

July 17, 1934.

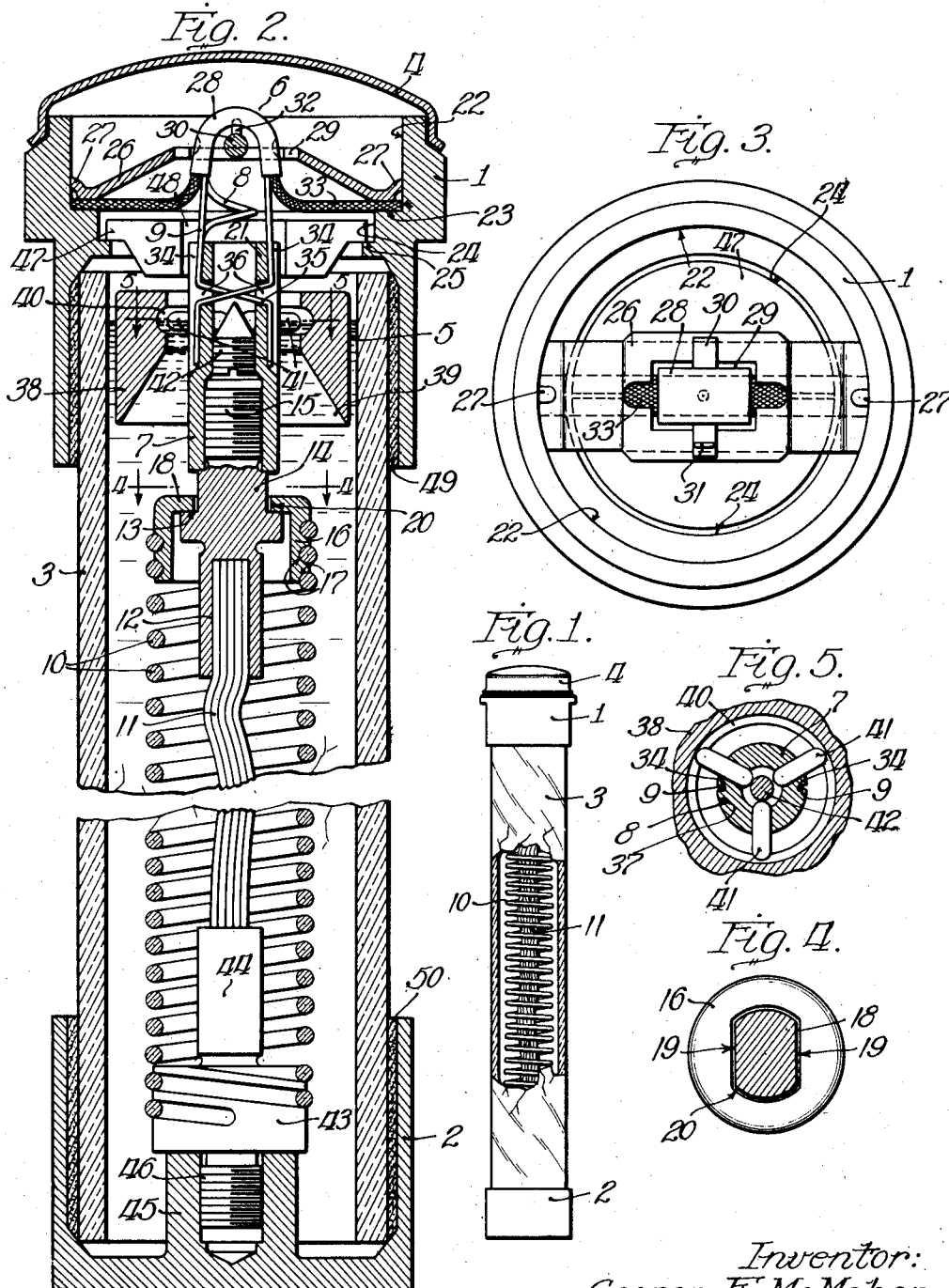
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ARC EXTINGUISHING LIQUID FOR CIRCUIT INTERRUPTERS AND THE LIKE

Filed Dec. 19, 1930

2 Sheets-Sheet 1



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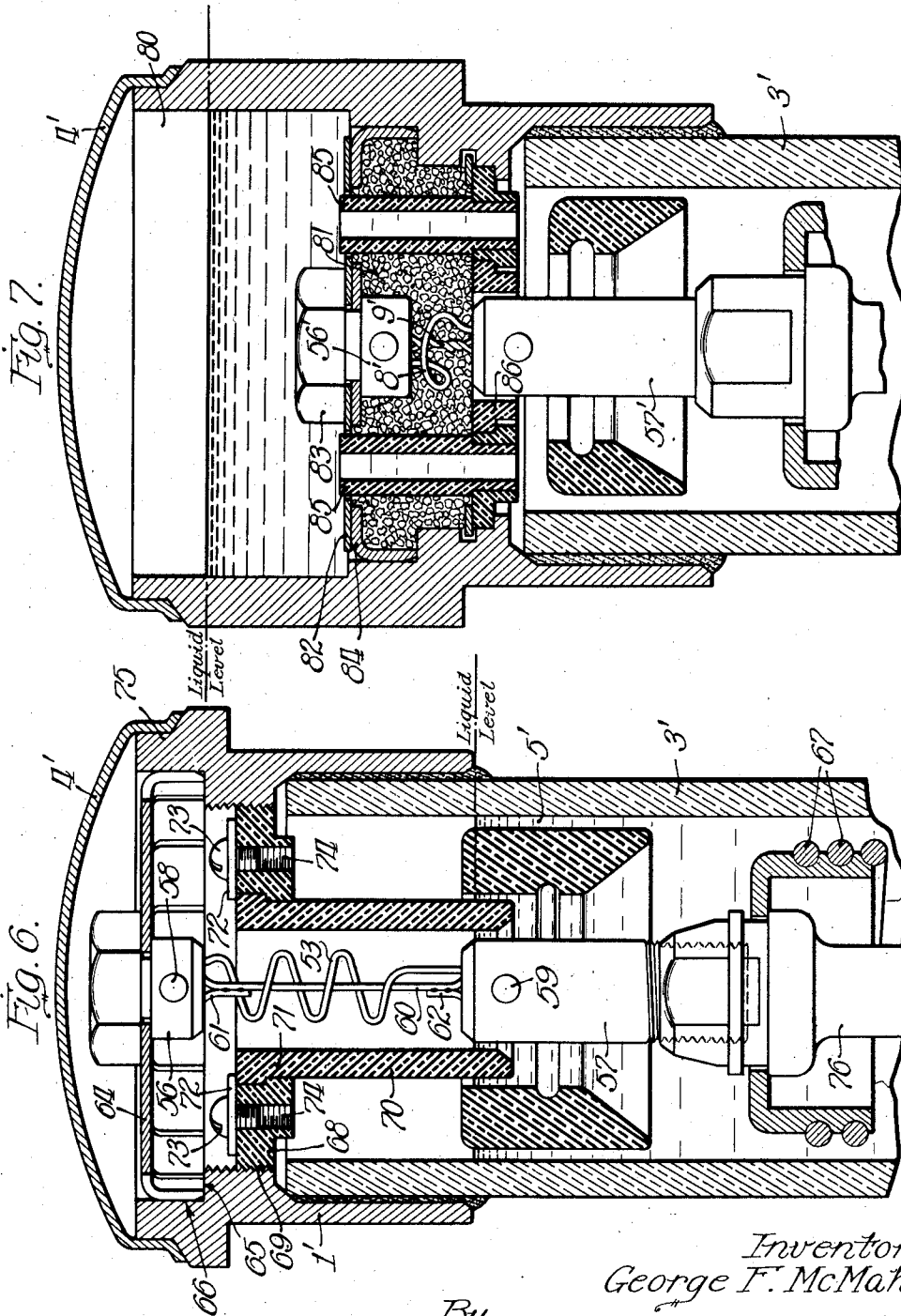
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UNITED STATES PATENT OFFICE

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ARC EXTINGUISHING LIQUID FOR CIRCUIT INTERRUPTERS AND THE LIKE

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Application December 19, 1930, Serial No. 503,481

18 Claims. (Cl. 200—120)

This invention relates to arc extinguishing liquids for circuit interrupters and the like, and more particularly for fuses of the substantially closed chamber liquid containing type for use on high voltage systems, although not limited to such systems.

Oil has been used but it has a number of disadvantages, among which are its inflammability and likelihood of causing an explosion and its hygroscopic character which causes it to deteriorate in insulating strength and to require relatively frequent renewing. When it leaks out of the chamber of the interrupting device it discolors and soils the floor or other part which it contacts.

As an improvement upon oil for circuit interrupting apparatus carbon tetrachloride has been employed. It is a thin relatively free flowing liquid having a low boiling point, being very volatile, and having a fairly low freezing point. Due to its better insulating value and its higher break down strength this was an improvement upon oil, but it was found to have defects which rendered it not entirely satisfactory in apparatus of this character. It is not stable, especially in contact with water, but is decomposed, forming carbon dioxide and hydrochloric acid. It attacks nearly all metals, particularly brass which it is desirable to employ in contact with the liquid, combining with and removing the zinc and copper from the brass and forming gummy molasses-like deposits of zinc chloride and chlorides of copper. This action on metal is increased by the presence of moisture or light. The corrosive action on brass, bronze and copper releases the screws and other parts of the apparatus, and decreases the life of the parts and reduces the dielectric strength of the liquid. Its vapor pressure is relatively high and as a consequence, it is not as suited as desired in an open chamber. Due to its great fluidity it will escape through minute openings, and as it leaves no stain it is difficult to ascertain the condition of the apparatus.

To overcome the defects of carbon tetrachloride a number of so-called poly-chloro-derivatives of ethane and ethylene have been proposed, the particular substances heretofore proposed in this connection being as follows:

50	Tetrachloroethylene	-----	(C ₂ Cl ₄)
	Tetrachloroethane	-----	(C ₂ H ₂ Cl ₄)
	Pentachloroethane	-----	(C ₂ HCl ₅)
	Hexachloroethane	-----	(C ₂ Cl ₆)

I have discovered a substance which is valuable for use as an arc extinguishing liquid for circuit

interrupters and the like. The particular substance which I have discovered to be valuable in this connection is trichloroethylene (C₂HCl₃) which I find is especially adapted for use in circuit interrupters and the like in mixture with other halogen derivatives of a hydrocarbon, and particularly with certain other halogen derivatives of a hydrocarbon having more than one carbon atom to the molecule as will hereinafter appear, although trichloroethylene may be used alone to advantage within the scope of the present invention. It is stable in contact with water and is not decomposed by water to form carbon dioxide and hydrochloric acid as is carbon tetrachloride, is of good dielectric strength, fairly high boiling point (88° C.), low freezing point (−86.4° C.), and has higher heat of evaporation and lower vapor pressures than carbon tetrachloride. Corrosion of the metals in contact therewith is reduced, as is the matter of electrical and mechanical failure resulting therefrom, and the problems of reduced dielectric strength of the liquid and gumming molasses-like zinc chloride deposits are lessened. Trichloroethylene is more transparent to light and appears to absorb less light than tetrachloroethylene, and as already pointed out, is not easily decomposed in sunlight in the presence of water where air has been excluded.

In mixture or solution with tetrachloroethylene in proportions which will hereinafter appear, the dielectric strength is from 400 to 600 volts per mil, there is practically no corrosion nor decomposition in sunlight in the presence of water, practically no gummy metallic chloride deposits, the boiling point is of the order 112° C., the arc quenching properties are satisfactory, and the freezing point is from −40° C. to −49° C.

It is also proposed within the scope of the present invention to add hexachloroethane (C₂Cl₆) to the fuse liquid of the present invention although this may, of course, be omitted as will hereinafter appear.

In order to acquaint those skilled in the art with the manner of carrying out the present invention, I shall describe certain specific embodiments of the invention in connection with the accompanying drawings, in which:

Figure 1 is a side elevational view of a fuse with a portion of the sleeve forming the fuse casing broken away and showing the liquid of the present invention therein;

Figure 2 is an enlarged fragmentary section of one form of fuse structure with the present liquid in the chamber thereof;

Figure 3 is a top plan view of the fuse structure of Figure 2 with the vent cap removed;

Figure 4 is a detail section taken on the line 4-4 of Figure 2;

Figure 5 is a detail section taken on the line 5-5 of Figure 2; and

Figures 6 and 7 are vertical sections through the upper ends of other fuse structures and showing the liquid of the present invention in connection therewith.

The fuses herein specifically illustrated and described are of the Schweitzer & Conrad liquid quenched type, but it is to be understood that the invention herein disclosed and claimed is not to be limited to these particular fuses.

Referring first to Figures 1 to 5, the fuse therein illustrated is of the type more fully disclosed in the copending application of Nicholas J. Conrad, Serial No. 436,012, filed March 15, 1930, to which application reference is here made for the specific details of this device.

Suffice it, for the purpose of the present application, to say that the device illustrated in Figures 1 to 5 comprises a generally elongated body having metal ferrules 1 and 2 upon the upper and lower ends respectively of a glass sleeve 3. Upper ferrule 1 has an open top closed by a cap 4 adapted to be removable under certain circumstances evidenced in the operation of the fuse. Sleeve 3, ferrules 1 and 2 and cap 4 form a closed chamber within which is contained, preferably to about the level indicated, the body of arc extinguishing liquid designated at 5. Suitable arcing or fuse terminals 6 and 7 (Figure 2) are connected by a fusible link 8 and held in definite relation with respect to each other by a strain wire 9. A tension spring 10 is connected between the movable terminal 7 and the ferrule 2, and a flexible conductor or cable 11 is connected and serves as a current carrying conductor between the movable terminal 7 and the lower ferrule 2, which forms an external terminal at the lower end of the device, the conductor 11 being preferably of high conductivity to shunt the spring 10 in order to prevent any material flow of current therethrough which might injure the spring. At the same time the conductor 11 is sufficiently soft and flexible to be readily collapsed by the spring 10.

The upper end of flexible conductor 11 is fastened in a tubular socket 12, the socket member having an annular shoulder 13 and a shank portion 14 above this shoulder. The shank portion is threaded at its upper end at 15 and a flanged ring 16 peripherally grooved at 17 to receive the coils of the spring 10 has an inwardly extending flange 18 loosely embracing the shank portion 14 between the shoulder 13 and the threaded end 15, this portion of the shank being flattened upon diametrically opposite sides at 19 (Figure 4), and the opening 20 in the top ring 16 is similarly shaped to prevent relative rotation between the ring 16 and the socket member. The threaded end 15 is threaded into a threaded socket at the lower end of the cylindrical arcing terminal 21.

The top of ferrule 1 which forms an external terminal at the upper end of the device has a cylindrical bore 22 terminating in a shoulder 23, there being a bore 24 of reduced diameter below bore 22 which latter bore terminates in a shoulder 25. A cross plate or bridge piece 26 fits snugly within bore 22 seating at its opposite ends on shoulder 23 and having struck up lips 27 bearing against the inner periphery of the ferrule to in-

crease the depth of cooperation of the ends of the plate 26 therewith. The terminal 6 is in the form of an inverted U-shaped anchor 28 which extends through a central opening 29 in plate 26 and has universal support upon an anchoring member 30 which extends across the opening 29, through the right of the anchor 28 and has support at its opposite ends on plate 26, being adapted to be held in place by a wire cotter pin 31. A short pin 32 secured to anchoring member 30 constitutes a single point support for anchor 28, a shallow depression being formed in the anchor 28 to seat the same upon the pin 32.

Anchor 28 has complete freedom of motion on pin 32 and comprises a short length of copper tubing through which passes a flexible braided conductor 33 of copper or the like and the strain wire 9, which is preferably of nickle chromium iron, which may be purchased on the market as "Nichrome", or "Chromel", or under other names, being of high mechanical strength and of high electrical resistance. The function of the anchor 28 and its support is to provide a universal mounting of limited motion to permit convenient handling and assembly without injurious stresses being exerted upon the strain wire. The end of the fuse wire 8 is also extended into one end of the tubular anchor 28, which anchor is flattened to firmly secure conductor 33, strain wire 9 and fuse wire 8 therein, the ends of conductor 33 being extended out and secured between the opposite ends of the plate 26 and the shoulder 23 of the ferrule 1.

The ends of the strain wire 9 are laid in grooves 34 in the terminal member 21, being crossed at 35 through an opening 36, and the upper end of the terminal 21 is compressed or formed to bring the periphery thereof along the grooves 34 together to firmly grip the ends of the strain wire 9 and the lower end of the fuse wire 8 which is laid in a groove 37 (Figure 5) to the terminal member 21.

The terminal member 21 has means for securing thereto a liquid director 38 which comprises a generally cylindrical short cylinder with a flared inlet opening 39 and a groove 40 by means of which it is mounted upon the arcing or fuse terminal 21. The groove 40 is engaged by a series of pins 41, three in number being shown, which pins have their ends rounded and their outer ends pressed into the groove 40 by an expanding screw 42 (Figures 2 and 5) which is a pointed grub-screw carried in threads within the bore of the terminal 21.

The lower end of the spring 10 is threaded around a spring fastener 43 similar to the engagement with the ring 16 and secured to or formed integral with the lower cable terminal 44. The lower ferrule 2 is provided with an axial inwardly extending boss 45 bored and internally threaded to receive a threaded extension 46 on the lower end of the cable terminal 44.

A ring 47 preferably of bakelite and which may be termed a barrier ring, rests or is seated peripherally upon the shoulder 25 and has a central opening 48 through which the terminal 21 extends. This barrier ring is preferably split, comprising two semi-circular halves which lie at their upper ends in the bore 24 and embrace the top of the fuse and strain wires 8 and 9 and the upper end of the terminal 21.

The upper terminal or ferrule 1 is provided with

a cylindrical socket into which the upper end of the glass tube 3 is placed and secured by means of a suitable metal or alloy, or other seal 49 providing a somewhat elastic fluid-type joint.

- b The lower terminal or ferrule 2 is provided with a similar cylindrical socket into which the lower end of the glass tube 3 is placed and similarly secured and sealed at 50.

- 10 The sides of the upper terminal 1 and likewise of the lower terminal 2 are preferably slabbed off to provide parallel contact surfaces for engagement with a suitable fuse mounting.

- Assuming that the fuse has been subjected to overload of sufficient amount to cause the fusible wire and the strain wire to be melted and an arc to form, as soon as the metals have sufficiently softened to permit the tension of the spring 10 to separate the terminal 21 from the anchor 28 which constitutes the other terminal, the downward motion of the terminal 21 and liquid director 38 immediately begins. While the liquid director is not absolutely tight in the glass sleeve, it operates nevertheless like a piston, causing the liquid 5 to be projected upwardly through the annular space between the liquid director 38 and the terminal 21, this liquid playing upon the arc as the same is lengthened by the downward motion and tending to chill and quench the arc.

- 30 If the pressure generated by the blowing of the fuse is sufficient the cap 4 is adapted to be removed or blown off thereby, thus permitting the escape of pressure and avoiding shattering of the glass tube 3.

- 35 The fuses shown in Figures 6 and 7 are of the type more fully disclosed in the copending application of Nicholas J. Conrad, Serial No. 470,416, filed July 24, 1930.

- In Figure 6 the upper and lower arcing terminals 56 and 57 have transverse holes provided with pins 58 and 59, the supporting strain wire 60 being looped at its ends at 61, 62 around pins 58, 59 to provide a universal joint of limited motion. The fuse wire 53 is suitably connected between terminals 56, 57, and the terminal 56 is secured to plate 64 which has down-turned spring fingers seating upon shoulder 65 and expandable to grip counterbore 66 by the tension of spring 67. The barrier ring 68 has threaded engagement in terminal 1' at 69 and extending through the central bore of ring 68 is the fibre tube 70 provided at its upper end with a head 71 seated in a counterbore at the top of the ring 68, the tube being held in place by washers 72 held under the heads of screws 73 mounted in openings 74. Cap 4' is sealed at 75 to the ferrule 1' with a cementitious material of suitable character to maintain a fluid tight joint which will not be deteriorated by the liquid 5' inside the tube, nor by the external weather as by water. The connection between the cable socket member 76 and the arcing terminal 57 is generally of the type shown in Figure 2, the specific details varying as brought out in the Conrad application last above referred to. The level of the liquid 5' within the fuse chamber is preferably to about that shown.

- In Figure 7 the liquid within the chamber is preferably to about the level shown, extending up into the chamber 80 so that the blowing of the fuse occurs well below the level of the liquid and within the cork or filling of other heat-insulating material at 81. A metal plate 82 is clamped between the nut 83 and the plate 84 and has a plurality of holes through which extend

the upper ends of tubes 85 which are preferably of bakelite, and the lower ends of which preferably open through openings in the insulating ring 86. The fuse wire is indicated at 8' and the strain wire at 9', whereas the upper arcing terminal is indicated 56' and the lower arcing terminal at 57'.

Trichloroethylene which I have discovered to be especially adapted for use as an arc extinguishing liquid in devices of the character above set forth in mixture with other halogen derivatives of a hydrocarbon, more particularly with other halogen derivatives of a hydrocarbon having more than one carbon atom to the molecule, and still more particularly in mixture with tetrachloroethylene to which hexachloroethane may be added or omitted as will hereinafter appear, although trichloroethylene may within the scope of the present invention be used alone to advantage, is characterized by the fact as already pointed out that it is free from injurious action by water, is a good dielectric, is non-inflammable and has valuable fire extinguishing and arc quenching properties. It has a fairly high boiling point, a very low freezing point and a higher heat of evaporation than that of carbon tetrachloride, it is not easily oxidized by water to form carbon dioxide and hydrochloric acid as is carbon tetrachloride. Corrosion of metals in contact therewith is reduced, as is the matter of electrical and mechanical failure resulting therefrom. Zinc chloride and other metallic chloride deposits and reduced dielectric strength of the liquid which follow corrosion and ready reaction with water and other substances are also lessened.

In mixture with tetrachloroethylene it is especially valuable as a fuse liquid from the standpoint of corrosion, dielectric strength, boiling point, fire extinguishing and arc quenching properties and freezing point.

I have made comparative tests of the foregoing and other substances as fuse liquids in devices of the character herein set forth with and without the addition of drops of water and subjecting same to various light rays, and I find that trichloroethylene and tetrachloroethylene are the best liquids from a corrosion standpoint. I have tested the same in various mixtures in 200 ampere 25000 volt type D Schweitzer and Conrad fuses and in 10 ampere 25000 volt Schweitzer and Conrad fuses, and I find that a mixture of 10% C_2HCl_3 + 90% C_2Cl_4 operates satisfactorily on all phases and that this mixture has excellent dielectric properties. I have also found that a mixture of 94% C_2Cl_4 + 6% C_2HCl_3 is well suited as an arc extinguishing liquid in these devices and with the advantages above set out.

It is also proposed within the scope of this invention to include the addition of hexachloroethane (C_2Cl_6) to the above mixtures where suitable or desired. The addition of hexachloroethane up to 25% to the mixtures of 94% C_2Cl_4 + 6% C_2HCl_3 does not greatly increase the chlorine content, but it has been found to have a possible beneficial effect in several ways. It decreases the amount of flame and increases the amount of energy necessary to vaporize the liquid. It is not as susceptible to decomposition by moisture as carbon tetrachloride. Hexachloroethane is crystalline at room temperatures and is soluble in the above liquids.

Following is a table of properties of trichloroethylene, tetrachloroethylene and mixtures of the order of 90 to 94% tetrachloroethylene to 10

to 6% trichloroethylene in comparison with the properties of carbon tetrachloride:

	Boiling point	Freezing point	Dielectric strength 1/4" gap, volts per mil	Reaction toward water and moisture
10 Carbon tetrachloride CCl ₄	° C. 76.8	° C. -23.0	Min. Mx. 225-300	Decomposed into CO ₂ +HCl
Trichloroethylene C ₂ HCl ₃	88.0	-86.4	350-500	None.
Tetrachloroethylene C ₂ Cl ₄	120.8	-22.4	380-600	None.
15 Mixture of trichloroethylene, of order of 10% to 6% and tetrachloroethylene 90% to 94%.	112.0	-40.0 to -49.0	380-600	None.

I do not intend, of course, to be limited to the particular proportions above set out in connection with the foregoing mixtures, and as already pointed out, I do not intend to limit the use of the present invention to particular fuse structures shown nor, in fact, to fuse structures at all as the liquid means of the present invention is applicable to other circuit interrupting and like apparatus.

I claim:

1. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising trichloroethylene in mixture with tetrachloroethylene.

2. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising trichloroethylene in mixture with tetrachloroethylene in proportions of the order 90 to 94% tetrachloroethylene to 10 to 6% trichloroethylene.

3. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising hexachloroethane in a mixture of trichloroethylene and tetrachloroethylene.

4. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising trichloroethylene in mixture with tetrachloroethylene and hexachloroethane in said mixture in proportions up to 25% thereof.

5. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising trichloroethylene in mixture with tetrachloroethylene in proportions substantially of the order 90 to 94% tetrachloroethylene to 10 to 6% trichloroethylene and hexachloroethane in said mixture in proportions up to substantially 25% of the combined proportions of trichloroethylene and tetrachloroethylene.

6. In combination with a circuit interrupter, comprising a pair of metal arcing terminals and having a container, a bath of arc extinguishing liquids for said terminals, said liquids comprising two liquids one of which has highly effective arc extinguishing characteristics, and one of said two liquids serving to reduce the freezing point of the liquid bath, said mixture being substantially free of any reaction with moisture which would cause corrosion of the metal terminals, said liquids comprising each a halogen derivative of a hydrocarbon.

7. In combination with a circuit interrupter, comprising a pair of metal arcing terminals and having a container, a bath of arc extinguishing material for said terminals, said bath comprising a liquid in which there is dissolved a solid, both the liquid and the solid having arc extinguishing characteristics, said material being substantially free of any reaction with moisture which would cause corrosion with the metal terminals, said liquid and said solid comprising each a halogen derivative of a hydrocarbon, and said liquid comprising trichloroethylene.

8. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, means independent of the current flow for separating said terminal means, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising trichloroethylene in mixture with a halogen derivative of a hydrocarbon.

9. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, means independent of the current flow for separating said terminal means, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising trichloroethylene in mixture with a halogen derivative of a hydrocarbon having more than one carbon atom in the molecule.

10. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, means independent of the current flow for separating said terminal means, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising trichloroethylene.

11. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, means independent of the current flow for separating said terminal means, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising a non-inflammable and relatively non-corrosive halogen derivative of a hydrocarbon, said derivative being stable in contact with water, of good dielectric properties, with a relatively high boiling point and a freezing point of the order of -86° C.

12. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, means independent of the current flow for separating said terminal means, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising a non-inflammable

and relatively non-corrosive mixture of halogen derivatives of a hydrocarbon, said mixture being stable in contact with water, of a dielectric strength of the order of 400 to 600 volts per mil, and having a boiling point of the order of 112° C., good arc quenching properties and a freezing point of the order of from -40° C. to -49° C.

13. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, means independent of the current flow for separating said terminal means, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means and comprising trichloroethylene and hexachloroethane in mixture or solution therewith.

14. In combination, a substantially closed container, metallic conducting means within said container, a fusible element within the container and connected to said conducting means, means independent of the current flow for separating said metallic conducting means, and an arc extinguishing liquid enclosed by said container and comprising trichloroethylene mixed with another halogen derivative of a hydrocarbon.

15. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means, and comprising a mixture of tetrachloroethylene with a halogen derivative of a hydrocarbon, said derivative having only three halogen atoms in the molecule.

16. In combination, a substantially closed container, circuit terminal means in said container adapted to be separated for breaking a flow of current, means independent of the current flow for separating said terminal means, and an arc extinguishing liquid disposed within said container in arc extinguishing relation to said terminal means, said liquid comprising a mixture of a plurality of halogen derivatives of a hydrocarbon, one of said derivatives having only three halogen atoms in the molecule.

17. In combination with a circuit interrupter, comprising a pair of metal arcing terminals having a container, a bath of arc extinguishing liquid for said terminals, said liquid comprising a plurality of constituents, each of which comprises a halogen derivative of a hydrocarbon, said liquid bath having a freezing point below normal minimum atmospheric temperatures, said liquid being substantially incombustible, and being substantially free of any reaction with moisture which would cause corrosion of the metal terminals.

18. In combination with a circuit interrupter, comprising a pair of metal arcing terminals, and having a container, a bath of arc extinguishing material for said terminals, said bath comprising a liquid in which there is dissolved a solid, both the liquid and the solid having arc extinguishing characteristics, said material being substantially free of any reaction with moisture which would cause corrosion of the metal terminals, said liquid and said solid comprising each a halogen derivative of a hydrocarbon.

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