June 9, 1942.

G. F. McMAHON

CIRCUIT INTERRUPTER

Filed Nov. 7, 1938

2,285,602

2 Sheets-Sheet 1.

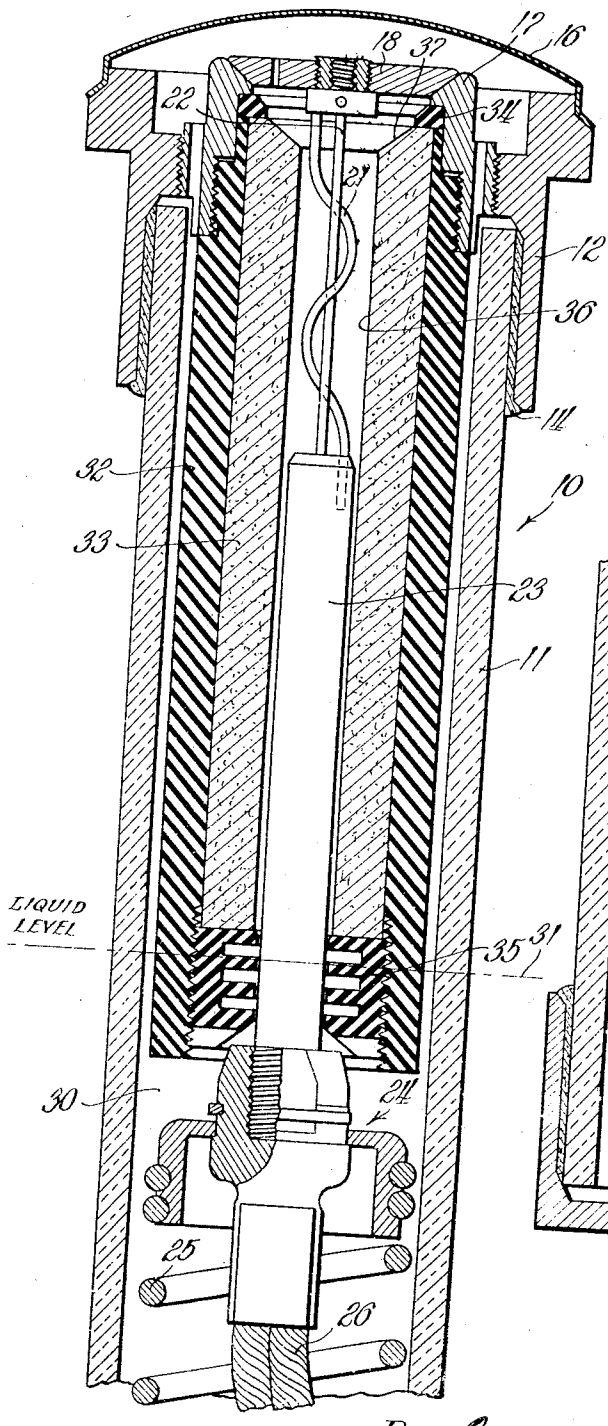
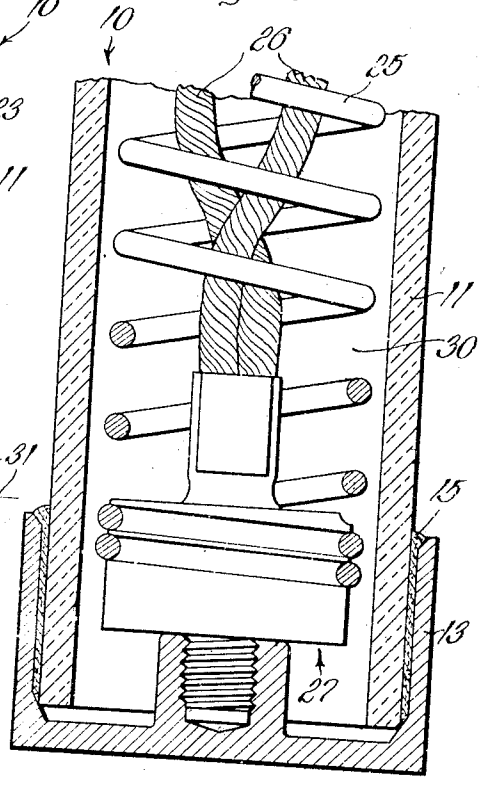


Fig. 1A.

Fig. 1B.



Inventor
George F. McMahon
By Brownjacon Bostwick Dennis
Attys.

June 9, 1942. G. F. McMAHON 2,285,602

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Fig. 2.

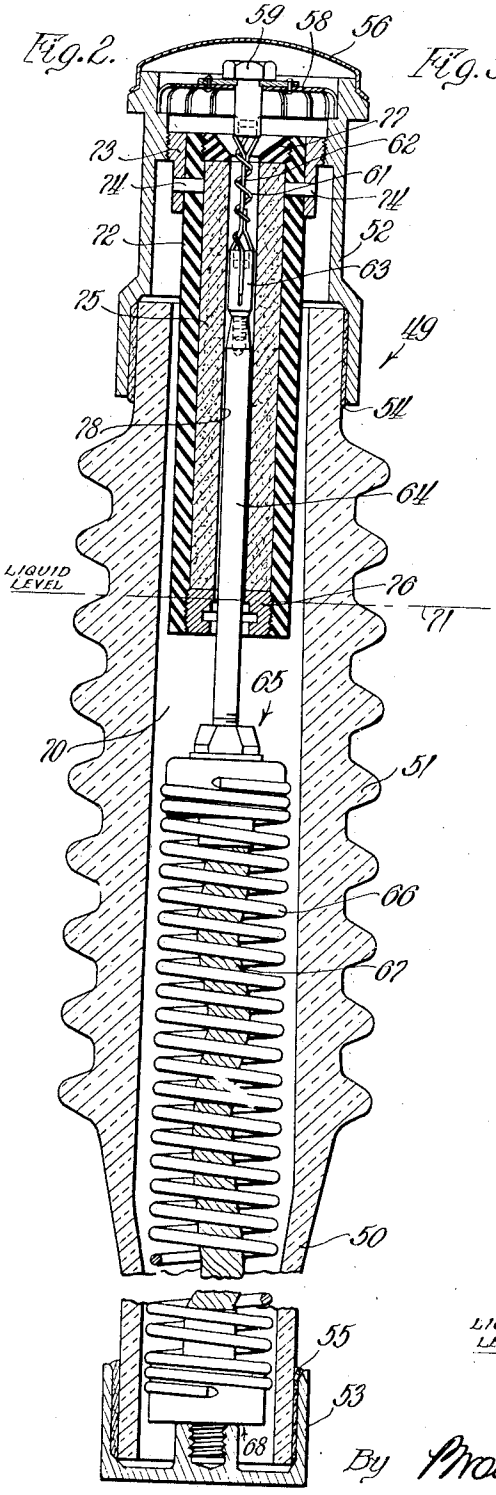
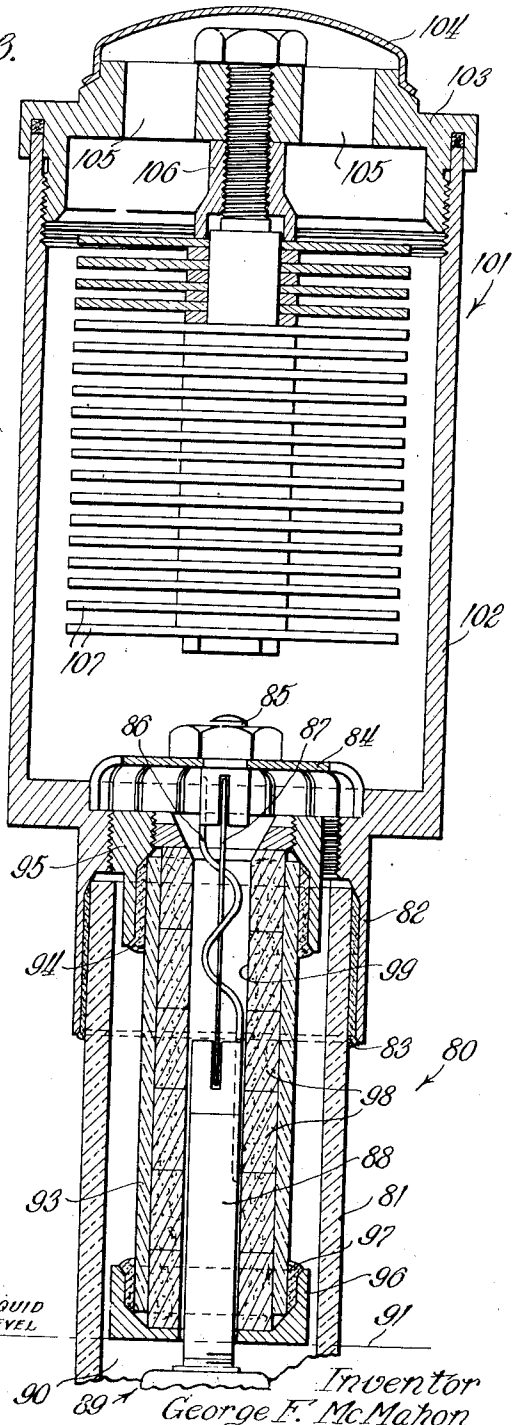


Fig. 3.



Inventor
George F. McMahon
By Brown Jackson Boettcher & Dennis
Attys.

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UNITED STATES PATENT OFFICE

2,285,602

CIRCUIT INTERRUPTER

George F. McMahon, Chicago, Ill., assignor to Schweitzer & Conrad, Inc., Chicago, Ill., a corporation of Delaware

Application November 7, 1938, Serial No. 239,263

37 Claims. (Cl. 200—120)

My invention relates generally to circuit interrupting apparatus, and it has particular relation to the provision of means for extinguishing arcs in high tension electric power circuts.

Various attempts have been made in the past to provide circuit interrupters that are capable of efficiently and economically interrupting fault circuits in high tension electric power systems over a range extending from a few amperes to several thousands of amperes. The circuit interrupter intended for use in interrupting fault currents in the lower ranges, i. e., less than five thousand amperes may not be capable of satisfactorily interrupting fault currents above this range. It is to the provision of means for interrupting fault currents over substantially the entire range of current values and at voltages likely to be encountered in commercial practice that my invention is addressed.

Attention will first be directed to certain prior patents which illustrate what has been done in this field. A review of these patents indicates that they do not provide a satisfactory and economical solution to the problem for which the present invention affords a satisfactory and complete answer.

Ringwald Patent Re. 19,097, shows a fuse in which the fusible element is embedded in a body of chlorinated naphthalene. On blowing of the fusible element chlorine is released from this material and assists in extinguishing the arc thus formed. This device is satisfactory for interrupting only relatively small fault currents and obviously would not be satisfactory for use over the entire range likely to be encountered in commercial practice. There is a suggestion that fluorine might be used instead of chlorine since it is a more active chemical, and there is an indication that further experimental work would be carried out along this line. However, in so far as I am aware, any such experimental work was never carried out by said patentee Ringwald. Attention is here directed to the fact that the chlorinated napthalene proposed by Ringwald is soluble in the halogen derivatives of hydrocarbons which are customarily employed as arc extinguishing liquids.

Strom et al. Patent No. 2,077,282, discloses an insulating and arc extinguishing material in the form of solid blocks of boric acid. This material may also be in powered form. According to this patent electrical conductors are arranged to be insulated by the boric acid. In the event of a short circuit between the conductors water vapor is evolved from the boric acid which has excellent arc extinguishing properties and as a result promptly and efficiently causes the extinguishment of any arcs that may be formed.

In Strom et al. Patent No. 1,971,836, use is made of the boric acid, just mentioned, in a fuse. A body of boric acid formed by several blocks thereof is provided having a central main bore and an auxiliary parallel bore. The arrangement is such that small fault current arcs are interrupted in the small bore, while large fault current arcs are interrupted in the large bore. In either case the arc extinguishing is effected by the evolution of water vapor from the walls of the bores, the water vapor tending to blanket the arc in a manner now well known.

In my Patent No. 1,966,901, I have disclosed a fuse device in which one of the terminals is drawn below the surface of an arc extinguishing liquid when the fuse blows. The arc extinguishing liquid is directed into the arc stream where it assists in extinguishing it. In this patent I have disclosed the use of an arc extinguishing liquid comprising trichloroethylene in mixture with tetrachloroethylene.

In my Patent No. 2,077,429, I have disclosed a fuse construction which is generally similar to that of my prior patent with the exception that a condenser is added for the purpose of cooling and condensing the products of the arc when the fuse blows. In this case a preservative in the form of aniline is mixed with the arc extinguishing liquid in order to prevent deterioration of its dielectric properties.

Triplett Patent No. 2,091,424, shows a fuse construction in which a liquid arc extinguishing medium is provided for extinguishing relatively small fault current arcs. The higher ranges of fault current arcs are interrupted by the evolution of water vapor from the inner surface of a sleeve of boric acid or silicic acid, or from water vapor that is obtained by the destruction of vials containing the same. Difficulty is encountered in maintaining the dielectric properties of the liquid arc extinguishing medium when the boric acid or silicic acid is used. Moreover, the water vapor evolved on the operaton of the device using either of these acids or water itself will cause the arc extinguishing liquid to be contaminated, thereby reducing its dielectric properties and making it possible that an arc may be maintained through it or may be restruck because of its lowered insulating properties.

Accordingly, the principal object of my invention is to provide a circuit interrupter that is capable of interrupting in a satisfactory and eco-

nomical manner any fault current arc that can occur in a commercial electric power system.

Another object of my invention is to provide for interrupting a small fault current arc or a large fault current arc in a single circuit interrupter in an improved manner.

Another object of my invention is to provide an arc extinguishing material which will accomplish interruption of large short circuit currents at a minimum of pressure.

A further object of my invention is to employ both solid and liquid arc extinguishing materials for interrupting fault current arcs over the entire range met in commercial practice in a new and improved manner.

A still further object of my invention is to employ a solid arc extinguishing material which will not reduce the dielectric strength of the liquid either before or after the circuit interrupter has operated.

Another object of my invention is to provide a solid arc extinguishing material that does not evolve water vapor when subjected to the heat of an arc and which is insoluble in commercial arc extinguishing liquids such as halogen derivatives of hydrocarbons.

Still another object of my invention is to provide a solid arc extinguishing material that is substantially unaffected by the heat generated by the current flow through the fusible element of a fuse during normal operation.

Still another object of my invention is to provide a solid arc extinguishing material which will evolve a medium that will chemically combine with the vaporized particles of a silver fusible element when the fuse blows to form a non-conducting substance.

Other objects of my invention will in part be obvious and in part appear hereinafter.

Accordingly, my invention is disclosed in the embodiments shown in the accompanying drawings and it comprises the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereinafter set forth and the scope of the application of which will be indicated in the appended claims.

For a more complete understanding of the nature and scope of my invention reference may be had to the following detailed description taken in connection with the accompanying drawings, in which:

Figures 1—A and 1—B taken together illustrate a longitudinal sectional view of a fuse type of circuit interrupter embodying my invention;

Figure 2 is a longitudinal sectional view of another embodiment of my invention in which the fuse housing is provided with a number of corrugations; and

Figure 3 is a detail sectional view of the upper end of a fuse type of circuit interrupter embodying my invention with which a condenser is provided.

Referring now particularly to Figures 1—A and 1—B, the reference character **10** designates generally a circuit interrupter constructed in accordance with my invention. The interrupter **10** is provided with a cylindrical housing **11** formed of insulating material, preferably glass, having at its upper and lower ends terminal ferrules **12** and **13**, respectively. The ferrule **12** is secured to the upper end of the housing **11** by a suitable alloy as indicated at **14**, and the lower ferrule **13** is likewise secured in place by alloy as indicated at **15**. The upper ferrule **12** is provided with a vent cap **16** which may be blown off under severe overload operation in order to vent the interior of the housing **11** to the atmosphere and permit the ready escape of the products formed as a result of the arc which is drawn on operation of the device.

A support member **17** is threaded into the upper ferrule **12** as illustrated, and it is provided with a central opening that is closed by a metal button or terminal **18**. It will be understood that the ferrule **12**, metal support member **17** and the metal button or terminal **18** together form one terminal of the circuit interrupter **10**.

Secured to the metal button or terminal **18** is a fusible element **21** that is preferably composed of pure silver or an alloy containing a large percentage of silver. A strain wire **22**, preferably formed of high strength metal such as "nichrome" wire is also secured to the metal button or terminal **18** for relieving the fusible element **21** of tension strains that would otherwise be imposed thereon.

At their lower ends the fusible and strain elements **21** and **22** are suitably secured in the upper end of a rod-like terminal **23**. It will be understood that an arc is formed between the upper terminal comprising the ferrule **12**, support member **17** and the metal button or terminal **18** and the rod-like terminal **23** when the fusible and strain elements **21** and **22** have melted. Ordinarily, this is accompanied by an expulsion of the metal button and terminal **18** after the vent cap **16** has been blown off, with the result that the arc plays between the metal support member **17** and the upper end of the rod-like terminal **23**.

At its lower end the terminal **23** is threaded into a spring and cable fastener shown generally at **24**. A coil tension spring **25** and a pair of flexible leads **26** are secured at their upper ends to the spring and cable fastener **24** as shown. At their lower ends the spring **25** and cables **26** are secured to a spring and cable fastener shown generally at **27**, which is threaded into a suitable boss in the lower ferrule **13**.

With a view to extinguishing relatively small current arcs, i. e., arcs through which about 2000 or less amperes flow, the rod-like terminal **23** is drawn below the surface of a liquid arc extinguishing material **30** which fills the lower end of the housing **11** to the level indicated at **31**. The interruption of arcs in this current range is effected by evolving from the arc extinguishing liquid **30** gases which serve to blanket the arc and deionize the arc space at the zero points of the alternating current cycles, and at the same time providing a blast action outwardly of the housing **11**.

The liquid **30** that may be employed may vary, depending upon the operating conditions and other factors. For example, the arc extinguishing liquids disclosed in my prior patents referred to hereinbefore may be employed. I have found that an arc extinguishing liquid composed of six per cent. trichloroethylene and ninety-four per cent. tetrachloroethylene having a trace of aniline therein will serve this purpose admirably.

Difficulty has been experienced in interrupting some of the higher short circuit currents which may occur in some installations when reliance is placed solely upon a liquid arc extinguishing material. Accordingly, I propose to extend the current range of circuit interrupters of the liquid arc extinguishing type by modifying them in such manner that they are capable of interrupt-

ing higher ranges of current while at the same time retaining the excellent arc extinguishing characteristics of a liquid arc extinguishing material for the low current ranges.

For this purpose I have provided a tubular housing **32** of insulating material such as "Bakelite" which may be threaded into the support member **17** at its upper end as illustrated. Within the tubular housing **32** there is positioned a tubular member **33** of a solid arc extinguishing material. A ring **34** is provided at the upper end of the tubular member **32** for holding the tubular body of arc extinguishing material **33** in place. At the lower end a plug **35** is threaded into the tubular member **32** for adjustably securing the body **33** of arc extinguishing material in place. The body **33** of arc extinguishing material is provided with a longitudinal bore **36** through which the rod-like terminal **23** is freely movable and from which it may be quickly withdrawn by the coil tension spring **25** on blowing of the fusible and strain elements **21** and **22**. The upper end of the body **33** of arc extinguishing material is flared outwardly as indicated at **37** in order to assist in the expulsion of the products of the arc that is formed on operation of the interrupter.

The character of the body **33** of arc extinguishing material is such that relatively little if any arc extinguishing gases are evolved from the surface of the bore **36** in the small current operating range. In this range, as indicated, reliance is placed for arc extinction upon the withdrawing of the rod-like terminal **23** below the level of the liquid **30** and the evolution of an arc extinguishing medium therefrom which provides a blast action through the bore **36** and tends to expel the ionized particles which would otherwise serve to permit the restriking or maintaining of the arc.

The characteristics required in the body **33** of arc extinguishing material are such that extreme care must be exercised in selecting it. It should be of such a nature that the heat generated by the fusible and strain elements **21** and **22** during normal operation will not cause any evolution of arc extinguishing vapors therefrom or other deterioration thereof. At the same time it must be capable of evolving large quantities of an arc extinguishing medium as the result of heat generated on flow of relatively large arc current so as to provide the desired blast and arc extinguishing action under these severe operating conditions. The arc extinguishing medium which is evolved under these conditions should be such that it will not materially increase the pressure inside the housing **11** to a point where it might be destroyed before the vent cap **16** is blown off.

There are other important characteristics. The material forming the body **33** of arc extinguishing material should be relatively inert or insoluble in the arc extinguishing liquid **30**. Further, it should remain intact throughout its useful life. When it is recalled that circuit interrupters of this class may remain connected in a circuit for many weeks or months, or possibly years, without being called upon to operate, it will be appreciated that the insulating properties of the liquid **30** should remain unchanged regardless of the time that the device has been in service.

The arc extinguishing medium that is evolved from the body **33** of arc extinguishing material must be such that it will not contaminate the liquid **30** or combine therewith in such manner as to reduce its dielectric properties. Thus, either before or after operation of the device the body **33** of solid arc extinguishing material must have such characteristics that it will not in the slightest impair or affect the insulating qualities of the arc extinguishing liquid **30**. When it is recalled that the liquid **30** is intended to provide a major portion of the dielectric between the upper ferrule **12** and the rod-like terminal **23** after the device has operated, the importance of maintaining the liquid **30** uncontaminated will be more readily appreciated.

After conducting a long series of experiments and tests under actual operating conditions I have found that there are certain materials and combinations of materials that will satisfy the above enumerated requirements for the body **33** of arc extinguishing material. In particular, I have found that metallic compounds of fluorine in which the fluorine content is fifty per cent. or above by weight provide the desired characteristics for the body **33** of arc extinguishing material. The following table sets forth three of these compounds and certain data with respect thereto:

Symbol	Material	Melting point, °C.	Per cent fluorine by weight
LiF	Lithium fluoride	870	73.2
MgF_2	Magnesium fluoride	1,396	60.9
AlF_3	Aluminum fluoride	1,040	67.8

It will be observed that the materials set forth in this table comprise halogenated anhydrous materials, or inorganic halides, or metallic halides which are insoluble in halogenated hydrocarbons. Because of its high fluorine content lithium fluoride is the preferred material. However, magnesium fluoride and aluminum fluoride may be employed.

I have also found that a mixture of thirty-seven per cent. lithium fluoride and sixty-three per cent. aluminum fluoride provides a suitable solid arc extinguishing material. In such a mixture the melting point is lower than the melting points of either of the ingredients. This permits the evolution of fluorine at lower temperatures.

When these various fluorine compounds are employed fluorine in gaseous form is evolved from the surface of the bore **36** on flow of relatively great fault current through the arc. The fluorine combines with the vaporized silver of the fusible element **21** to form silver fluoride which is highly resistant to current flow.

Other solid arc extinguishing materials may be employed that have the characteristics enumerated above. For example, arsenic trioxide (As_2O_3) and molybdenum trioxide (MoO_3) may be employed. Arsenic trioxide sublimes readily as the temperature increases and it has no definite melting point. Molybdenum trioxide melts at about 791° C. and is somewhat slower to act than is arsenic trioxide.

I have found that none of the materials enumerated hereinbefore that are suitable for forming the body **33** of solid arc extinguishing material will contaminate the usual arc extinguishing liquid employed in apparatus of this kind. It will be recalled that the liquid **30** comprises one or more halogen derivatives of hydrocarbons as set forth in my prior patents previously referred to. Since these materials are anhydrous there is

no possibility that the liquid 30 will be contaminated by water or water vapor derived from them, and its dielectric properties correspondingly reduced. This is true both before and after the device has operated in so far as any evolution of water or water vapor from the material 33 is concerned. Consequently, it is possible to form the body 33 of arc extinguishing material of lithium fluoride or of the other materials mentioned, or of combinations thereof and permit the circuit interrupter 10 to stand for long periods of time without in the slightest causing a deterioration in its interrupting ability. Therefore, it will be apparent that the present invention materially extends the range of current values which can be successfully interrupted by devices of this nature.

In the modified construction shown in Figure 2 of the drawings a circuit interrupter designated generally at 49 is provided having certain characteristics which are not found in the circuit interrupter 10 previously described. The circuit interrupter 49 comprises a tubular housing 50 that is preferably formed of glass. The housing 50 is provided adjacent the upper end with a number of corrugations 51. These corrugations 51 serve not only to increase the mechanical strength of the tubular housing 50, but they also serve to more uniformly distribute the dielectric stresses to which the interrupter 49 is subjected during or after operation. In Conrad Patent No. 2,091,431, the importance of the corrugations 51 is more fully disclosed. In the present construction a larger number of corrugations has been employed in order to satisfactorily meet certain operating conditions.

At its upper end the housing 50 is provided with a ferrule 52 while a ferrule 53 is provided at the lower end. The ferrule 52 is secured to the housing 50 by suitable alloy as indicated at 54, and likewise the ferrule 53 is secured in position by suitable alloy as indicated at 55. A vent cap 56 serves to close the upper end of the ferrule 52 and may be readily blown off on the generation of sufficient pressure within the housing 50.

A metallic spider 58 is mounted on a suitable flange at the upper end of the ferrule 52. It carries a terminal stud 59 to which are attached a silver fusible element 61 and a strain element 62. It will be understood that the terminal stud 59, spider 58 and ferrule 52 comprise the upper terminal of the interrupter 49.

At their lower ends the fusible and strain elements 61 and 62 are secured to an auxiliary terminal 63 which is threaded in the upper end of a rod-like terminal 64. The lower end of the rod-like terminal 64 is threaded in a suitable spring and cable anchor shown generally at 65. The upper end of a coil tension spring 66 and the upper end of a flexible cable 67 are secured as illustrated to the spring and cable fastener 65. At their lower ends the spring 66 and cable 67 are secured to a spring and cable fastener shown generally at 68, which is threaded in a suitable boss carried by the ferrule 53.

A filling of arc extinguishing liquid 70 is provided in the housing 50, to the level indicated at 71, for the purpose of extinguishing arcs in the small current range, as previously described. The liquid 70 that is employed may be as hereinbefore specified.

With a view to extending the range of current interruption of the interrupter 49 while at the same time retaining the advantages of the low current operating range afforded by the liquid 70, a tubular member 72 of insulating material such as "Bakelite" is secured at its upper end in a metallic ring 73 by suitable pins 74, the ring 73 being threaded in the ferrule 52 as shown. Within the tubular member 72 is a body 75 of solid arc extinguishing material that may be composed of lithium fluoride or any of the other solid arc extinguishing materials set forth hereinbefore, or mixtures thereof.

The body 75 of solid arc extinguishing material is held in place in the tubular member 72 by a plug 76 at the lower end and by a suitable ring 77 at the upper end, both the plug 76 and the ring 77 being threaded in the tubular member 72. As shown, the ring 77 is flared outwardly to facilitate the expulsion of the products of the arc.

The body 75 of solid arc extinguishing material is provided with a bore 78 through which a rod-like terminal 64 is freely movable. The length of the body 75 of solid arc extinguishing material and the number of corrugations 51 may be varied for different voltage ratings.

In operation, when the fusible and strain elements 61 and 62 are blown because of an overload an arc is formed between the terminal stud 59 and the auxiliary terminal 63. If the arc thus formed is a relatively small current arc then it may be readily extinguished on withdrawal of the auxiliary terminal 63 below the level of the liquid 70 by the spring 66. The arc extinguishing medium that is evolved from the liquid 70 in such case will serve to deionize the arc path as described. If the flow of current is sufficiently great through the arc sufficient pressure may be generated to blow off the vent cap 56. However, in the low current range sufficient heat is not generated by the arc to evolve appreciable quantities of an arc extinguishing medium from the surface of the bore 78 of the body 75 of solid arc extinguishing material.

Now, when a relatively great current flows through the arc on blowing of the fusible and strain elements 61 and 62, the bore 78 is substantially filled thereby and sufficient heat is generated to evolve a considerable amount of arc extinguishing medium from the surface of the bore 78 which serves to deionize the arc space and to extinguish the arc.

After the arc has been extinguished the rod-like terminal 64 accompanied by the auxiliary terminal 63 will have been withdrawn through the bore 78 to a position below the level of the liquid 70. In such case there is a considerable dielectric stress present between the rod-like terminal 64 and the upper ferrule 52 since they are now separated by a dielectric and are maintained at a considerable difference of potential. This dielectric stress is distributed by the corrugations 51 to a large extent so as to reduce the concentration of electrostatic stress which might puncture the wall of the housing 50.

Another function of the corrugations 51 is to resist the mechanical stress that is applied to the housing 50 when the circuit interruption takes place. At the time because of the rapid evolution of gases from the solid and liquid arc extinguishing materials considerable pressure is generated within the housing 50. By providing the corrugations 51 this mechanical stress and shock are efficiently resisted.

Referring now particularly to Figure 3 of the drawings, it will be observed that only the upper end portion of a modified form of circuit inter-

rupter is shown generally at 80. This circuit interrupter comprises a housing 81, preferably of glass, having a ferrule 82 at its upper end which is secured thereto by a suitable alloy as indicated at 83. The ferrule 82 carries a spider 84 which in turn carries a terminal stud 85, the stud 85, spider 84 and ferrule 82 constituting the upper terminal of the interrupter 80. Secured to the stud 85 are a silver fusible element 86 and a strain element 87. At their lower ends the fusible and strain elements 86 and 87 are secured to a rod-like terminal 88 the lower end of which is threaded in a suitable spring and cable fastener shown generally at 89.

As previously described, an arc extinguishing liquid 90 is provided in the housing 81 to the level indicated at 91. This arc extinguishing liquid is of the nature previously set forth and is intended to effect efficient and rapid interruption of arcs in the small current range.

In the embodiments of the invention shown in Figures 1—A and 2 a tubular member 32 and 72, respectively, is shown for holding the body of solid arc extinguishing material. This tubular member is formed, as described, of insulating material such as "Bakelite". In some instances it has been noted that a flashover may be caused along the surface of this material between the upper terminal and the rod-like terminal after the device has operated. This is due to the fact that the surface of the tubular member 32 or 72 has been rendered conducting by carbonization or breakdown of the "Bakelite" which sometimes happens at excessively high voltages.

With a view to obviating this difficulty, I have provided in the embodiment of the invention shown in Figure 3 a tubular housing 93 that is formed of glass. At its upper end the glass housing 93 is alloyed as indicated at 94 in a suitable ring 95 that is threaded in the ferrule 82. At its lower end the tubular housing 93 is provided with a ferrule 96 that is alloyed thereto as indicated at 97. A body of solid arc extinguishing material in the form of blocks 98 thereof is positioned inside of the glass housing 93. These blocks together form a body of solid arc extinguishing material having a longitudinal bore 99 through which the rod-like terminal 88 is readily movable.

With a view to condensing the products of the arc and particularly the gas evolved from the solid and liquid arc extinguishing materials, a condenser shown generally at 101 is provided at the upper end of the housing 81. The condenser 101 comprises an extension 102 formed integrally with the ferrule 82. The extension 102 is closed at its upper end by a cap 103 to which is secured a vent cap 104. The cap 103 is provided with suitable apertures 105 through which the gases may be vented when the vent cap 104 is blown off. The cap 103 is also provided with a stem 106 that carries a plurality of condenser plates or fins 107 on the surface of which the gases may be cooled and condensed.

The operation of the circuit interrupter 80 is generally similar to that previously described. The gases evolved from the liquid arc extinguishing material or from the solid arc extinguishing material are cooled and condensed by the fins or plates 107. If sufficient pressure is generated within the extension 102 the vent cap 104 may be blown off, thereby venting the interior of the circuit interrupter to the atmosphere.

Since certain further changes may be made in the foregoing constructions and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter shown in the accompanying drawings or set forth herein shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. A circuit interrupter comprising, in combination, a pair of arcing terminals relatively movable apart along a predetermined path, a liquid arc extinguishing material along one part of said path adapted to evolve an arc extinguishing medium due to the heat of an arc when the current flow therethrough is relatively small, the insulating properties of said liquid arc extinguishing material being substantially reduced on contamination with water, and a solid anhydrous arc extinguishing material along another part of said path and adapted to evolve an arc extinguishing medium due to the heat of the arc only when the current flow therethrough is relatively great, the insulating properties of said liquid arc extinguishing material being substantially unimpaired by the presence of said solid arc extinguishing material and the arc extinguishing medium evolved therefrom.

2. A circuit interrupter comprising, in combination, a pair of arcing terminals relatively movable apart along a predetermined path, a liquid arc extinguishing material along one part of said path adapted to evolve an arc extinguishing medium due to the heat of an arc when the current flow therethrough is relatively small, the insulating properties of said liquid arc extinguishing material being substantially reduced on contamination with water, and a solid anhydrous inorganic arc extinguishing material along another part of said path and adapted to evolve an arc extinguishing medium due to the heat of the arc only when the current flow therethrough is relatively great, the insulating properties of said liquid arc extinguishing material being substantially unimpaired by the presence of said solid arc extinguishing material and the arc extinguishing medium evolved therefrom.

3. In a circuit interrupter having arcing terminals, a liquid arc extinguishing material along one part of the path of an arc drawn between said terminals adapted to evolve an arc extinguishing medium due to the heat of the arc, and a solid halogenated arc extinguishing material along another part of said arc path adapted to evolve an arc extinguishing medium due to the heat of the arc, said solid arc extinguishing material being substantially insoluble in said liquid arc extinguishing material whereby the dielectric properties thereof remain substantially unimpaired.

4. In a circuit interrupter having arcing terminals, a liquid arc extinguishing material along one part of the path of an arc drawn between said terminals adapted to evolve an arc extinguishing medium due to the heat of the arc when the current flow therethrough is relatively small, and a solid halogenated arc extinguishing material along another part of said arc path adapted to evolve an arc extinguishing medium due to the heat of the arc when the current flow therethrough is relatively great, said solid arc extinguishing material being substantially insoluble in said liquid arc extinguishing material whereby the dielectric properties thereof remain substantially unimpaired.

5. In a circuit interrupter having arcing terminals, an arc extinguishing liquid comprising

one or more halogen derivatives of a hydrocarbon and disposed along one part of the path of the arc drawn between said terminals and adapted to evolve an arc extinguishing medium due to the heat of the arc when the current flow therethrough is relatively small, and a solid halogenated anhydrous arc extinguishing material disposed along another part of said arc path and adapted to evolve an arc extinguishing medium due to the heat of the arc when the current flow therethrough is relatively great, said solid arc extinguishing material being substantially insoluble in said liquid arc extinguishing material whereby the dielectric properties thereof remain substantially unimpaired.

6. In a circuit interrupter having arcing terminals, a liquid arc extinguishing material along one part of the path of an arc drawn between said terminals adapted to evolve an arc extinguishing medium due to the heat of the arc, and a solid arc extinguishing material comprising one or more metallic halides along another part of said arc path adapted to evolve an arc extinguishing medium due to the heat of the arc.

7. In a circuit interrupter having arcing terminals, an arc extinguishing liquid comprising one or more non-metallic halides and disposed along one part of the path of the arc drawn between said terminals and adapted to evolve an arc extinguishing medium due to the heat of the arc, and a solid arc extinguishing material comprising one or more metallic halides disposed along another part of said arc path and adapted to evolve an arc extinguishing medium due to the heat of the arc.

8. In electrical apparatus, an inorganic arc extinguishing material containing at least fifty per cent. by weight of fluorine.

9. In a circuit interrupter having arcing terminals, a solid inorganic arc extinguishing material containing at least fifty per cent. by weight of fluorine along the path of the arc drawn between said terminals and evolving fluorine in the form of gas due to the heat of the arc for extinguishing the same.

10. In a circuit interrupter having arcing terminals, a liquid arc extinguishing material along one part of the path of an arc drawn between said terminals adapted to evolve an arc extinguishing medium due to the heat of the arc when the current flow therethrough is relatively small, and a solid inorganic arc extinguishing material containing at least fifty per cent. by weight of fluorine along another part of said arc path adapted to evolve fluorine in the form of gas due to the heat of the arc when the current flow therethrough is relatively great.

11. In a circuit interrupter having arcing terminals, an arc extinguishing liquid comprising one or more halogen derivatives of a hydrocarbon and disposed along one part of the path of the arc drawn between said terminals and adapted to evolve an arc extinguishing medium due to the heat of the arc when the current flow therethrough is relatively small, and a solid inorganic arc extinguishing material containing at least fifty per cent. by weight of fluorine disposed along another part of said arc path and adapted to evolve fluorine in the form of gas due to the heat of the arc when the current flow therethrough is relatively great.

12. A circuit interrupter comprising, in combination, a pair of arcing terminals relatively movable apart along a predetermined path, a silver fusible element interconnecting said terminals, and arc extinguishing material comprising one or more metallic halides along said path, said arc extinguishing material evolving one or more halogens in gaseous form on blowing of said silver fusible element to form one or more silver halides.

13. A circuit interrupter comprising, in combination, a pair of arcing terminals relatively movable apart along a predetermined path, a silver fusible element interconnecting said terminals, and a solid arc extinguishing material comprising one or more metallic halides along said path, said arc extinguishing material evolving one or more halogens in gaseous form on blowing of said silver fusible element to form one or more silver halides.

14. A circuit interrupter comprising, in combination, a pair of arcing terminals relatively movable apart along a predetermined path, a silver fusible element interconnecting said terminals, and inorganic arc extinguishing material containing a substantial amount of fluorine along said path, said arc extinguishing material evolving fluorine in the form of a gas due to the heat of the arc formed on blowing of said silver fusible element to form silver fluoride.

15. A circuit interrupter comprising, in combination, a pair of arcing terminals relatively movable apart along a predetermined path, a silver fusible element interconnecting said terminals, and a solid inorganic arc extinguishing material containing at least fifty per cent. by weight of fluorine along said path, said arc extinguishing material evolving fluorine in the form of a gas due to the heat of the arc formed on blowing of said silver fusible element to form silver fluoride.

16. A circuit interrupter comprising, in combination, a pair of arcing terminals relatively movable apart along a predetermined path, a silver fusible element interconnecting said terminals, and a solid arc extinguishing material comprising lithium fluoride along said path, said arc extinguishing material evolving fluorine in the form of a gas due to the heat of the arc formed on blowing of said silver fusible element to form silver fluoride.

17. In electrical apparatus, an arc extinguishing material comprising lithium fluoride.

18. In a circuit interrupter having arcing terminals, a solid arc extinguishing material comprising lithium fluoride disposed along the path of the arc drawn between said terminals and evolving fluorine due to the heat of the arc for extinguishing the same.

19. In a circuit interrupter having arcing terminals, a liquid arc extinguishing material along one part of the path of an arc drawn between said terminals adapted to evolve an arc extinguishing medium due to the heat of the arc, and a solid arc extinguishing material comprising lithium fluoride along another part of said arc path adapted to evolve fluorine due to the heat of the arc for extinguishing the same.

20. In a circuit interrupter having arcing terminals, an arc extinguishing liquid comprising one or more halogen derivatives of a hydrocarbon and disposed along one part of the path of the arc drawn between said terminals and adapted to evolve an arc extinguishing medium due to the heat of the arc, and a solid arc extinguishing material comprising lithium fluoride along another part of said arc path adapted to evolve fluorine due to the heat of the arc for extinguishing the same.

21. In electrical apparatus, an arc extinguishing material comprising magnesium fluoride.

22. In a circuit interrupter having arcing terminals, a solid arc extinguishing material comprising magnesium fluoride disposed along the path of the arc drawn between said terminals and evolving fluorine due to the heat of the arc for extinguishing the same.

23. In a circuit interrupter having arcing terminals, a liquid arc extinguishing material along one part of the path of an arc drawn between said terminals adapted to evolve an arc extinguishing medium due to the heat of the arc, and a solid arc extinguishing material comprising magnesium fluoride along another part of said arc path adapted to evolve fluorine due to the heat of the arc for extinguishing the same.

24. In a circuit interrupter having arcing terminals, an arc extinguishing liquid comprising one or more halogen derivatives of a hydrocarbon and disposed along one part of the path of the arc drawn between said terminals and adapted to evolve an arc extinguishing medium due to the heat of the arc when the current flow therethrough is relatively small, and a solid arc extinguishing material comprising magnesium fluoride along another part of said arc path adapted to evolve fluorine due to the heat of the arc when the current flow therethrough is relatively great for extinguishing the same.

25. In electrical apparatus, an arc extinguishing material comprising aluminum fluoride.

26. In a circuit interrupter having arcing terminals, a solid arc extinguishing material comprising aluminum fluoride disposed along the path of the arc drawn between said terminals and evolving fluorine due to the heat of the arc for extinguishing the same.

27. In a circuit interrupter having arcing terminals, a liquid arc extinguishing material along one part of the path of an arc drawn between said terminals adapted to evolve an arc extinguishing medium due to the heat of the arc, and a solid arc extinguishing material comprising aluminum fluoride along another part of said arc path adapted to evolve fluorine due to the heat of the arc for extinguishing the same.

28. In electrical apparatus, an arc extinguishing material comprising a mixture of metallic halides the melting point of which is substantially less than that of any of the halides forming the mixture.

29. In electrical apparatus, an arc extinguishing material comprising a mixture of lithium fluoride and aluminum fluoride.

30. In electrical apparatus, an arc extinguishing material comprising a mixture of thirty-seven per cent. of lithium fluoride and sixty-three per cent. of aluminum fluoride.

31. In a circuit interrupter having arcing terminals, an arc extinguishing liquid comprising one or more halogen derivatives of a hydrocarbon and disposed along one part of the path of the arc drawn between said terminals and adapted to evolve an arc extinguishing medium due to the heat of the arc when the current flow therethrough is relatively small, and a solid arc extinguishing material comprising aluminum fluoride along another part of said arc path adapted to evolve fluorine due to the heat of the arc when the current flow therethrough is relatively great for extinguishing the same.

32. A circuit interrupter comprising, in combination, a tubular insulating housing having a plurality of corrugations intermediate its ends for increasing the mechanical strength thereof and distributing dielectric stress, stationary and movable arcing terminals within said housing, a quantity of arc extinguishing liquid in said housing, means for drawing said movable arcing terminal into said arc extinguishing liquid and away from said stationary terminal for extinguishing an arc drawn therebetween, and a tubular body of a solid arc extinguishing material comprising a metallic halide surrounding said movable terminal and adapted to have an arc extinguishing medium in gaseous form evolved from its inner surface due to the heat of an arc drawn between said terminals for extinguishing the same.

33. A circuit interrupter comprising, in combination, a tubular housing formed of insulating material, stationary and movable arcing terminals within said housing, a quantity of arc extinguishing liquid in said housing, means for drawing said movable arcing terminal into said arc extinguishing liquid and away from said stationary terminal for extinguishing a relatively small current arc drawn therebetween, a tubular body of a solid anhydrous arc extinguishing material insoluble in said liquid surrounding said movable terminal and adapted to have an arc extinguishing medium evolved from its inner surface due to the heat of a relatively great current arc drawn between said terminals for extinguishing the same, and means for cooling and condensing the products of the arc drawn between said terminals and the arc extinguishing mediums evolved from said liquid and solid arc extinguishing materials.

34. A circuit interrupter comprising, in combination, a tubular housing formed of insulating material, stationary and movable arcing terminals within said housing, a quantity of arc extinguishing liquid in said housing, means for drawing said movable arcing terminal into said arc extinguishing liquid and away from said stationary terminal for extinguishing a relatively small current arc drawn therebetween, a tubular body of a solid arc extinguishing material comprising a metallic halide surrounding said movable terminal and adapted to have an arc extinguishing medium in gaseous form evolved from its inner surface due to the heat of a relatively great current arc drawn between said terminals for extinguishing the same, and means for cooling and condensing the products of the arc drawn between said terminals and the arc extinguishing mediums evolved from said liquid and solid arc extinguishing materials.

35. A circuit interrupter comprising, in combination, a tubular housing formed of insulating material, stationary and movable arcing terminals within said housing, a quantity of arc extinguishing liquid in said housing, means for drawing said movable arcing terminal into said arc extinguishing liquid and away from said stationary terminal for extinguishing a relatively small current arc drawn therebetween, a tubular body of a solid arc extinguishing material comprising lithium fluoride surrounding said movable terminal and adapted to have fluorine in gaseous form evolved from its inner surface due to the heat of a relatively great current arc drawn between said terminals for extinguishing the same, and means for cooling and condensing the products of the arc drawn between said terminals and the arc extinguishing mediums evolved from said liquid and solid arc extinguishing materials.

36. A circuit interrupter comprising, in combination, a tubular housing formed of insulating material, stationary and movable arcing terminals within said housing, a quantity of arc extinguishing liquid in said housing, means for drawing said movable arcing terminal into said arc extinguishing liquid and away from said stationary terminal, a tubular body of solid arc extinguishing material insoluble in said liquid surrounding said movable terminal and adapted to have an arc extinguishing medium evolved from its inner surface due to the heat of the arc drawn between said terminals, and a sleeve of insulating material surrounding said body of solid arc extinguishing material for holding the same in operative position, said sleeve of insulating material being characterized by having its outer surface substantially free from the formation thereon of a conducting path resulting from an arc being formed therealong.

37. A circuit interrupter comprising, in combination, a tubular housing formed of insulating material, stationary and movable arcing terminals within said housing, a quantity of arc extinguishing liquid in said housing, means for drawing said movable arcing terminal into said arc extinguishing liquid and away from said stationary terminal, a tubular body of solid arc extinguishing material surrounding said movable terminal and adapted to have an arc extinguishing medium evolved from its inner surface due to the heat of the arc drawn between said terminals, and a sleeve of insulating material surrounding said body of solid arc extinguishing material for holding the same in operative position, said sleeve of insulating material formed of carbon free material whereby the outer surface thereof is substantially free from the likelihood of a conducting path being formed thereon during current interruption.

GEORGE F. McMAHON.