

Sept. 14, 1948.

A. P. STROM
CIRCUIT INTERRUPTER

2,449,518

Filed Feb. 15, 1943

2 Sheets-Sheet 1

Fig. 1.

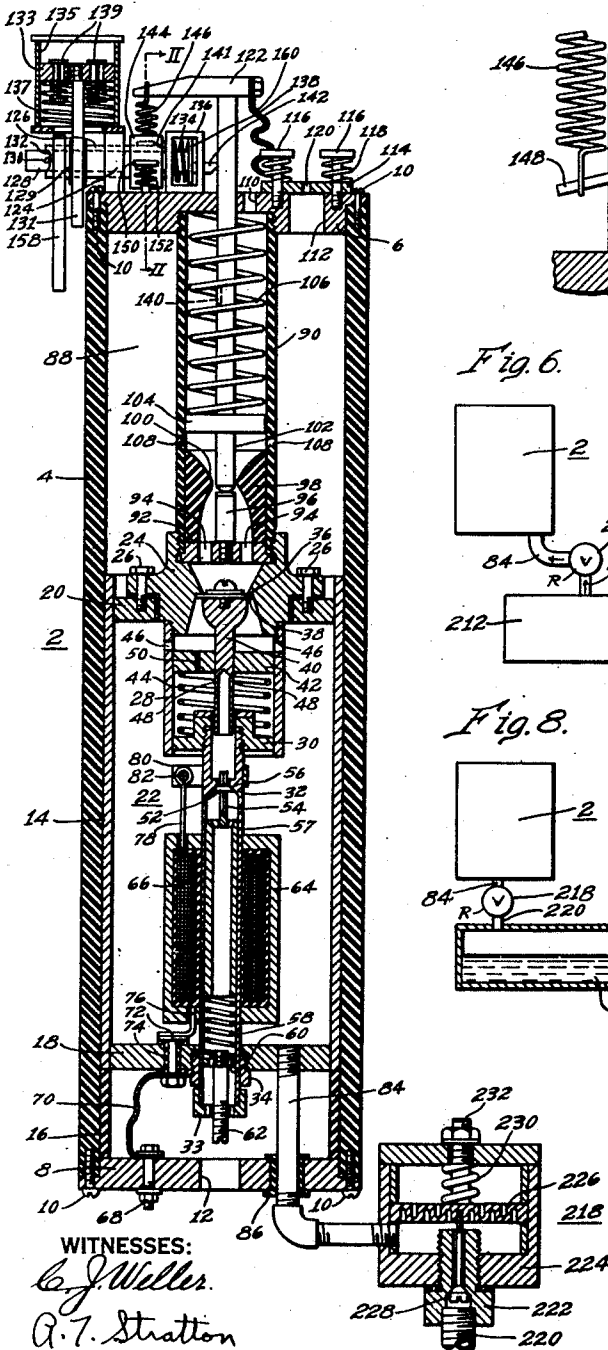


Fig. 2.

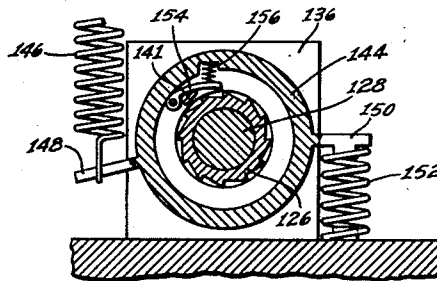


Fig. 6.

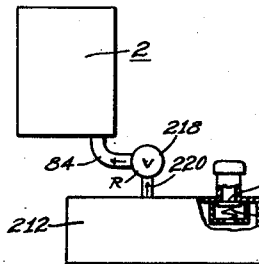


Fig. 7.

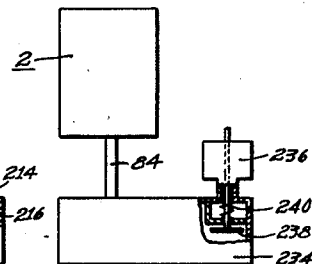


Fig. 8.

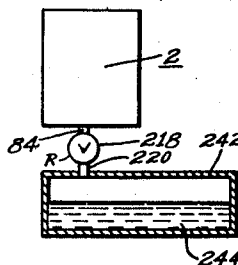


Fig. 9.

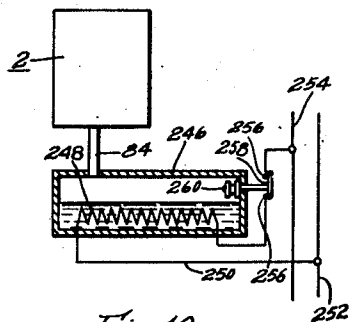
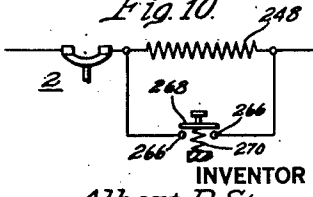


Fig. 10.



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2 Sheets-Sheet 2

Fig. 3.

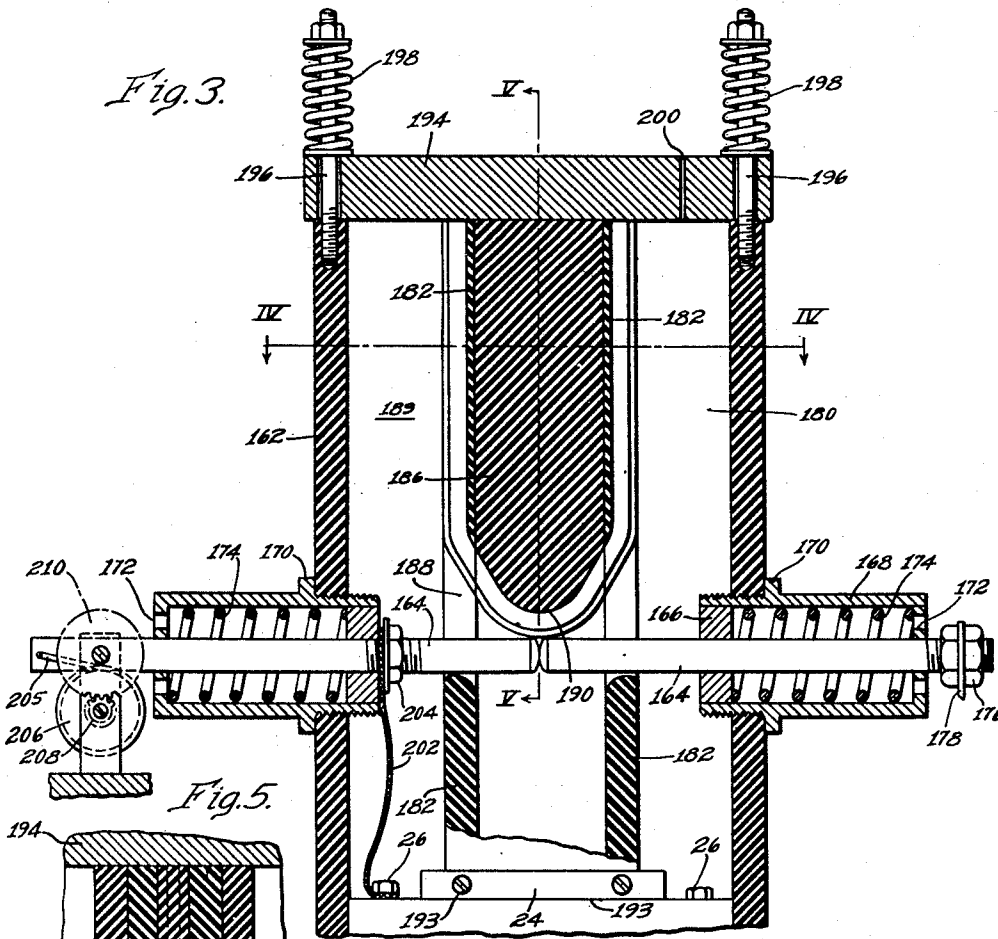
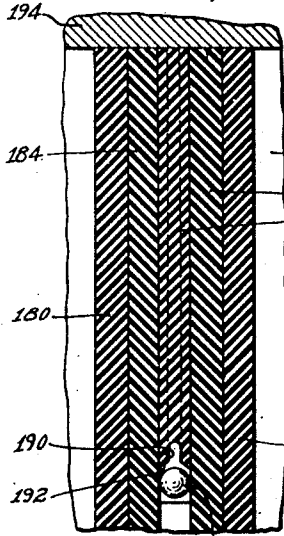


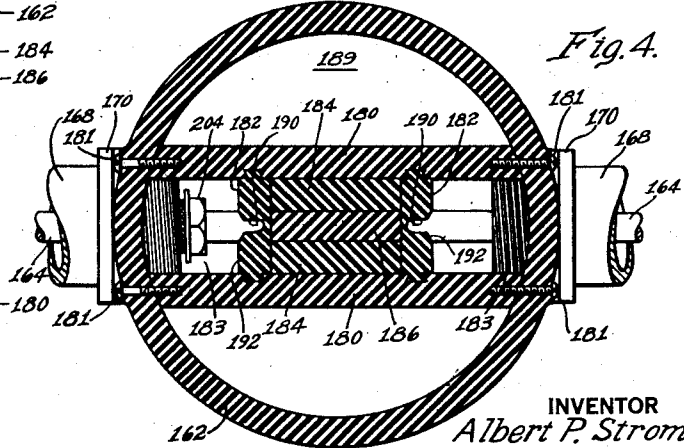
Fig. 5.



WITNESSES:

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Fig. 4.



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CIRCUIT INTERRUPTER

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29 Claims. (Cl. 200—82)

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This invention relates generally to electric circuit interrupters, and more particularly to interrupters wherein a gas under pressure is utilized to operate the interrupter and to extinguish the arc formed in a circuit interrupting operation.

Although this invention will be hereinafter particularly described in connection with an automatic reclosing circuit breaker especially adapted for pole mounting on rural lines wherein the several features of the invention have certain novel cooperation, it will become apparent as the disclosure proceeds, that certain of the novel features of this invention are also useful with other types of circuit breakers.

One object of this invention is to provide a novel automatic reclosing circuit breaker construction wherein a gas under pressure is used to actuate the breaker and to aid in extinguishing the arc formed upon separation of the breaker contacts.

Another object of this invention is to provide novel arc-extinguishing means for a circuit breaker utilizing a compressed gas.

Another object of this invention is to provide in a circuit breaker of the type described, novel means utilizing a compressed gas for separating the breaker contacts.

Another object of this invention is to provide in an automatic reclosing type circuit breaker utilizing a compressed gas as the operating medium, novel means for providing a time delay in the reclosure of the breaker contacts.

Another object of this invention is to provide a circuit breaker having novel fluid pressure means for separating the breaker contacts and extinguishing the arc formed.

Circuit breakers of this type are desirable because a single means (a compressed gas) is utilized for operating the breaker and extinguishing the arc, as distinguished from breakers using a liquid arc-extinguishing medium, and a separate electro-mechanical operating means for the breaker contacts.

Where breakers of the type embodying this invention are installed in remote locations, such as rural lines, it is necessary to provide a source of gas under pressure at least sufficient to operate the breaker through a plurality of operating cycles.

Accordingly, another object of this invention is to provide novel means for supplying a gas under pressure to a circuit breaker of the type described.

These and other objects of this invention will become more apparent upon consideration of the following detailed description of preferred em-

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bodiments thereof when taken in connection with the accompanying drawings, in which:

Figure 1 is a longitudinal section view of a circuit interrupter and pressure regulating feed valve embodying this invention;

Fig. 2 is an enlarged sectional view of the lock-out mechanism shown in Fig. 1, and taken substantially on the line II—II of Fig. 1;

Fig. 3 is a partial longitudinal section view of a modified form of interrupter constructed in accordance with this invention;

Fig. 4 is a transverse sectional view of the interrupter shown in Fig. 3 and taken substantially on the line IV—IV thereof;

Fig. 5 is a partial longitudinal section view of the interrupter shown in Fig. 3 taken at right angles to Fig. 3 substantially on the line V—V thereof;

Fig. 6 is a diagrammatic view illustrating one means for supplying fluid pressure to the interrupter comprising this invention;

Fig. 7 illustrates another type of fluid supply means;

Fig. 8 is a view similar to Figs. 6 and 7 of still another type of fluid supply means, with the supply tank shown in section;

Fig. 9 is a view similar to Fig. 8 showing still another means for supplying fluid pressure to an interrupter; and

Fig. 10 shows a modified circuit arrangement for use with the gas generating means of Fig. 9.

In Fig. 1 of the drawings there is illustrated a complete circuit breaker 2 embodying this invention, wherein the breaker is enclosed in a tube 4 of insulating material, such for example, as fiber, porcelain, or the like. The ends of insulating tube 4 are provided with metal end plugs 6 and 8 secured over the ends of tube 4 in any desired manner, and as shown, the end plugs are provided with shoulders adapted to seat on the outer ends of tube 4 with screws 10 passing through the shouldered portions to threadedly engage apertures provided in the insulating tube. The lower end plug 8 is provided with a substantially centrally located vent aperture 12, for a purpose hereinafter referred to.

A metal tube 14 is provided in the lower end of insulating tube 4 spaced from the lower end thereof by a spacer ring 16 of insulating material, such as fiber, for the purpose of forming a reservoir chamber in the lower portion of tube 4 within metal tube 14. The reservoir chamber 22 is closed at its ends by an upper end plug 20 and a lower end plug 18 secured in the ends of the tube 14, for example, as by welding or the

like. Upper end plug 20 is provided with a relatively large central aperture for the reception of a sleeve member 24 secured to end plug 20 by screws 26, and this sleeve provides a central passage therethrough which is flared outwardly at each end thereof, as shown on the drawings. A shoulder 36 is provided intermediate the ends of the passage through sleeve 24, to form a seat for valve disc 38. Sleeve 24 is provided with a reduced portion depending into reservoir chamber 22, to which is threadably secured the upper end of a cylinder sleeve 28 having the lower end thereof closed by a head 30. Cylinder head 30 is provided with a threaded socket on the lower side thereof for threadably receiving the upper end of an air vent pipe 32. This vent pipe 32 extends downwardly through the reservoir chamber 22, and through a stuffing box 34 in the chamber closure plug 18 into a vent space between the reservoir closure plug 18 and closure plug 8 for insulating tube 2.

Valve 38, referred to above, constitutes the main air valve for admitting air under pressure into the interrupting chamber in the upper part of insulating tube 4. The valve 38 is mounted on a stem 40 having secured thereto a piston 42 closely slidably engaging the inner walls of cylinder 28. A coil compression spring 44 engages between piston 42 and cylinder head 30 for normally biasing valve 38 to its closed position shown in Fig. 1. The upper end of cylinder 28 is provided with apertures 46 so that this end of the cylinder and the upper side of piston 42 will always be in communication with the pressure in reservoir chamber 22. Piston 42 is provided with a leak passage 50 so that fluid under pressure at the upper side of the piston may slowly pass through the piston to the lower side thereof to equalize the pressure on opposite sides of the piston. The lower end of valve stem 40 extends into vent pipe 32 and is preferably hollow in form, and provided with apertures 48 within the lower portion of cylinder 28, and below piston 42 for the purpose of venting the lower portion of the cylinder. Vent pipe 32 is provided with an annular inwardly extending shoulder 56 forming a seat for an auxiliary valve 52 mounted on a valve stem 54 which, in turn, is integral with a substantially cylindrical solenoid core 57 slidably mounted in vent pipe 32. The core 57 may be of any desired magnetic material, such for example, as soft iron or the like. A coil compression spring 58 is adapted to be engaged between the lower end of solenoid core 57 and an adjustable apertured spring seat 60, for normally biasing the core and valve 52 upwardly to a position wherein the valve is in engagement with seat 56 to close off vent pipe 32. Spring seat 60 in the lower end of vent pipe 32 may be maintained in any adjusted position by means of a screw 62 supporting the seat and threadably engaging an apertured end cap 33 for the lower end of vent tube 32.

Supported on vent tube 32, in any desired manner, is a solenoid casing 64 for mounting an annular solenoid coil 66 in a position to act on core 57. The lower end plug 8 for interrupter casing 4 is provided with a terminal bolt 68 extending therethrough and to which a line conductor may be secured, and this bolt is connected by a flexible shunt 70 to a conducting bolt 72 extending through lower end plug 18 for reservoir casing 22, and this bolt is insulated from end plug 18, for example, as by an insulating bushing 74. One terminal 76 of the solenoid coil is connected to conducting bolt 72, and the other terminal 78 of the coil is connected to a metal strap 80 clamped to

vent pipe 32 by a bolt 82. An air supply pipe 84 extends through an insulating bushing 86 in end plug 8 and is threaded into a threaded aperture in reservoir end plug 18 to supply a compressed gas to the reservoir chamber.

It will now be apparent that upon energization of solenoid coil 66, sufficient to draw core 57 downwardly against the bias of spring 58, valve 52 will be opened, thereby venting the lower end of cylinder 28 to atmosphere through the lower hollow end of valve stem 40, vent pipe 32, the vent chamber below plug 18, and aperture 12. This will permit the pressure within the reservoir chamber 22, which also exists in the upper end of cylinder 28 above piston 42, since the cylinder is in communication with the chamber by virtue of aperture 46 in the upper end thereof, to move piston 42 downwardly and thereby open the main air valve 38. Valve 38 will remain open so long as solenoid coil 66 is energized. However, as soon as the solenoid is deenergized, coil spring 58 is effective to move core 57 and valve 52 upwardly to close vent pipe 32 and permit a pressure to build up at the lower side of piston 42 through leak passage 50, so that coil spring 44 will be effective to move the piston and valve 38 upwardly to reclose this valve. Solenoid coil 66 is preferably connected in series with the circuit through the breaker, so that upon the occurrence of an overload in the circuit, the coil will be sufficiently energized to open vent valve 52 and thereby permit opening of the main air valve 38. Thereafter, as will more fully appear hereinafter, as soon as the circuit is interrupted, coil 66 is deenergized and main air valve 38 is reclosed as soon as sufficient pressure has leaked through piston passage 50 to substantially equalize the pressure on opposite sides of this piston.

The upper portion of insulating tube 4 provides a pressure chamber 88 in which circuit interruption occurs. In this embodiment of the invention, concentric insulating tube 90 is mounted between end plug 6 and sleeve 24, and preferably has the ends thereof threaded into threaded sockets provided in these members. Insulating tube 90 is preferably provided with a shouldered end plug 92 secured in position against a shoulder provided on sleeve 24, and end plug 92 is provided with apertures 94 permitting air flow into the lower end of the tube. A fixed contact rod 96 is threadably engaged in a central aperture in end plug 92, and extends upwardly within tube 90 a short distance into a throat defined by insulating member 98 secured in the lower end of tube 90. Insulating throat member 98 may be of any desired insulating material, preferably an insulating material which is capable of evolving an arc-extinguishing gas when in proximity to an electric arc, such for example, as fiber, boric acid, a synthetic resin or the like. As shown, insulating member 98 forms a restricted throat 100, and a passage flaring outwardly from the throat, and a movable contact 102 slidably mounted within the tube 90 is adapted to engage the fixed contact rod 96 substantially at the narrowest portion of throat 100. Movable contact rod 102 is slidably mounted through a central aperture in end plug 6, and is provided adjacent its lower end with an integral piston portion 104 adapted to closely slidably fit the inner surface of tube 90. A coil compression spring 106 engages between piston 104 and top closure plug 6 to normally bias contact rod 102 into engagement with fixed contact rod 96. Preferably, insulating tube 90 is provided with apertures 108 to communicate the in-

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terior of this tube with the pressure chamber 88. At the other end of tube 90, end plug 6 is provided with a vent aperture 110 for venting the upper end of tube 90, above piston 104, to the atmosphere. The upper end of pressure chamber 88 is also provided with a vent aperture 112 through end plug 6, but this aperture is normally covered by a plate 114 slidably mounted on screws 116 mounted on end plug 6. Cover plate 114 is biased into engagement with end plug 6 by coil compression springs 118 engaging between the heads of screws 116 and cover plate 114, and the cover plate is provided with a restricted vent aperture 120 for controlling the escape of air through aperture 112 in end plug 6.

In the operation of the interrupting means described above, when air is admitted to the lower end of insulating tube 90 by the opening of main valve 38, in the manner previously described, compressed gas is admitted and passes through apertures 108 into pressure chamber 88. As soon as sufficient pressure is built up in the lower end of tube 90 and chamber 88, piston 104 will be forced upwardly to thereby move contact rod 102 away from fixed contact rod 96, and draw an arc therebetween. The blast of gas entering tube 90 will pass through the arc, being concentrated at throat 100 in insulating member 98, to aid in extinguishing the arc. As soon as the arc is extinguished, main valve 38 will reclose since solenoid coil 66 is in series with contact rods 102 and 96, but contact rod 102 will not move downwardly into engagement with contact rod 96 because of the pressure which has been built up in pressure chamber 88, and accordingly, in the lower portion of insulating tube 90. This pressure will be slowly relieved by escape of gas through restricted vent 120, until it drops to a low enough value to permit spring 106 to move contact rod 102 back into engagement with contact rod 96. The time required for reclosure of the interrupter contact obviously may be predetermined by the size of the restricted vent aperture 120. Furthermore, by providing restricted vent aperture 120 in a movable cover plate 114, the maximum pressure built up within pressure chamber 88 may be controlled by the force exerted by springs 118 on the cover plate. In other words, springs 118 will determine the maximum pressure which can be built up in pressure chamber 88 and knowing the size of restricted vent aperture 120, the time delay in reclosing the interrupter contacts may be readily predetermined. From the above it is readily apparent that the structure thus far described is operable to interrupt the circuit in response to the occurrence of overloads, and to automatically reclose the circuit a predetermined time after interruption occurs.

The upper end of contact rod 102 projecting from insulating casing 4 is provided with a cross arm 122 for actuating a mechanism for locking the contacts separated after a predetermined number of successive circuit interrupting operations. The lockout mechanism is adapted to be supported on end closure plug 6, and includes a supporting bearing 124 for a sleeve 126 rotatably mounted in bearing 124 and in one side of an open rectangular bearing support 136. A locking pin 128 is slidably and rotatably mounted in sleeve 126, and is provided with a laterally projecting stop lug 130 to engage one end of sleeve 126 and to enter a notch 132 in this end of the sleeve upon predetermined rotation of the sleeve

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relative to stop pin 128. A coil compression spring 134 engages between a flange 138 provided on pin 128, and the other end of sleeve 126, to normally maintain stop lug 130 on pin 128 in engagement with the adjacent end of sleeve 126. Contact rod 102 is provided with a notch 140 intermediate the ends thereof, adapted to be engaged by a projecting latch portion on latch pin 128 under predetermined conditions. An actuating sleeve 144 is rotatably mounted on sleeve 126 of the lockout mechanism and is adapted to be oscillated by movement of contact rod 102. To this end, a coil tension spring 146 is connected between cross arm 122 on the contact rod and an actuating lug 148 integral with sleeve 144. Sleeve 144 is provided with another lug 150 located substantially diametrically opposite lug 148 to be engaged by a return spring 152 under compression between lug 150 and end plug 6. A pawl 154 is preferably mounted interiorly of actuating sleeve 144 and is provided with a spring 156 to cause engagement of the pawl with the ratchet-like periphery of the portion of sleeve 126 within actuating sleeve 144.

The outer end of sleeve 126 is provided with a pinion 129 adapted to be engaged by teeth (not shown) formed on the piston rod 131 of a dashpot piston 133. The dashpot piston 133 is adapted to be slidably mounted within cylinder 135 supported on bearing 124, and a coil compression spring 137 is provided between piston 133 and a shoulder at the lower end of cylinder 135, to normally bias the piston toward the upper end of the cylinder, and to normally maintain sleeve 126 in the position shown in Fig. 2. Dashpot piston 133 is also provided with passages therethrough controlled by spring biased valves 139 in a manner such that fluid, such as air, may pass through the apertures in the piston freely by unseating valves 139 in the downward movement of the piston, but upward movement of the piston by spring 137 will be at a controlled speed because of the necessity of fluid trapped above the piston to escape around the relative small clearance between the piston and cylinder 135. It will be noted that a cam lug 141 supported on rectangular supporting member 136 projects into the adjacent end of actuating sleeve 144, and in the normal position of the parts shown in Fig. 2 acts to maintain pawl member 154 out of engagement with the ratchet teeth on sleeve 126.

In the operation of the lockout mechanism, it will be observed that each time contact rod 102 moves upwardly to interrupt the circuit, actuating sleeve 144 will be rotated in a clockwise direction as viewed in Fig. 2, to move pawl 154 away from cam lug 141 and permit engagement thereof with the ratchet teeth formed on sleeve 126 to rotate this sleeve a predetermined amount in a clockwise direction. When the circuit is reclosed, return spring 152 will rotate actuating sleeve 144 in the opposite direction back to the position shown in Fig. 2, wherein pawl 154 is out of engagement with the ratchet teeth on sleeve 126, so that dashpot piston 133 which has been moved downwardly from the position shown in Fig. 1 a predetermined amount during the circuit interrupting operation, will be moved by spring 137 upwardly at a predetermined slow rate to thereby slowly return sleeve 126 to its normal position shown in Fig. 2. In the event the fault on the circuit does not clear, the contacts will immediately separate again, before sleeve 126 has returned to its original position to thereby rotate sleeve 126 a further amount in a clockwise direction, as

viewed in Fig. 2. Obviously, on non-clearing faults, sleeve 126 after a predetermined number of successive circuit interrupting operations will have been rotated sufficiently to bring notch 132 thereon in alignment with stop lug 130, so that latch pin 128 may be moved to the right, as shown in Fig. 1, by spring 134 so that on the next circuit interrupting operation the latch pin will engage notch 140 on the movable contact rod when these parts come into alignment. Accordingly, upon the occurrence of a predetermined number of successive circuit interrupting operations, it is apparent that the contact rod 102 will be locked in an open circuit position. However, if the circuit clears before the occurrence of the aforesaid predetermined number of successive circuit interrupting operations, dashpot spring 137 will continue to slowly move piston 133 upwardly and thereby rotate sleeve 126 in a counterclockwise direction, as viewed in Fig. 2, to eventually return the sleeve to its original position shown in Fig. 2, so that in the event a non-clearing fault subsequently appears on the circuit, the same predetermined number of successive circuit interrupting operations will occur prior to lockout operation of the breaker. After an automatic lockout operation of the breaker as described above, the breaker may be reset by manually rotating handle 158 an amount sufficient to cam stop lug 130 out of slot 132 whereby contact rod 102 will be moved into engagement with contact 96 by spring 106, and the sleeve 126 of the lockout mechanism will be returned to normal position by spring 137 in dashpot cylinder 135.

The electric circuit through the interrupter shown in Fig. 1, extends as previously referred to, from terminal bolt 68 through flexible shunt 70, conducting bolt 72, through solenoid coil 66, clamping strip 80, vent pipe 32, cylinder head 30, cylinder 28, sleeve 24, end plug 92, and fixed contact rod 96 to movable contact rod 102 and a flexible shunt 160 to upper end plug 6. It will, accordingly, be observed that solenoid coil 66 is connected in series circuit relation with contacts 102 and 96 so as to be responsive to overloads occurring in the circuit to open main air valve 38 and cause interruption of the circuit by contacts 96 and 102, and so that when interruption occurs the solenoid will be deenergized and permit reclosing of main air valve 38 and consequent reclosure of the contacts in the manner described above.

In Figs. 3, 4 and 5, there is illustrated a slightly modified form of interrupter which may utilize a tubular casing 162 similar to the casing 4, and having a reservoir chamber, solenoid and valve operating mechanism in the lower portion thereof like that shown in Fig. 1. The upper portion of tubular casing 162, however, is provided with opposed side openings for receiving contact rods 164 which extend across the casing and normally into engagement substantially centrally thereof. Each contact rod 164 is provided with a piston 166 secured to an intermediate portion thereof, and each piston is adapted to closely fit in cylinders 168 threaded into the side apertures in tubular casing 162, and provided with an annular shoulder 170 for limiting the amount which the cylinders may be screwed into the casing. Cylinders 168 are provided with outer end walls having apertures 172 so that the outer ends of the cylinders will be vented to the atmosphere, and each cylinder encloses a coil compression spring 174 engaging between the end wall of the cylinder and piston 166 to normally bias the contact rods towards

each other and into engagement. One contact rod is preferably provided with a threaded outer end, for the reception of a securing means such as nuts 176, for securing a line conductor 178 thereto.

Contact rods 164 preferably extend into an arc-extinguishing structure centrally provided within the upper end of tubular casing 162, and when the contacts separate they are adapted to draw an arc within this structure. The arc-extinguishing structure is preferably built up from a plurality of insulating plates, which may be of any desired insulating material, either a refractory insulating material, such as porcelain, or an insulating material which is capable of evolving an arc-extinguishing gas when in proximity to an electric arc, such as fiber, a synthetic resin or the like. As shown, the arc-extinguishing structure is confined between a pair of chordal side plates 180 which are secured in position within insulating tube 162, for example, as by screws 181, passing through tube 162 and threaded into apertures in the side edges of plates 180. Spaced end plates 182 extend across the space between side plates 180 and are secured in position in any desired manner, such for example, as by being dovetailed with the side plates. In the rectangular space defined by side plates 180 and end plates 182, there is provided inner side plates 184 adjacent side plates 180 respectively, and a central plate 186. End plates 182 as shown, are spaced from the walls of insulating tube 162 to form arcing spaces 183, and these plates are provided with openings 188 intermediate the ends thereof to receive contact rods 164, and inasmuch as central plate 186 terminates above contact rods 164, the openings 188 in the end plates form a transverse passage extending through the arc-extinguishing structure for receiving contact rods 164 when they are in engagement. The lower end of central insulating plate 186, and the outer side of each end insulating plates 182 is provided with a narrow slot 190 having an outwardly flaring entrance 192. This slot is substantially U-shaped in form, and extends along one end plate 182 around the rather blunt end of central plate 186, and along the other end plate 182 for a purpose to be hereinafter referred to. The plates forming the arc-extinguishing structure may be secured to sleeve 24 in any desired manner, such for example, as by screws 193. The upper end of tubular casing 162 is provided with a cover plate 194 having spaced apertures about the periphery thereof so as to be slidably mounted on bolts 196, and normally maintained in engagement with the upper end of tubular casing 162 by coil compression springs 198 mounted on each bolt. Cover plate 194 is provided with a leak vent passage 200 similar to the passage 120 in cover plate 114 of the species of the invention shown in Fig. 1.

The electrical circuit through this embodiment of the invention may extend from line conductor 178 through the right-hand movable contact 164, as shown in Fig. 3, to the other contact 164, thence to sleeve 24 by way of a flexible shunt 202 secured to the movable contact as by a nut 204, and to sleeve 24 by one of the securing bolts 26 thereof. From sleeve 24 the circuit may proceed in the manner described in connection with Fig. 1 through a series solenoid coil 66 to the other line conductor.

In operation, it will be observed that plates 184 and 182 of the arc-extinguishing structure being extended downwardly below contacts 164

form an air passage for air admitted by the main valve through sleeve 24, so that when this valve is opened and air is admitted, it will flow up past contact rods 164 through openings 188 into pressure chamber 189 formed within tubular casing 162. As soon as a pressure has been built up within pressure chamber 189 sufficient to overcome the pressure exerted by coil springs 174, the contacts will be moved relatively outwardly by action of the pressure on pistons 166 to thereby draw an arc. Air continuing to flow upwardly will pass substantially transversely through the arc thus drawn, and force the central portion of the arc laterally into engagement with the upper portion of the arc-extinguishing structure. It will be noted that end plates 182 in cooperation with inner side plates 184 and central plate 186 form, in effect, an arc splitter member so that air passing laterally through the arc will force the arc into substantially U-shaped form around the lower end of this arc splitting member.

In the interruption of arcs in which arc splitting members are employed and a gas blast is used to blow the arc into engagement with the splitter, two theories of operation have been proposed. One of these theories supposes that at current zero, the ionized path around the splitter structure is physically broken, and the two ends of the path then are separated by the flow of gas along the splitter at a rate sufficient to prevent breakdown as the voltage rises after current zero. A more reasonable theory of interruption with an arc splitter is believed to be that which assumes that the ionized path about the splitter is never really broken, because as the surface of the splitter is approached, the velocity of gases flowing along the splitter gradually approaches zero. Interruption, therefore, cannot occur because of an actual break in the ionized path of the arc, but may occur due to a reduction in the section and density of ionization, accompanied, of course, by an increase in length of the ionized path, all occurring at a time near current zero. In accordance with the first theory mentioned above, relatively thin arc splitters have been used with a knife-like edge, supposedly to obtain an actual break in the ionized path. However, it will be observed that in accordance with the second theory of interruption mentioned above, wherein an actual break in the path does not occur, it is not essential that a splitter structure having a knife-edge and being relatively thin be employed; rather in accordance with this theory, interruption may be aided by increasing deionization of the arc near a current zero.

The particular construction of splitter shown in Figs. 3, 4 and 5, is constructed to take advantage of the second theory of interruption set forth above. In other words, it will be noted that the splitter comprising plates 186, 182 and 184 is relatively thick and provided with a blunt edge adjacent the arc, and is so shaped that the arc passage on either side of the splitter and around the end adjacent the arc converges to a narrow slot or groove 190 at the center. When the arc is blown into a splitter constructed in the manner shown in Figs. 3, 4 and 5, there is ample room on each side of the splitter for arc decomposition products to escape during the high current portion of a half cycle. Then as the current approaches zero, the ionized path of the arc is driven into narrow groove 190 at the center of the splitter where it is closely surrounded on three sides by bounding walls to which ions may be

quickly lost. If these walls are of a gas generating material, the gases evolved therefrom will obviously further accelerate deionization. Actual tests with an interrupter constructed substantially as shown in Figs. 3, 4 and 5 indicate the correctness of the second arc interruption theory stated above, because it was possible to obtain successful operations with considerably lower gas pressures than those required with the knife-edge type of arc splitter.

As soon as circuit interruption occurs and the arc is extinguished between contacts 164, the main air valve will be closed in the manner previously described in connection with the embodiment of the invention shown in Fig. 1, but the contacts 164 will remain open because of the pressure built up within pressure chamber 189. Furthermore, this pressure will maintain the contacts separated a length of time predetermined by the size of the restricted vent 200. Accordingly, the contacts 164 will not be reclosed until the lapse of a predetermined time after a circuit interrupting operation due to pressure built up in pressure chamber 189, substantially in the same way as in the operation of the first described embodiment of this invention, due to pressure built up in chamber 88.

Lockout means may also be provided in the embodiment of the invention shown in Figs. 3, 4 and 5 and if desired, a lockout mechanism like that shown in Figs. 1 and 2 may be actuated by a gear 210 which, in turn, is adapted to be driven by a pinion 208 integral with a pulley 206. The pulley 206 is adapted to be actuated by a cord 205 wrapped around the pulley and having its free end secured to a contact rod 164, so that the gear train will be actuated each time the contacts separate.

In Fig. 6 through Fig. 10, there are shown various means for supplying a gas under pressure for a circuit interrupter of the type shown in Figs. 1 through 5, especially where interrupters such as those described are used for pole mounting at remote locations, such for example, as for the protection of rural electric lines. In such applications, it would be uneconomical to provide a separate prime mover such as an air compressor, for supplying the interrupter with the required operating medium, but at the same time, it is required that a sufficient quantity of gas under pressure be available to at least furnish an operating medium for the interrupter sufficient to actuate the interrupter through a plurality of circuit interrupting operations such as might occur between inspection periods. One way of accomplishing this is illustrated in Figs. 1 and 6, wherein a storage tank 212 for a compressed gas, such for example, as air, is provided with an inlet controlled by a valve 214 normally biased closed by a spring 216. Obviously, this storage tank may be charged by a portable compressor or the like through the tank inlet. Tank 212 is adapted to store gas at a relatively high pressure, for example, at a pressure of at least 100 lbs. per square inch, whereas the circuit interrupter may require a pressure on the order of 20 to 50 lbs. per square inch to operate the contacts and extinguish the arc. Accordingly, a pressure reducing valve is interposed between the inlet pipe 84 of the interrupter and outlet pipe 220 from storage tank 212, to conserve the gas stored in tank 212 and supply gas at the desired pressure to the interrupter 2. As shown in Fig. 1, this pressure reducing valve 218 may be of any desired conventional type, and that shown is provided with a valve casing 224

having a fitting 222 threaded into an aperture at one end of the casing, and this fitting in turn is provided with a threaded socket for receiving outlet pipe 220 from tank 212. Fitting 222 has a passage therethrough controlled by valve 228 secured to a flexible diaphragm 226 mounted in valve casing 224, and biased downwardly in a direction to open valve 228 by a coil compression spring 230. A stem 232 secured to diaphragm 226 extends through an opening in valve casing 224 and has a nut on the outer end thereof to limit opening movement of valve 228. The compression spring 230 is chosen to exert a force on the diaphragm sufficient to open valve 228 when the pressure beneath the diaphragm falls to a value below that required by the interrupter. As soon as the pressure below the diaphragm exceeds this value, the diaphragm will obviously be moved upwardly and close valve 228.

In the arrangement shown in Fig. 6, it will be apparent that gas may be stored at a relatively high pressure in tank 212 in a quantity sufficient to operate interrupter 2 through a plurality of circuit interrupting operations, and by use of a pressure reducing valve 218, gas may be supplied to the interrupter at a greatly reduced pressure.

In Fig. 7 there is illustrated an arrangement wherein interrupter 2 is adapted to be supplied from a pressure generating tank 234 wherein pressure is adapted to be generated by the chemical combination of different materials. Thus a supply of one material may be maintained in tank 234, such for example as calcium carbonate, (CaCO_3) and a supply of another material may be maintained in supply tank 236, such for example as sulphuric acid (H_2SO_4), which when brought into engagement will react to produce calcium sulphate (CaSO_4), water (H_2O) and carbon dioxide (CO_2). A large quantity of carbon dioxide gas will thus be produced to build up a pressure within tank 234. These two materials are maintained separated, and flow of material from tank 236 may be by gravity into tank 234 under the control of pressure actuated valve 238. Valve 238 is biased to an open position by a spring 240, so that it will open upon a drop in pressure in tank 234, and be closed by a rise in pressure above a desired value. Accordingly, when the pressure drops within tank 234, the material from supply tank 236 will be admitted until sufficient pressure is built up within tank 234 to close valve 238. Dependent upon the particular materials used to create pressure within tank 234, a pressure reducing valve such as the valve 218 shown in Figs. 1 and 6, may or may not be used, this being also dependent upon the pressure that it is desired to maintain within tank 234. In any event, the amount of chemical contained in tanks 234 and 236 may obviously be sufficient to create a sufficient quantity of compressed gas for interrupter 2, to actuate it through a number of successive circuit interrupting operations.

In Fig. 8 there is shown a construction wherein a storage tank 242 is connected with interrupter 2 by way of a regulating valve 218, and storage tank 242 is adapted to be at least partially filled with a liquid 244 having a boiling point at a temperature lower than the normal range of atmospheric temperature. Such a liquid, for example, could be liquid carbon dioxide, and this would obviously maintain a gas pressure within tank 242 equal to the vapor pressure of the liquid at atmospheric temperature. Here again there is provided a means for supplying a sufficient amount of gas under pressure for operating the interrupter 2

through a number of successive circuit interrupting operations.

In Fig. 9 a storage tank 246 is provided to be directly connected with inlet pipe 84 of interrupter 2, and this storage tank is provided with a resistance heating element 248 to generate gas under pressure by vaporization of a liquid therein. The liquid used may be water if desired, because water vapor or steam has extremely good arc-extinguishing characteristics. The resistance heater 248 may be energized from the same circuit in which interrupter 2 is connected, or from an auxiliary circuit, by a connection of one terminal thereof to one wire 252 of the circuit by a conductor 250, and connection of the other terminal of the heater and the other conductor 254 of the supply circuit through the spaced contacts 256 respectively of a control switch. The contacts 256 are adapted to be bridged by a bridging contact 258 mounted on a stem slidably mounted through a wall of storage tank 246, and extended into a flexible bellows 260 mounted within the tank and normally maintained in a distended condition by a coil compression spring therein (not shown). In operation, it is obvious that as long as a predetermined low pressure exists within storage tank 246, the circuit to heater 248 will be closed and pressure will be generated by vaporization of the liquid within the tank. When this pressure rises to a predetermined value, bellows 260 will be collapsed to move bridging contact 258 out of engagement with contacts 256 to thereby interrupt the circuit of the heater and discontinue generation of pressure. It is believed obvious that in this embodiment of the invention, sufficient liquid may be provided in a tank 246 of reasonable size to provide generation of sufficient pressure to operate the interrupter through a plurality of circuit interrupting operations.

In Fig. 10 there is shown a method for energizing resistance heater 248 by connection in series circuit with the contacts of interrupter 2. In this circuit, a pair of contacts 266 are provided in shunt relation with resistor heater 248 and these contacts are adapted to be bridged by a contact 268 spring biased normally to an open circuit position. Bridging contact 268 may be actuated, like contact 258, by a bellows member mounted within the storage tank, so as to be moved into engagement with contacts 266 upon the attainment of a predetermined high pressure within the tank, against the action of spring 270, to bypass resistor 248. Obviously upon a drop in pressure within the storage tank to a predetermined amount, contact 268 will move out of engagement with contacts 266 to open the shunt circuit and thereby energize heater 248.

In all of the methods of supplying fluid under pressure to an interrupter of the type herein disclosed, it is apparent that a source of supply is provided for supplying sufficient fluid under pressure to cause a plurality of successive operations of the interrupter. The pressure supplying means can be replenished periodically, and this may be done whenever it is necessary to reset the breaker following an automatic lockout operation. In the embodiments of the invention shown in Figs. 6 through 10, these sources of supply of fluid pressure may be made relatively simple and small in size, especially where periodical inspection is maintained. Also after the interrupter has operated a predetermined number of times and the contacts locked in open circuit position, it is necessary that they be manually reset, so that when this occurs and it becomes necessary to send an

attendant out to reset the breaker, he can at the same time recharge any of the fluid supply means shown in Figs. 6 through 10.

In the foregoing, there has been particularly disclosed an automatic reclosing circuit breaker of an especially novel and compact form which may be readily used for pole-top mounting, and which utilizes a compressed fluid, preferably a gas, such as air, to both separate the contacts and extinguish the arc formed. Moreover, several means have been disclosed for providing a supply of compressed gas at remote locations where such a breaker may be used. As to the breaker itself, two species of arc-extinguishing structures utilizing a compressed gas have been disclosed, and in both of these constructions, the gas is also utilized to provide a predetermined time delay in the reclosing of the breaker contacts; and both constructions may also be provided with means operating automatically in response to a predetermined number of successive circuit interrupting operations for locking the breaker contacts in an open circuit condition.

Having described preferred embodiments of this invention in accordance with the Patent Statutes, it is desired that the invention be not limited to these particular embodiments inasmuch as it will be obvious, particularly to persons skilled in the art, that many modifications and changes may be made therein without departing from the broad spirit and scope of this invention.

I claim as my invention:

1. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement, fluid actuated means for separating said contacts to interrupt the circuit a distance greater than that required to prevent re-striking of an arc following a circuit interrupting operation, means responsive to a predetermined condition of the circuit for admitting a fluid under pressure to said fluid actuated means to open the circuit and responsive to circuit interruption for cutting off admission of said fluid, and a restricted vent for said fluid actuated means, so that fluid admitted thereto to separate said contacts will escape therefrom only at a predetermined rate to permit automatic reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof and thereby automatically reclose the circuit said predetermined time after a circuit interrupting operation and re-energize said condition-responsive means if said predetermined condition still exists in said circuit.

2. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement, fluid actuated means for separating said contacts to interrupt the circuit a distance greater than that required to prevent re-striking of an arc following a circuit interrupting operation, means responsive to a predetermined condition of the circuit for admitting a fluid under pressure to said fluid actuated means to open the circuit and responsive to circuit interruption for cutting off admission of said fluid, means directing said fluid through at least a part of the arc formed upon separation of said contacts before it reaches said fluid actuated means, and a restricted vent for said fluid actuated means so that fluid admitted thereto to separate said contacts will escape therefrom only at a predetermined rate to permit automatic reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof,

and thereby automatically reclose the circuit said predetermined time after a circuit interrupting operation, and re-energize said condition-responsive means if said predetermined condition still exists in said circuit.

3. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement, fluid actuated means for separating said contacts to interrupt the circuit a distance greater than that required to prevent re-striking of an arc following a circuit interrupting operation, electroresponsive means connected in series circuit relation with said contacts for admitting a fluid under pressure to said fluid actuated means in response to a predetermined electrical condition of the circuit and for cutting off admission of said fluid when said condition is not present in the circuit, and a restricted vent for said fluid actuated means so that fluid admitted thereto to separate said contacts will escape therefrom only at a predetermined rate to permit automatic reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof, and thereby automatically reclose the circuit said predetermined time after a circuit interrupting operation, and re-energize said condition-responsive means if said predetermined condition still exists in said circuit.

4. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts, means responsive to a predetermined condition of the circuit for admitting a fluid under pressure to said fluid actuated means to open the circuit and responsive to circuit interruption for cutting off admission of said fluid, a pressure chamber in open communication with said fluid actuated means so that pressure will be built up in said chamber upon admission of fluid to said fluid actuated means, and said chamber being normally closed except for a restricted open vent for said chamber to permit fluid therein to escape at a predetermined rate to permit automatic reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof.

5. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts, means responsive to a predetermined condition of the circuit for controlling the admission of a fluid under pressure to said fluid actuated means to open the circuit and responsive to circuit interruption for cutting off admission of said fluid, a pressure chamber in open communication with said fluid actuated means so that a pressure will be built up in said chamber upon admission of fluid to said fluid actuated means, said chamber being normally closed except for a restricted open vent for said chamber to permit fluid therein to escape at a predetermined rate to permit automatic reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof, and pressure limiting means for said chamber to predetermine the maximum pressure which can be built up in said chamber to determine the maximum time delay in the reclosure of said contacts.

6. In an automatic reclosing circuit interrupter, a pressure chamber, a fluid inlet passage

for said chamber, means forming an arc passage in said fluid inlet passage, separable contacts normally biased closed and adapted when separated to draw an arc at least partially in said arc passage, fluid piston and cylinder means associated with at least one of said contacts with said cylinder in open communication with said chamber, means responsive to a predetermined condition of the circuit for admitting a fluid under pressure to said inlet passage to flow through said arc passage and into said chamber where it acts on said piston means to separate said contacts to open the circuit and responsive to circuit interruption for cutting off admission of said fluid, and said chamber being normally closed except for a restricted open vent for said chamber to permit fluid therein to escape at a predetermined rate and permit automatic reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof.

7. In an automatic reclosing circuit interrupter, a pressure chamber, means forming an arc passage in said chamber, separable contacts normally biased closed and adapted when separated to draw an arc at least partially in said passage, fluid piston and cylinder means associated with at least one of said contacts with said cylinder and passage in open communication with said chamber, means responsive to a predetermined condition of the circuit for admitting a fluid under pressure to said passage to pass through the arc struck therein and into said chamber where it acts on said piston means to separate said contacts to open the circuit and responsive to circuit interruption for cutting off admission of said fluid and said chamber being normally closed except for a restricted open vent for said chamber to permit fluid therein to escape at a predetermined rate to permit automatic reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof.

8. In an automatic reclosing circuit interrupter, a pressure chamber, means forming an arc passage in said chamber, separable contacts normally biased closed and adapted when separated to draw an arc at least partially in said passage, fluid piston and cylinder means associated with at least one of said contacts with said cylinder in open communication with said chamber, electro-responsive means for admitting a fluid under pressure to said chamber to separate said contacts and build up a pressure in said chamber, said chamber being normally closed except for a restricted open vent for said chamber to permit fluid therein to escape at a predetermined rate to permit automatic reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof, and means mounted on said chamber responsive to separation of said contacts for automatically maintaining said contacts separated in response to a plurality of successive circuit interrupting operations thereof.

9. In a circuit interrupter, concentric tubular casing members, common end closures for said tubular members, contacts centrally arranged in the inner of said tubular members adjacent one end thereof, one of said contacts being longitudinally slidably mounted away from said one end of said member and the other of said contacts, said one contact having piston means thereon, fluid supply means communicating with said one end of said inner tubular member, a

vent for the other end of said inner tubular member to the outside of said members, fluid passage means through the side wall of said inner tubular member, and restricted vent means for said outer tubular member, whereby upon admission of a fluid under pressure by said fluid supply means, said fluid actuates said slidable contact out of engagement with said other contact, passes through the arc struck between said contacts and builds up a pressure in said outer tubular member which is dissipated through said restricted vent a predetermined time after said fluid supply is cut off to delay reclosure of said contacts for a predetermined time.

10. In a circuit interrupter, a tubular enclosure having end closures and a partition therein dividing said enclosure into a pressure compartment and a reservoir compartment, means forming an arc passage in said pressure compartment communicating therewith and supported between an end closure and said partition, separable contacts adapted to strike an arc in said passage, fluid actuating means communicating with said pressure compartment for separating said contacts, an opening through said partition, main valve means controlling the passage of fluid through said opening, means in said reservoir compartment for actuating said main valve means to permit fluid flow into said pressure compartment to separate said contacts and extinguish the arc, a source of fluid under pressure in communication with said reservoir compartment, and a restricted vent for said pressure compartment to dissipate fluid pressure and permit reclosure of said contacts a predetermined time after closure of said main valve means.

11. In a circuit interrupter, a tubular enclosure having end closures and a partition therein dividing said enclosure into a pressure compartment and reservoir compartment, inner concentric tubular means forming an arc passage in said pressure compartment communicating therewith and supported between an end closure and said partition, separable contacts adapted to strike an arc in said passage, fluid actuating means for separating said contacts, an aperture through said partition aligned with said tubular means, main valve means controlling the passage of fluid through said opening, means in said reservoir compartment for actuating said main valve means to permit fluid flow into said pressure compartment and separate said contacts, a source of fluid under pressure in communication with said reservoir compartment, and a restricted vent for said pressure compartment to dissipate fluid pressure therein and permit reclosure of said contacts a predetermined time after closure of said main valve means.

12. In a circuit interrupter, a tubular enclosure having end closures and a partition therein dividing said enclosure into a pressure compartment and a reservoir compartment, means forming an arc passage in said pressure compartment communicating therewith and supported between an end closure and said partition, separable contacts adapted to strike an arc in said passage, fluid actuating means for separating said contacts, an aperture through said partition, main valve means controlling the passage of fluid through said opening, means in said reservoir compartment for actuating said main valve means to permit fluid flow into said pressure compartment and separate said contacts, a source of fluid under pressure in communication with said reservoir compartment, including a high

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pressure source of fluid and pressure reducing valve means in the connection between said source and said reservoir compartment, and a restricted vent for said pressure compartment to dissipate fluid pressure and permit reclosure of said contacts a predetermined time after closure of said main valve means.

13. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts and extinguishing the arc, a reservoir for fluid under pressure, electroresponsive means controlling the admission of fluid from said reservoir to said fluid actuated means in response to a predetermined condition of the circuit through said contacts, means to maintain said contacts separated in response to a predetermined number of successive circuit interrupting operations thereof, a relatively high pressure fluid storage tank, and pressure reducing valve means between said tank and reservoir for maintaining a predetermined lower pressure in said reservoir, whereby said tank will be capable of storing fluid under pressure at least sufficient for actuating said contacts said predetermined number of circuit interrupting operations.

14. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts and extinguishing the arc, a reservoir for fluid under pressure, electroresponsive means controlling the admission of fluid from said reservoir to said fluid actuated means in response to a predetermined condition of the circuit through said contacts, means to maintain said contacts separated in response to a predetermined number of successive circuit interrupting operations thereof, a relatively high pressure fluid storage tank, a pressure creating substance in said tank, and means responsive to a decrease of pressure in said tank for causing said substance to create pressure therein, whereby said tank will be capable of storing fluid under pressure at least sufficient for actuating said contacts for said predetermined number of circuit interrupting operations.

15. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts and extinguishing the arc, a reservoir for fluid under pressure, electroresponsive means controlling the admission of fluid from said reservoir to said fluid actuated means in response to a predetermined condition of the circuit through said contacts, means to maintain said contacts separated in response to a predetermined number of successive circuit interrupting operations thereof, and at least a sufficient quantity of a pressure creating liquid in said reservoir having a boiling point temperature substantially below atmospheric temperatures to supply sufficient fluid under pressure to actuate said contacts for said predetermined number of circuit interrupting operations.

16. In an automatic reclosing circuit interrupter, a pressure chamber, means forming an arc passage in said chamber including an arc splitting member, separable contacts normally biased closed and adapted when separated to

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draw an arc at least partially in said passage and transversely of said arc splitting member, fluid piston and cylinder means associated with at least one of said contacts with said cylinder in open communication with said chamber, means for admitting a fluid under pressure to said chamber in a direction transversely of said arc to force said arc against and about said member to extinguish the arc, and to separate said contacts and build up a pressure in said chamber, and a restricted open vent for said chamber to permit fluid therein to escape at a predetermined rate to permit reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof.

17. In an automatic reclosing circuit interrupter, a pressure chamber, means forming an arc passage in said chamber, separable contacts normally biased closed and adapted when separated to draw an arc at least partially in said passage, fluid piston and cylinder means associated with each of said contacts with said cylinder means in open communication with said chamber, means responsive to a predetermined condition of the circuit for admitting a fluid under pressure to said chamber to separate said contacts and build up a pressure in said chamber and means responsive to circuit interruption for cutting off admission of said fluid, and a restricted open vent for said chamber to permit fluid therein to escape at a predetermined rate to permit reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof.

18. In an automatic reclosing circuit interrupter, a pressure chamber, means forming an arc passage in said chamber including an arc splitting member, separable contacts normally biased closed and adapted when separated to draw an arc at least partially in said passage and transversely of said arc splitting member, fluid piston and cylinder means associated with at least one of said contacts with said cylinder in open communication with said chamber, means for admitting a fluid under pressure to said chamber in a direction transversely of said arc to force said arc against and about said member to extinguish the arc, and to separate said contacts and build up a pressure in said chamber, said arc splitting member having a narrow groove in the surface thereof contacted by said arc, and a restricted open vent for said chamber to permit fluid therein to escape at a predetermined rate to permit reclosure of said contacts under the influence of said bias only a predetermined time after separation thereof.

19. In an automatic reclosing circuit interrupter, separable contacts which are biased closed, fluid actuating means for separating said contacts against said bias, means responsive to a predetermined condition of the circuit for passing an arc extinguishing fluid through the zone of separation of said contacts and then to said actuating means, enclosure means for storing said fluid under pressure at least in said zone and said actuating means, said condition responsive means acting to cut off the supply of said fluid in response to circuit interruption, and said enclosure means having a restricted vent permitting escape of said fluid at a predetermined rate to thereby delay for a predetermined time automatic reclosure of said contacts under the influence of said bias.

20. In an automatic reclosing circuit interrupter, separable contacts which are biased closed,

fluid actuating means for separating said contacts against said bias, means responsive to a predetermined condition of the circuit for passing an arc extinguishing fluid under pressure through the zone of separation of said contacts and to said actuating means, enclosure means for storing said fluid under pressure at least in said zone and said actuating means, said condition responsive means acting to cut off the supply of said fluid in response to circuit interruption, and said enclosure means having a restricted vent permitting escape of said fluid at a predetermined rate to thereby delay for a predetermined time automatic reclosure of said contacts under the influence of said bias.

21. In a circuit interrupter, contacts separable to draw an arc therebetween along a predetermined path, means independent of instantaneous current values of the arc for projecting a blast of arc-extinguishing fluid substantially transversely of said arc, means of insulating material positioned in the path of lateral movement of said arc under the influence of said fluid blast, said means of insulating material defining a continuous outer passage of relatively large cross section located in a plane which extends longitudinally through said arc path and at the side of said path toward which the arc is moved by the fluid blast and in which the arc can play at high instantaneous current values, and said means of insulating material also defining a continuous inner channel of substantially smaller cross section located remote from the arc path but communicating with said passage by an entrance portion flaring outwardly in section toward said passage, said inner channel extending in the same plane as said outer passage and being substantially parallel therewith whereby said arc may play in said channel at instantaneous low values of current.

22. In a circuit interrupter, contacts separable to draw an arc therebetween along a predetermined path, means independent of instantaneous current values of the arc for projecting a blast of arc-extinguishing fluid substantially transversely of said arc, arc splitting means of insulating material positioned in the path of lateral movement of said arc under the influence of said gas blast, said arc splitting means having end and side surfaces adjacent said predetermined path, and a narrow continuous groove in said end and side surfaces for receiving said arc at relatively low instantaneous current values.

23. In a circuit interrupter, contacts which are separable along a predetermined path to draw an arc, arc-extinguishing means of solid insulating material adjacent one side of the arc path and extending in a direction transversely of said arc, means for projecting a fluid blast transversely through the arc in a direction to move the arc toward said arc-extinguishing means and cause the arc to loop about the adjacent end portion thereof, and a continuous narrow slot in the sides and said adjacent end portion of said arc-extinguishing means, whereby the magnetic forces due to looping of the arc oppose said fluid blast at high instantaneous values of arc current but at low instantaneous current values said blast moves the arc into said slot where it is extinguished.

24. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts, means responsive to a predetermined condition of the

circuit for admitting a fluid under pressure to said fluid actuated means to open the circuit and responsive to circuit interruption for cutting off admission of said fluid, time delay means for delaying reclosing of said contacts under the influence of said bias including a chamber for storing fluid pressure the value of which stored pressure determining the delay period, said chamber communicating with said fluid actuated means to receive and store fluid under pressure supplied to said fluid actuated means, and restricted open vent means for said chamber to slowly dissipate pressure stored therein.

25. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts, means responsive to a predetermined condition of the circuit for admitting a fluid under pressure to the arcing space between said contacts when separated and to said fluid actuated means to open the circuit and responsive to circuit interruption for cutting off admission of said fluid, time delay means for delaying reclosing of said contacts under the influence of said bias including a chamber for storing fluid pressure the value of which stored pressure determining the delay period, said chamber communicating with said fluid actuated means and arcing space to receive and store fluid under pressure supplied thereto, and restricted open vent means for said chamber to slowly dissipate pressure stored therein.

26. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, means for separating said contacts, means responsive to a predetermined condition of the circuit for admitting a fluid under pressure to the arcing space between said contacts when separated and for causing operation of said contact separating means and being responsive to circuit interruption for cutting off admission of said fluid, time delay means for delaying reclosing of said contacts under the influence of said bias including a chamber for storing fluid pressure the value of which stored pressure determining the delay period, said chamber communicating with said arcing space to receive and store fluid under pressure supplied to said arcing space, and restricted open vent means for said chamber to slowly dissipate pressure stored therein.

27. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts and extinguishing the arc, a high pressure fluid storage tank, electroresponsive means controlling the admission of fluid from said tank to said fluid actuated means in response to a predetermined condition of the circuit through said contacts, means to maintain said contacts separated in response to a predetermined number of successive circuit interrupting operations thereof, and pressure reducing valve means between said tank and fluid actuated means for supplying a predetermined lower pressure in said fluid actuated means, whereby said tank will be capable of storing fluid under pressure at least sufficient for actuating said contacts said predetermined number of circuit interrupting operations.

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28. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts and extinguishing the arc, a high pressure fluid storage tank, electroresponsive means controlling the admission of fluid from said tank to said fluid actuated means in response to a predetermined condition of the circuit through said contacts, means to maintain said contacts separated in response to a predetermined number of successive circuit interrupting operations thereof, a pressure creating substance in said tank, and means responsive to a decrease of pressure in said tank for causing said substance to create pressure therein, whereby said tank will be capable of storing fluid under pressure at least sufficient for actuating said contacts for said predetermined number of circuit interrupting operations.

29. In an automatic reclosing circuit interrupter, separable contacts normally biased into engagement so as to automatically reclose following a circuit interrupting operation, fluid actuated means for separating said contacts, means responsive to a predetermined condition of the circuit for admitting a fluid under pressure to the arcing space between said contacts when separated and to said fluid actuated means to open the circuit and responsive to circuit interruption for cutting off admission of said fluid, time delay means for delaying reclosing of said contacts under the influence of said bias includ-

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ing a chamber for storing fluid pressure the value of which stored pressure determining the delay period, said chamber communicating with said fluid actuated means and arcing space to receive and store fluid under pressure supplied thereto, restricted open vent means for said chamber to slowly dissipate pressure stored therein, and pressure limiting means for said chamber to predetermine the maximum pressure which can be built up in said chamber to determine the maximum time delay in the reclosure of said contacts.

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