Jan. 19, 1960 C. F. CROMER ET AL 2,922,010

CIRCUIT INTERRUPTERS

Filed Dec. 20, 1956 6 Sheets-Sheet 1

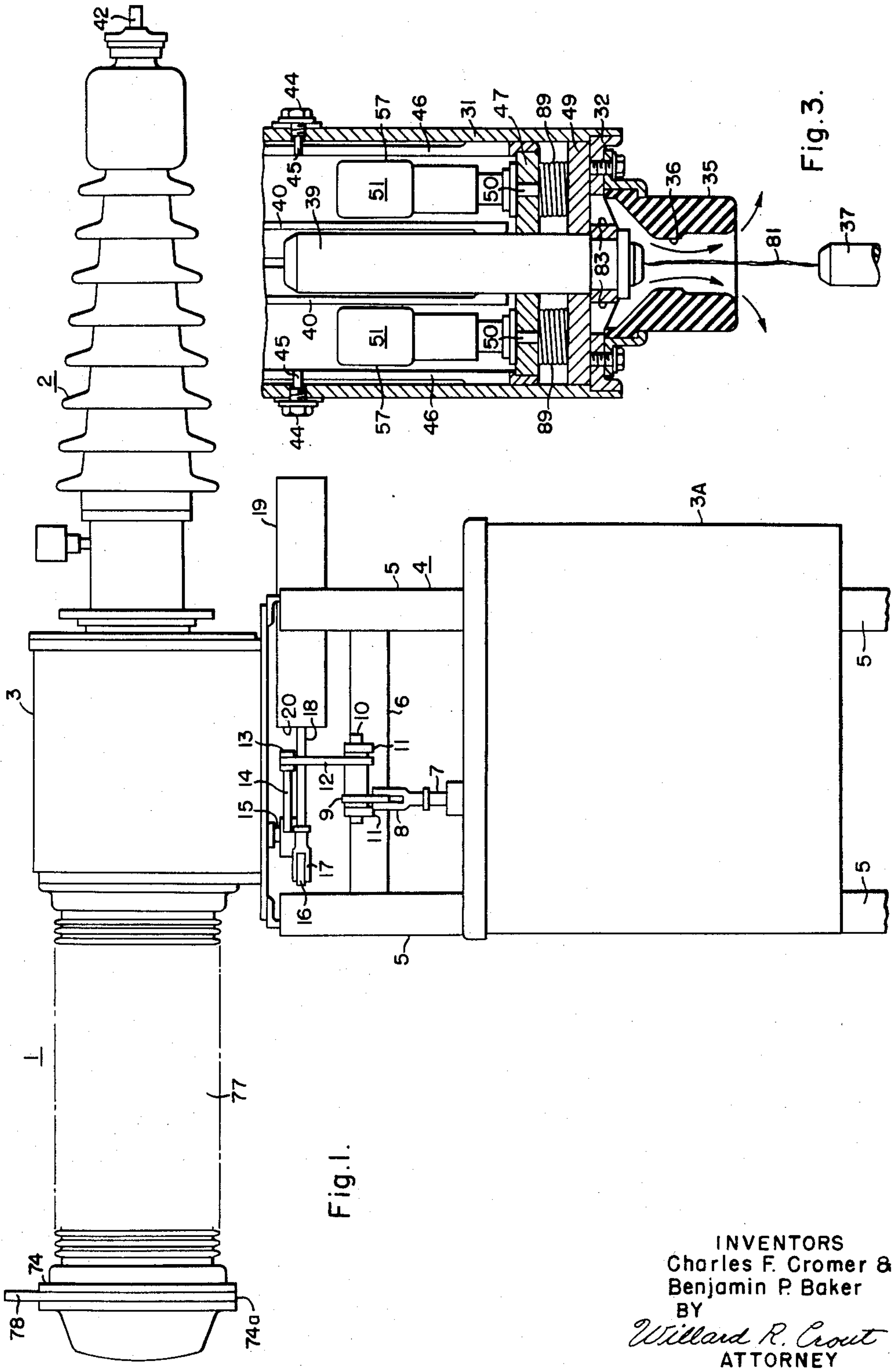

Fig. 3.

Fig. 1.

INVENTORS
Charles F. Cromer &
Benjamin P. Baker
BY
Willard R. Crout
ATTORNEY

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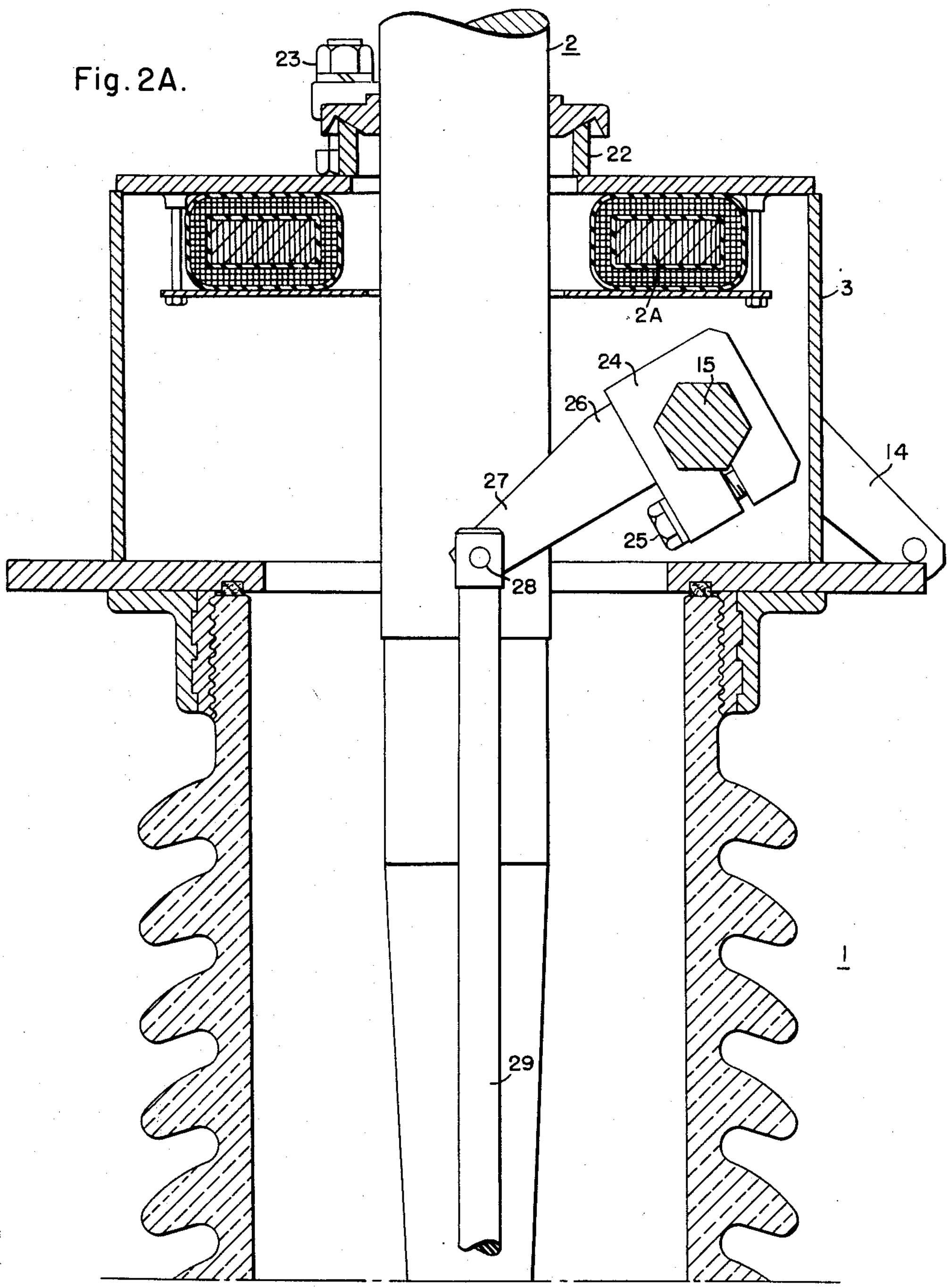
Fig. 2A.



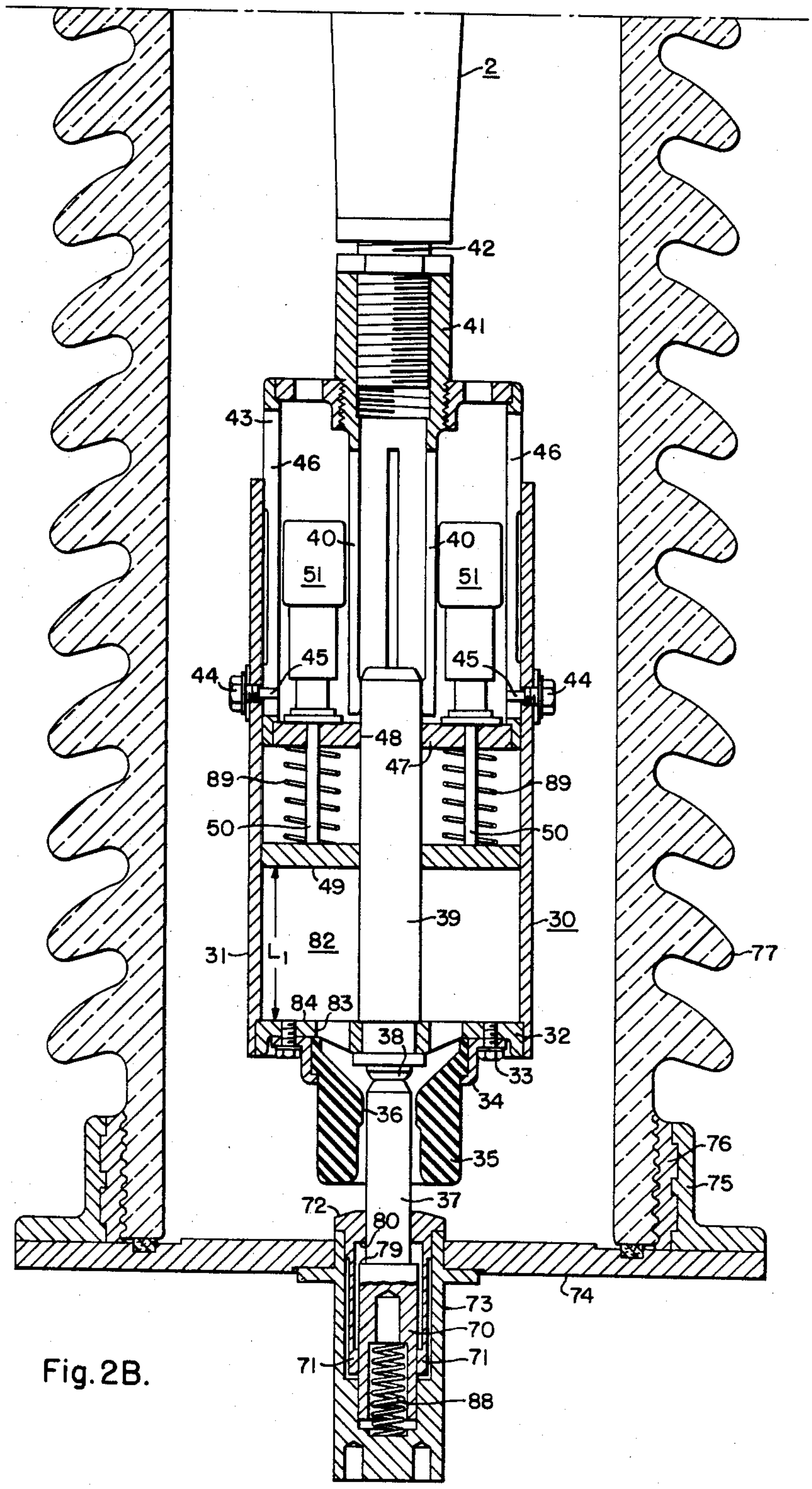

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Fig. 2B.

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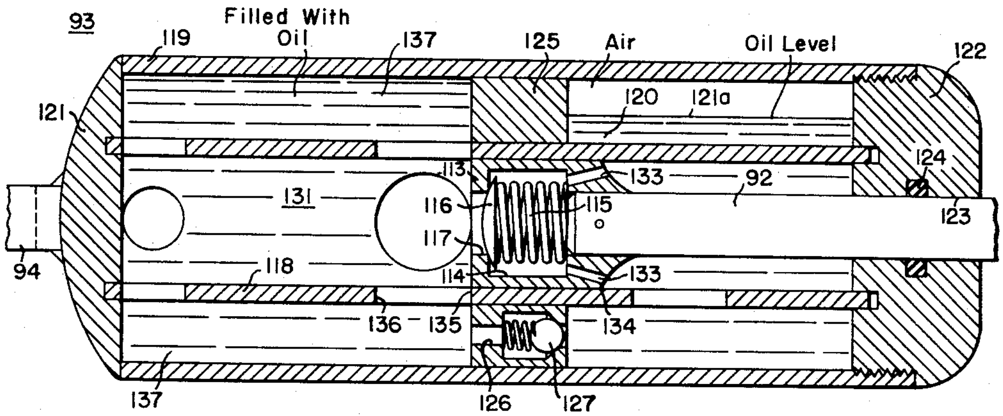

Fig.6.

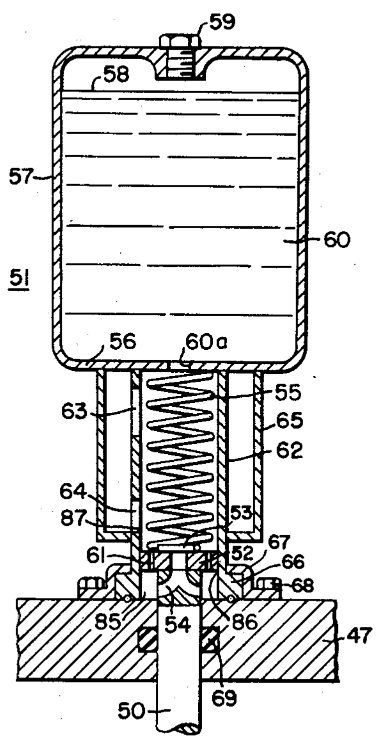

Fig.4.

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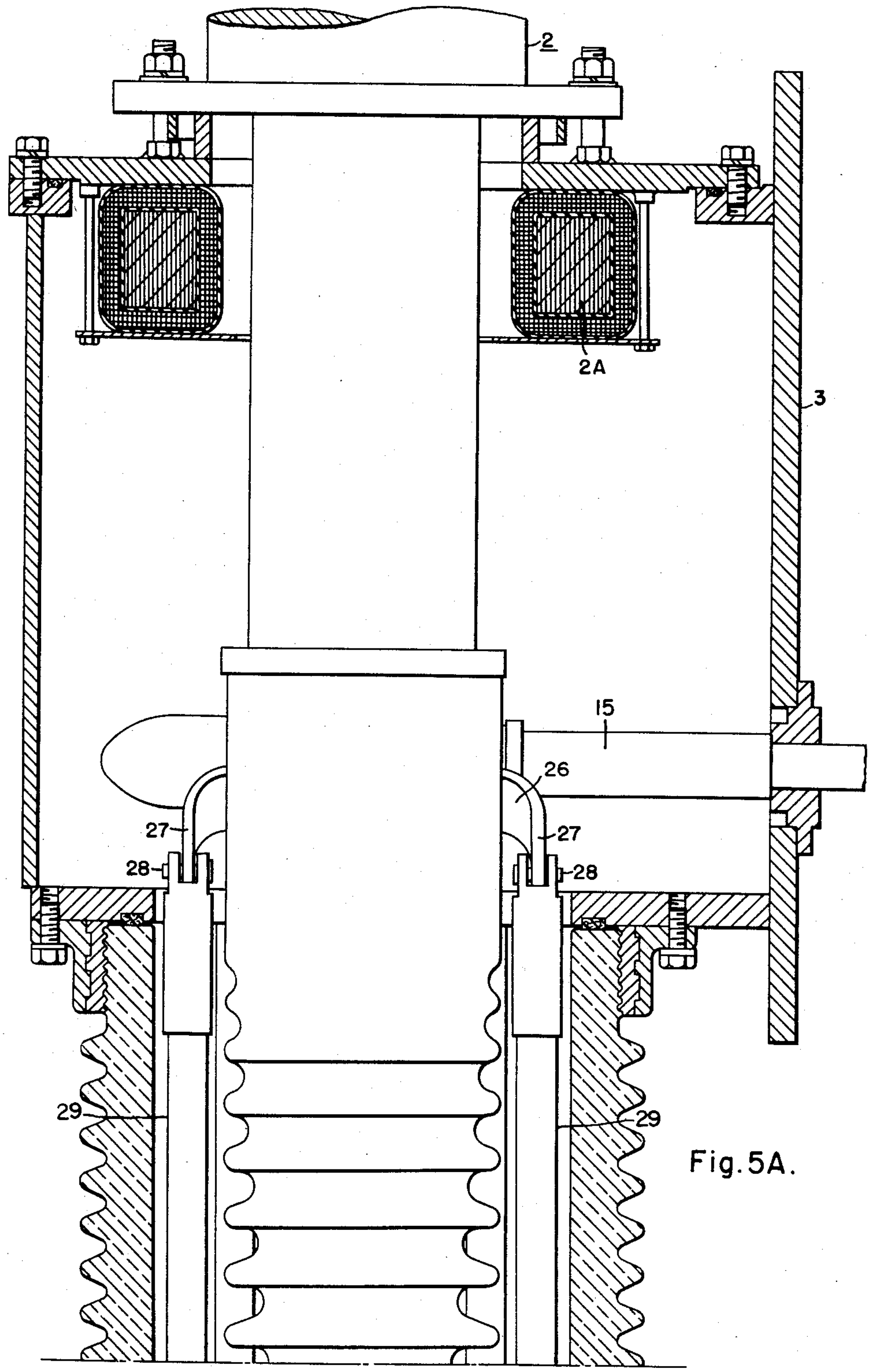
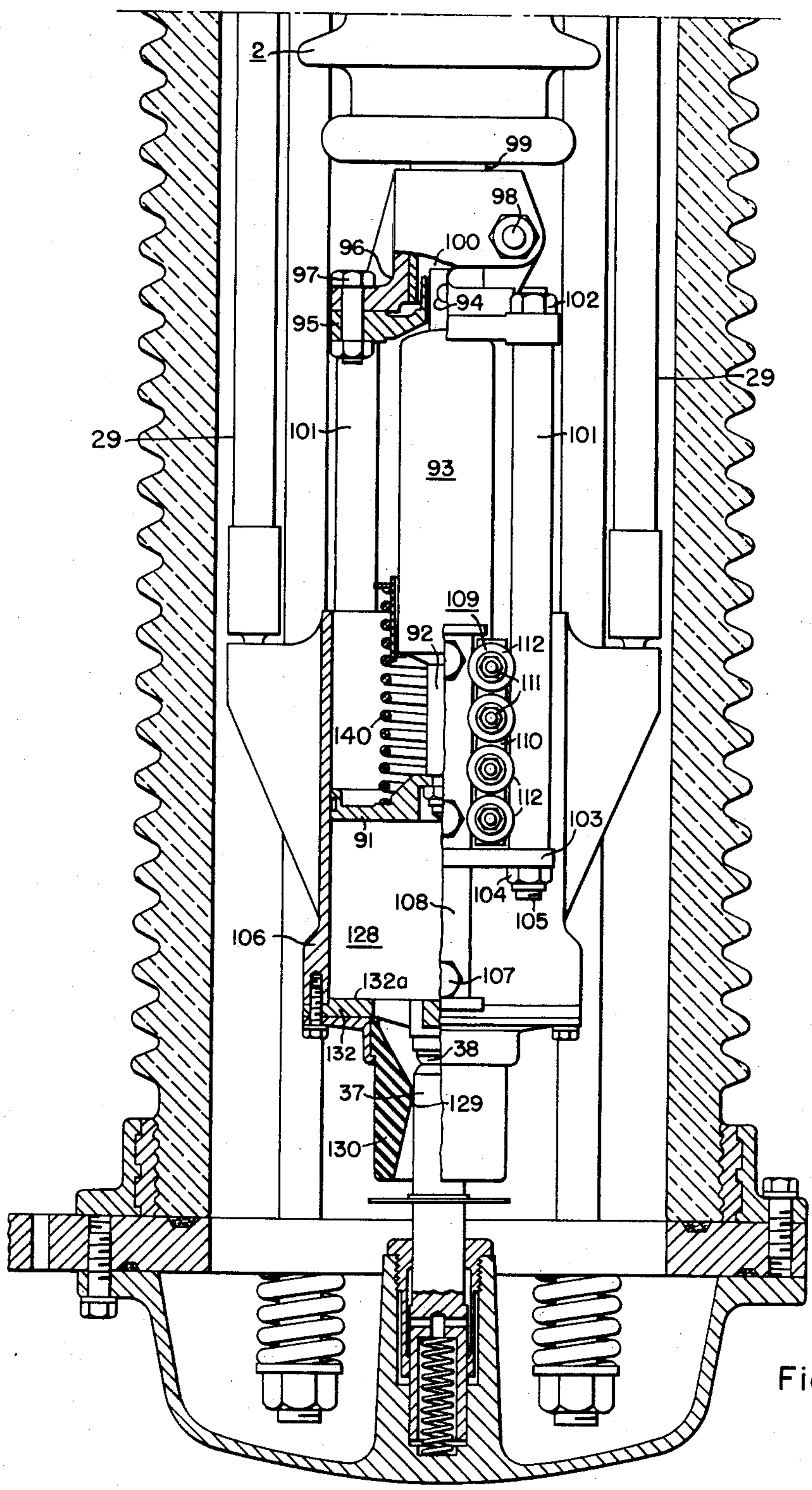


Fig. 5A.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106
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132
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37
129
130

Fig.5B.

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CIRCUIT INTERRUPTERS

Charles F. Cromer, Trafford, and Benjamin P. Baker, Monroeville, Pa., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application December 20, 1956, Serial No. 629,636

7 Claims. (Cl. 200—148)

This invention relates to circuit interrupters in general and, more particularly, to arc-extinguishing structures therefor.

A general object of the present invention is to provide an improved circuit interrupter in which arc elongation and arc extinction are very rapidly achieved, to result in more efficient circuit interruption than has been achieved in circuit interrupters heretofore used.

A more specific object of the present invention is to provide an improved fluid-blast circuit interrupter utilizing a piston construction, in which fluid is more quickly compressed within the piston assembly to more quickly effect arc extinction, and yet means are provided to insure an adequate isolating gap in the open-circuit position.

Yet, a further object of the invention is to provide an improved fluid-blast circuit interrupter in which a movable cylinder assembly carrying the movable contact moves over a relatively stationary piston to inject fluid into the established arc, and wherein the relatively stationary piston is subsequently movable with the movable cylinder assembly to result in an isolating gap distance of sufficient length in the open-circuit position of the interrupter.

In the United States patent application filed December 20, 1956, Serial No. 629,604, now United States Patent No. 2,866,045, issued December 23, 1958, to Winthrop M. Leeds, and assigned to the assignee of the instant application, there is shown and described a circuit interrupter of the single-bushing type, in which the grounded intermediate part of the terminal bushing is supported by a grounded framework, and wherein an interrupting unit is secured to the interior end of the terminal bushing, being surrounded thereabout by an insulating casing. Suitable means operating from the grounded intermediate support for the terminal bushing is effective to operate an operating cylinder over a piston arrangement, which was stationary in the aforesaid application.

It is a further object of the present invention to improve upon the single-bushing type of circuit interrupter set out in the foregoing Leeds application, in which fluid pressure is more quickly brought about, and yet an adequate isolating gap is obtained when the circuit interrupter is moved to the open-circuit position.

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

Fig. 1 is a side elevational view of a single-bushing type of circuit interrupter embodying the present invention, and shown in the closed-circuit position;

Figs. 2A and 2B collectively illustrate an enlarged, sectional view taken through the circuit interrupter of Fig. 1, with a portion of the terminal bushing omitted, and the contact structure being illustrated in the closed-circuit position;

Fig. 3 is a fragmentary sectional view similar to that of Fig. 2B, but illustrating the position of the several parts in the fully open-circuit position;

Fig. 4 is an enlarged sectional view taken through the shock-absorbing mechanism utilized in conjunction with the interrupter of Figs. 2A and 2B;

Figs. 5A and 5B collectively illustrate an enlarged, vertical sectional view through a modified type of interrupting assembly, the contact structure being shown in the closed-circuit position; and

Fig. 6 is a longitudinal, sectional view taken through the shock absorber utilized in the interrupter of Fig. 5B.

Referring to the drawings and more particularly to Fig. 1 thereof, the reference numeral **1** generally designates a circuit interrupter of the single-bushing type. The circuit interrupter **1** generally includes a terminal bushing, generally designated by the reference numeral **2**, which may be of substantially standard construction having a current transformer **2A** thereabout. The intermediate, grounded, central portion of the terminal bushing **2** is clamped to, and supported by, an intermediate grounded mechanism housing **3**, which is supported by a grounded framework **4**, composed of vertically extending angle-iron members **5** and cross-braces **6**, also of angle-iron construction, which may be welded thereto.

As illustrated in Fig. 1, a mechanism housing compartment **3A** is also supported by the vertical angle-irons **5**, and is used to enclose a suitable operating mechanism, which may be of conventional type, and the details of which form no part of the present invention. The operating mechanism within the compartment **3A** may be employed to effect vertical reciprocal motion of a link **7** having a bifurcated upper end, which is pivotally connected, as at **8**, to an arm **9**, the latter being fixedly secured to a horizontally extending operating shaft **10**. The operating shaft **10** may be journaled within a pair of brackets **11**, the latter being supported by the crossbrace **6**.

A second arm **12** is fixedly secured to the operating shaft **10**, and is pivotally connected, as at **13**, to an arm **14**, the latter being fixedly connected to a vertically extending operating shaft **15**. Also secured to the operating shaft **15**, and extending outwardly at right angles thereto, is a spring arm **16** pivotally connected, as at **17**, to a spring rod **18**. The spring rod **18** extends interiorly within a spring housing **19**, the latter housing a coiled compression spring, not shown, which seats against one end **20** of the spring housing **19**, and has its other end seated upon a washer fixed to the outer end of the spring rod **18**, and forming a spring seat. The accelerating compression spring disposed within the spring housing **19** is charged, or compressed, during the closing operation of the interrupter by the mechanism disposed within the mechanism compartment **3A**. During the opening operation, the mechanism is unlatched to permit the accelerating compression spring within the subular spring housing **19** to move the spring rod **18** to the right, acting upon the spring arm **16** and effecting rotative opening motion of the operating shaft **15**.

Although Fig. 1 illustrates the interrupter **1** in a horizontal position, it can be mounted in any position such as the vertical position, and Figs. 2A and 2B show this slight variation. Referring more particularly to Figs. 2A and 2B, which illustrate a longitudinal sectional view through a portion of the circuit interrupter **1** mounted in a vertical position, it will be observed that the mechanism housing **3** has affixed thereto a clamping sleeve **22**, to which is secured, as by a number of bolts **23**, the terminal bushing **2**. A clamp **24** encircles the rotatable operating shaft **15**, being clamped thereto by a bolt **25**. The clamp **24** has secured thereto a yoke member **26** (Fig. 5A). The outer ends **27** of the yoke member **26** are pivotally connected by pins **28** to a pair of insulating operating rods **29**. The operating rods **29** are connected to a movable operating cylinder assembly, generally designated by the reference numeral **30**, and including an operating cylinder **31**. In other words, the lower ends of the two insulating operating rods **29** are pivotally connected to the side walls of the movable operating cylinder **31**.

The operating cylinder **31** has a spider plate **32** secured to the lower end thereof by any suitable means, to which is clamped, by bolts **33**, a clamping flange **34**, the latter serving to clamp an insulating orifice member **35** to the spider plate **32**. The orifice member **35** has an orifice opening **36**, through which extends, in the closed-circuit position, a relatively stationary contact **37**. The relatively stationary contact **37** makes abutting contacting engagement with a movable contact **38**, the latter being fixed to the spider plate **32** and having an upwardly extending contact extension **39**. The contact extension **39** makes sliding contacting engagement with a plurality of laterally flexible contact fingers **40** integrally formed with a contact foot **41**, the latter being threadedly secured to the lower threaded end of a terminal stud **42** which extends through the center of the terminal bushing **2**.

The operating cylinder **31** slides over a slotted stationary cylinder **43** being guided thereabout by guide lugs **44**, the inner ends **45** of which slide in the grooves, or slots **46** of the stationary cylinder **43**. The lower end of the stationary cylinder **43**, as viewed in Fig. 2B, has a ring-shaped plate **47** secured thereto with a central opening **48**, through which slides the contact extension **39** during the opening and closing operations.

A relatively stationary piston **49** has secured thereto a plurality of piston rods **50**, the upper ends of which are operatively associated with a plurality of shock-absorber assemblies **51**, the internal construction of which is more readily apparent from an inspection of Fig. 4 of the drawings.

Generally, the shock-absorber assemblies **51**, shown in Fig. 4, include a piston **52** secured to the upper end of the piston rod **50** and having a pivotally mounted flap valve **53** controlling a passage **54** through the upper end of the piston rod **50**. The piston rod **50** is biased downwardly by a compression spring **55**, the upper end of which seats against the lower end **56** of a container **57** containing a suitable amount of shock-absorber fluid, such as oil, to the level **58**. A plug **59**, disposed at the upper end of the container **57**, may be used for replenishing the oil **60**.

The piston **52** has a plurality of restricted passages **61** therethrough, through which the oil may leak relatively slowly. The piston **52** moves within a piston cylinder **62**, the latter having openings **63** and **64**, and disposed within a closed outer cylinder **65**. The lower end of the cylinder **62** has an outwardly extending flange **66**, which is clamped, by a flange ring **67**, to the plate **47** by means of bolts **68**. Preferably, a gasketed seal **69** prevents any interexchange of fluid lengthwise along the piston rod **50**.

Referring back to Fig. 2B, it will be noted that the relatively stationary contact **37** has a lower portion **70** which bears against a plurality of flexible contact fingers **71**, the latter being integrally formed with an apertured plug **72** inserted within a stationary contact housing **73**. The contact housing **73** may be suitably clamped to a lower closure plate **74**. The closure plate **74** is suitably secured by means, not shown, to a flange ring **75** secured by cement **76** to a casing **77**, the latter being preferably formed from a suitable weatherproof material, such as porcelain.

In the closed-circuit position of the interrupter **1**, as illustrated in Figs. 1, 2A, 2B and Fig. 4, the electrical circuit therethrough includes the terminal stud **42** (Fig. 1), through the terminal bushing **2** to the contact foot **41**. The circuit then extends by way of the flexible fingers **40** to the contact extension **39**, through the movable contact **38** and through the relatively stationary contact **37** to the finger contacts **71**. The circuit then extends through the conducting closure plate **74** and an abutting plate **74a** to a terminal pad **78**, to which a line connection may be made.

During the opening operation, suitable means, not shown, are actuated to effect release or unlatching of the mechanism disposed within the mechanism compartment 3A. This unlatching will permit the accelerating compression spring, disposed in spring housing **19**, to effect, through the spring rod **18**, rotative motion of the spring arm **16** and hence clockwise rotative motion of the operating shaft **15**, as viewed in Fig. 2A.

The rotation of the operating shaft **15** will effect, through the yoke **27** and insulating operating rods **29**, upward opening movement of the movable operating cylinder assembly **30**. This will cause upward movement of the movable contact **38**, the relatively stationary contact **37** following this opening motion for a predetermined time, until a shoulder **79**, formed on the plug **70**, strikes the surface **80** on the plug **72**. When this occurs, the movable contact **38** will separate upwardly away from the stationary contact **37** drawing an arc **81**, shown in Fig. 3, for clarity, even though Fig. 3 illustrates the fully open-circuit position of the interrupter.

It will be observed that the upward movement of the operating cylinder **31** over the piston **49** will diminish the volume within the region **82** (Fig. 2B), thereby compressing the fluid, such as SF_6 therein, forcing the latter downwardly through apertures **83** within spider plate **32** and through the orifice opening **36** to effect extinction of the arc **81**.

It is desirable to provide such a flow of gas through the orifice **36** by the compression of the volume of gas confined in the region **82** of the operating cylinder **31**. The differential pressure P_d which can be produced across the interrupting orifice **35** is a function of the initial absolute pressure P_1 and the ratio of the initial volume V_1 to the second, or reduced volume V_2.

Let it be assumed that in order to interrupt a fixed current, a required pressure differential, P_d, is necessary—

Then

$$P_d = P_1\left(\frac{V_1}{V_2} - 1\right)$$

assuming no losses and isothermal compression.

The initial volume of the cylinder is:

$$V_1 = \frac{\pi D^2 L_1}{4}$$

and

$$P_d = P_1\left(\frac{L_1}{L_2} - 1\right)$$

or the differential pressure is a function of the ratios of the initial and final lengths (L_1 and L_2) of the cylindrical volume. Then if the initial length is reduced, the required pressure differential can be obtained with a shorter travel, and result in a proportionate reduction of arcing time or dead-time.

Although interruptions can be obtained at this reduced gap length, in order to meet required voltage test specifications, a longer isolation gap is required.

This invention proposes a method in which the shorter interrupting times may be obtained, and further provides for the necessary isolating gap, and in so doing eliminates external shock absorbers.

The piston **49** is initially stationary, but the characteristics of the shock absorber assembly **51** are such that during low-load conditions the piston **49** will not move until the surface **84** of the spider plate **32** strikes it and carries it with the operating cylinder **31** to the fully open-circuit position, shown in Fig. 3, and providing a greater isolating gap distance between the contacts **37**, **38** than would be the case if the piston **49** were stationary at all times.

During the high-fault current conditions, when the arcing pressure is very rapidly built up through the orifice 36 by the arc 81, the pressure within region 82 of the operating cylinder 31 will be sufficient to cause slight retraction of the piston 49 even before the surface 84 of spider member 32 strikes it. As an example, for one particular piece of equipment, the total force exerted on the piston 49 must be 1500 pounds before the latter begins to move. It will move one inch under this force, and then will move offering little opposition for the remaining two inches of its travel. The surface 84 of spider member 32 will be in contact with the piston 49 during the final two inches of travel of piston 49.

To understand the hesitating action of the relatively "fixed" piston 49, reference may be had to Fig. 4, wherein it will be observed that initially upward opening travel of the piston rod 50 will be opposed by the suction created in the region 85 under the piston 52. However, oil will leak through the restricted openings 61, until the lower edge 86 of the piston 52 moves above the lower edge 87 of the opening 64, at which time there will be unimpeded upward movement of the piston rod 50 because of the circulation of oil around the bypassing cylinder 65 and upward through opening 60*a* in container 60. The piston 52 will thereupon move to its upward position quickly. Thus the shock-absorber assembly 51 provides a variable resistance means which initially resists rapid movement of the relatively "fixed" piston and subsequently permits relatively free retraction of said piston wtih the movable operating cylinder 31 to the fully open-circuit position of Fig. 3.

During the closing operation, the mechanism within the mechanism compartment 3A is actuated to effect downward movement of link 7, thereby effecting simultaneous closing rotation of the operating shaft 15 and charging, or compression, of the accelerating spring disposed within the spring casing 19. This will cause, through the operating rods 29, downward closing movement of the operating cylinder 31 to effect contact reengagement between contacts 37, 38. A compression spring 88, within the contact housing 73, provides the requisite contact pressure. The piston 49 moves quickly downwardly because of the flap-valve action 53, permitting oil to move quickly out of the chamber 85, below the piston 52 and through the passages 54. This closing motion of the piston rod 50 is not only assisted by the compression spring 55, but it is also assisted by a plurality of closing springs 89 encircling the piston rods 50, as shown in Fig. 2B.

From the foregoing description, it will be apparent that the use of a hesitating piston 49, which is initially substantially stationary during the initial opening movement, and subsequently movable within the operating cylinder 31, affords a greater isolating gap distance between the contacts 37, 38, and results in a circuit interrupter of very high speed in action, and very quickly causing a considerable pressure differential P_d across the orifice opening 36 by the relatively short distance L_1 between the spider plate 32 and the piston 49 which may be employed. As mentioned hereinbefore, the shorter the distance L_1 is, the less opening travel is required of operating cylinder 31 to build up the requisite differential pressure P_d across the orifice opening 36 to quickly bring about arc extinction. If, however, the piston 49 remains constantly stationary at all times, the isolating gap distance between the contacts 37, 38, in the open position of the interrupter, might be hazardous, and, therefore, it is proposed to subsequently effect the isolating travel of the piston 49 together with the operating cylinder 31. This brings about a consequent adequate isolating gap distance between the contacts 37, 38.

Figs. 5A, 5B and 6 illustrate a modification of the invention, similar in many respects to that heretofore described. Here a piston 91, analogous to the piston 49, heretofore described, is supported by a piston rod 92, associated with a centrally disposed shock-absorber assembly 93. The upper end of the shock absorber 93 has an apertured lug portion 94, which is fixedly secured to a spider plate 95 bolted to a contact foot 96 by bolts 97. The contact foot 96 is threadedly secured and clamped, as by a clamping bolt 98, to the lower threaded end of a terminal stud 99 having a lower recess 100. Extending downwardly from the spider plate 95 are four contact guide rails 101, having reduced ends, which are threaded to accommodate nuts 102. The spider plate 95 has four apertures to accommodate the reduced ends of the contact guide rails 101. The lower ends of the contact guide rails 101 are braced by cross-braces 103, having apertured ends, through which pass the reduced lower end portions 105 of the guide rails 101. Nuts 104, threaded on the lower ends 105 of the guide rails 101, fixedly secure the apertured cross-braces 103 in position.

Bolted to the side walls of a movable operating cylinder 106 by bolts 107, is a movable contact rail 108. Interposed between the contact rail 108, which is movable with operating cylinder 106, and the stationary contact rails 101 is a plurality of contact roller assemblies 109. Each contact roller assembly 109 includes a rectangular plate 110 having four spaced apertures therethrough, through each of which extends a pin 111 supporting a pair of contact rollers 112. Suitable springs may be provided, encircling the pins 111, to bias the contact rollers 112 toward each other, and into engagement with both the movable guide rail 108 and the stationary guide rails 110. This construction is set out more in detail, and is claimed, in the aforesaid Leeds Patent 2,866,045.

Fig. 6 more clearly shows the internal construction of the shock-absorber assembly 93. It will be noted that the piston rod 92 has a piston 113 having a recess 114. Disposed in the recess 114 is a spring 115, which biases a valve 116 over an opening 117.

The piston 113 moves within a guide cylinder 118, which, in turn, is disposed interiorly within an outer cylinder casing 119 containing a suitable fluid, such as oil 120. The cylinder casing 119 has a closure cap 121 at one end, with which the apertured lug 94 may be integrally formed. At the other end of the cylinder casing 119 is an apertured closure cap 122 having a central opening 123, through which the piston rod 92 extends. A suitable gasketed seal 124 may be provided to prevent interexchange between the oil and SF_6 fluids.

Stationarily mounted between the outer cylinder casing 119 and the inner operating cylinder 118 is an apertured ring 125, having openings 126 therethrough, which are controlled by ball valves 127. The ball valves 127 readily permit the passage of fluid from right to left through openings 126, as viewed in Fig. 6, but the ball valves 127 oppose the rightward passage of fluid through the openings 126, as will be obvious.

The region to the left of ring 125 is entirely filled with oil, whereas the region to the right of ring 125 has an oil level at 121*a* with air above it to accommodate the volume of piston rod 92, which moves within shock-absorber assembly 93 during the working part of the stroke.

During the opening operation, the operating cylinder 106 (Fig. 5B) moves upward, carrying the movable contact 38 away from the relatively stationary contact 37 and compressing the fluid, such as SF_6 gas, within the region 128 below piston 91. This gas will be forced out through the orifice opening 129, provided by orifice member 130, in a manner similar to that heretofore described. The upward movement of the operating cylinder 106 will be guided by the guide rails 101, 108 and the roller assemblies 109. This will reduce friction, and will readily transfer current between the movable contact 38, movable guide rails 108 and the stationary guide rails 101, which are connected to the terminal stud 99.

The piston 91 is initially stationary, since the leftward movement of the piston rod **92**, as viewed in Fig. 6, will be opposed by the oil pressure built up in chamber **131**. In other words, the piston **113** is attempted to be moved into chamber **131**, and there is no place for the oil to move, the valves **127** closing the openings **126**, and the spring **115** closing the opening **117**. However, when the surface **132***a* (Fig. 5B) of the spider plate **132** strikes the piston **91**, and increases the leftward pressure exerted upon the piston rod **92**, as viewed in Fig. 6, the oil pressure within the region **131** will be sufficient to compress the spring **115** and permit the oil to pass out of region **131** through the opening **117** and passages **133** to the back side of piston **113**.

When the edge **134** of piston **113** has moved to the left beyond the edge **135** of opening **136**, the oil may then circulate around the piston **113** by way of the bypassing channels **137**. This will permit rapid leftward movement of the piston **113** to take place, with a consequent rapid upward isolating movement of the piston **91**, shown in Fig. 5B. Again the shock-absorber assembly **93** provides a variable resistance means to rapid movement of the piston **91**. Initially, there is a high resistance to rapid movement of the piston **91**, and subsequently relatively free retraction of the piston **91** with the operating cylinder **106** is permitted.

From the foregoing description, it will be apparent that there is provided an improved operating cylinder arrangement, in which the piston therein is initially stationary, and subsequently moves with the movable operating cylinder to the open-circuit position, increasing thereby the isolating gap distance between the separated contacts **37, 38**. By positioning the pistons **49, 91** closer to the relatively stationary contacts **37**, there is a reduction in the necessary travel of the operating cylinders **31, 106** to produce the required pressure differential P_d across the orifice openings. The shock-absorber assemblies **51, 93** have the characteristics of offering high resistance over a short portion of the piston stroke, and then a minimum resistance for the remainder of the travel, in which the piston is retracted to the full-open position of the contacts by the operating cylinder.

It will be noted that both shock absorbers **51, 93** are of the two-stage type, the resistance or loading they offer to retraction of the respective "fixed" pistons **49, 91**, being a function of the position of the "fixed" pistons **49, 91**. During the first stage of operation of the shock absorbers **51, 93**, during initial retraction of the pistons **49, 91** high resistance or loading is encountered. During the second stage, following said initial retraction of the pistons **49, 91**, low resistance or loading is afforded by the shock absorbers **51, 93**.

The resistance device **51, 93**, as disclosed further eliminates the necessity of external shock absorbers, and, with a large oil reservoir associated with the device **51, 93**, the interrupter may be mounted in any position, either horizontal or vertical. During the closing of the interrupter, the secondary pistons **49, 91**, may be retrieved to their initial closed-circuit position by the retrieving springs **89** or **140**.

An application of the principles of the present invention to fluid-blast interrupters utilizing operating cylinder arrangements results in very rapid build-up of pressure across the orifice, and a consequent high-velocity injection of fluid through the orifice and into engagement with the established arc. By the feature of the piston being movable during the latter part of the opening stroke, an adequate isolating gap distance is provided between the separated contacts so that no flashover may occur therebetween in the fully open-circuit position of the interrupter.

Although there have been shown and described specific operating cylinder arrangements, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein by those skilled in the art, without departing from the spirit and scope of the invention.

We claim as our invention:

1. A fluid-blast circuit interrupter including contact means for establishing an arc, a movable operating cylinder, a piston disposed within said operating cylinder, an operating mechanism for effecting contact separation and for driving said movable operating cylinder to the open position over the piston for fluid compression therebetween, means for directing the compressed fluid against the arc, a two-stage shock absorber connected to said piston for providing two types of loading therefor for the retraction thereof, said two-stage shock absorber having the characteristics during the first stage of loading of affording relatively high resistance to the operating mechanism during initial retracting movement of said piston during the opening operation from the closed-circuit position thereof, said operating mechanism moving said operating cylinder into abutting engagement with said piston toward the end of the opening operation for carrying said piston therewith for obtaining an appreciable isolating gap distance between the separated contacts, the second stage of loading afforded by the two-stage shock absorober coming into existence after a predetermined initial retracting distance covered by said piston toward the end of the opening operation and following arc extinction, and the two-stage shock absorber having the characteristics during the second stage of loading of affording only slight resistance to the operating mechanism during isolating retraction of said piston with said operating cylinder at the end of the opening operation of the interrupter.

2. The combination in a fluid-blast circuit interrupter of a relatively stationary contact, a movable operating cylinder, a movable contact movable with said operating cylinder and separable from said relatively stationary contact to establish an arc, a piston disposed within said operating cylinder, an operating mechanism for effecting contact separation and for driving said movable operating cylinder to the open position over the piston for fluid compression therebetween, means for directing the compressed fluid against the arc, a two-stage shock absorber connected to said piston for providing two types of loading therefor for the retraction thereof, said two-stage shock absorber having the characteristics during the first stage of loading of affording relatively high resistance to the operating mechanism during initial retracting movement of said piston during the opening operation from the closed-circuit position thereof, said operating mechanism moving said operating cylinder into abutting engagement with said piston toward the end of the opening operation for carrying said piston therewith for obtaining an appreciable isolating gap distance between the separated contacts, the second stage of loading afforded by the two-stage shock absorber coming into existence after a predetermined initial retracting distance covered by said piston toward the end of the opening operation and following arc extinction, and the two-stage shock absorber having the characteristics during the second stage of loading of affording only slight resistance to the operating mechanism during isolating retraction of said piston with said operating cylinder at the end of the opening operation of the interrupter.

3. The combination in a fluid-blast circuit interrupter of a relatively stationary contact, means defining an orifice, a movable operating cylinder carrying said orifice, a movable contact movable with said operating cylinder and separable from said relatively stationary contact to draw an arc through said orifice, a piston disposed within said operating cylinder, an operating mechanism for effecting contact separation and for driving said movable operating cylinder to the open position over the piston for fluid compression therebetween, means including said orifice for directing the compressed fluid against the arc, a two-stage shock absorber connected to said piston for

providing two types of loading therefor for the retraction thereof, said two-stage shock absorber having the characteristics during the first stage of loading of affording relatively high resistance to the operating mechanism during initial retracting movement of said piston during the opening operation from the closed-circuit position thereof, said operating mechanism moving said operating cylinder into abutting engagement with said piston toward the end of the opening operation for carrying said piston therewith for obtaining an appreciable isolating gap distance between the separated contacts, the second stage of loading afforded by the two-stage shock absorber coming into existence after a predetermined initial retracting distance covered by said piston toward the end of the opening operation and following arc extinction, and the two-stage shock absorber having the characteristics during the second stage of loading of affording only slight resistance to the operating mechanism during isolating retraction of said piston with said operating cylinder at the end of the opening operation of the interrupter.

4. A circuit interrupter including a hollow insulating casing, means supporting a relatively stationary contact adjacent one end of said hollow insulating casing, a terminal bushing extending into the other end of said hollow casing, a movable operating cylinder, the interior end of said terminal bushing supporting said movable operating cylinder, a movable contact cooperable with said relatively stationary contact to establish an arc, the movable operating cylinder carrying said movable contact, a piston disposed within said operating cylinder, an operating mechanism for effecting contact separation and for driving said movable operating cylinder to the open position over the piston for fluid compression therebetween, means for directing the compressed fluid against the arc, a two-stage shock absorber connected to said piston for providing two types of loading therefor for the retraction thereof, said two-stage shock absorber having the characteristics during the first stage of loading of affording relatively high resistance to the operating mechanism during initial retracting movement of said piston during the opening operation from the closed circuit position thereof, said operating mechanism moving said operating cylinder into abutting engagement with said piston toward the end of the opening operation for carrying said piston therewith for obtaining an appreciable isolating gap distance between the separated contacts, the second stage of loading afforded by the two-stage shock absorber coming into existence after a predetermined initial retracting distance covered by said piston toward the end of the opening operation and following arc extinction, and the two-stage shock absorber having the characteristics during the second stage of loading of affording only slight resistance to the operating mechanism during isolating retraction of said piston with said operating cylinder at the end of the opening operation of the interrupter.

5. A circuit interrupter including a hollow insulating casing, means supporting a relatively stationary contact adjacent one end of said hollow insulating casing, a terminal bushing extending into the other end of said hollow casing, an orifice member, a movable contact, an operating cylinder mounted on the inner end of said terminal bushing and carrying said orifice member and said movable contact, the movable contact being separable from said relatively stationary contact to establish an arc through said orifice member, a piston disposed within said operating cylinder, an operating mechanism including an insulating operating rod extending longitudinally of said terminal bushing for effecting movement of said operating cylinder over said piston and also contact separation, a two-stage shock absorber connected to said piston for providing two types of loading therefor for the retraction thereof, said two-stage shock absorber having the characteristics during the first stage of loading of affording relatively high resistance to the operating mechanism during initial retracting movement of said piston during the opening operation from the closed-circuit position thereof, said operating mechanism moving said operating cylinder into abutting engagement with said piston toward the end of the opening operation for carrying said piston therewith for obtaining an appreciable isolating gap distance between the separated contacts, the second stage of loading afforded by the two-stage shock absorber coming into existence after a predetermined initial retracting distance covered by said piston toward the end of the opening operation and following arc extinction, and the two-stage shock absorber having the characteristics during the second stage of loading of affording only slight resistance to the operating mechanism during isolating retraction of said piston with said operating cylinder at the end of the opening operation of the interrupter.

6. The combination in a fluid-blast circuit interrupter of a movable operating cylinder carrying a movable contact, a relatively stationary contact cooperable with said movable contact to establish an arc, a relatively "fixed" piston over which said movable operating cylinder moves to compress fluid, an operating mechanism for driving said operating cylinder over said "fixed" piston, orifice means associated with said movable operating cylinder and movable contact to direct said compressed fluid toward the established arc, a two-stage shock absorber connected to said piston for controlling the motion of said relatively "fixed" piston and operable during the first stage to initially oppose any rapid movement of said relatively "fixed" piston so that compression of fluid may readily take place, said two-stage shock absorber being operable during the second stage during the latter portion of the circuit interrupter opening operation and following a predetermined retracting motion of the piston to permit relatively free further retraction of said relatively "fixed" piston an appreciable isolating distance travel with said operating cylinder and movable contact for insuring an adequate isolating distance between the contacts in the fully open circuit position thereof, and said two-stage shock absorber imposing only a light load upon said operating mechanism during the second stage of the operation thereof.

7. The combination in a fluid-blast circuit interrupter of a movable operating cylinder, a movable contact movable with said movable operating cylinder at least during a portion of the opening travel of said movable operating cylinder, a relatively stationary contact cooperable with said movable contact to establish an arc, a relatively "fixed" piston over which said movable operating cylinder moves to compress fluid, an operating mechanism for driving said operating cylinder over said "fixed" piston, orifice means associated with said movable operating cylinder and movable contact to direct said compressed fluid toward the established arc, a two-stage shock absorber connected to said piston for controlling the motion of said relatively "fixed" piston and operable during the first stage to initially oppose any rapid movement of said relatively "fixed" piston so that compression of fluid may readily take place, said two-stage shock absorber being operable during the second stage during the latter portion of the circuit interrupter opening operation and following a predetermined retracting motion of the piston to permit relatively free further retraction of said relatively "fixed" piston an appreciable isolating distance travel with said operating cylinder and movable contact for insuring an adequate isolating distance between the contacts in the fully open circuit position thereof, and said two-stage shock absorber imposing only a light load upon said operating mechanism during the second stage of the operation thereof.

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