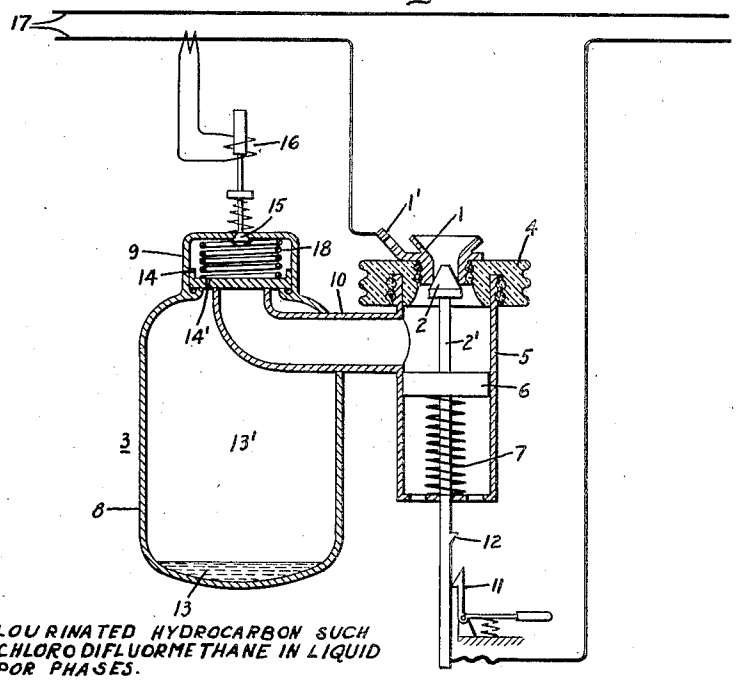
Nov. 12, 1940. D. C. PRINCE 2,221,720

ELECTRIC CIRCUIT INTERRUPTER

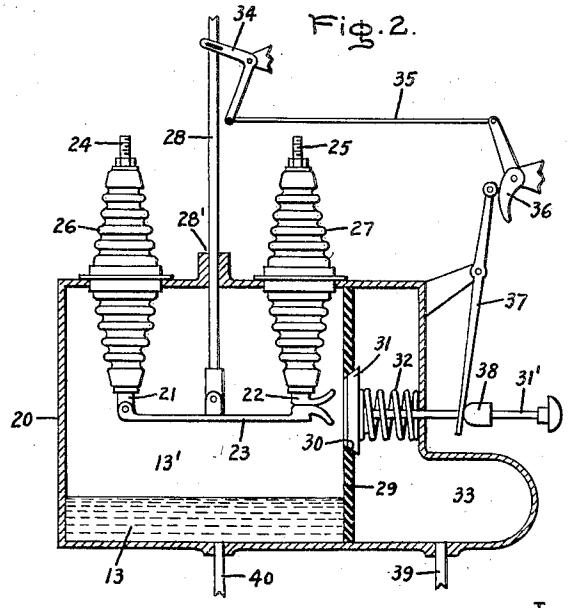
Filed March 29, 1938 3 Sheets-Sheet 1

Fig. 1.



A FLOURINATED HYDROCARBON SUCH AS DICHLORO DIFLUORMETHANE IN LIQUID & VAPOR PHASES.

Fig. 2.



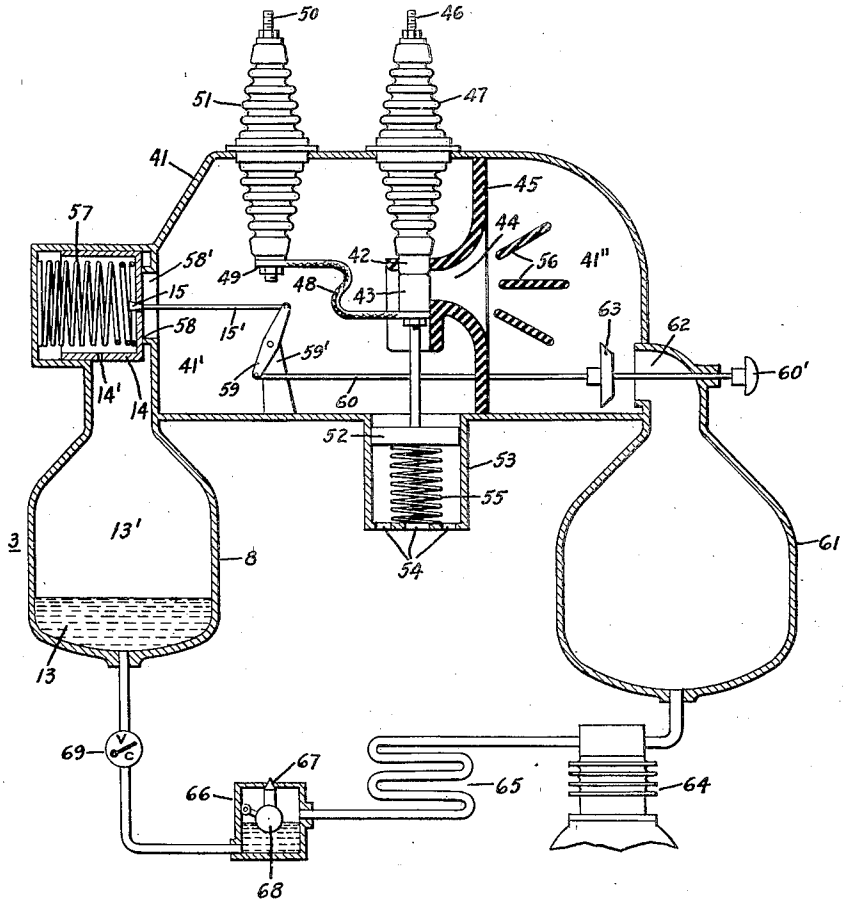
Inventor:
David C. Prince,
by Harry E. Dunham
His Attorney.

Nov. 12, 1940. D. C. PRINCE 2,221,720

ELECTRIC CIRCUIT INTERRUPTER

Filed March 29, 1938 3 Sheets-Sheet 2

Fig. 3.



Inventor:
David C. Prince,
by Harry E. Dunham
His Attorney.

Nov. 12, 1940. D. C. PRINCE 2,221,720

ELECTRIC CIRCUIT INTERRUPTER

Filed March 29, 1938 3 Sheets-Sheet 3

Fig. 4.

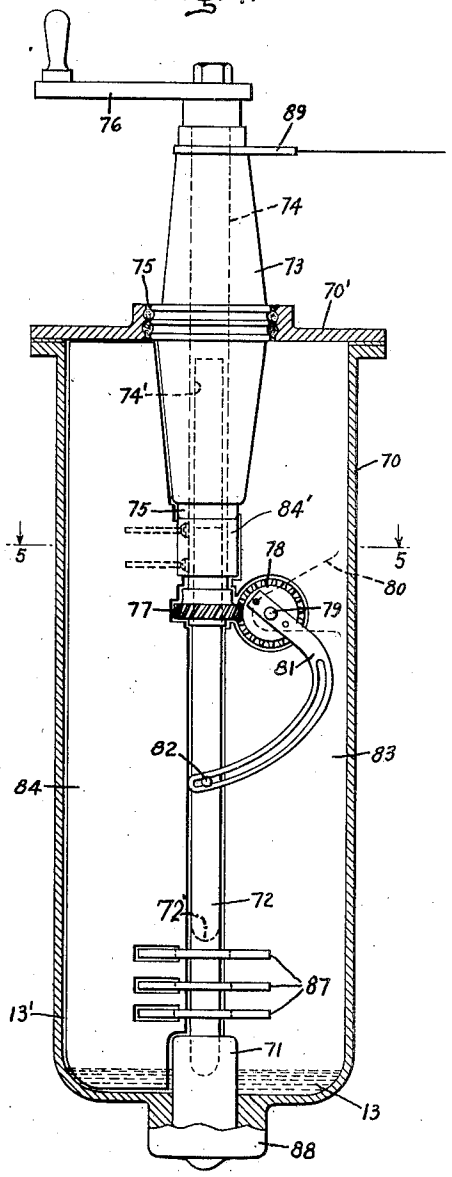


Fig. 5.

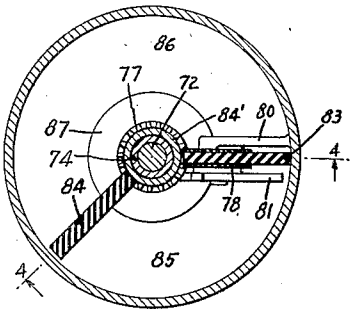
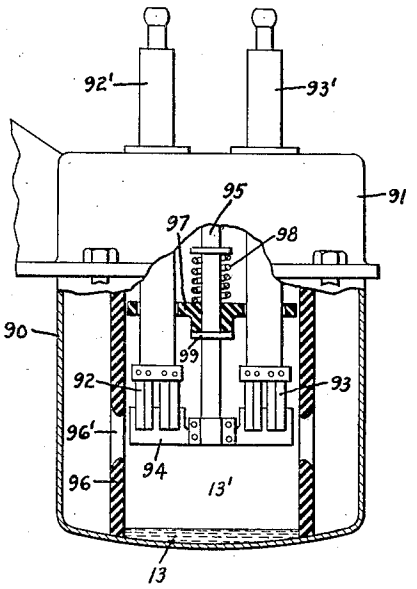


Fig. 6.



Inventor:
David C. Prince,
by Harry E. Dunham
His Attorney.

Patented Nov. 12, 1940

2,221,720

UNITED STATES PATENT OFFICE

2,221,720

ELECTRIC CIRCUIT INTERRUPTER

David C. Prince, Swarthmore, Pa., assignor to General Electric Company, a corporation of New York

Application March 29, 1938, Serial No. 198,680
In Germany August 25, 1937

16 Claims. (Cl. 200—148)

My invention relates to electric circuit interrupters, and more particularly to those of the gas jet or blast type wherein a gas under pressure is directed through the arc path upon opening of the circuit for extinguishing arcing.

The interruption of high tension power arcs has heretofore been accompanied by a number of problems and hazards notwithstanding great improvement in the interrupting capacity of circuit interrupters. A particularly serious problem is that of fire hazard involved in the use of oil circuit breakers. An oil breaker fire may not only cause destruction of the breaker itself but also, due to progressive breakdown of adjacent apparatus, shut-down of an entire station. However, in spite of its inflammability oil has excellent arc-interrupting and dielectric characteristics, and it has largely continued in use for this reason. Also, oil is satisfactory in certain other important respects; that is, it is non-corrosive and the gas released during arcing is non-poisonous.

Because of this fire hazard switchgear engineers have searched many years for a satisfactory substitute for oil that will be safe and practicable and that also will have high interrupting capacity and dielectric strength. A number of non-inflammable liquids including carbon tetrachloride, water, etc. have been tried, but in general they have proved unsatisfactory for various reasons such as poor dielectric strength after exposure to arcing, corrosive action, etc.

Also, the gas-blast type circuit breaker using a high velocity current of gas for interrupting the arc has been tried out commercially in foreign countries, chiefly to eliminate the fire hazard of oil, but the high gas pressures generally required for effective interruption of short circuit or power arcs have greatly limited the use of this type of breaker. The interrupting agency generally used is air although carbon dioxide has also been tried. Although the air blast has been applied to high voltage breakers, it has serious disadvantages including low dielectric strength as compared with oil, a tendency to deposit moisture on the creepage surfaces thereby causing voltage breakdown along said surfaces and high energy input during compression. Possible loss of pressure aggravated by the high pressures required is a hazard also.

In case of carbon dioxide (CO_2) which under certain operating conditions has a comparatively high latent heat of evaporation, considerable difficulty has been encountered in controlling the gas blast due to the refrigerating action of the carbon dioxide during vaporization in passing through the control valve to the breaker. The control or reducing valve in certain cases has become frozen due to the accumulation of carbon dioxide snow, and the breaker thereby rendered inoperative.

I eliminate many of the above disadvantages of arc-extinguishing fluids such as oil, air and carbon dioxide, by the use of a new gaseous arc-extinguishing medium, that has high dielectric strength as compared with air and oil, and that has a workable vapor pressure at normal ambient temperatures for producing an effective arc-interrupting blast.

In accordance with my invention the arc-interrupting capacity of gas blast circuit breakers can be greatly increased at a comparatively low blast pressure by the use of a gaseous medium including a fluorinated hydrocarbon. The term "fluorinated gaseous hydrocarbon" as used herein is intended to mean compounds which may be derived by fluorinating hydrocarbon compounds although such fluorinated compounds may contain no hydrogen. By way of example, I have discovered that a gas blast breaker using dichlorodifluormethane as the gaseous interrupting medium is capable of interrupting 200,000 kva. at 4 atmospheres blast pressure as contrasted with the best performance of the same breaker using air under similar conditions in interrupting 100,000 kva. at 10 atmospheres air blast pressure. Arc interruption in accordance with my invention is accomplished with but a few half cycles of arcing in the case of alternating currents and is unaccompanied by corrosive or poisonous gases, objectionable flame or other disturbance.

I have also found that in the case of dichlorodifluormethane the vapor pressure in a closed chamber containing both the liquid and vapor phases is sufficient throughout a wide range of ambient temperatures to cause extinction of a high tension power arc, the vapor pressure being, for example, 4 atmospheres at 20° C. Also, the vapor at this pressure has a dielectric strength better than that of oil, and is non-inflammable, non-poisonous and non-corrosive.

In carrying out my invention I prefer to employ a chlorine-fluorine derivative of aliphatic hydrocarbons and, particularly, chlorine-fluorine derivatives of hydrocarbons containing one or two carbon atoms, that is, of methane or ethane. Such halogenated hydrocarbons have an appreciable gaseous phase over the range of temperatures normally encountered in the operation of electric circuit breakers.

Although a preferred fluorinated gaseous hydrocarbon used in accordance with my invention is dichlorodifluormethane other hydrocarbon derivatives may be used. Preferably the chosen compounds should have an appreciable gaseous phase at the ordinary operating temperatures of the circuit breaker and in many cases should remain gaseous even when subjected to considerable compression at such temperatures. The following additional gases and vapors are available for use in accordance with my invention, the choice of a particuar gas depending on the conditions of the service for which the gas is intended; mono-chlorotrifluoromethane ($CClF_3$), trichloromonofluoromethane (CCl_3F), dichlorotetrafluoromethane ($C_2Cl_2F_4$), trichlorotrifluoromethane ($C_2Cl_3F_3$), and carbon tetrafluoride (CF_4). As a class these compounds are stable chemically and electrically, are non-inflammable and have other desirable properties for the present purposes, being substantially non-corrosive with respect to metals.

The use of a gaseous medium of the character above described for insulating high tension electric apparatus is described and broadly claimed in an application, Serial No. 155,943, filed July 27, 1937, by Franklin S. Cooper, for Gas insulated electric device, and assigned to the same assignee as this application.

My invention will be more fully set forth in the following description referring to the accompanying drawings and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

Referring to the drawings Fig. 1 is an elevational view in section of a gas blast type of circuit breaker embodying the present invention; Fig. 2 is a similar view showing another form of my invention wherein the arc is drawn within a vessel containing arc-extinguishing fluid in both liquid and vapor phase; Fig. 3 is a partly diagrammatic illustration partly in section showing another form of my invention wherein the vapor pressure is utilized both to create an arc-extinguishing blast and to separate the contacts; Fig. 4 is an elevational sectional view along the line 4—4 of Fig. 5 of an impulse type circuit breaker embodying my invention; Fig. 5 is a sectional plan view taken along the line 5—5 of Fig. 4, and Fig. 6 is an elevational view partly in section of another form of impulse circuit breaker embodying my invention as applied to a conventional breaker tank.

The circuit breaker shown by Fig. 1 comprises relatively movable contacts 1 and 2 and a source of vapor pressure generally indicated at 3 for producing the arc-extinguishing blast between the contacts upon separation thereof. The contact structure can be of any suitable type, the fixed contact 1 in the present instance being in the form of an electrically conducting nozzle having a breaker terminal at 1', and a movable contact 2 formed as a conical valve-like member adapted to engage the restricted part of the nozzle in the closed circuit position. The breaker housing may comprise an insulator 4 which serves as an insulating support for the nozzle contact 1 and a cylinder 5. The operating means for the contact 2 includes a piston member 6 operable within the cylinder 5 secured to the contact rod 2' and biased by a spring 7 toward the closed circuit position.

The source 3 of compressed gas comprises in the present instance a steel tank or bomb 8 communicating through a valve housing at 9 and a conduit 10 with the switch cylinder 5. When vapor under pressure is admitted to the switch cylinder the piston 6 is depressed against the bias of spring 7 causing separation of the contacts 1 and 2 and opening of the nozzle contact 1. The contact separation forms a gap through which the gas exhausts at high velocity to interrupt arcing. The switch is held in open-circuit position by any suitable means, a latch 11 adapted to coact with a detent 12 on the switch rod being shown by way of example. When the latch is released the spring 7 returns the contact 2 to the closed circuit position shown.

In accordance with my invention the pressure source 3 includes a gaseous arc-extinguishing medium of the character above described that is stored in the tank 8. The liquid phase is indicated at 13 and the vapor phase at 13', the pressure of which in the case of dichlorodifluormethane, is approximately 4 atmospheres at 20° C. There is, therefore, provided a workable and effective blast pressure at an ordinary ambient temperature.

A simple form of valve is indicated at 14 for controlling the passage of the vapor under pressure to the switch cylinder 5. Release of the valve 14 is in turn controlled by a pilot valve 15 that is actuated by the usual overload relay 16. In operation a short circuit or overload on the power line 17 causes energization of the solenoid of relay 16 so as to open the pilot valve 15, thereby venting the valve housing 9 to atmosphere. Since the pressure at opposite sides of the valve 14 is normally balanced by reason of a bleed vent 14' this sudden release of pressure at the upper side of the valve 14 results in rapid upward or opening movement of the valve by the pressure in the space 13' so as to uncover the opening of the conduit 10. The vapor under pressure in the space 13' accordingly flows into the switch casing 5 to open the breaker and extinguish arcing by reason of the blast through the nozzle contact 1. After clearing of the circuit, the pilot valve 15 automatically closes and the valve 14 is returned to its seat by a spring 18.

The rapid and positive interruption of the arc that I am able to obtain is due, not only to the very high dielectric strength of the gas blast employed, but also to a number of highly desirable properties of this gaseous arc-extinguishing medium. When a gas or vapor blast is directed through an arc, it performs several functions tending to extinguish arcing. In the first place, the arc is cooled and this in itself is an important factor in effective positive interruption at a current zero. In this respect dichlorodifluormethane is particularly effective since its heat-absorbing capacity per unit volume is approximately three times that of air. Therefore, an intense cooling of the arc path occurs during the blast. Another function of the blast is to sweep away the products of arcing, which may include highly heated metalic vapor and other vapors and gases of low dielectric strength and to interpose a medium of high dielectric strength between the separated contacts.

As above pointed out, the dielectric strength of dichlorodifluormethane at ordinary ambient temperatures is very high, being even better than that of oil at 20° C., with the result that interruption at a current zero is positive and complete. By reason of this high dielectric strength, the recovery voltage is not effective to cause restriking of the arc even though the contacts are much more closely spaced than is customary for

isolating purposes in air. The above factors all combine to cause interruption of the arc before it has been drawn to an appreciable length, so that the arc energy and consequent generation of heat are comparatively small.

From the viewpoint of the station operator, a gaseous medium including a fluorinated hydrocarbon has a number of important advantages not found in other arc-extinguishing fluids. Since the boiling point of dichlorodifluormethane is below the usual ambient temperature, maintenance of the desired vapor pressure without special heating means and thermostatic controls is possible. Accordingly, a simple arrangement such as shown by Fig. 1 can be used both efficiently and effectively at usual ambient station temperatures for interrupting high voltage power arcs even under short circuit conditions. Furthermore, even in case of extremely low ambient temperatures the vapor pressure is sufficient and practicable for efficient arc interruption. For example, at −9° F. the vapor pressure of dichlorodifluormethane is still 5 pounds gauge, and at 140° F. the pressure is but slightly above 200 pounds which is not excessive for properly designed apparatus. However, in the case of station operation these extremes would rarely be encountered. As above pointed out in connection with CO_2, the low latent heat of evaporation of dichlorodifluormethane which is but 60 B. t. u. per pound at 85° F. is an advantage, particularly where reducing valves are employed. Also the comparatively low mobility, i. e. high viscosity of the vapor as compared with air is an advantage rather than a disadvantage since the high dielectric strength of the vapor permits arc rupture at much lower blast velocities, and consequently with less arc energy, than are necessary in the case of air and, furthermore, permits the use of a comparatively large exhaust port. That is, the arc can be more readily driven into a port of large diameter where it is subjected to the entire gas blast. This results in more effective interruption of the arc at a current zero. The critical temperature and pressure of dichlorodifluormethane both lie outside the ambient range, being 580 pounds at 233° F.

The particular relation of the circuit controlling contacts with respect to the atmosphere or low pressure exhaust region and the comparatively high pressure vapor phase is not limited to the arrangement above described. For example, the arc may actually form within a chamber containing the high pressure vapor and means may be provided for directing a high velocity current or blast of the vapor through the arc in this high pressure atmosphere for interrupting the same.

An arrangement of this character is illustrated by Fig. 2 wherein a substantially sealed switch casing **20** for confining the arc-interrupting fluid **13** in both the liquid and vapor phases has mounted therein relatively movable contacts including a pair of stationary contacts **21** and **22**. A movable contact **23** is pivotally mounted with respect to the fixed contact **21**. The exterior circuit connections are made by means of the conductor studs **24**, **25** which are mounted in and insulated with respect to the switch casing by insulating bushings **26** and **27** respectively. Operation of the movable contact **23** is effected in a well-known manner by means of a reciprocally movable operating rod **28** extending into the switch casing through a seal indicated at **28'**.

The casing **20** is provided with an insulating partition **29** having an exhaust port or pressure relief opening at **30** adjacent and directly opposite the break formed by the contacts **22** and **23**. The exhaust port is normally closed by a valve **31** that is resiliently biased, such as by a spring **32**, to close the exhaust port against the pressure of the vapor in the space **13'**. The partition **29** forms in effect within the casing **20** a high pressure chamber containing the liquid and vapor phases of the arc-extinguishing fluid annd a comparatively low pressure or exhaust chamber **33**. Accordingly, when the valve **31** is opened, the rush of vapor into the exhaust chamber **33** causes a high velocity gas blast across the break formed upon separation of the contacts **22** and **23**. As previously pointed out, this high velocity blast is effecive both to interrupt arcing and to prevent restriking of the arc by reason of the high dielectric strength of the gas or vapor in the space **13'**.

By way of example a simple mechanical arrangement is disclosed for effecting operation of the valve **31** in accordance with the circuit opening operation. As illustrated the operating rod **28** is suitably connected through a crank **34** and link **35** to a pivoted cam member **36** that in turn coacts with a lever **37** operatively related to the valve stem **31'**. In the closed circuit position shown the above-described linkage permits the spring **32** to hold the valve **31** in its normal seating position for sealing the vapor pressure in the space **13'**. When the circuit is to be opened, lowering of the operating rod **28** by suitable means (not shown) not only effects separation of the contacts **22** and **23** but also, by reason of the resulting clockwise rotation of cam **36** causes the lever **37** acting on the abutment **38** of the valve stem **31'** to open the valve against the bias of spring **32**. When this occurs an arc-interrupting blast from the high pressure chamber takes place transversely of the arc and through the port **30** into the exhaust chamber **33**. If desired, the exhaust vapor can be conserved, such as by drawing it from the exhaust chamber **33** through a conduit **39**, and condensing and cooling the same so that it can be returned in liquid form to the high pressure chamber through a conduit **40**.

The valve **31** can of course be operated in other ways, such as by well-known remote control systems, the valve stem **31'** also being indicated as provided with manual operating means.

In the arrangement above described it will be noted that the arc-interrupting blast is not necessarily directed into a space at atmospheric pressure. The main essential is that the arc gap be traversed, preferably at high velocity, by a current or blast of gas or vapor of the character above described. The arrangement of Fig. 2 is illustrated in an essentially simple form and it will be understood that in practice suitable means could be provided for closing the valve **31** after the arc-interrupting blast.

There is shown by Fig. 3 a more complete arrangement wherein the arc is interrupted exteriorly of the main pressure chamber by the release of vapor therefrom. In this arrangement the switch casing **41** has mounted therein relatively movable contacts **42** and **43** separable within a gas-confining passage **44** formed by an insulating partition **45** in the casing. The contact **42** is relatively fixed and is connected to the terminal conductor stud **46** mounted in the casing by an insulating bushing **47**. The coacting movable contact **43** is flexibly connected at **48** to the lower

terminal 49 of the other conductor stud 50 having an insulating bushing 51.

Operation of the movable contact 43 is effected by means of a piston 52 operable within a cylinder 53 forming part of and in communication with the switch casing. The cylinder 53 is open to atmosphere at 54 and has mounted therein a spring 55 for biasing the piston and movable contact towards the closed circuit position illustrated. In the arrangement so far described it will be apparent that separation of the contacts 42 and 43 in the passage 44 forms a break through which gas under pressure in the arc chamber 41' will flow into the exhaust chamber 41''. Arc splitters 56 of insulating material are located at the exhaust of the passage 44 for facilitating in a well-known manner arc interruption.

The source of pressure 3, as in the case of Fig. 1, comprises a presure tank or bomb such as a steel casing 8, that contains the arc-extinguishing fluid in both liquid and vapor phases at 13 and 13'. The pressure casing is normally maintained sealed by a valve 14 that is in turn controlled by a pilot valve 15 in the manner of Fig. 1. That is, the bleed vent 14' permits equalization of pressure acting on opposite sides of the valve body 14, so that when the pilot valve 15 is closed the spring 57 is effective to bias the valve against its seat at 58. When, however, the pilot valve 15 is opened by movement towards the left (as viewed in Fig. 3) the sudden release of pressure at the inner side of the valve member causes the vapor pressure at 13' rapidly to open the valve and uncover the opening 58' leading directly into the switch arc chamber 41'. The high pressure vapor so admitted into the chamber 41' is effective both to depress the piston 52 for causing separation of the contacts and to cause a vapor blast to cross the arc path at the entrance of pasage 44 for interrupting the arc in the manner previously described.

Since interruption of the arc is the principal object of the present invention auxiliary contact control means are eliminated in the interest of simplicity. For example, the contact 43 can obviously be provided with suitable latching means for holding the same in open circuit position, or a conventional disconnect switch connected in the breaker circuit can be opened immediately after arc interruption for maintaining the circuit open, or both provisions can be made.

The control of the pilot valve 15 may be by any suitable means, a simple manual linkage being illustrated by way of example. The valve stem 15' is operated exteriorly of the casing by means of a manually operated rod 60 that is connected to the valve actuating crank 59 pivotally mounted at 59' in the casing 41. When tension is applied to the rod 60 the pilot valve 15 is opened and the circuit opening cycle instituted as above described.

For the purpose of conserving the supply of arc-extinguishing vapor, a storage or collecting reservoir 61 is provided in communication with the exhaust chamber at 62. The passage 62 is controlled by a valve 63 carried by the rod 60. Normally, when the main pressure sealing valve 14 is closed, the valve 63 is open so that the exhaust vapors and gases remaining in the chamber 41'' after a circuit interruption can be drawn into the reservoir 61. When, however, a circuit-opening operation is instituted by drawing the rod 60 towards the right, such as by the manual handle at 60', the valve 63 is closed thereby sealing the exhaust chamber. This prevents the use of an excess amount of arc-interrupting vapor for a single interruption. That is, the high pressure blast that initially takes place at the arc passage 44 is effective to interrupt the arc after which the pressure rapidly equalizes in the casing 41 and no further discharge of vapor takes place. The valve 14 is closed by pressing at 60' the rod 60 towards the left so as to close the pilot valve 15. This seals the casing 8 and opens the valve 63 so that the remaining vapor in the casing 41 can be drawn through the pressure 62 into the reservoir 61.

The vapor from the reservoir 61 is returned in liquefied form to the main pressure casing 8 by conventional compressor and cooling means generally indicated at 64 and 65 respectively. For the purpose of eliminating extraneous gases from the system, a simple valving device at 66 can be provided in the return conduit so as to permit escape of trapped non-condensible gases at 67 when the float 68 drops due to appreciable accumulation of such gases. A non-return valve at 69 can also be provided.

Accordingly, there is provided in the arrangement shown by Fig. 3 a complete and self-contained arc-interrupting device of the gas blast type wherein both arcing and the arc-interrupting blast take place within a completely sealed unit. This obviously precludes the usual objectionable features associated with conventional blow-out types of circuit-breaking devices wherein flame and highly heated arc gases are sometimes projected an appreciable distance from the breaker in case of high or short circuit current interruptions. Also, no objectionable gases or vapors are released in the switching station nor is the usual loud report involved.

In the form of circuit breaker commonly known as the impulse type wherein the fluid blast is produced by a movable vane, piston, or equivalent structure, the amount of energy required to produce an effective gas blast has heretofore been considered very high, if not excessive. In applying my invention to this type of circuit breaker, I eliminate this disadvantage to a great extent by reason of the comparatively high dielectric strength of the fluorinated hydrocarbon vapor. That is, the gas blast as previously pointed out is effective to interrupt arcing at much lower pressures than heretofore believed possible. Accordingly, a circuit breaker of the impulse type when using a fluorinated hydrocarbon vapor is not only more efficient but is of simpler and less expensive construction due to the lower gas pressures that are required for arc interruption.

There is shown by way of example in Figs. 4 and 5 a simple form of impulse circuit breaker having a casing of conventional form provided with means for driving vapor under pressure across the arc gap coincident with separation of the contacts, the operation taking place entirely within a sealed chamber. More specifically, the casing 70 which contains the arc-extinguishing fluid in both liquid and vapor phases at 13 and 13' has mounted therein relatively movable contacts comprising a stationary contact 71 and a coacting rod contact 72 mounted for vertical reciprocal movement with respect to the fixed contact. The rod contact 72 is suitably operated from the exterior of the casing, a simple manual device being illustrated by way of example. A bushing 73 for a rotatable crank shaft 74 is mounted in the cover 70' of the switch casing, and is provided with suitable gas seals at 75 for preventing loss of pressure. The pres-

ent invention is not concerned with any specific type of seal, and it is understood that pressure seals such as are generally used in the refrigeration art can be used where required.

The shaft 74, which can be rotated by means of manually operable crank 76, is provided with a central bore at 74' so as to be in telescopic and electrically conducting relation to the rod contact 72. The rod contact is thereby guided for reciprocal movement in the shaft 74. For the purpose of operating the rod contact 72 in accordance with predetermined rotation of the crank 76, there is secured to the lower end of the shaft 74 a spur gear 77 arranged to mesh with a corresponding gear 78 whose axis is disposed at right angles to the axis of gear 77. The gear 78 is suitably mounted at 79 on a supporting lug 80 in the switch casing, and is rigidly secured to a camming arm 81 having a pin and slot connection at 82 with the rod contact. From the foregoing it will be apparent that rotation of the crank 76 is effective through the pin and slot connection at 82 to raise or lower the rod contact 72 within the crank bore 74'.

When the rod contact 72 is raised causing separation of the contacts within the vapor at 13', the manually operated means is also effective simultaneously to rotate a vane for driving the high pressure vapor through the arc path. To this end the switch casing 70 is divided into two chambers that constitute in effect during the circuit-interrupting operation low pressure (or exhaust) and high pressure chambers respectively.

Referring more particularly to Fig. 5 there is shown an insulating partition structure comprising a fixed insulating plate 83 and a movable insulating vane 84 extending longitudinally of the casing so as to form a chamber 85 and a complementary chamber 86. The insulating plate 83 is rigidly mounted within the casing as shown by Fig. 4, so as to be substantially continuous between the upper and lower walls thereof and the side wall and central contact rod 72. The insulating vane 84 is secured at 84' to the rotatable crank 74 so as to rotate with it.

Accordingly, when the crank 76 is rotated to open the circuit the contacts 71 and 72 are separated to form an arc gap coincident with clockwise rotation of the vane 84 as viewed in Fig. 5. The vapor in the chamber 86 is thereupon under pressure above that in chamber 85 dependent on the speed and extent of rotation of the vane 84, and the only immediate release for this pressure is by way of the arc gap leading into the low pressure or exhaust chamber 85. This arc gap is defined by the upper dotted line position 72' of the rod contact 72 and the plates 83 and 84. Accordingly, a blast of the arc-extinguishing vapor is directed transversely of the arc space defined by the contacts 71, 72 and the insulating members 83 and 84 without necessitating exhaust of the blast vapors to atmosphere or auxiliary reservoirs. For the purpose of increasing the effectiveness of the blast, insulating arc splitters extending transversely of the arc can be secured to the fixed insulating plate 83 at 87. The exterior circuit connections can be made at 88 and 89 to the fixed and movable contact terminals respectively.

This arrangement is essentially simple and complete since closure of the contacts automatically returns the vane 84 to its initial position coincident with a reverse vapor jet which may be very desirable in case of closing the breaker on heavy currents.

Since this circuit breaker unit is entirely self-contained and completely sealed extraneous gases formed during operation of the breaker may accumulate within the casing. These gases or vapors can readily be segregated by means of suitable gas-absorbing material disposed within the casing. Furthermore, in the case of carbon formation, the dielectric strength of the vapor is not affected, since any carbon which forms tends to settle in the liquid at the bottom of the casing.

Another form of circuit breaker of the impulse type to which my invention is applicable is illustrated by Fig. 6, wherein a circuit breaker tank construction of conventional design is also employed. The switch casing comprises a steel tank 90 having a cover or dome structure 91 secured in sealed relation thereto for containing the arc-extinguishing fluid in both liquid and vapor phases at 13 and 13' respectively. The relatively movable contacts are mounted within the casing above the liquid and comprise a pair of fixed contact structures 92 and 93 of well-known construction for coacting with a movable bridging contact 94. The bridging contact is operated in a vertical direction by the conventional lift rod 95 that is connected to suitable operating linkage disposed in the dome 91. The fixed contacts 92 and 93 are secured to the lower ends of the lead-in conductor bushings 92' and 93' respectively, which are mounted and sealed with respect to the dome 91. In the arrangement so far described opening and closing of the circuit is effected simply by lowering and raising the bridging member 94 so as to form two breaks in series in the circuit.

For the purpose of projecting arc-extinguishing vapor across the aforesaid breaks, there is provided insulating baffle structure comprising a pair of insulating plates 96 coacting with the side walls of the breaker casing to form a central arc chamber in which the contact structure is disposed. The insulating partitions are each provided with aperatures 96' which are located substantially opposite the breaks formed at the contacts 92 and 93. For the purpose of placing the vapor in the central or high pressure chamber under sufficient pressure when the contacts are separated, an insulating piston 97 is resiliently mounted on the lift rod 95 so as to compress the vapor beneath the same when the circuit is opened. As illustrated the insulating piston 97 is resiliently held by a spring 98 against a collar 99 secured to the lift rod. When the lift rod is lowered for opening the circuit, the contacts are separated so as to form breaks opposite the exhaust ports 96' and the piston 97 compresses the vapor beneath the same so as to cause two distinct gas blasts through the breaks at each of the ports 96'. In case of high arc counter-pressure, the resilient connection at 98 permits the piston 97 to move upwardly independently of any movement of the contacts and thereby prevents a possible undesired reclosure of the contacts and possible damage to the switch structure.

Accordingly, a simple, complete and self-contained circuit breaker is provided as in the case of Figs. 4 and 5 wherein arc interruption is effected without noise, emission of flame, or objectionable gases, or loss of interrupting vapor.

It should be understood that my invention is not limited to specific details of construction and arrangement thereof herein illustrated, and that changes and modifications may occur to one

skilled in the art without departing from the spirit of my invention.

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

1. An electric circuit breaker of the gas blast type comprising relatively movable contacts, piston structure related to a movable contact for effecting opening of the circuit, a chamber containing a fluorinated hydrocarbon in both liquid and vapor phases, and valve means for controlling admission of said fluorinated hydrocarbon vapor to said contacts and said piston structure for causing simultaneously separation of said contacts and a blast of said vapor across the arc formed thereat.

2. An electric circuit breaker of the gas blast type comprising relatively movable contacts, piston structure associated with one of said contacts for effecting opening of the circuit, a chamber in which said contacts are disposed having an inlet port and an exhaust port, said contacts being adjacent said exhaust port, a sealed container having an arc-extinguishing fluid in both liquid and vapor phases arranged to be in communication with said chamber through said inlet port, valve structure for controlling said inlet port, a low pressure chamber communicating with said exhaust port, and means for actuating said valve whereby the vapor of said fluid enters said contact chamber at high velocity to cause separation of said contacts and an arc-interrupting blast across said contacts prior to exhaust into said low pressure chamber.

3. An electric circuit breaker of the gas blast type comprising relatively movable contacts, a switch chamber in which said contacts are disposed having inlet and exhaust ports, said contacts being positioned adjacent said exhaust port and arranged so that separation of said contacts forms a break transversely of said port, piston structure related to one of said contacts for effecting the circuit opening movement thereof, a container having an arc-extinguishing fluid in both liquid and vapor phases adapted to be in communication with said chamber through said inlet port, a valve for controlling admission of said vapor to said chamber, a low pressure chamber communicating with said exhaust port, a reservoir in communication with said low pressure chamber, valve means for controlling communication between said low pressure chamber and reservoir, means for restoring vapor in said reservoir to the liquid phase and returning the same in sealed relation to said container, and means for operating the aforesaid valves for admitting said vapor at high velocity to said switch chamber whereby said piston structure is operated to separate said contacts and a blast of said vapor is directed between said contacts into said low pressure chamber.

4. An electric circuit breaker of the gas blast type comprising a sealed casing containing an arc-extinguishing fluid in both liquid and vapor phases, relatively movable contacts separable in said casing above the level of the liquid, and piston structure sealed within said casing and operable in accordance with separation of said contacts for directing a blast of vapor across the arc gap so formed.

5. An electric circuit breaker comprising an arc chamber, relatively movable contacts separable within said chamber, a pressure chamber containing an arc-extinguishing fluid in both liquid and vapor phases, a valve for controlling communication between said pressure and arc chambers, a second valve for controlling an exhaust opening of said arc chamber, and means interconnecting said valves for effecting predetermined sequential operation thereof.

6. An electric circuit breaker of the gas blast type comprising an arc chamber having an exhaust opening, relatively movable contacts disposed in said chamber, a pressure chamber containing an arc-extinguishing vapor under pressure, valve means for controlling communication between said pressure and arc chambers, admission of said vapor to said arc chamber causing interruption of arcing at said contacts, a second valve means for controlling said exhaust opening, and means interconnecting said valve means arranged so that opening of one valve means causes closing of the other valve means.

7. An electric circuit breaker comprising a casing having an insulating partition dividing said casing into an arc chamber and exhaust chamber, said partition having an opening therein, relatively movable contacts separable in said arc chamber opposite said opening, a piston for causing separation of said contacts in communication with said arc chamber, a pressure chamber containing an arc-extinguishing fluid, a valve for controlling communication between said pressure and arc chambers, a second valve for controlling an exhaust opening of said exhaust chamber, and means interconnecting said valves arranged so that actuation of said first valve to admit fluid under pressure to said arc chamber for separating said contacts coincident with a fluid blast across the arc gap so formed simultaneously causes closing of said second valve.

8. An electric circuit breaker comprising an arc chamber containing an arc-extinguishing fluid in both liquid and vapor phases, relatively movable contacts separable within said vapor, a valve for controlling an opening opposite the arc gap formed upon separation of said contacts, and means inter-connecting said contacts and valve for effecting opening of said valve substantially coincident with separation of said contacts whereby exhaust of vapor from said chamber causes interruption of arcing.

9. An electric circuit breaker comprising a casing having a partition defining a pressure chamber and an exhaust chamber, an arc-extinguishing fluid in both liquid and vapor phases in said arc chamber, relatively movable contacts separable in said vapor, a valve for controlling an opening in said partition substantially opposite the point of separation of said contacts, means normally biasing said valve closed, and structure interconnecting said contacts and valve for effecting opening of said valve substantially coincident with the separation of said contacts whereby exhaust of vapor under pressure into said exhaust chamber causes interruption of arcing, said switch casing being sealed with respect to atmosphere for precluding escape of vapors and arc gases.

10. An electric circuit breaker comprising an hermetically sealed casing, an arc-extinguishing fluid in both liquid and vapor phases in said casing, relatively movable contacts separable in said vapor, and a pressure producing member in said casing movable in accordance with separation of said contacts for causing flow of said vapor between said contacts for extinguishing arcing thereat, the aforesaid arc-interrupting operation taking place entirely within said casing without venting thereof.

11. An electric circuit breaker comprising an

hermetically sealed casing containing an arc-extinguishing fluid in both liquid and vapor phases, a fixed contact mounted within said casing and a coacting movable rod contact guided for reciprocal rectilinear movement with respect thereto, separation of said contacts taking place within said vapor, insulating partition structure for dividing said casing into at least two chambers, a part of said structure being movable for driving vapor from one of said chambers into another chamber, said vapor being directed across the arc gap formed upon separation of said contacts, and means interconnecting said rod contact and movable structure.

12. An electric circuit breaker comprising an hermetically sealed casing containing an arc-extinguishing fluid in both fluid and vapor phases, insulating structure forming an arc chamber in said casing having exhaust ports communicating with said casing at opposite sides of said chamber, relatively movable contacts separable in said chamber to form two breaks in series opposite said exhaust ports respectively, and piston structure associated with the movable contact structure for driving vapor from said chamber through said exhaust ports for extinguishing arcing thereat in accordance with circuit-opening movement of said contact structure.

13. A gas blast electric circuit breaker of the type wherein an arc gap is formed entirely within a gas and a source of energy independent of the arc itself is used to cause an interrupting gas blast to traverse the arc gap comprising interrupting contacts separable to form said arc gap, a gaseous arc extinguishing medium including gaseous fluorinated hydrocarbon, and means fir directing a blast of said gaseous fluorinated hydrocarbon through said arc gap for extinguishing arcing.

14. A gas blast electric circuit breaker of the type wherein an arc gap is formed entirely within a gas and a source of energy independent of the arc itself is used to cause an interrupting gas blast to traverse the arc gap comprising separable electric terminals, and means for directing a blast of gaseous dichlorodifluormethane across the arc gap formed between said terminals upon opening of the circuit.

15. A gas blast electric circuit breaker of the type wherein an arc gap is formed entirely within a gas and a source of energy independent of the arc itself is used to cause an interrupting gas blast to traverse the arc gap comprising separable contacts, an arc-extinguishing fluid consisting of a fluorinated hydrocarbon having a vapor pressure not exceeding approximately four atmospheres at 20 degrees C., the vapor having high dielectric strength at said temperature, and means for causing a blast of said vapor across the arc gap formed between the contacts upon separation thereof for interrupting arcing.

16. A gas blast electric circuit breaker of the type wherein an arc gap is formed entirely within a gas and a source of energy independent of the arc itself is used to cause an interrupting gas blast to traverse the arc gap comprising an hermetically sealed casing containing a fluorinated hydrocarbon in both liquid and vapor phases, relatively movable contacts separable to form an arc gap entirely within said vapor phase, said vapor having a dielectric strength comparable with or better than that of circuit breaker oil at an ambient temperature of approximately 20° C., said vapor also being at a pressure of a few atmospheres at the ordinary ambient temperature of said circuit breaker, and means for interrupting arcing between said contacts comprising a blast of said fluorinated hydrocarbon vapor directed through said arc gap.

DAVID C. PRINCE.