Dec. 17, 1946. B. P. BAKER 2,412,857

CIRCUIT INTERRUPTER

Filed Jan. 9, 1943 4 Sheets-Sheet 1

Fig. 1.

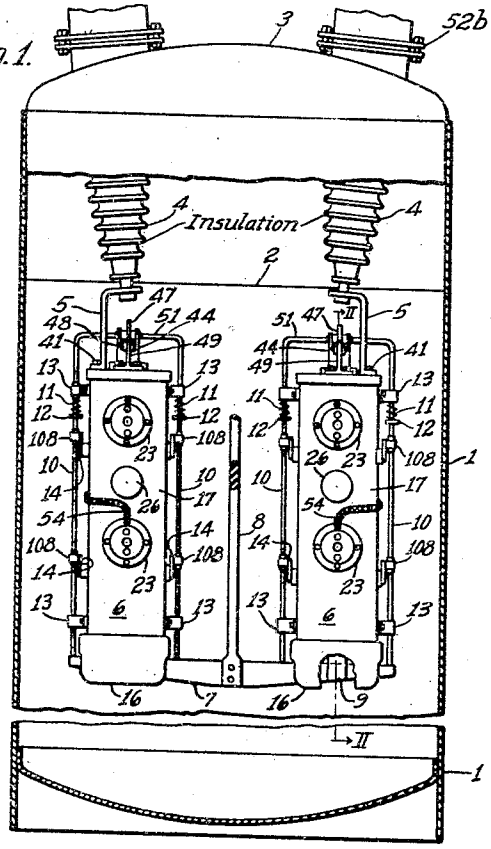


Fig. 3.

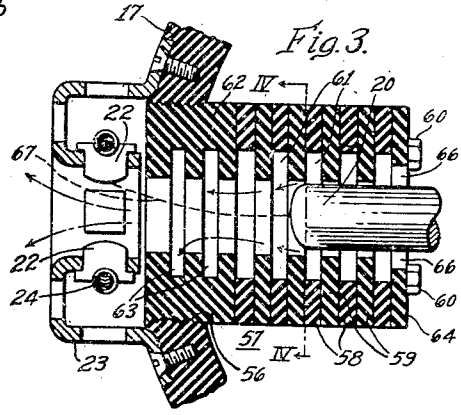
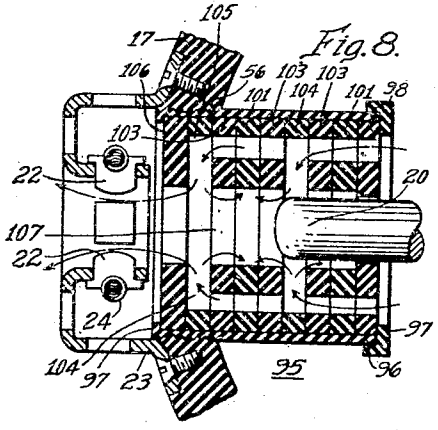


Fig. 8.



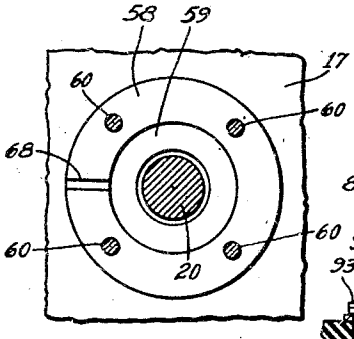


Fig. 4.

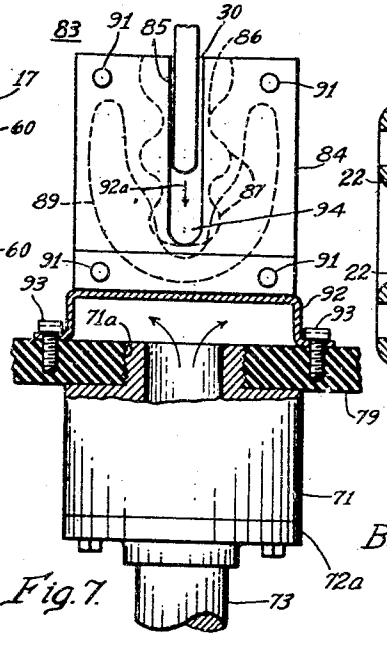


Fig. 7.

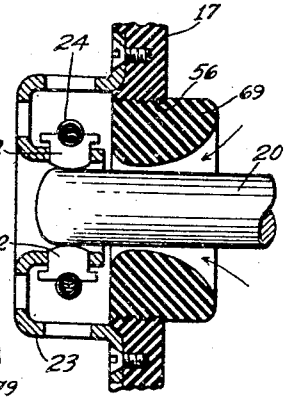


Fig. 5.

WITNESSES:

C. J. Weller.

W. R. Crout

INVENTOR

Benjamin P. Baker.

BY

F. N. Lyle.

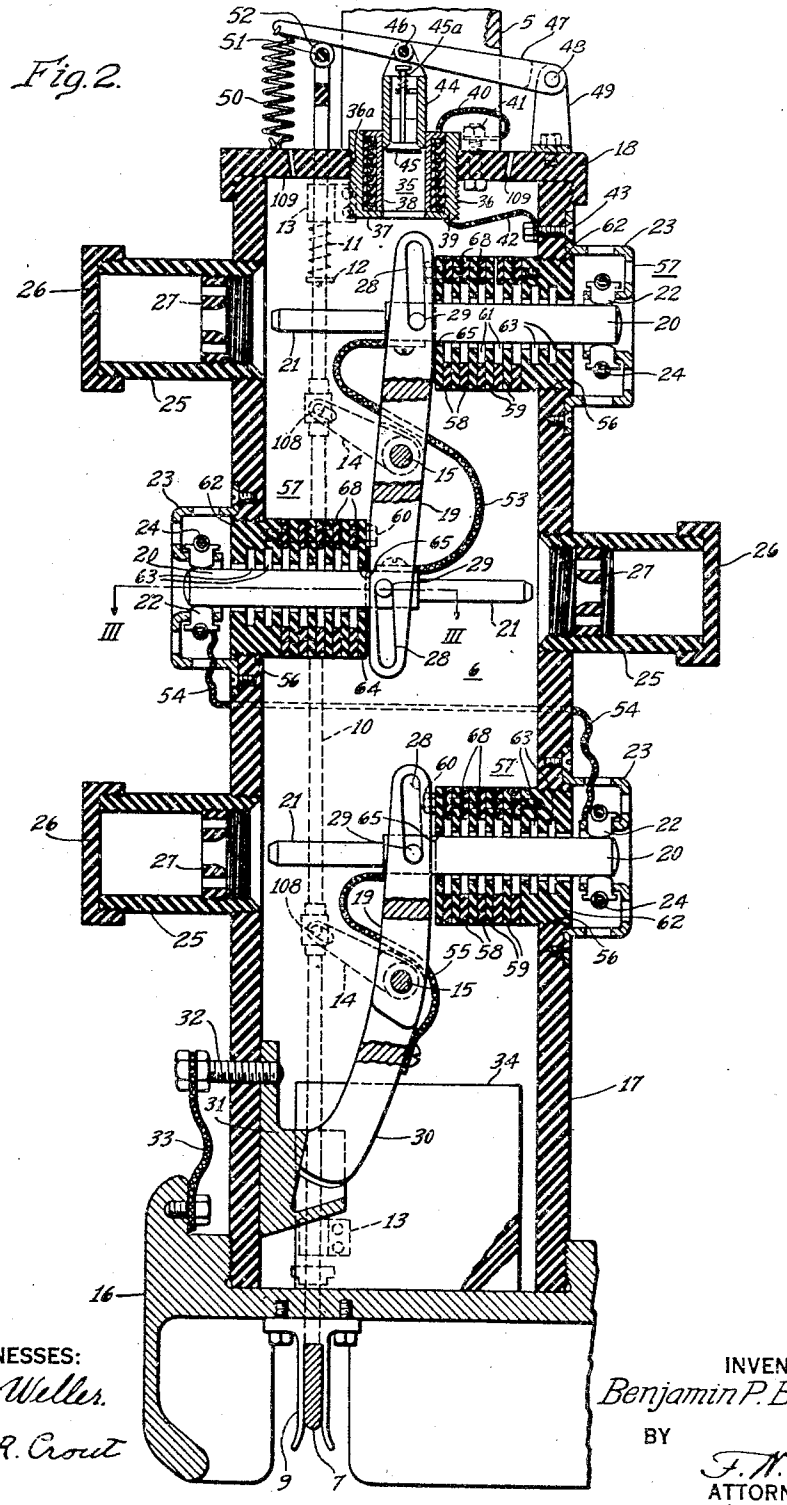
ATTORNEY

Dec. 17, 1946. B. P. BAKER 2,412,857

CIRCUIT INTERRUPTER

Filed Jan. 9, 1943 4 Sheets-Sheet 2

Fig. 2.



WITNESSES:

C. J. Weller.

W. R. Crout

INVENTOR

Benjamin P. Baker.

BY

F. W. Lyle.

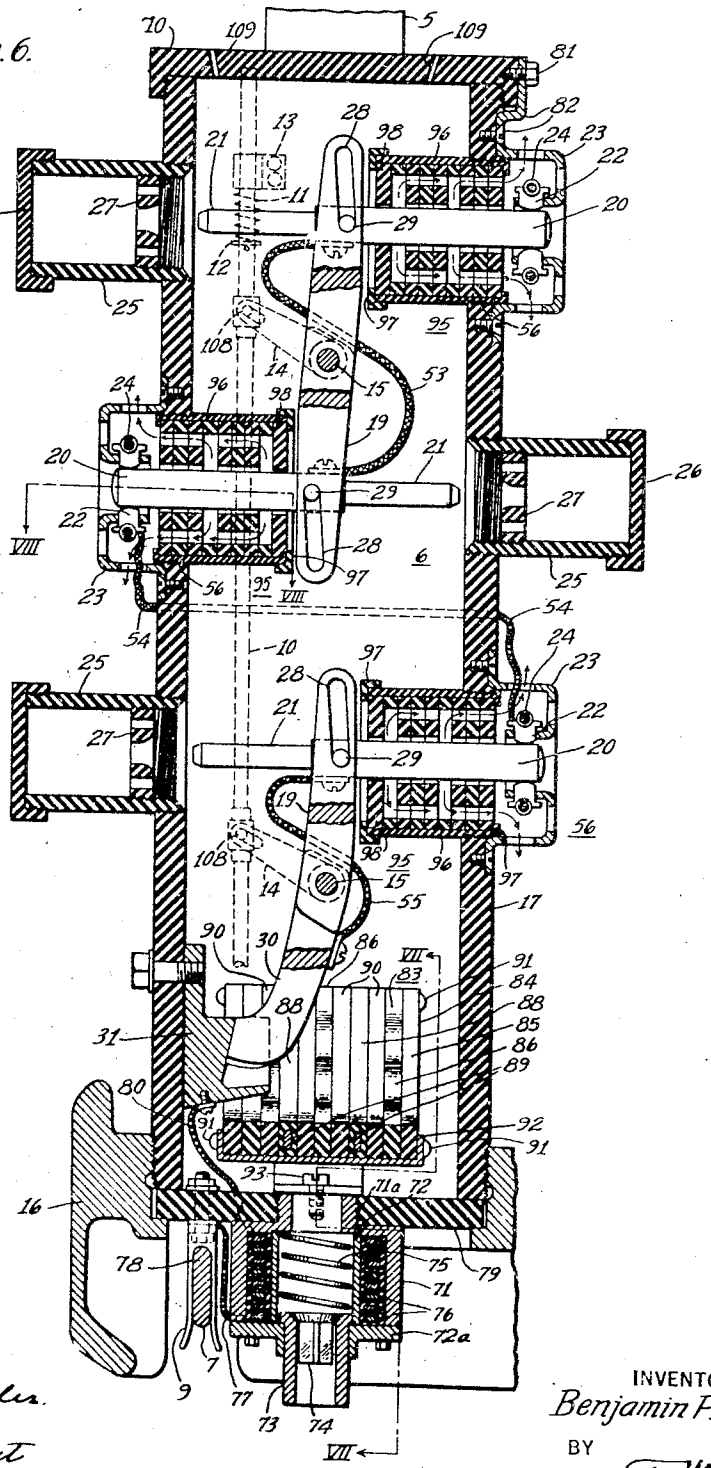
ATTORNEY

Dec. 17, 1946. B. P. BAKER 2,412,857

CIRCUIT INTERRUPTER

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Fig. 6.



WITNESSES:

C. J. Miller.

W. R. Crout

INVENTOR

Benjamin P. Baker.

BY

F. W. Lyle.

ATTORNEY

Dec. 17, 1946. B. P. BAKER 2,412,857

CIRCUIT INTERRUPTER

Filed Jan. 9, 1943 4 Sheets-Sheet 4

Fig.9.

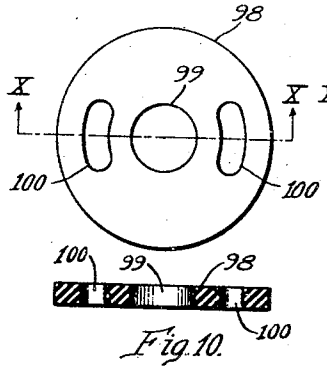


Fig.10.

Fig.15.

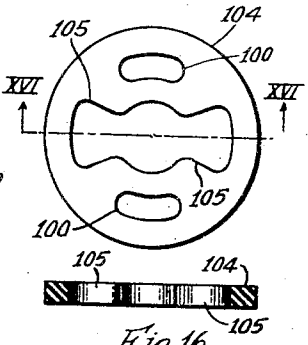


Fig.16.

Fig.21.

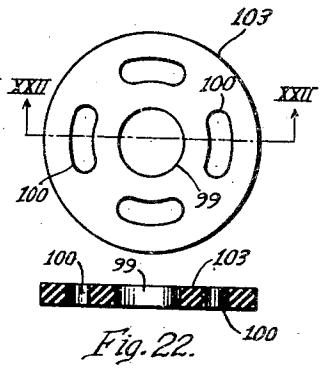


Fig.22.

Fig.11.

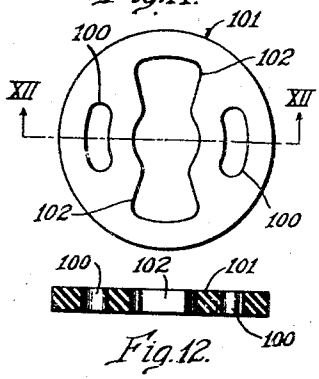


Fig.12.

Fig.17.

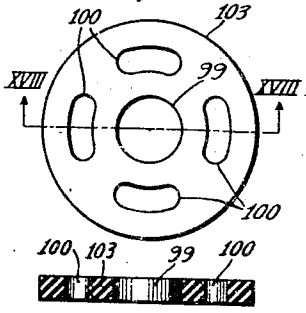


Fig.18.

Fig.23.

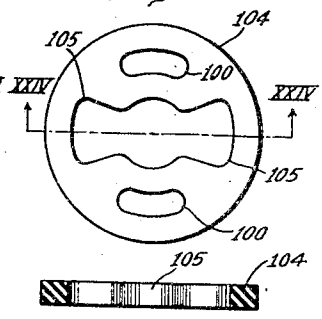


Fig.24.

Fig.13.

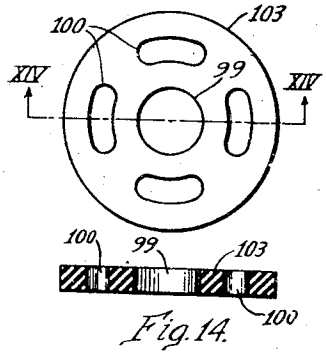


Fig.14.

Fig.19.

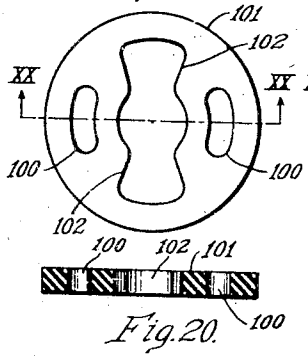


Fig.20.

Fig.25.

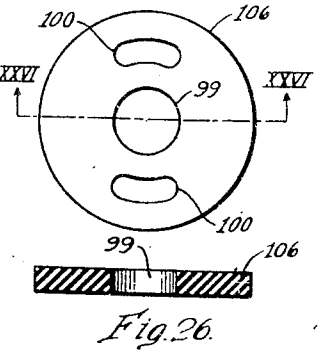


Fig.26.

WITNESSES:

C. J. Weller.

W. R. Crout

INVENTOR

Benjamin P. Baker.

BY

F. W. Lyle.

ATTORNEY

Patented Dec. 17, 1946

2,412,857

UNITED STATES PATENT OFFICE

2,412,857

CIRCUIT INTERRUPTER

Benjamin P. Baker, Turtle Creek, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application January 9, 1943, Serial No. 471,847

19 Claims. (Cl. 200—150)

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

An object of my invention is to provide an improved circuit interrupter comprising a substantially closed chamber and to position the stationary contact external to the chamber so that during the opening operation an arc may be drawn from the stationary contact through an aperture in the wall of the chamber into the interior of the chamber.

Another object is to provide an improved circuit interrupter of the type described in the immediately preceding paragraph and to provide means for putting the fluid disposed within the chamber under pressure to cause an ejection of at least a part of the fluid out of the chamber and through the aperture to extinguish the arc.

Another object is to provide an improved circuit interrupter comprising a substantially closed chamber and to dispose a plurality of relatively stationary contacts external to the chamber. I also provide a plurality of movable contacts cooperable with the stationary contacts to draw a plurality of serially related arcs through apertures disposed in the wall of the chamber. Preferably I put the fluid disposed in the chamber under pressure and cause its ejection out of the apertures to extinguish the serially related arcs.

Another object of my invention is to provide an improved circuit interrupter having improved piston means for facilitating circuit interruption. I associate a series coil with the piston means to assist the actuation of the piston means during the interruption of high currents.

Another object is to provide an improved circuit interrupter comprising a substantially closed chamber having a pair of stationary contacts disposed externally of the chamber and substantially on opposite sides thereof. I provide suitably disposed apertures adjacent to the stationary contacts in the walls of the chamber through which a pair of movable contacts are actuated to draw a plurality of serially related arcs from the stationary contacts through the apertures and into the chamber. Preferably I dispose improved interrupting means adjacent to the apertures to facilitate the extinction of the serially related arcs.

Another object is to provide an improved circuit interrupter comprising a substantially closed chamber in which a plurality of serially related arcs are established. I contemplate establishing a pressure generating arc within the chamber to

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put the fluid disposed therein under pressure and to thus cause the motion of the fluid adjacent one or more of the serially related arcs to effect the extinction thereof.

Another object is to provide an improved circuit interrupter of the type described in the immediately preceding paragraph in which means are provided for effecting the lateral movement of the pressure generating arc so that the pressure generating arc will contact fresh fluid to increase the pressure formed within the chamber.

Another object is to provide an improved circuit interrupter of the type drawing a pressure generating arc and one or more series interrupting arcs. I provide an interrupting unit adjacent the pressure generating arc which not only increases the gas generation of the pressure generating arc as compared to a plain break, but also adds interrupting ability to the entire circuit interrupter.

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

Figure 1 is an elevational view, partially in section, of a circuit interrupter embodying my invention and shown in the closed circuit position;

Fig. 2 is an enlarged cross-sectional view taken substantially on the line II—II of Fig. 1 and also shows the interrupter in the closed circuit position;

Fig. 3 is an enlarged fragmentary view taken on the line III—III of Fig. 2 but showing the disposition of the contacts during a circuit opening operation;

Fig. 4 is a view in cross-section taken on the line IV—IV of Fig. 3;

Fig. 5 shows a modification of my invention;

Fig. 6 is an enlarged elevational view in cross-section of an interrupter shown in the closed circuit position similar to Fig. 2 but embodying a modification of my invention;

Fig. 7 is a fragmentary enlarged view in elevation, partially in section, taken on the line VII—VII of Fig. 6;

Fig. 8 is an enlarged fragmentary view taken on the line VIII—VIII of Fig. 6 but showing the disposition of the contacts during a circuit opening operation; and

Figs. 9 through 26 show plan and sectional views in cross-section of plate details utilized in the interrupting units employed in the modification of my invention shown in Fig. 6.

Referring to the drawings and more particu-

larly to Figure 1, the reference numeral 1 designates a tank filled to the level 2 with a suitable arc extinguishing fluid, in this instance oil. Clamped to the cover 3 of the tank 1 are two insulating bushings 4. Depending from the lower ends of the insulating bushings 4 are conducting brackets 5 which rigidly support in position two substantially closed chambers generally designated by the reference numeral 6.

A conducting bridging member 7 arranged for vertical longitudinal reciprocating motion by means of an insulating lift rod 8 electrically connects the chambers 6 in the closed circuit position of the interrupter as shown in Fig. 1. Disconnect fingers 9 electrically engage the bridging member 7 as shown. Disposed externally of each chamber 6 are two insulating operating rods 10 biased downwardly by compression springs 11, the latter being disposed between washers 12 rigidly secured to the rods 10 and fixed guides 13 rigidly secured to the chambers 6.

Operating levers 14 connected by the pins 100 to the rods 10 rotate torsion shafts 15 (see Fig. 2) which actuate the movable contact structure disposed within the chambers 6. Electrostatic shields 16 are disposed at the lower ends of the chambers 6 to minimize corona formation.

Referring more particularly to Fig. 2, it will be noticed that the chamber 6 comprises a cylindrical insulating casing 17 having at its upper end an insulating cover plate 18 threadedly secured thereto. Levers 19 rigidly secured to the torsion shafts 15 are utilized to actuate the movable contacts 20. The movable contacts 20 have rear guide portions 21, the purpose for which will appear more clearly hereinafter.

Stationary contacts 22, in this instance comprising segmental conducting members, are supported on annular conducting brackets 23 rigidly secured by screws to the cylindrical insulating casing 17. A helical tension spring 24 biases the segmental contacts 22 into engagement with the movable contacts 20 as shown.

Disposed on opposite sides of the cylindrical insulating casing 17 from the stationary contacts 22, are insulating guide cylinders 25 having insulating cover caps 26. Disposed within the guide cylinders 25 are insulating guide spiders 27 which cooperate during the opening operation with the guide portions 21 to produce straight line movement of the movable contacts 20. Slots 28 disposed in the levers 19 cooperate with pins 29, the latter rigidly secured to the movable contacts 20, to cause the opening and closing motion of the movable contacts 20 in response to rotation of the levers 19 as a result of rotation of the torsion shafts 15.

At the bottom end of the lower lever 19 is a movable contact 30 which cooperates with a stationary contact 31 to establish a pressure generating arc during the opening operation of the interrupter. A stud 32 electrically connects the stationary contact 31 to a connector 33 which is secured to the electrostatic shield 16. The disconnect fingers 9 in this instance are rigidly secured to the electrostatic shield 16 as shown, the electrostatic shield 16 being threadedly secured to the lower end of the casing 17 and closing the lower end thereof. Two vertically upstanding insulating plates 34, only one of which is shown in Fig. 2, provide means for preventing the pressure generating arc established upon the separation of the movable contact 30 from the stationary contact 31 from contacting the casing 17 and injuring the same.

At the upper end of the casing 17 I dispose piston means generally designated by the reference numeral 35. The piston means 35 comprises a cylindrical iron member 36 screwed into an aperture 36a formed in the cover plate 18. The cylindrical iron member 36 has a lower flange portion 37 which supports a guide cylinder 38 made of a non-magnetic material, in this instance brass. A series coil 39 is disposed between the iron member 36 and the brass guide cylinder 38 and is electrically connected in series circuit by means of the connector 40, the other end of which is electrically connected to the support bolt 41 which supports the conducting bracket 5 to the cover plate 18.

The other end of the series coil 39 is electrically connected by means of the connector 42 to the stud bolt 43 which secures the annular conducting bracket 23 to the casing 17.

Operating within the brass guide cylinder 38 is a piston armature 44 composed of a suitable magnetic material, in this instance iron. Within the piston armature 44 is a valve 45 which is slightly biased to a closed position by the compression spring 45a. The compression spring 45a exerts just enough upward biasing force to overcome the weight of the valve 45.

The upper end of the piston armature 44 is pivotally mounted by a pin 46 to a lever 47, the latter being pivotally supported at its right-hand end by a pin 48 to the bracket 49. A tension spring 50 biases the left-hand end of the lever 47 in a downward direction.

In this embodiment of my invention the insulating operating rods 10 are bridged at their upper ends by an insulating cross rod 51 which engages in the closed circuit position of the interrupter the lever 47.

In the closed circuit position of the interrupter the electrical circuit therethrough comprises the conducting bracket 5, support bolt 41, connector 40, series coil 39, connector 42, stud bolt 43, annular conducting bracket 23, upper stationary contacts 22, upper movable contact 20, connector 53, intermediate movable contact 20, intermediate stationary contacts 22, connector 54, lower stationary contacts 22, lower movable contacts 20, connector 55, movable pressure generating contact 30, stationary pressure generating contact 31, stud 32, connector 33, electrostatic shield 16, disconnect fingers 9, movable conducting bridging member 7 to the right-hand chamber 6 through which the circuit passes in a similar manner to the upper right-hand bracket 5.

When it is desired to open the electrical circuit through the interrupter shown in Fig. 1 the insulating lift rod 8 is actuated downwardly by suitable mechanism, not shown, to cause downward movement of the conducting bridging member 7. The conducting bridging member 7 slides downward in the disconnect fingers 9, but maintaining electrical contact therewith. The initial downward movement of the conducting bridging member 7 permits the compression springs 11 to cause downward movement of the insulating operating rods 10. The downward movement of the insulating operating rods 10 causes a counterclockwise rotation of the operating levers 14 as viewed in Fig. 2. The counterclockwise rotation of the levers 14 as viewed in Fig. 2 causes a counterclockwise rotation of the torsion shafts 15 to result in counterclockwise rotation of the levers 19. The counterclockwise rotation of the levers 19 causes the simultaneous

formation of four serially related arcs associated with each chamber 6. The arc drawn between the movable contact 30 and the stationary contact 31 is a pressure generating arc which puts the fluid, in this instance oil, disposed within the chamber 6, under pressure. The oil within the chamber 6 being under pressure assists in the interruption of the other three serially related arcs associated with the chamber 6. Following the interruption of any one of the serially related arcs the circuit through the entire interrupter is broken, and the further downward movement of the conducting bridging member 7 breaks electrical engagement with the fingers 9 and produces two isolating gaps in the circuit, one gap being formed between each pair of disconnect fingers 9 at the lower end of each chamber 6 and the movable conducting bridging member 7. Consequently, in the open circuit position of the interrupter all potential stress is removed from the chambers 6.

The interrupting means associated with each pair of relatively movable contacts will now be described. Apertures 56 are formed in the side walls of the casing 17 adjacent the stationary contacts 22. Also disposed adjacent each stationary contact 22 is an interrupting unit, generally designated by the reference numeral 57 and shown enlarged in Fig. 3. The interrupting unit 57 comprises a plurality of insulating washer members 58 (see Fig. 4) having relatively large internal diameters. Alternately disposed between the insulating washer members 58 are insulating washer members 59 having relatively small inner diameters as more clearly shown in Fig. 4. The washer members 58, 59 are supported by tie bolts 60. The washer members 58, 59 when assembled on the tie bolts 60 provide a plurality of annular recesses 61 (see Fig. 3). An insulating bushing 62 is threadedly secured in the aperture 56 and has a corrugated inner surface 63 as shown. The annular corrugations 63 in the bushing 62 cooperate with the annular recesses 61 provided by the washer members 58, 59 to provide an interrupting unit 57 having an annularly corrugated inner surface.

The inner insulating plate 64 (see Fig. 3) has a guide portion 65 (see Fig. 2) which assists in guiding the movable contacts 20. The guide portions 65 are enlarged at 66 (see Fig. 3) to permit fluid flow from within the casing 17 through the interrupting unit 57 and out between the stationary contacts 22 as shown by the arrows in Fig. 3. When the movable contact 20 separates from the stationary contacts 22 during the opening operation, an arc 67 is established which is subjected to a longitudinal flow of fluid through the interrupting unit 57 and out between the stationary contacts 22. When the instantaneous value of the current through the arc 67 decreases in its cyclic variation the longitudinal flow through the interrupting unit 57 carries with it the hot ionized gases and that portion of the oil which has lost its dielectric strength as a result of its contact with the arc, so that as the current zero approaches, the last thread of conducting ionized gas is surrounded by fresh clean turbulent oil, which quickly transforms the entire arc path from one of fair conductivity to one of good insulation. This fluid flow causes the dielectric strength of the space within the interrupting unit 57 to rise so rapidly that the recovery voltage is unable to reestablish another half cycle of arcing. To allow the gas to escape from the recesses of the interrupting unit following arc extinction, vents 68 (see Fig. 4) may be provided in the washer members 58.

Certain features of the interrupting units 57 are described and claimed and the theory thereof given in my application filed May 15, 1940, Serial No. 335,218, which issued December 6, 1942 as Patent 2,304,529 and which was assigned to the assignee of this application.

In place of the interrupting unit 57 shown in Fig. 3, an insulating nozzle 69 may be used, being threadedly secured in the apertures 56 provided in the casing 17 as more clearly shown in Fig. 5. When this construction is used the arc 67 is established centrally within the nozzle 69 and is subjected to a flow of fluid indicated by the arrows in Fig. 5.

It will be apparent that the tension spring 50 (see Fig. 2) may initially assist the compression springs 11 in biasing the operating meechanism to the open circuit position. During the interruption of high short circuit currents the pressure generated by the pressure generating arc established between the contacts 30, 31 will correspondingly be high to produce a high pressure within the chamber 6. This high pressure will cause fluid to flow through the interrupting units 57 to extinguish the arcs drawn therein in the manner previously described.

During the interruption of low currents the pressure generated by the contacts 30, 31 is correspondingly low, and supplementary means for raising the pressure within the chamber 6 is desirable. In this event the piston means 35 assists the pressure generating arc drawn between the contacts 30, 31 to raise the pressure within the chamber 6. It will be apparent that upon downward movement of the insulating rods 13 the cross rod 51 and the roller 52 will also move down to permit the tension spring 50 to force the lever 47 in a counterclockwise direction about the pivot pin 48 to result in the piston armature 44 being forced downwardly to compress the fluid within the chamber 6. Consequently the piston armature 44 assists the pressure generating arc drawn between the contacts 30, 31 to raise the pressure within the chamber 6 during the interruption of low currents. This increase of pressure within the chamber 6 facilitates the interruption of the arcs within the interrupting units 57.

It will be apparent that the series coil 39 will move the piston armature 44 downward. In any magnetic circuit composed of movable parts the parts tend to move in a direction offering least reluctance to the magnetic flux. Since the reluctance of the piston armature 44 is relatively small as compared with the brass guide cylinder 38, the piston armature 44 will be moved down into the center of the series coil 39 to a point where the reluctance offered to the magnetic flux is a minimum.

It will consequently be apparent that I have provided means for assisting the tension spring 50 in operating the piston means 35 during high short circuit currents at a time when high pressure within the chamber 6 is desirable to effect the interruption of the high current arcs 67 established between the stationary contacts 22 and the movable contacts 20. The assistance furnished by the series coil 39 will obviously decrease as the current through the series coil 39 decreases. Thus during the interruption of small currents the tension spring 50 may be relied upon to operate the piston means 35. However, during the interruption of high short circuit currents the current through the series coil 39 will be increased

and in this event both the tension spring 50 and the series coil 39 will cooperate to force the piston armature 44 downward to raise the pressure within the chamber 6.

A further advantage of the coil 39 is that it exerts its force on the piston 44 immediately when the high current or short circuit is established. This speeds up the opening movement of the contacts and exerts considerable pressure on the oil, even before the pressure forming arc between contacts 30 and 31 is formed, or has reached sufficient length to become very effective. For high speed operation this feature is very important.

During the closing of the interrupter the valve 45 will open to permit fluid, in this instance oil, to flow into the interior of the chamber 6 through the piston armature 44. This provision of the valve 45 speeds up the closing operation, and also insures that fresh fluid will enter the chamber 6 through the top thereof during the closing operation. During the opening operation the valve 45 will, of course, remain closed.

It is thus apparent that any breaker operation at low current or at no current will cause the piston 44 and valve 45 to operate as a pump, circulating fluid in the top through the valve 45 and out through the interrupters 57, thus replacing the oil in the casing 17, with fresh oil from the larger volume in tank 1.

During the closing operation the insulating lift rod 8 moves upward to raise the conducting bridging member 7. The conducting bridging member 7 first electrically engages the disconnect fingers 9 and slides upward between them. Further upward movement of the conducting bridging member 7 raises the insulating operating rods 10 against the bias of both the compression springs 11 and the tension spring 50. This upward movement of the insulating rods 10 rotates the operating levers 14, the torsion shafts 15 and the levers 19 to result in contact being made between the movable contacts 20 and the stationary contacts 22 to effect a closing of the circuit through the interrupter.

It will be obvious that I have positioned the stationary contacts 22 externally of the chamber 6. This has distinct advantages. The movable contacts 20 establish and draw the arcs 67 from the stationary contacts 22 through the apertures 56 and into the interior of the chamber 6. By initiating the arcs 67 outside of the chamber 6 there is thus provided sufficient space for venting around the stationary contacts 22. Also this construction has the additional advantage of having the stationary contacts 22 exposed for ready inspection, adjustment and cooling.

In the embodiment of my invention shown in Fig. 6 the insulating casing 17 has a metallic top cover plate 70 threadedly secured thereto. A cylindrical member 71 composed of magnetic material, in this instance iron, is threadedly secured in an aperture 71*a* provided in the insulating bottom plate 79. A guide cylinder 72 composed of a suitable non-magnetic material, in this instance brass, is supported by an annular plate 72*a*, the latter being composed of a suitable magnetic material, in this instance iron. A piston armature 73 having a valve 74 disposed therein is biased downwardly by a compression spring 75. Disposed between the iron cylinder member 71 and the brass guide cylinder 72 is a series coil 76 connected in series circuit. One end of the series coil 76 is connected by the connector 77 to the stud bolt 78 which secures the disconnect fingers 9 to the insulating bottom plate 79. The other end of the series coil 76 is connected by the connector 80 to the stationary contact 31. A bolt 81 electrically connects the metallic top cover plate 70 to a connector 82, the lower end of which is electrically connected to the upper conducting bracket 23.

Consequently, in the closed circuit position of the interrupter shown in Fig. 6 the electrical circuit therethrough comprises the conducting bracket 5, plate 70, bolt 81, connector 82, conducting bracket 23, stationary contacts 22, movable contact 20, connector 53, intermediate movable contact 20, intermediate stationary contacts 22, connector 54, lower stationary contacts 22, lower movable contacts 20, connector 55, movable contact 30, stationary contact 31, connector 80, series coil 76, connector 77, stud bolt 78, disconnect fingers 9 to conducting bridging member 7. The circuit then passes through the conducting bridging member 7 to the other chamber 6 through which the circuit passes in an identical manner to the other line terminal not shown.

Associated with the lower contacts 31, 30 is an interrupting unit generally designated by the reference numeral 83. The unit 83 comprises an end insulating plate 84, the configuration of which is more clearly shown in Fig. 7. Referring to Fig. 7, it will be observed that the end insulating plate 84 has a cutout portion 85 to accommodate the movement of the movable contact 30. Immediately adjacent to the end insulating plate 84 is a pocket insulating plate 86 which forms a plurality of pockets 87 more clearly shown in Fig. 7. The pockets 87 retain a plentiful supply of fresh fluid ready to be acted upon by the pressure generating arc established between the contacts 30, 31.

Immediately adjacent to the pocket insulating plate 86 is a group of three insulating plates, the center one of which is herein called an insert insulating plate 88. The insert insulating plate 88 has a configuration, in this instance identical with the configuration of the end insulating plate 84. The insert insulating plate 88, however, has a recess disposed therein to accommodate the insertion of an insert of magnetic material 89, in this instance composed of iron and having a configuration more clearly shown in Fig. 7. On each side of the insert insulating plate 88 is a guard insulating plate 90 having a configuration identical to the end insulating plate 84. Tie bolts 91 rigidly secure the insulating plates into position, and they are supported in spaced relation above the insulating bottom plate 79 by a bracket 92 secured by screws 93 to the bottom insulating plate 79. The plates within the interrupting unit 83 may be repeated.

When the movable contact 30 is separated from the stationary contact 31 a pressure generating arc is established. The magnetic inserts 89 distort the magnetic field about the pressure generating arc to cause it to move downward as indicated by the arrow 92*a* in Fig. 7 into the lower portion 94 of the interrupting unit 83, where the pressure generating arc constantly contacts fresh fluid, in this instance oil, to generate increased gas and hence to greatly increase the pressure within the chamber 6.

By my providing the magnetic inserts 89 the pressure generating arc established between the contacts 30, 31 will be biased downwardly into the lower portion 94 of the interrupting unit 83 to constantly be maintained at the gas-oil boundary and thus to generate an increased amount of

gas. The increased amount of gas formed as a result of the lateral movement of the pressure generating arc increases the pressure within the chamber 6. It will, furthermore, be obvious that not only does the interrupting unit 83 function to move the pressure generating arc laterally to effect increased pressure within the chamber 6, but also an interrupting action takes place so that the pressure generating arc thus may be extinguished by the interrupting action furnished by the interrupting unit 83.

Even if the magnetic inserts 88 are omitted so that comparatively little lateral motion of the pressure generating arc takes place, still the drawing of said arc past the pockets 87 constantly causes fresh liquid to engage the arc and hence to greatly increase the pressure within the chamber 6 and the interrupting ability of the entire circuit interrupter.

Consequently, in this embodiment of my invention, I have provided four effective interrupters associated with each chamber 6, the lower interrupter 83 not only affording an interrupting action but also considerably raising the pressure within the chamber 6 to effect fluid flow through the three interrupting units 95 associated with the other three serially related arcs drawn during an opening operation of the interrupter.

General aspects of the interrupting unit 83 have been described and claimed in the following patents, 1,899,605 which issued February 28, 1933, to Benjamin P. Baker and Ernest G. Kees; 1,911,072 which issued May 23, 1933, to Lloyd W. Dyer and Winthrop M. Leeds; 1,914,137 which issued June 13, 1933, to Winthrop M. Leeds; 1,991,901 which issued February 19, 1935, to Winthrop M. Leeds; 2,039,054 which issued April 28, 1936, to Samuel H. Boden and Stanley T. Schofield and 2,138,382 which issued November 29, 1938, to Winthrop M. Leeds and Ennio Ortensi, all of the foregoing patents being assigned to the assignee of this application.

The interrupting units 95 will now be described with particular attention directed to Fig. 8. An insulating cyclindrical member 96 is threadedly secured in the apertures 56 provided in the casing 17. The insulating cylindrical member 96 has disposed at each end flange portions 97 which serve to compress and hold in rigid position a plurality of insulating plates which form the interrupting unit 95.

At the inner end of the interrupting unit 95 is disposed an end insulating plate 98, the configuration of which is more clearly shown in Figs. 9 and 10. The insulating plate 98 has formed therein a central aperture 99 and two cutout portions 100, the purpose for which will appear more clearly hereinafter.

Immediately adjacent to the end insulating plate 98 is an insulating discharge plate 101 the configuration of which is more clearly shown in Figs. 11 and 12. The insulating discharge plate 101 has two discharge passages 102 and two cutout portions 100. Immediately adjacent to the insulating discharge plate 101 is an insulating orifice plate 103, the configuration of which is more clearly shown in Figs. 13 and 14. The insulating orifice plate 103 has a central aperture 99 and four cutout portions 100.

Immediately adjacent to the orifice plate 103 is an insulating inlet plate 104, the configuration of which is more clearly shown in Figs. 15 and 16. The insulating inlet plate 104 has two entrance passages 105 and two cutout portions 100. Then follows an orifice plate 103, an insulating discharge plate 101, an orifice plate 103, an insulating inlet plate 104, and finally an end insulating plate 106 the configuration of which is more clearly shown in Figs. 25 and 26. The insulating end plate 106 has a central aperture 99 and two cutout portions 100.

Referring to Fig. 8 it will be observed that upon assembling the several insulating plates within the insulating cylindrical member 96, the central apertures 99 align to form an arcing passage means generally designated by the reference numeral 107. It will also be observed that the cutout portions 100 align to form passages which communicate at their inner end with the interior of the chamber 6, and serve to force fluid into the arcing passage means 107 at a plurality of spaced points therealong. Referring to Fig. 6 it will be observed that the cutout portions 100 also serve to provide discharge passages which lead to the region external to the chamber 6 and which are spaced at a plurality of spaced intermediate points along the passage means 107. The direction of the fluid discharge is shown by the arrows in Fig. 6. The direction of flow of the fluid from the interior of the chamber 6 into the arcing passage means 107 is indicated by the arrows in Fig. 8.

It will be obvious that the fluid entering the interrupting unit 95 through the inlet plates 104 may either exhaust directly between the stationary contacts 22 or pass through the central aperture 99 in the orifice plates 103 to exhaust through the discharge passages 102 provided in the insulating discharge plates 101.

General features of the interrupting unit 95 are described and broadly claimed in an application entitled "Circuit Interrupter" filed November 11, 1942, Serial No. 465,244, now U. S. Patent 2,406,469, issued August 27, 1946, by Leon R. Ludwig, Winthrop M. Leeds and Benjamin P. Baker and which was assigned to the assignee of this application.

The operating mechanism shown in Fig. 6 operates in a manner identical to the operating mechanism previously described in connection with Figs. 1 and 2. A further description thereof, consequently, seems unnecessary. It will be observed that by varying the distance between the pins 108 rigidly secured to the insulating operating rods 10 and the torsion shafts 15, the speed of rotation of the levers 19 as a function of the downward velocity of the conducting bridging member 7 may be varied. Obviously, by increasing the distance between the pins 108 and the torsion shafts 15, the rotation of the levers 19 and, consequently, the speed of operation of the contacts 20, 22 may be increased with respect to the downward velocity of the conducting bridging member 7.

I have provided small vents 109 at the top of the chambers 6 to permit any accumulated gas formed during an opening operation to escape out of the chamber 6. This helps to maintain the dielectric strength of the fluid within the chamber 6 at a high value.

It will be observed that the series coil 76 will cause the actuation of the piston armature 73 upward to assist raising the pressure within the chamber 6 during the interruption of high short circuit currents. Thus during the interruption of high short circuit currents there is not only an increased pressure caused by the pressure generating arc drawn between the contacts 30, 31, but also the piston armature 73 is then actuated against the biasing action of the compression

spring 75 to further raise the pressure within the chamber 6.

The rise in pressure within the chamber 6 is desirable during the interruption of high short circuit currents to effect the necessary fluid flow through the interrupting units 95 to effect the extinction of the arcs 67 drawn between the stationary contacts 22 and the movable contacts 20 in Fig. 6.

It will be observed that when the current being interrupted is high the biasing action exerted by the inserts 99 is greater and hence a greater volume of gas will be formed at the pressure generating arc drawn at the contacts 30, 31 to increase the pressure within the chamber 6. During the interruption of low currents the series coil 76 will not be as effective as on the interruption of high short circuit currents to cause upward movement of the piston armature 73.

Thus I have provided a means for utilizing the high short circuit currents to effect increased pressure within the chamber 6 during the interruption of high short circuit currents.

When the piston armature 73 is actuated upwardly, the valve 74 remains closed. When the compression spring 75 returns the piston armature 73 to its lower position the valve 74 opens to permit oil to flow into the chamber 6.

Although I have shown four serially related breaks associated with each chamber 6, not counting the disconnect break, it is apparent that for a higher voltage more breaks could be used.

Since the magnetomotive force of the series coils 39 in Fig. 2 and 76 in Fig. 6 is proportional to the product of the number of turns in the series coils and the electric current flowing through the series coils, it is readily apparent that by increasing the number of turns in the series coils 39, 76 the respective piston armatures 44, 73 will be actuated at correspondingly lower current values. Consequently, by increasing the number of turns in the series coils, the pistons will be operative at lower current values to increase the pressure within the chambers 6. The number of turns in the series coils 39, 76 will then be determined by the operating conditions required.

It will, furthermore, be observed that in the operation of the interrupter shown in Fig. 2 if the pressure within the chamber 6 becomes very high during the interruption of high currents the piston means 35 may be held in its raised position, the insulating cross rod 51 and the roller 52 meanwhile separating from the lever 47. In this event the tension spring 50 will not assist the compression springs 11 to bias the operating mechanism to the open circuit position. Also in this event it will be apparent that upon the subsidence of the pressure within the chamber 6 of Fig. 2 after interruption the piston means 35 will then be operative due to the tension in the tension spring 50 to flush contaminated fluid out through the apertures 56 in the casing 17. As mentioned previously, however, the turns in the series coil 39 may be increased to such an extent that the piston means 35 will be operative even during the existence of high pressure within the chamber 6 caused by the interruption of high currents.

It will be readily apparent that although I have shown my invention as applied to liquid type circuit interrupters, the same were merely for purposes of illustration and my invention is not limited to use only in liquid type circuit interrupters, but also may be used in connection with

circuit interrupters used in gaseous mediums or even in air. If the circuit interrupters are operated in a gaseous medium, for instance air, the several insulating washers used in the interrupting units 57, the insulating plates used in the interrupting units 95 and the insulating plates used in the interrupting units 83 may all be composed of a suitable material which evolves a vapor upon being subjected to the action of an electric arc. Such a use of gas evolving material would facilitate the interruption of the arcs.

The term fluid as used herein and in the appended claims comprises liquids, vapors, gases and sprays.

Although I have shown and described specific embodiments of my invention, it is to be clearly understood that the same were merely for purposes of illustration, and that changes and modifications may be made without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. In a circuit interrupter, means defining a substantially closed stationary chamber, a plurality of relatively stationary contacts mounted external to the chamber so as to be freely vented, a plurality of apertures in the wall of the chamber, a plurality of movable contacts movable away from the stationary contacts and through the apertures to within the chamber to draw a plurality of serially related arcs through the apertures, and means other than the arcs for putting the fluid within the chamber under pressure to cause an ejection of fluid out of the chamber and through the apertures substantially longitudinally of the arc to extinguish the arcs.

2. In a circuit interrupter, a substantially enclosed stationary chamber, a pair of stationary contacts mounted substantially on opposite walls of the chamber so as to be freely vented, a pair of apertures through the walls of the chamber disposed adjacent to the two stationary contacts, a pair of cooperable moving contacts separable from the stationary contacts to draw two serially related arcs adjacent the two apertures, lever means for causing motion of the pair of moving contacts, means other than the arcs for putting fluid within the chamber under pressure to force the fluid out the apertures adjacent the arcs to effect the extinction of the same, and a torsion shaft for causing motion of the lever means.

3. In a circuit interrupter, a substantially enclosed chamber, a plurality of pairs of stationary contacts, an aperture through the wall of the chamber adjacent each contact, each pair of stationary contacts being mounted substantially on opposite sides of the chamber, a plurality of pairs of moving contacts to draw a plurality of arcs adjacent the apertures, a plurality of levers for causing the motion of the pairs of moving contacts, a plurality of torsion shafts for causing the motion of the levers, means for putting fluid disposed within the chamber under pressure to effect an ejection of the same out the apertures to extinguish the arcs, and means for simultaneously causing the rotation of the levers.

4. In a circuit interrupter, a substantially closed stationary chamber, a pair of stationary contacts mounted externally of the chamber so as to be freely vented and substantially on opposite sides thereof, a pair of apertures in the wall of the chamber adjacent the stationary contacts, a cooperable pair of moving contacts movable away from the pair of stationary contacts to draw two serially related arcs through the pair of apertures, means for putting fluid disposed within

the chamber under pressure to effect an ejection of the same out the apertures to extinguish the arcs, a lever for simultaneously causing the motion of the pair of moving contacts, and means pivotally mounting the lever intermediate its ends.

5. In a circuit interrupter, a chamber, piston means for putting the fluid within the chamber under pressure, spring means for urging the actuation of the piston means during a circuit interrupter opening operation, and a series coil to assist the spring means during the opening operation.

6. In a circuit interrupter, a substantially stationary closed chamber, a pair of relatively stationary contacts mounted externally of the chamber so as to be freely vented and substantially on opposite sides thereof, a pair of apertures in the wall of the chamber adjacent the pair of stationary contacts, at least one insulating nozzle disposed in one of the apertures, a pair of movable contacts movable through the pair of apertures from within the chamber to engage the pair of stationary contacts in the closed circuit position of the interrupter, means for simultaneously actuating the pair of movable contacts away from the pair of stationary contacts and through the pair of apertures to draw two serially related arcs through the apertures, and means other than the arcs for putting the fluid within the chamber under pressure to cause the ejection of the fluid out of the chamber through the apertures to extinguish the arcs.

7. In a circuit interrupter, a substantially closed chamber, a pair of stationary contacts mounted externally of the chamber and substantially on opposite sides thereof, a pair of apertures in the wall of the chamber adjacent the pair of stationary contacts, a pair of interrupting units disposed adjacent the pair of apertures, the arcing surface of each interrupting unit having a plurality of recesses to form a corrugated arcing surface, a pair of movable contacts cooperable with the pair of stationary contacts to draw two serially related arcs through the pair of apertures and into the pair of interrupting units, and means for putting fluid within the chamber under pressure to cause the ejection of fluid through the pair of interrupting units and out the apertures to effect the extinction of the arcs.

8. In a circuit interrupter, a substantially closed chamber, a pair of relatively stationary contacts mounted externally of the chamber and substantially on opposite sides thereof, a pair of apertures in the wall of the chamber adjacent the pair of stationary contacts, at least one insulating nozzle disposed in one of the apertures, a pair of movable contacts movable through the pair of apertures to engage the pair of stationary contacts in the closed circuit position of the interrupter, lever means for simultaneously actuating the pair of movable contacts away from the pair of stationary contacts and through the pair of apertures to draw two serially related arcs through the apertures, and means for putting the fluid within the chamber under pressure to cause the ejection of the fluid out of the chamber through the apertures to extinguish the arcs.

9. In a circuit interrupter, a substantially closed chamber, a pair of stationary contacts mounted externally of the chamber and substantially on opposite sides thereof, a pair of apertures in the wall of the chamber adjacent the pair of stationary contacts, a pair of interrupting units disposed adjacent the pair of apertures, the

arcing surface of each interrupting unit having a plurality of recesses to form a corrugated arcing surface, a pair of movable contacts cooperable with the pair of stationary contacts to draw two serially related arcs through the pair of apertures and into the pair of interrupting units, lever means for simultaneously actuating the pair of movable contacts, and means for putting fluid within the chamber under pressure to cause the ejection of fluid through the pair of interrupting units and out the apertures to effect the extinction of the arcs.

10. In a circuit interrupter, a substantially closed chamber, means for establishing a plurality of serially related arcs within the chamber, means for putting liquid disposed within the chamber under pressure to facilitate the extinction of the arcs, said last-mentioned means comprising relatively movable contacts separable to establish a pressure generating arc, and means affecting the magnetic field about the pressure generating arc to cause it to move into engagement with fresh liquid to give increased pressure within the chamber.

11. In a circuit interrupter, two substantially closed chambers, movable contact structure disposed in each chamber, a plurality of torsion shafts extending through the walls of each chamber to operate the movable contact structure disposed therein, an operating lever connected to each shaft, at least one operating rod for each chamber which is connected to the plurality of operating levers associated therewith; and a conducting bridging member operable to cause the formation of two disconnect gaps in the series circuit, the bridging member also causing the actuation of the operating rod associated with each chamber.

12. In a circuit interrupter, a substantially closed chamber, a stationary contact mounted external to the chamber, arcing passage means extending from the contact through the wall of the chamber, the stationary contact being disposed adjacent one end of the passage means, a cooperable movable contact movable through the arcing passage means to establish an arc therein, means for putting fluid disposed within the chamber under pressure, and means for directing the fluid under pressure into the arcing passage means at a plurality of spaced points along the length of the arcing passage means to effect the extinction of the arc.

13. In a circut interrupter, a substantially closed chamber, a stationary contact mounted externally of the chamber, arcing passage means extending from the contact through the wall of the chamber, the stationary contact being disposed adjacent one end of the passage means, a cooperable movable contact movable through the arcing passage means to establish an arc therein, means for putting fluid disposed within the chamber under pressure, and means for directing the fluid under pressure into the arcing passage means at a plurality of spaced points along the length of the arcing passage means to effect the extinction of the arc, and a plurality of discharge passages disposed at a plurality of spaced intermediate points along the length of the arcing passage means and communicating to the region exterior to the chamber.

14. In a circuit interrupter, a substantially closed chamber, a pair of stationary contacts mounted externally of the chamber and substantially on opposite sides thereof, a pair of movable contacts movable through the wall of

the chamber to engage the stationary contacts in the closed circuit position of the interrupter, an interrupting unit disposed adjacent each stationary contact through which the movable contact passes to establish an arc therein, lever means for simultaneously actuating the pair of movable contacts, means for putting fluid within the chamber under pressure, each interrupting unit utilizing the fluid under pressure to direct a plurality of jets toward the arc established within the unit from spaced points along the arc.

15. In a circuit interrupter, a substantially closed chamber, a pair of stationary contacts mounted externally of the chamber and substantially on opposite sides thereof, a pair of movable contacts movable through the walls of the chamber to engage the stationary contacts in the closed circuit position of the interrupter, an interrupting unit disposed adjacent each stationary contact through which the movable contact passes to establish an arc therein, lever means for simultaneously actuating the pair of movable contacts, means for putting fluid within the chamber under pressure, each interrupting unit utilizing the fluid under pressure to direct a plurality of jets toward the arc established within the unit from spaced points along the arc, each interrupting unit also providing a plurality of discharge passages from spaced intermediate points along the arc which communicate to the region external to the chamber.

16. In a circuit interrupter, a chamber, means for putting fluid within the chamber under pressure, a stationary contact mounted externally of the chamber, a movable contact movable through a wall of the chamber to engage the stationary contact in the closed circuit position of the interrupter, an interrupting unit disposed adjacent the path of movement of the movable contact, the movable contact being separable from the stationary contact to establish an arc within the unit, the unit forming a plurality of entrance passages through which the fluid under pressure strikes the arc at a plurality of spaced points along the arc, the unit also forming a plurality of discharge passages spaced at intermediate points along the arc which communicate with the region external to the chamber.

17. In a circuit interrupter, means for establishing a pressure generating arc and one or more series interrupting arcs, means utilizing the pressure created by the pressure generating arc to assist in effecting extinction of one or more of the interrupting arcs, and means for effecting lateral movement of the pressure generating arc to cause the latter to engage fresh fluid to generate increased pressure for effecting a more rapid interruption of the electrical circuit through the interrupter.

18. In a circuit interrupter, means for establishing a pressure generating arc and one or more series interrupting arcs, means utilizing the pressure created by the pressure generating arc to assist in effecting extinction of one or more of the interrupting arcs, and magnetic means for effecting lateral movement of the pressure generating arc to cause the latter to engage fresh fluid to generate increased pressure for effecting a more rapid interruption of the electrical circuit through the interrupter.

19. In a circuit interrupter, means for establishing a pressure generating arc and one or more series interrupting arcs, means utilizing the pressure created by the pressure generating arc to assist in effecting extinction of one or more of the interrupting arcs, one or more fluid retaining pockets, means for lengthening the pressure generating arc past one or more of the fluid retaining pockets so that the pressure generating arc will continue to engage fresh fluid to generate increased pressure for effecting a more rapid interruption of the electrical circuit through the interrupter, and magnetic means cooperating with said last-mentioned means to move the arc laterally.

BENJAMIN P. BAKER.