

Feb. 26, 1957

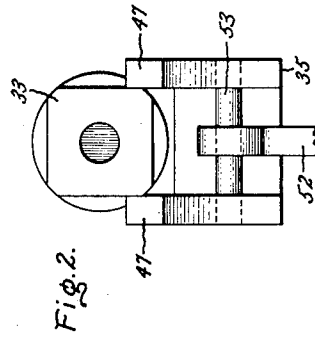
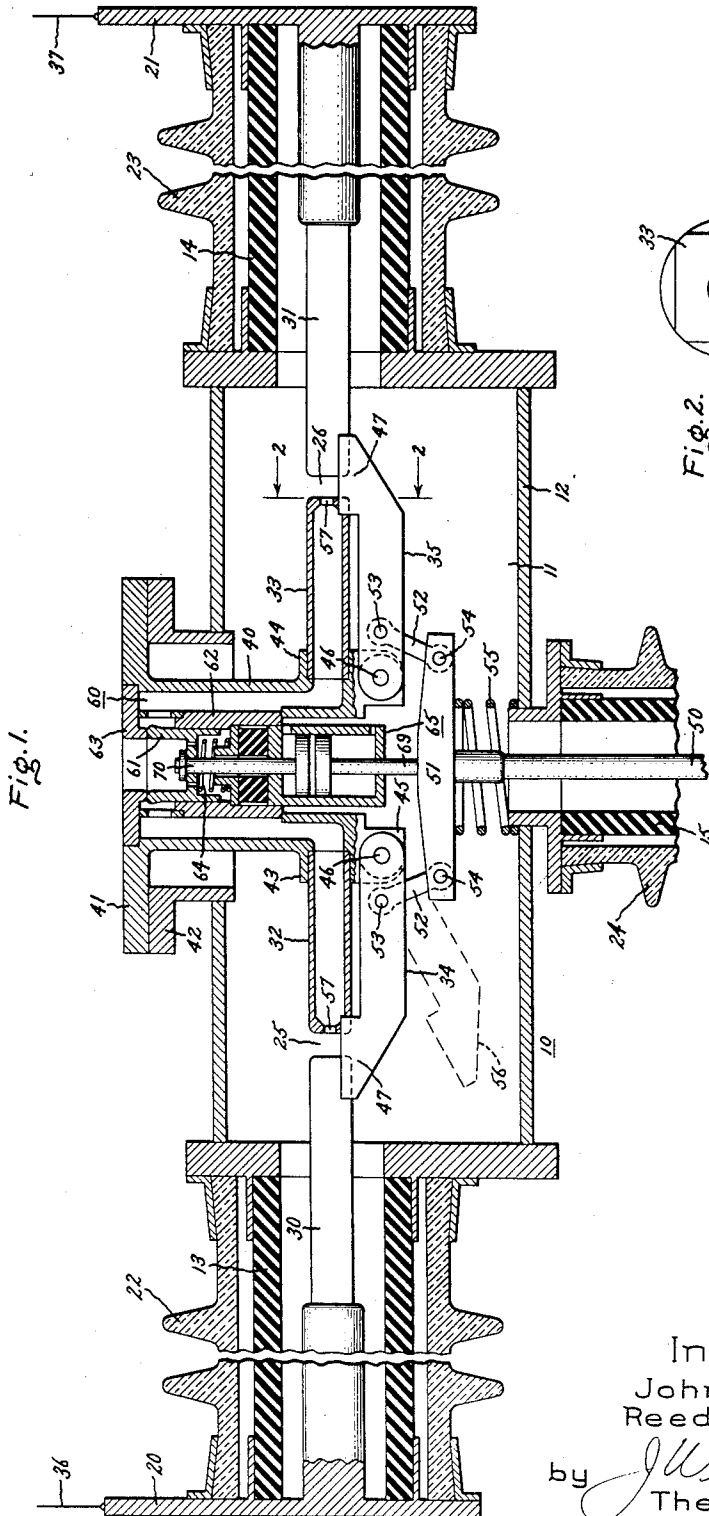
J. W. BEATTY ET AL

2,783,337

FLUID BLAST CIRCUIT INTERRUPTER

Filed Dec. 10, 1953

2 Sheets-Sheet 1



Inventors:
John W. Beatty,
Reed M. Anderson,
by *W. W. H. H. H.*
Their Attorney.

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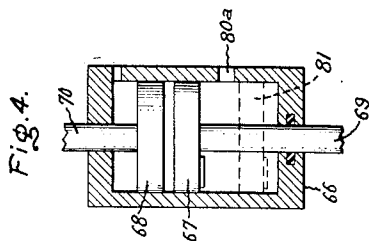
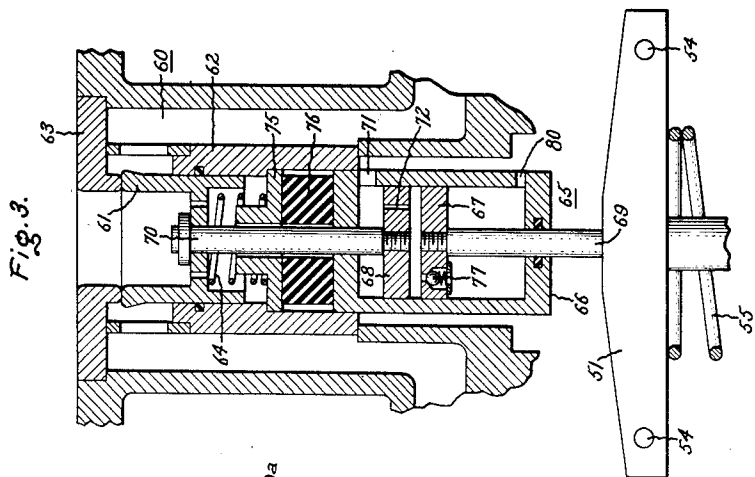
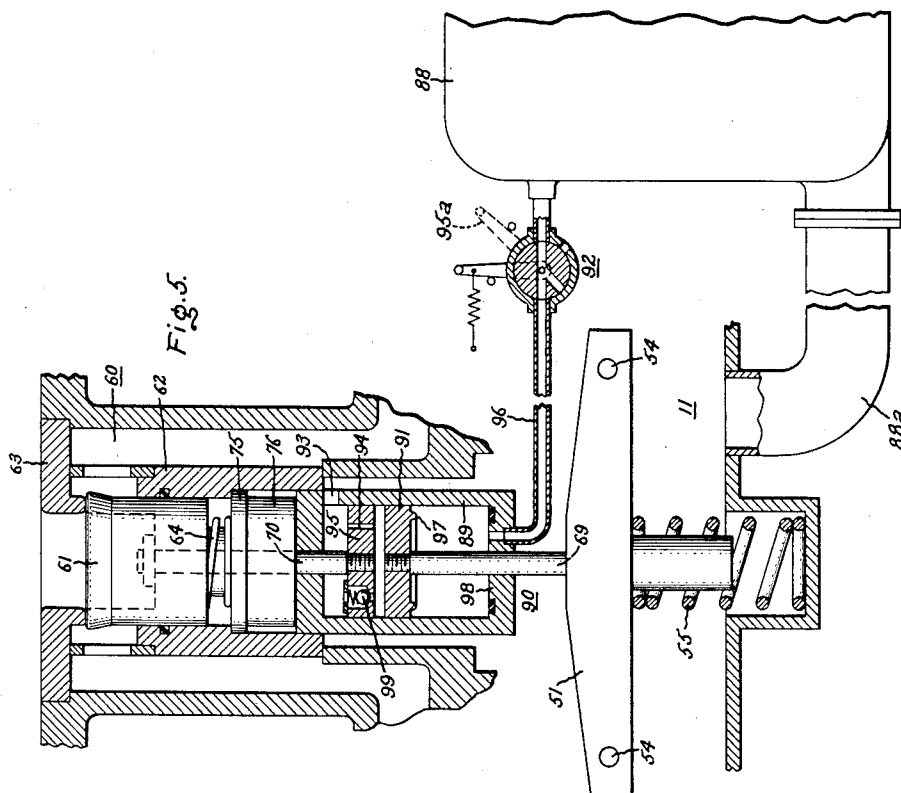
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FLUID BLAST CIRCUIT INTERRUPTER

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2 Sheets-Sheet 2



Inventors:
John W. Beatty,
Reed M. Anderson,
by *W. H. Sawyer*
Their Attorney.

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2,783,337

FLUID BLAST CIRCUIT INTERRUPTER

John W. Beatty, Lansdowne, and Reed M. Anderson, Glenolden, Pa., assignors to General Electric Company, a corporation of New York

Application December 10, 1953, Serial No. 397,324

20 Claims. (Cl. 200—148)

This invention relates to circuit interrupters of the fluid-blast type and, more particularly, to means for controlling the blast valve and the movable contact structure of such an interrupter.

Although our invention has been illustrated by showing it as applied to an interrupter of the gas-blast type, it is to be understood that the invention is equally applicable to interrupters of the liquid-blast type.

In the sustained pressure type of fluid-blast circuit breaker, high speed interruption of electrical circuits is obtained by locating the relatively movable interrupting contacts of the circuit breaker within an interrupting chamber filled with high pressure fluid. For producing a fluid-blast action which aids in extinguishing the arc established when the contacts are separated, there is usually provided a blast valve which is controlled so as to cause high pressure fluid, during circuit interruption, to flow rapidly past the contacts and to atmosphere. In order that a blast action be present when the contacts are separated and in order to conserve high-pressure fluid after circuit interruption, it is important that the movement of this blast valve be accurately coordinated with the movement of the contacts. More particularly, it is preferred that the blast valve should open immediately prior to initial contact separation and should close immediately after the circuit has been interrupted.

It is, therefore, an object of our invention to provide a simple and reliable means for controlling the blast valve of a fluid-blast type of circuit interrupter.

It is a further object of our invention to interrelate the movable contact structure and the blast valve by means of a fluid coupling which provides for opening of the blast valve before contact separation and which permits closing of the blast valve independently of movement of the contact structure after a predetermined contact separation.

It is a further object of our invention to incorporate a structurally simple contact-controlling dashpot into such a fluid coupling.

It is a further object of our invention to provide a novel arrangement of relatively movable contacts which is capable of providing rapid contact separation and is especially adapted for use in gas-blast interrupters of the sustained pressure type.

In carrying out these objects in accordance with one form of the present invention, the movable contact structure and the blast valve are operatively interconnected by a pneumatic coupling which comprises a cylinder and a pair of oppositely-disposed pistons reciprocable therein. One of these pistons acts as a driving piston and is coupled to the movable contact structure, whereas the other of the pistons is coupled to the blast valve and acts as a follower piston. Contact opening movement of the driving piston establishes on opposite sides of the follower piston a pressure differential acting in a direction to move said follower piston in coupled follow-up relationship to said driving piston whereby to open the normally-closed

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blast valve. Means are provided for rapidly reducing this pressure differential after a predetermined opening stroke whereby to release the follower piston so as to permit the blast valve to close. Another feature of one form of the present invention is that the cylinder has a restricted end portion which confines the gas ahead of the driving piston as it moves toward open position whereby to provide a dashpot action at the end of the opening stroke.

Further objects and advantages of our invention will become apparent as the following description proceeds, and the features of novelty which characterize our invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of our invention, reference may be had to the accompanying drawings in which Fig. 1 is an elevational view, partly in section, of a gas-blast circuit interrupter embodying the present invention; Fig. 2 is an enlarged sectional view taken along the line 2—2 of Fig. 1; Fig. 3 is a detailed view showing a pneumatic coupling constructed in accordance with the present invention; Fig. 4 illustrates a modified form of pneumatic coupling; and Fig. 5 illustrates still another modification of the pneumatic coupling of the present invention.

Referring now to Fig. 1 there is shown a circuit breaker of the gas-blast type comprising an interrupting unit generally indicated at 10. This interrupting unit comprises an enclosed interrupting chamber 11 defined, in part, by a metallic casing 12 and a pair of tubular members 13 and 14 of insulating material mounted at opposed ends of the casing 12. The interrupting chamber 11 communicates through an insulating conduit 15 with a source (not shown) of high pressure gas so that, preferably, the chamber 11 is normally filled with gas at a pressure equal to that of the source. The outer ends of the chamber 11 are sealed by means of terminal plates 20 and 21 supported from the tubular members 13 and 14. The tubular members 13 and 14, which are constructed of a material possessing high mechanical strength so as to be capable of withstanding the sustained gas pressure within chamber 11, are preferably enclosed within tubular weather-proof porcelain insulators 22 and 23. For supporting the interrupting unit 10 there is provided a tubular insulating column 24 which surrounds the conduit 15 and is preferably of porcelain.

The stationary contact structure for the circuit breaker of Fig. 1 comprises, in general, a pair of elongated rod contacts 30 and 31 supported from terminal plates 20 and 21, respectively, and extending inwardly therefrom, and a centrally-disposed pair of electrically interconnected tubular nozzle-type contacts 32 and 33. These pairs of contacts define, at their extremities, a pair of gaps 25 and 26, which are bridged by a pair of pivotally-mounted movable contact blades 34 and 35. The terminal plates 20 and 21 are respectively connected to power lines 36 and 37, so that the electrical circuit through the breaker is as follows: from power line 36 and terminal plate 20, current will flow through the rod contact 30, bridging contact 34, tubular contacts 32 and 33, then through bridging contact 35, rod contact 31, and finally through the terminal plate 21 to power line 37.

For supporting the centrally-disposed tubular contacts 32 and 33 in axially-aligned relationship, there is provided a generally cylindrical casting 40. The casting 40 has at its upper end a flange 41 which is supported from the casing 12 by means of a suitable flanged adaptor 42 carried by the casing 12. At its lower end the casting 40 is formed with a pair of tubular projections 43 and 44 which tightly receive and are united with the inner ends of the tubular contacts 32 and 33.

For pivotally supporting the movable bridging contacts

34 and 35, each of the tubular projections 43 and 44 has a clevis 45 carrying a suitable pivot pin 46 extending freely through an aperture formed in the inner end of the movable bridging contact. As best seen in the sectional view of Fig. 2, proper contact-wipe is obtained by forming the extremities of the rod contact 31 and the nozzle contact 33 of a rectangular external cross-section and the bridging contact 35 with spaced arms 47 having essentially flat inner surfaces which slidably contact the flat sides of the associated stationary contacts 31 and 33.

For effecting opening and closing operation of the bridging contacts 34 and 35 of Fig. 1, there is provided a reciprocable actuating rod 50 which is connected at its lower end to a suitable operating mechanism (not shown). At its upper end the actuating rod 50, which is of insulating material, is connected to the pivotal bridging contacts 34 and 35 through an actuating crosshead 51 secured to the rod 50. This crosshead has at each of its ends a connecting link 52 which is pivotally joined at 54 and 53 to the crosshead and a bridging contact, respectively, by suitable pivot pin structure. A compression spring 55 biases the contacts 34 and 35 toward closed position. Thus, it will be apparent that when the actuating rod 50 is moved rapidly downward against the bias of spring 55, the bridging contacts 34 and 35 are rapidly moved from the solid line position to the dotted line position 56 whereby to effect interruption of the circuit through the circuit breaker, as will be described in greater detail hereinafter.

For producing a gas-blast action for extinguishing the arcs which are established at the gaps 25 and 26 when the bridging contacts are moved downwardly to the dotted line position of Fig. 1, there is provided an exhaust passage 60 which leads from the interrupting chamber 11 through the tubular contacts 32, 33 and through the cylindrical casting to the surrounding atmosphere. The tubular contacts 32 and 33 are provided with nozzle throats 57 defining inlets to the exhaust passage 60. For controlling the flow of arc-extinguishing gas through the nozzle throats 57 and through the exhaust passage 60, there is provided at the outer end of the exhaust passage 60 a cylindrically-shaped reciprocable blast valve 61 which slides smoothly in a surrounding tubular valve housing 62 and abuts, in its closed position, against a stationary annular valve seat 63. Thus, the exhaust passageway 60 is defined by the nozzle throats 57, the inner walls of the tubular contacts 32 and 33, the inner walls of cylindrical casting 49, the cooperating outer wall of a tubular valve housing 62, and the valve seat 63 which is suitably united to casting 49. The blast valve 61 is preferably of the balanced piston type, as shown, and is biased toward a normally-closed position by means of a valve reset spring 64. Since the chamber 11 is normally filled with high-pressure gas, it will be apparent that when valve 61 is moved down to open (by means described more fully hereinafter) gas in the chamber 11 will flow at high speed through the nozzle throats 57, and out the passage 60 past valve 61 to atmosphere. This rapid flow of gas through the nozzle throats 57 creates an axial arc-enveloping blast action at gaps 25 and 26 which is effective to extinguish the arcs drawn thereat.

A more specific description of the manner in which arcs are established and interrupted during opening operation of the breaker is as follows: When the pivoted blades 34 and 35 are moved rapidly downward, a pair of series-related arcs are established, one between rod contact 30 and blade 34 and one between rod contact 31 and blade 35. Since immediately prior to contact separation, opening of blast valve 61 has taken place, the high pressure gas flowing into the throats 57 has created a blast action at the gaps 25 and 26. This blast action constitutes a hose-like gas stream flowing at high speed which envelops the arc so that such action rapidly transfers the arcs from the blades 34 and 35 into the tubular contacts 32 and 33,

respectively, and subsequently effects rapid extinction of these arcs.

Since any interrupting blast produces but a limited decrease in pressure in the chamber 11, high pressure gas is always present at the gaps 25 and 26, and since, in general, the dielectric strength of a gas varies directly with its pressure, it is possible to obtain full across-the-line insulation with only a very small contact separation at gaps 25 and 26. The small separation required makes it possible for the movable blades 34 and 35 to carry out both interruption and isolation functions within a very short time after contact separation is initiated. As a result, a large portion of the opening stroke of the blades 34 and 35 is available and therefore is used for deceleration action without, however, affecting the interrupting or isolating characteristics of the device. For example, where each of the pivoted blades moves through a total angle of 28° and full insulation is obtained after a 14° rotation (the position at which the space between the rod contact 30 and the blade 34 approximates the space between rod contact 30 and tubular contact 32), the final 14° of rotation is available for deceleration of the moving parts of the circuit breaker. Deceleration is further facilitated by the pivoted construction of the blades 34, 35, because only the outer ends of the blades are moved at relatively high velocity. The heavier operating mechanism is connected to the blades adjacent the pivot points 46 and, hence, moves at a much slower speed, thereby facilitating deceleration of the moving parts at the end of the opening stroke.

Thus, from the above description of the opening characteristics of the circuit breaker, it should be apparent that the disposition of the pivoted contact structure of the present invention within a high pressure gas chamber is a significant factor in making possible positive interruption and isolation within a very short time whereby a large portion of the contact opening stroke remains available and is utilized for smooth deceleration of the moving parts of the breaker.

It is important that movement of the blast valve 61 be accurately coordinated with movement of the movable contacts 32 and 33. More particularly, in order to effect rapid arc extinction, it is desirable that the arc-extinguishing blast action be initiated somewhat before the arc is established between interrupting contacts. Additionally, in order to conserve gas, it is important that the blast valve be closed as soon as the circuit has been interrupted after an adequate contact separation. For effectively and reliably obtaining this desired coordination between the movement of the blast valve 61 and the contacts 34 and 35, in accordance with one form of this invention, there is provided a pneumatic coupling 65 which operatively interconnects the movable contacts 34, 35 and the blast valve 61. Referring more particularly to the detailed view of Fig. 3, the pneumatic coupling 65 comprises a stationary enclosing cylinder 66 and a pair of coaxially disposed cooperating pistons 67 and 68 reciprocable within the cylinder. The lower or driving piston 67 is actuated from the crosshead 51 by means of a piston rod 69 connected between piston 67 and crosshead 51 and extending slidably through a sealed opening in the lower end wall of the cylinder 66. The upper or follower piston 68 is coupled to the blast valve 61 by means of a piston rod 70 which is connected between piston 68 and blast valve 61. The outer peripheries of the reciprocable pistons 67 and 68 are sealed with respect to the internal wall of cylinder 66 so that substantially no gas flows past the pistons around the outer peripheries thereof. Preferably, conventional piston rings (not shown) may be used to insure a reliable seal.

The manner in which the pneumatic coupling 65 provides the desired coaction between the movable contacts and the blast valve will now be described. When the movable contacts are in closed position, the piston 67 and 68 are in the position of Fig. 3. Since, at its upper end,

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the cylinder 66 is provided with an inlet port 71 communicating with the interrupter chamber 11 and since the upper piston 68 is provided with a small bleed passage 72 extending therethrough, the gas on both sides of the upper piston 68 is at the same pressure as the gas at the pressure source when the pistons are in the position of Fig. 3. The same pressure also exists below the driven piston 67 by reason of the restricted exit port 80 from the cylinder 66 near its lower end communicating with the casing 11. Now when the actuating rod 50 is moved rapidly downward (by mechanical means not shown) to effect opening of the circuit breaker, the lower piston 67, being directly coupled to the rod 50, also moves rapidly downward. This downward movement instantaneously reduces the pressure of the gas in the small restricted space between the two pistons whereby a pressure differential is rapidly established on axially opposite faces of the upper piston 68. As downward movement of the lower piston continues, this pressure differential rapidly builds up to a value wherein it provides sufficient downward force to overcome the opposing action of valve reset spring 64 and thereby to cause the upper piston 68 to move in follow-up relationship to the lower piston 67. As a result of this movement of the upper or follower piston, the blast valve 61 is withdrawn from its seat and opened, as desired. The smaller the initial space between the pistons, the faster will be the follow-up movement of the follower piston with respect to the driving piston. The movable contacts 34 and 35 have sufficient wipe with respect to the cooperating stationary contacts to permit the blast valve 61 to be opened just before separation of the contacts occurs. As a result, the desired blast action has been initiated at the gaps 25 and 26 at the instant the arcs are drawn at the gaps.

The upper piston will move downward in follow-up relationship to the lower piston until the valve 61 strikes an annular stop 75, which is supported at the top of the cylinder 66 upon an annular slightly yieldable buffer element 76. When this abutting action occurs, downward movement of the upper piston 68 ceases, at an appropriate fully-open valve position, but the lower piston 67 continues to move downward, driven by the breaker operating mechanism. This continued downward movement of lower piston 67 again reduces the pressure between the two pistons and, at the same time, due to the compression of gas in the restricted chamber at the underside of the piston 67, increases the pressure on the underside of piston 67. The resulting pressure differential across the lower piston 67 thus produces a moderate retarding action which becomes effective during the last portion of the opening stroke. As a result, smooth deceleration of the moving parts of the circuit breaker is effected as the opening stroke is completed.

As previously explained, in order to conserve the high-pressure gas within chamber 11, the valve 61 should be returned to closed position at an appropriate point during the opening stroke, or, at least, as soon as the opening stroke is completed. Since the circuit breaker of Fig. 1 is preferably latched in open position by latch means (not shown), it will be apparent that valve 61 must be capable of returning to its closed position independently of the operating mechanism which produced opening of the valve. This independence of motion is effectively obtained in one form of the circuit breaker of the present invention by release means comprising the bleed passage 72 extending through the upper piston 68. Specifically, while the contacts are moving toward fully open position and the pistons 67 and 68 are moving downwardly in coupled follow-up relationship, a restricted flow of gas into the space between the pistons is taking place through bleed passage 72. This flow through bleed passage 72 tends to equalize the pressure on opposite sides of the follower piston 68 so that after a predetermined downward movement of the follower piston, the pressure differential on opposite sides of this

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piston is sufficiently reduced to permit valve reset spring 64 to predominate whereby to return the follower piston and the blast valve to the closed-valve position. Preferably, the bleed passage 72 is of such a size that in approximately 3 cycles sufficient gas flows through passage 72 to effect the reversal of the follower piston and the blast valve.

From the above description of the opening operation, it will be apparent that the pneumatic coupling 65 not only serves to effectively coordinate the movement of the valve 61 and the contacts 34, 35 in the desired manner, but also serves as an effective dashpot for smoothly decelerating the moving parts of the circuit breaker at the end of opening stroke.

It additionally will be apparent that the pneumatic coupling of the present invention is especially adapted to control the blast valve 61 in a manner which permits establishment of a blast action at the gaps 25 and 26 at a very early instant after the circuit breaker responds to a fault. More particularly, since the space above the valve-connected upper piston 68 communicates freely (at 71) with the sustained-pressure interrupter chamber 11, full supply pressure will always be present above the piston 68, and as a result, a large downward force on piston 68, and accordingly, valve 61, is produced by a slight downward movement of the lower piston 67 from the closed position of Fig. 3. This rapid opening response of blast valve 61 permits the desired blast action to be initiated almost simultaneously with initiation of the opening movement of the cross head 51.

Closing operation of the breaker is effected by means of the closing spring 55 which, when unlatched, moves the crosshead 51 and the contacts 34, 35 upwardly into closed position. The check valve 77 in the lower piston 67 permits relatively-free gas flow downwardly past piston 67 thereby allowing for rapid closing operation without excessive retardation from the pneumatic coupling 65.

Fig. 4 illustrates an alternative arrangement for obtaining the desired independence of motion between valve 61 and contacts 34, 35 at a predetermined point in the opening stroke. Parts in Fig. 4 which correspond to the parts of Fig. 3 are designated by corresponding reference numerals. In the arrangement of Fig. 4, a release port 80a, which is relatively large compared to the port 80 of Fig. 3, is provided for interconnecting the interrupter chamber 11 in the interior of cylinder 66. This port 80a is preferably disposed slightly above the lowermost position 81 (shown in dotted lines) that the driving piston 67 will occupy at the end of its opening stroke. As a result, when the driving piston 67 is moved toward its lowermost position 81 with the follower piston 68 in coupled follow-up relationship, and the port 80a is brought into communication with the space between the pistons, the pressure differential on opposite sides of the upper follower piston will instantaneously be reduced so that the follower piston releases from its driving piston to return immediately to the valve closed position under the influence of the valve reset spring 64. It will be apparent that rapid release of the follower piston from its coupled relationship to the driving piston may be obtained at any desired point in the opening stroke by placing the port 80a at the desired point of release along the bore of cylinder 66. It will also be apparent that by utilizing the port 80a for releasing the pistons from coupled relationship, it is possible to dispense with the bleed passage formed in the follower piston.

In the modification of Fig. 4, a very effective retarding force is applied to the moving parts of the breaker as the opening stroke is completed by virtue of the fact that as the driving piston 67 passes below the port 80a, the piston must compress the gas confined in the closed lower portion of the cylinder 66.

Fig. 5 illustrates still another modification of the present invention wherein the parts corresponding to the

parts of Fig. 1 are designated by corresponding reference numerals. This modification differs from those previously described, principally by reason of the fact that in Fig. 5 the actuating means for the circuit breaker is incorporated directly into the pneumatic coupling structure instead of being separate therefrom. More particularly, Fig. 5 shows a pneumatic coupling 90 connected between the blast valve 61 and the crosshead 51, as in Fig. 1, but in Fig. 5 opening movement from the closed-contact position shown is produced by dumping gas from the closed cylinder below the lower piston 91 by means of a two-way control valve 92 controlled by suitable fault-responsive means (not shown). Sustained-pressure interrupting chamber 11 communicates freely with the supply reservoir 88 by means of conduit 88a, so that when the pistons are in the contact-closed position shown, the gas on both sides of lower or driving piston 91 is at a pressure corresponding to the pressure in supply reservoir 88. This is the case because the upper side of the piston 91 communicates with the sustained-pressure interrupting chamber 11 through an inlet 93 formed in cylinder 89 and through a bleed passage 94 formed in upper follower piston 95; similarly, the lower side of driving piston 91 communicates with the supply 88 through conduit 96 and valve 92. Accordingly, as in the first embodiment in Fig. 3, in the normally-closed breaker position all pneumatic pressures above the two pistons are equalized so that the blast valve and contacts must rely upon their respective springs 64 and 55 for maintaining their closing bias. Now, when control valve 92 is rotated clockwise from the solid line position to the dotted line position 95a so as to vent the conduit 96 to atmosphere, a pressure differential is created on opposite sides of lower piston 91. This pressure differential is sufficient to move the piston 91 and the interconnected crosshead rapidly downward against the bias of closing spring 55 and, as a result, to open the contacts of the circuit breaker. This downward movement of the lower piston reduces the pressure on the underside of the upper piston 95 thereby causing the upper piston to move downward in coupled follow-up relation to the lower piston until the valve 61 strikes the stop 75. The bleed passage 94 permits a metered gas flow to the coupling space between the two pistons, so that after a predetermined time delay, the pressures on opposite sides of the upper piston tend to equalize, and the valve 61 will return to closed position under the influence of its reset spring 63, as described with respect to the modification of Figs. 1-3.

An additional feature of the modification of Figure 5 is that the means for holding the circuit breaker in open-contact position is incorporated directly into the pneumatic coupling. More specifically, the lower piston 91 is formed with an annular raised seat 97 which seats in sealing relation against the lower wall 98 of cylinder 89 when the piston 91 is in its lowermost position. When this condition occurs, the force exerted by the gas pressure above the lower piston 91 maintains the piston in its lowermost position so long as the control valve 92 is open to atmosphere. This provides a simple and effective means for holding the circuit breaker contacts in open position, as desired.

Closing operation of the circuit breaker of Fig. 5 may be effected by returning control valve 92 from venting position 95a to the solid line position, thereby supplying high pressure gas to the underside of lower piston 91. This high pressure gas acting together with the spring 55 moves the piston 91 upwardly, whereby to close the contacts of the circuit breaker. The check valve 99 disposed in upper piston 95 permits the lower piston 91 to move upwardly without appreciable retardation resulting from the air in the coupling space ahead of the upwardly moving piston 91.

While we have shown and described particular embodiments of our invention, it will be obvious to those

skilled in the art that various changes and modifications may be made without departing from our invention in its broader aspects and, we, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A fluid-blast circuit interrupter comprising separable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member movable to separate said contacts, fluid coupling cylinder structure, a follower piston movable in said cylinder structure and coupled to said blast valve, and means comprising a driving piston disposed in said cylinder structure and movable with said actuating member to establish on opposite faces of said follower piston a pressure differential acting in a direction to move said follower piston in coupled follow-up relationship to said driving piston.

2. A fluid-blast circuit interrupter comprising separable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member movable to separate said contacts, a fluid coupling operatively interconnecting said blast valve and said actuating member, said fluid coupling comprising a follower piston operatively connected to said blast valve and means comprising a driving piston movable with said actuating member to establish on opposite sides of said follower piston a pressure differential acting in a direction toward said follower piston whereby to move said follower piston in coupled follow-up relation to said driving piston.

3. A fluid-blast circuit interrupter comprising separable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member movable to effect separation of said contacts, fluid coupling cylinder structure, a follower piston movable in said cylinder structure and coupled to said blast valve, a driving piston disposed in said cylinder structure and movable with said actuating member through a predetermined stroke, said cylinder structure having an essentially closed wall portion slidably and sealingly receiving said pistons to restrict entry of fluid into the space between said pistons during at least a portion of said stroke thereby to couple said pistons to move substantially together during said portion of the stroke.

4. A fluid-blast circuit interrupter comprising separable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member movable to effect separation of said contacts, fluid coupling cylinder structure, a follower piston movable in said cylinder structure and coupled to said blast valve so as to occupy a first predetermined position when said valve is closed, a driving piston disposed in said cylinder structure and coupled to said actuating member so as to occupy a second predetermined position when said contacts are closed, said cylinder structure having an essentially closed wall portion which extends between said predetermined positions of said pistons and sealingly receives said pistons so as to restrict the flow of fluid into the space between said pistons whereby movement of said driving piston away from said follower piston reduces the fluid pressure in the space between said pistons whereby to move said follower piston in coupled follow-up relationship to said driving piston.

5. A fluid-blast circuit interrupter comprising relatively movable contacts, an actuating member for moving one of said contacts through an opening stroke between a closed and a fully-open position, a biased closed blast valve operable to provide a flow of fluid adjacent said contacts during said opening stroke, fluid coupling comprising a follower piston operatively connected to said blast valve and means comprising a driving piston movable with said actuating member for establishing on opposite sides of said follower piston a pressure differential acting in a direction to move said follower piston in follow-up relation

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to said driving piston during said opening stroke thereby to open said blast valve during said opening stroke, and release means effective after a predetermined portion of said opening stroke for reducing said pressure differential whereby to permit said biased closed blast valve to return to its closed position.

6. A fluid-blast circuit interrupter comprising relatively movable contacts, an actuating member for moving one of said contacts through an opening stroke between a closed and a fully-open position, a biased closed blast valve openable to provide a flow of fluid adjacent said contacts during said opening stroke, a fluid coupling comprising a follower piston operatively connected to said blast valve and means comprising a driving piston movable with said actuating member to establish on opposite sides of said follower piston a pressure differential acting in a direction to cause said follower piston to move in follow-up relation to said driving piston during said opening stroke thereby to open said blast valve during said opening stroke, said pistons defining a space therebetween after movement through a predetermined portion of said opening stroke, release means comprising a passageway communicating with said space and with a source of fluid at a higher pressure than the fluid in said space whereby to admit relatively high pressure fluid to said space so as to reduce said pressure differential sufficiently to permit said biased closed blast valve to return to closed position.

7. The interrupter of claim 6 in which said passageway is a bleed passage formed in said follower piston.

8. A fluid-blast circuit interrupter comprising relatively movable contacts, an actuating member for moving one of said contacts through an opening stroke between a closed and a fully-open position, a biased closed blast valve openable to provide a flow of fluid adjacent said contacts during said opening stroke, a fluid coupling arranged to effect opening of said blast valve during said opening stroke, said coupling comprising cylinder structure, a follower piston disposed in said cylinder structure and coupled to said blast valve, and means comprising a driving piston disposed in said cylinder structure and movable with said actuating member to establish on opposite sides of said follower piston a pressure differential acting in a direction to cause said follower piston to move in follow-up relationship to said driving piston during said opening stroke, said pistons defining a space therebetween after movement through a predetermined portion of said opening stroke, release means comprising a passageway formed in said cylinder structure and communicating with said space and with a source of fluid at a pressure higher than the fluid pressure in said space whereby to admit relatively high pressure fluid to said space so as to reduce said pressure differential sufficiently to permit said biased closed blast valve to return to closed position.

9. A fluid-blast circuit interrupter comprising separable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member movable to effect separation of said contacts, a fluid coupling operatively interconnecting said blast valve and said actuating member, said fluid coupling comprising cylinder structure, a follower piston disposed in said cylinder structure and operatively connected to said blast valve and means comprising a driving piston movable with said actuating member to establish on opposite sides of said follower piston a pressure differential acting in a direction to cause said driven piston to move in follow-up relation to said driving piston, said driving piston being movable between a first position wherein the contacts are closed and a second position wherein the contacts are fully-open, said cylinder structure having adjacent said second position a restricted end portion cooperating with said driving piston to retard said driving piston as it moves into said second position.

10. A fluid-blast circuit interrupter comprising relatively movable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member for effecting relative movement of said contacts, a

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fluid coupling comprising cylinder structure, a driving piston movable in said cylinder structure and operatively connected to said actuating member and a follower piston movable in said cylinder structure and operatively connected to said blast valve, said driving piston being movable through a predetermined stroke corresponding to relative movement of the contacts from a closed to a fully-open position, pressure control means for causing said follower piston to move in follow-up relationship to said driving piston, and stop means limiting the movement of said follower piston to a stroke which is shorter than said predetermined stroke for said driving piston.

11. A fluid-blast circuit interrupter comprising relatively movable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member for effecting relative movement of said contacts, a fluid coupling comprising cylinder structure and a driving and a follower piston movable therein, said driving piston being movable with said actuating member and said follower piston being operatively connected to said blast valve, said driving piston being movable through a predetermined stroke corresponding to relative movement of the contacts from a closed to a fully-open position, pressure control means for causing said follower piston to move in follow-up relationship to said driving piston, stop means limiting the movement of said follower piston to a stroke which is shorter than said predetermined stroke for said driving piston, said cylinder structure having a restricted end portion adjacent the position which said driving piston occupies when said contacts are in fully-open position.

12. A fluid-blast circuit interrupter comprising a chamber filled with fluid under pressure, separable contact members mounted within said chamber, an actuating members movable to separate said contact member, an exhaust passage extending from said chamber to a region of lower pressure, a blast valve movable to control the fluid flow through said exhaust passage, cylinder structure, a follower piston having oppositely disposed faces and movable in said cylinder structure, said follower piston being coupled to said blast valve, a driving piston disposed in said cylinder structure and cooperating with one face of said follower piston to define between said pistons a coupling space containing fluid at a predetermined pressure, the other face of said follower piston being in free communication with said chamber, said driving piston being movable with said actuating member to reduce the fluid pressure in said coupling space whereby to move said follower piston in coupled follow-up relationship to said driving piston.

13. In a fluid-blast circuit interrupter, a stationary nozzle-type contact of tubular configuration, a second contact disposed in generally axially-aligned relationship with said tubular contact and spaced therefrom to define a gap between said contacts, a cooperating movable contact member mounted for pivotal movement toward and away from said gap, said movable contact member having a bridging portion which bridges said gap when the contact member has been moved toward said gap and which is spaced from said gap when the contact member has been moved away from said gap, means including an actuating member connected to said contact member for producing pivotal movement of said contact member toward and away from said gap, and means operable upon movement of said contact member away from said gap to produce a fluid blast which flows through said gap and then into said nozzle-type tubular contact.

14. A circuit interrupter comprising a plurality of generally axially-aligned pairs of stationary contacts defining a pair of gaps, a pair of cooperating movable contact members each having a bridging portion which bridges one of said gaps, each of said movable contact members being pivotally mounted on pivot structure, actuating mechanism for producing simultaneous movement of said movable contacts, said actuating mechanism comprising

a reciprocable cross-head member which is connected to each of said movable contact members at a point on the movable contact member located between said pivot structure and said bridging portion.

15. A fluid-blast circuit interrupter comprising separable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member movable to separate said contacts, and a fluid coupling comprising cylinder structure and a pair of relatively movable pistons reciprocable in said cylinder structure, one of said pistons being operatively connected to said blast valve and the other of said pistons being operatively connected to said actuating member, flow control means for exhausting the space at one side of said other piston to a region of lower pressure whereby said other piston acts as the driving means for said actuating member.

16. A fluid-blast circuit interrupter comprising separable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member movable to separate said contacts, a fluid coupling containing fluid under pressure and operatively interconnecting said blast valve and said actuating member, said coupling comprising a follower piston operatively connected to said blast valve and means comprising a driving piston movable with said actuating member to establish a pressure differential on opposite sides of said driven piston so as to cause said follower piston to move in follow-up relation to said driving piston, flow control means for exhausting the space at one side of said driving piston to a region lower pressure whereby said driving piston acts as the driving means for said actuating member.

17. A fluid-blast circuit interrupter comprising separable contacts, a blast valve movable to control the flow of fluid adjacent said contacts, an actuating member movable to separate said contacts, a fluid coupling containing fluid under pressure and operatively interconnecting said blast valve and said operating mechanism, said fluid coupling comprising a follower piston operatively connected to said blast valve and means comprising a driving piston movable with said actuating member to establish a pressure differential on opposite sides of said follower piston acting in a direction to cause said follower piston to move in follow-up relation to said driving piston, flow control means for producing a reduced pressure on one side of said driving piston whereby said driving piston acts as the driving means for said actuating member, means for maintaining said reduced pressure on

said one side of said driving piston when said contacts are fully-open whereby to hold said contacts in fully-open position.

18. The interrupter of claim 17 in which said flow control means comprises a passage extending from said cylinder, and said driving piston having a portion which seals off said passage when the driving piston is moved to a position corresponding to the fully-open contact position whereby the contacts are held in fully-open position by fluid pressure within said cylinder.

19. In a fluid-blast circuit interrupter, separable contacts, a blast valve movable to an open position to produce a flow of fluid adjacent said contacts, cylinder structure, a first piston movable within said cylinder structure and coupled to said blast valve, a second piston movable within said cylinder structure and coupled in motion-transmitting relation with one of said contacts, and means for establishing on opposite sides of each of said pistons a pressure differential which drives said first piston in a direction to open said valve and drives said second piston in a direction to separate said contacts, and means responsive to movement of said second piston for equalizing the pressure on opposite sides of said first piston to allow said valve to close.

20. In a fluid-blast circuit interrupter, separable contacts, a normally-closed blast valve movable to an open position to produce a flow of fluid adjacent said contacts, cylinder structure, a first piston coupled to said blast valve and movable within said cylinder structure in one direction to open said blast valve, a second piston coupled to one of said contacts and movable within said cylinder structure in the same direction as said first piston during opening of said contacts, means for releasably coupling said pistons together for movement in the same direction during a contact-opening operation, and means responsive to movement of said contact-coupled piston in said one direction to admit pressurized fluid into a space between said two pistons whereby to release the coupling between said pistons and thus allow the valve to close.

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