the fully open-circuit position of the interrupting assemblage;

FIGURE 4 is an enlarged detail view of one of the control valves for the circuit interrupter of FIG. 2; and

FIGURE 5 is a considerably enlarged vertical sectional view taken through the delay device utilized in the circuit-interrupter construction of FIG. 2.

Referring to the drawings and more particularly to FIG. 1 thereof, the reference numeral 1 generally designates a compressed-gas circuit interrupter. Generally, the circuit interrupter 1 includes a grounded metallic pressurized tank 2 containing a suitable arc-extinguishing gas 3, such as sulfur-hexafluoride (SF_6) gas under pressure.

Extending downwardly interiorly within the tank 2 are a pair of terminal bushings 4, 5 containing hollow fluid-conducting terminal studs 6, more clearly shown in FIG. 2 of the drawings. As shown in FIG. 1, depending from the lower interior ends of the terminal bushings 4, 5 is a pair of arc-extinguishing assemblages, generally designated by the reference numeral 7. The two arc-extinguishing assemblages 7 are electrically interconnected by a conductor 8 and are disposed within the pressurized ambient 9 internally of the tank structure 2.

With reference to FIGS. 2 and 3 of the drawings, it will be apparent that each arc-extinguishing assemblage 7 comprises a blast-valve structure, generally designated by the reference numeral 10, a movable contact structure, generally designated by the reference numeral 11, and an overcenter toggle-spring mechanism, generally designated by the reference numeral 12.

The blast-valve structure 10 includes a movable blast-valve 13 cooperable with a blast-valve seat 14 to control the passage of high-pressure gas through an exhaust conduit 15 extending through the hollow terminal stud 6. As shown in FIG. 2, the blast valve 13 is biased toward a closed position by a compression spring 16, and is opened by pressure differences across first piston 17 secured to the valve stem 18 of the blast-valve 13. The actuating piston 17 moves within a conducting operating cylinder 19 having an inlet aperture 20. A control aperture 21 pneumatically interconnects the space 22 below the piston 17 with an opening control pipe 23. The control pipe 23 extends externally of the tank structure 2 and has the pressure therein controlled by an electrically-actuated valve structure 24. As shown, the valve structure 24 includes a double valve 25 serving either to exhaust the control pipe 23 to atmosphere through an opening 26 or to pressurize the control pipe 23 through a connecting passageway 27 to the pressurized tank 2. Additionally, a spring 28 is provided to normally effect a pressurizing of the control pipe 23 when the solenoid 29 of the valve structure 24 is deenergized.

Surrounding the operating cylinder 19 is a passageway or conduit means 30 communicating with the upper side of a second piston 31, which actuates a movable arcing contact 32. As shown, the movable arcing contact 32 has an orifice 33 extending therethrough. Contact fingers 34 contact the external sides of the movable arcing contact 32 and pass the current thereto from a conducting plate 35 forming part of a casting portion 36. The support casting 36, as shown, is affixed to the terminal bushing 4 and provides the operating cylinder 19 and conduit means 30.

As shown in FIG. 2, a compression closing spring 37 is provided, which biases the movable arcing contact 32 downwardly toward a closed position. Cooperating with the lower extremity of the movable arcing contact 32, and closing the orifice opening 33 therein, is a movable disconnecting contact 38. As pointed out hereinafter, the movable disconnecting contact 38 remains relatively stationary until the arc, not shown, is extinguished, at which time the movable disconnecting contact 38 moves downwardly toward a fully-opened disconnecting position, such as illustrated in FIG. 3 of the drawings.

Secured to, and movable with the movable disconnecting contact 38, is a pressure-responsive third actuating piston 39 having a lower stem portion 40. The stem portion 40 is secured, as by a threaded connection 41, to a coupling 42 providing a pivotal support 43 for a pair of spring holders 44, 45. Compression springs 46, 47 coact

with the spring holders 44, 45 and serve to bias the movable disconnecting contact 38 either upwardly toward a closed-circuit position, as illustrated in FIG. 2, or downwardly toward a fully-opened disconnecting position, such as illustrated in FIG. 3 of the drawings.

As illustrated in FIG. 2, the outer ends of the overcenter compression springs 46, 47 are seated upon spring holders 48, 49 pivoted respectively about pivot pins 50, 51 supported by brackets 52, 53 affixed to the base plate 54 of the interrupting assemblage 7.

As shown in FIG. 2, spring fingers 55 contact the external sides of the movable disconnecting contact 38 and serve to transmit the current therefrom to a plate portion 56 and hence through the conductor 8 to the other arc-extinguishing assemblage 7, as indicated in FIG. 1 of the drawings.

Surrounding the movable contact structure 11 is an insulating casing 57 having a plurality of gas inlet apertures 58. As a result, the region 59 adjacent the movable contact structure 11 is pressurized, as is the interior 9 within the tank structure 2. The control pipe 23 is also pneumatically connected by an insulating portion 60 to a control valve, generally designated by the reference numeral 61. As shown more clearly in FIG. 4 of the drawings, the control valve 61 includes a piston valve 62 having an annular portion 63. A compression spring 64 biases the piston valve 62 toward an upper position, as shown in FIG. 2. The control piston 62 moves within an operating cylinder 65 forming a part of the lower casting 66 of the assemblage 7.

A gas inlet aperture 67 is provided in the operating cylinder 65. In addition, a pair of diametrically-positioned apertures 68 permit communication through the annular passage 63 between the region 69 below the piston 39 and the region 9 within tank structure 2.

Interposed between the control valve 61 and the insulating portion 60 of opening pipe 23 is a pneumatic time-delay device, generally designated by the reference numeral 70, and shown more clearly in FIG. 5 of the drawings. As shown, the time-delay device 70 includes a valve casing 71 for accommodating a valve 72 spring-biased to a closed position by a light spring 73 and actuated by a pressure-responsive piston 74. Interconnecting the region 75 on the upper side of the piston 74 with the pipe 76 is a relatively small-size passageway 77. The relatively small-size opening 77 will only gradually permit gas to flow to the upper side of the piston 74, the purpose for which will become more apparent as the description proceeds.

As shown in FIG. 2, a closing valve device 80 is provided, which has a construction similar to that of the control valve 61. The closing valve device 80 is connected to a closing control pipe 81, which extends externally of the tank structure 2 and is pressurized, or exhausted by the operation of a closing valve structure, generally designated by the reference numeral 82. It will be observed that the closing valve structure 82 is substantially similar to the opening valve structure 24, previously described.

In the closed-circuit position of the circuit interrupter 1, as illustrated in FIG. 2 of the drawings, the electrical circuit therethrough includes line terminal 83, tubular conductor stud 6, conducting operating cylinder 19, conducting plate portion 35, conducting fingers 34, movable arcing contact 32, movable disconnecting contact 38, spring fingers 55, plate portion 56, and through the conductor 8 to the right-hand arc-extinguishing assemblage 7 in a similar manner. The circuit then extends to the right-hand line terminal 84.

During the opening operation suitable means, not shown, is effective to momentarily energize the solenoid 29 associated with opening control valve 24. This will move the double valve 25 upwardly against the spring pressure 28 and exhaust the opening control pipe 23 through the atmospheric opening 26. The exhausting of the opening control pipe 23 will correspondingly exhaust the region 22 below the blast-valve piston 17 and will effect opening of the blast-valve 13 thereby exhausting the passageway 30.

The exhaustion of the passageway 30 and the region above the piston 31 will permit the pressurized gas within the region 59 to act upwardly upon the lower surface 85 of the piston 31 and effect upward opening movement of the movable arcing contact 32. The upward opening movement of the movable arcing contact 32 will be followed by the movable disconnecting contact 38 so that the orifice opening 33 will continue to be closed until the actuating piston 39 passes through the distance "*l*" and abuts the plate portion 56. When this occurs, the lower movable disconnecting contact 38 will be halted, and the upper movable arcing contact 32 will separate therefrom drawing an arc and permitting the blasting of high-pressure gas through the orifice opening 33, through the conduit means comprising passageway 30 and out through the hollow terminal stud 6.

The purpose of delaying the separation of the contact structure 11, until the distance "*l*" has been taken up is to insure a substantial exhaustion of the passageway 30 and thereby to bring about a higher differential pressure across the orifice opening 33 to insure very fast arc extinction.

With reference to FIG. 5 of the drawings, it will be noted that the exhaustion of the opening control pipe 76 will not be immediately transmitted to the pipe 86, but will be delayed for a short time until the pressure is slowly relieved within the region 75 above the piston 74.

When this occurs, the valve 72 will open, and the exhaust pressure will be transmitted through the pipe 86 and into the control valve 61. The pressure acting through the aperture 67 will then drive the piston valve 62 downwardly against the spring pressure 64 and register the openings 91, 68 to thereby exhaust the region 69. The exhaustion of the region 69 will permit the high-pressure gas, acting within the region 87 above the piston 39 to drive the same downwardly and thereby move the movable disconnecting contact 38 downwardly to its fully-open disconnecting position, as illustrated in FIG. 3 of the drawings.

As mentioned previously, the solenoid 29 is only momentarily energized to effect opening of the circuit interrupter 1. Upon deenergization of the opening solenoid 29, the compression spring 28 will return the double or two-way valve 25 to its position, as shown in FIG. 2, thereby pressurizing the opening control line 23 and pressurizing the region 22 through the control opening 21. In addition, the line 76 will be pressurized and this will be transmitted through the valve 72 (now open) and through the pipe 86 to the lower end of the control valve 61. The entering high-pressure gas within the control valve 61, together with the spring pressure 64 will effect upward movement of the piston valve 62 to the position shown in FIG. 2, thereby re-registering the opening 68 with the annular opening 63, and again pressurizing the region 69. As a result, in the fully open-circuit position of the interrupter 1, the movable arcing contact 32 is moved downwardly to its lower position, as illustrated in FIG. 3, and the overcenter springs 46, 47 maintain the movable disconnecting contact 38 downwardly with both sides of the lower piston 39 being pressurized.

To effect a closing operation of the circuit interrupter 1, the solenoid 90, associated with the two-way closing valve structure 82 is momentarily energized. This will exhaust the closing pipe 81 and, as a result, the high pressure gas passing through the opening 95 will move the valve piston 92 upwardly to register the openings 93, 94. This will evacuate the region 87 and cause the high-pressure gas within the region 69 to move the piston 39 upwardly to its closed engaged position, such as illustrated in FIG. 2 of the drawings.

The closing spring **37** is purposely made stronger than the combined action of the overcenter compression springs **46, 47** so that the distance "*l*" will be present in the fully closed-circuit position of the assemblage **7**.

Upon deenergization of the closing solenoid **90**, the closing control pipe **81** will be pressurized, and this will immediately affect downward movement of the valve piston **92** assisted by the spring pressure **99** to repressurize the region **87** above the piston **39** through the registered opening **93**. As a result, in the fully closed-circuit position of the assemblage **7**, as viewed in FIG. 2 of the drawings, high-pressure gas exists on both sides of the lower piston **39**, and the passageway **30** is likewise pressurized. The assemblage **7** is then in condition for a subsequent opening operation to be performed.

From the foregoing description of the invention, it will be apparent that there is provided an improved compressed-gas circuit interrupter of simplified construction and highly effective to maintain the gap open in the fully-open-circuit position of the interrupter. The overcenter toggle spring **46, 47** insure that the contact structure **11** will be positively maintained in the open or in the closed-circuit positions. In addition, the exhausting of gas through the terminal bushings **4, 5** is maintained at a minimum by the fast operation of the blast valve **13**. Moreover, due to the takeup of the small distance "*l*" a considerable pressure differential is built up across the orifice **33** prior to disengagement of the contacts **32, 38**. This results in fast arc extinction and reliable operation.

Although there has been illustrated and described a specific structure, it is to be clearly understood that the same was merely for the purpose of illustration, and that changes and modfications 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 compressed-gas circuit interrupter including a pressurized tank having an exhausting terminal bushing extending therewithin and at least partially supporting an arc-extinguishing assemblage, said terminal bushing having a hollow terminal stud through which compressed gas may exhaust out of the tank, said arc-extinguishing assemblage including a movable arcing contact with a nozzle exhaust opening therethrough cooperable with a movable disconnecting contact to establish an arc during the opening operation, a downstream blast valve disposed at the inner extremity of said hollow terminal stud and having a first piston for actuating the same, a second piston secured to the nozzle-shaped arcing contact for actuating the same upon opening the blast valve, a third piston secured to the movable disconnecting contact for actuating the same and operable within an operating cylinder, overcenter spring means acting on said movable disconnecting contact and functioning to bias said contact either in the closed or fully-open-circuit position, a perforated casing structure surrounding said contacts and providing free communication between the pressurized tank and the region immediately adjacent the contacts, pneumatic means for effecting opening and closing of said contacts, said pneumatic means operable first to reduce the pressure back of the first piston to open the blast valve to thereby reduce the pressure in back of said second piston to open the movable arcing contact, said pneumatic means having a delay device for delaying the reduction of pressure to one side of the third piston within the operating cylinder, whereby a delayed opening of the movable disconnecting contact is obtained, and means for equalizing the pressure on both sides of the third piston at the end of both the opening and closing operations to thereby speed up subsequent circuit-interrupter operations.

2. The combination according to claim **1**, wherein the movable disconnecting contact follows the initial opening movement of the movable arcing contact for a limited travel to increase the differential pressure across the nozzle-shaped movable arcing contact at the time of contact part.

3. The combination according to claim **1**, wherein a closing spring acts on the second piston to effect closing motion of the movable arcing contact upon closure of the blast valve.

4. The combination according to claim **1**, wherein a metallic support casting is affixed to the inner end of the terminal bushing and provides a conduit means paralleling the first piston and also an operating cylinder for the second piston.

5. The combination according to claim **1**, wherein opening and closing pneumatic lines extend from the arc-extinguishing assemblage through the pressurized tank to two-way opening and closing control valves situated externally of the pressurized tank.

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