

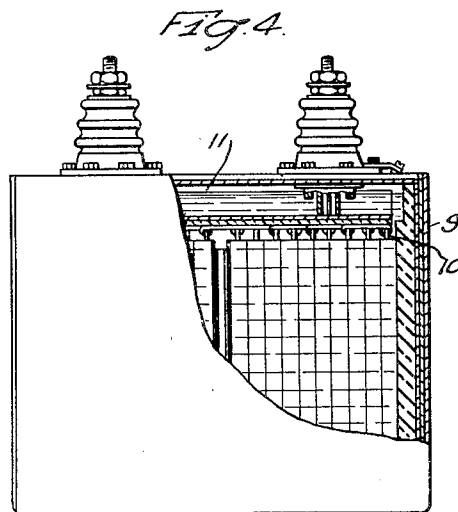
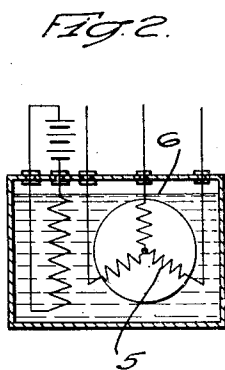
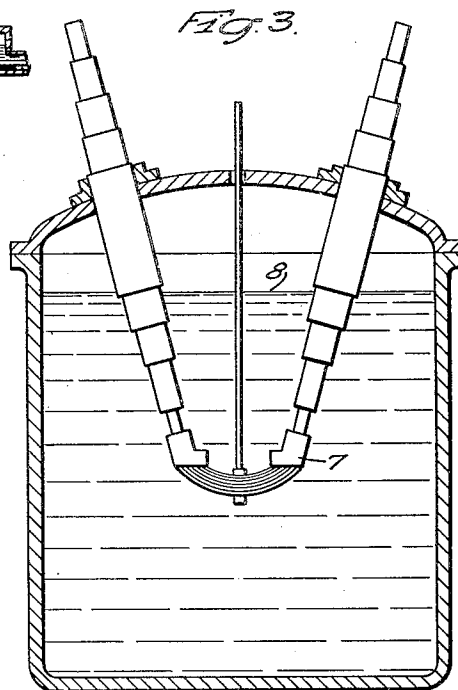
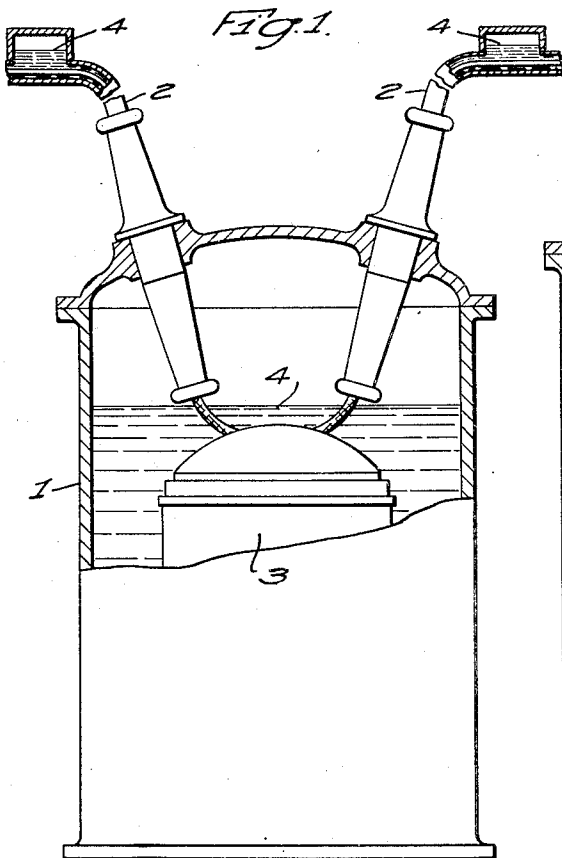
April 3, 1934.

H. M. ELSEY

1,953,216

INSULATING LIQUID

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WITNESSES:

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## UNITED STATES PATENT OFFICE

1,953,216

## INSULATING LIQUID

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27 Claims. (Cl. 175—361)

This invention pertains to electrical apparatus embodying liquefiable insulating medium. Such apparatus as transformers, capacitors, cables and other conductors, electric bushings, and various electric switches and circuit breakers exemplify this invention but, for illustration and without implying any limitation, reference in this description is made more particularly to trans-  
formers.

Conventionally, mineral insulating oils have been used as the dielectric in which transformer coils are immersed. Other media have been proposed from time to time because mineral oils deteriorate and form sludge, even in normal use, and because with the ever-present possibility of arcing through the insulation, mineral oils constitute serious explosion and fire hazards. Various chlorine compounds have been added to mineral oil with a view to minimizing flammability, but because of volatility or of inferior dielectric properties, such mixtures have not met with favor. More recent proposals of chlorine compounds having known dielectric properties have included chlorinated diphenyl compounds to replace mineral oil as insulating liquid in transformers. However, those liquids intensify the danger from any hot spots in the transformer, since their sluggishness in circulation is detrimental to heat transfer and since they exhibit a flash point of about 145° C.

Objects of this invention comprise providing electrical apparatus that embodies dielectric medium in which high insulating value is balanced with many valuable physical and chemical properties.

Other objects include minimizing explosion and fire hazard from insulating liquids in electrical apparatus; and substantially avoiding deterioration of metal, used in the conductors and in the containers of such apparatus, and deterioration in coatings of fibre or resinous material frequently used to protect or insulate electrical coils and cables or other conductors. Other objects include providing electrical apparatus with dielectric medium that is highly resistant to oxidation; is substantially non-sludging; is of high dielectric strength whether in solid condition or in liquid; and is extremely resistant even in initial breakdown to electric arcing. It is also an object of this invention to provide a dielectric that is readily miscible with other dielectrics.

This invention is predicated upon my discovery that dielectric media of marked chemical stability combined with suitable physical characteristics are obtained from fluorinated com-

pounds, particularly various fluorinated organic compounds.

Reference is made to the accompanying drawing of illustrative embodiments of this invention, in which:

Figure 1 shows a transformer 1 having cables 2 and transformer elements 3 immersed in fluorinated dielectric 4; and showing cable 2 outside the transformer as being filled with fluorinated dielectric 4;

Fig. 2 shows schematically a movable conductor 5 having fibrous or resinous insulation in contact with fluorinated dielectric 6;

Fig. 3 shows a switch 7 operating with fluorinated dielectric 8, and

Fig. 4 shows a capacitor 9 with elements 10 and fluorinated dielectric 11.

Referring to the dielectric media, I find that under electric stresses organic compounds containing fluorine atoms possess considerably greater chemical stability than corresponding chlorine, bromine or iodine compounds, and that this improvement is obtained even though the molecule contain other halogen or other substituted element or group than fluorine.

By way of specific illustration of this invention and without limitation, reference is made to a fluorinated hydrocarbon that is especially useful in transformers. I have discovered that suitable dielectric medium is obtainable with a fluorinated paraffine compound, particularly fluorinated ethane. Specifically tetrachlorodifluoroethane presents an illustrative, preferred embodiment of this invention; that is, ethane in which four hydrogen atoms are replaced by chlorine and two hydrogen atoms by fluorine. The formula of this compound is  $C_2Cl_4F_2$ .

This compound in practice has a relatively high specific resistance in comparison with many halogenated organic compounds that are free from fluorine. Another of its extremely valuable qualities is its miscibility with other insulating liquids. In a particular instance commercial 1, 2, 4-trichlorobenzene, low in any straight chain chlorine impurities, was mixed in approximately ninety percent by volume with approximately ten percent  $C_2Cl_4F_2$ . The mixture was very stable in an atmosphere substantially of oxygen. Even at 100° C. no sludge formed. The protective action of small proportions of the  $C_2Cl_4F_2$  further is illustrated. For, though the boiling point of the  $C_2Cl_4F_2$  used was about 90° C. and that of the trichlorobenzene was about 213° C., nevertheless this mixture on boiling freely in a Cleveland open test cup exhibited no flash point dur-

ing boiling away of as much as approximately fifty percent in volume of the mixture. This mixture possesses no fire point, when tested in the same apparatus. The proportion of  $C_2Cl_4F_2$  may be considerably less than ten percent, as approximately five percent, for example. Of these components of the mixture, the trichlorobenzene possesses the lower specific resistance and higher power factor. Hence its proportion in the mixture may be decreased from the proportions in the example given. Dielectric values of the mixture are high not only in its liquid state but in the solid.

Commercial trichlorobenzene often contains orthodichlorobenzene but it has not been necessary to eliminate that impurity. Its freezing point is above  $10^\circ C.$ , instead of  $16^\circ C.$  for pure 1, 2, 4-trichlorobenzene. The freezing point of the  $C_2Cl_4F_2$  used was about  $26^\circ C.$  Nevertheless the mixture described pours at  $-1^\circ C.$  or somewhat below. It is desirable to free commercial trichlorobenzene from contaminating straight chain chlorine compounds, but I found that this may be accomplished satisfactorily by intimate contact, for example distilling, with iron, sodium, calcium or magnesium; or in other manner.

Other advantages of this mixture exhibit themselves in use. Thus, this insulating medium efficiently conducts heat away from the electrical conductors, so as to minimize hot spots in a transformer. This is dependent on several factors. Not only does the mixture possess a specific heat comparable with other insulating fluid ordinarily used, about 0.38 calories per cubic centimeter per degree centigrade; but it readily dispels heat by convection, for its viscosity is exceedingly low and its coefficient of thermal expansion is high. Its viscosity is only about 1.49 centipoises at  $37.8^\circ C.$  ( $100^\circ F.$ ) or but slightly more than that of water, while the viscosity of mineral oils or of various chlorinated diphenyl compounds that have been proposed as substitutes for oil is over five times as high as that temperature. The low viscosity of this fluorine mixture is rendered even more effective by its high thermal expansivity. That is, with temperature rise this mixture becomes considerably lighter, because of its increase in volume, and so tends to improve circulation through convection currents. This high expansivity taken with low viscosity and high heat capacity combine to dispel heat in a very satisfactory manner. These excellent physical qualities combine with marked chemical stability, including absence of firepoint, to provide electrical apparatus with considerably improved utility.

This invention is susceptible of considerable modification and of practice in many different embodiments. Thus though tetrachlorodifluoroethane is illustrated in admixture with trichlorobenzene, its stabilizing value is obtainable even in admixture with conventional insulating mineral oil, or with other compounds, such as various diphenyl compounds, like diphenyl oxide or chlorinated diphenyl. Either insulating oil or oil substitutes, such as diphenyl derivatives may be added to tetrachlorodifluoroethane, whether some dielectric such as trichlorobenzene is present or not. A useful embodiment of this invention comprises approximately two percent by volume of tetrachlorodifluoroethane with about 44 percent by volume of trichlorobenzene and about 54 percent by volume of halogenated diphenyls, such as chlorinated diphenyl containing about 40 to 60 percent chlorine, preferably 54

percent. Or straight chain hydrocarbons containing various amounts of halogen, for example chlorine, may be substituted for all or part of the diphenyl derivatives in such mixtures.

Throughout this specification, this invention has been illustrated by reference to tetrachlorodifluoroethane as a preferred embodiment. However, in similar manner use may be made of pentachloromonofluoroethane. Mention is made also of trichlorotrifluoroethane, for example, as possessing desirable qualities of high stability, miscibility and good dielectric values. This invention is not limited to fluorinated ethanes as insulating media but many variations will be obtainable with other fluorinated straight chain compounds, or with fluorinated ring compounds, for example, fluorinated diphenyls. Moreover, this invention comprises a plurality of fluorinated hydrocarbons, as well as a single fluorinated compound, in admixture with one or more halogen compounds whether or not containing fluorine. Such, for example in addition to the chlorinated diphenyl mixture previously described, would be fluorinated diphenyl and fluorinated paraffin compound with trichlorobenzene, or a mixture of fluorinated paraffins, such as of the fluorinated ethanes mentioned, with these chlorinated cyclic compounds. In lieu of chlorobenzene, fluoro- or other halogenated benzene is comprehended by the principles of this invention.

According to the provisions of the patent statutes, I have explained the principle and mode of operation of my invention, and have described what I now consider to represent its best embodiments. However, I desire to have it understood that, within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim as my invention:

1. Electric apparatus having electrically conducting elements insulated with dielectric comprising fluorine compound.
2. Electric apparatus having electrically conducting elements insulated with dielectric comprising fluorinated hydrocarbon.
3. Electric apparatus having electrically conducting elements insulated with dielectric comprising fluorinated aliphatic hydrocarbon.
4. Electric apparatus having electrically conducting elements insulated with dielectric comprising fluorinated ethane.
5. Electric apparatus having electrically conducting elements insulated with mineral insulating oil admixed with fluorinated hydrocarbon.
6. Electric apparatus having electrically conducting elements insulated with oil admixed with fluorinated ethane.
7. Electric apparatus having electrically conducting elements insulated with dielectric comprising tetrachlorodifluoroethane.
8. A transformer having coils immersed in dielectric comprising fluorinated compound.
9. A transformer having coils immersed in dielectric comprising halogenated hydrocarbon in a mixture containing fluorine compound.
10. A transformer having coils immersed in dielectric comprising halogenated diphenyl compound in admixture with fluorinated paraffin compound.
11. A transformer having coils immersed in dielectric comprising tetrachlorodifluoroethane.
12. A transformer having coils immersed in dielectric comprising tetrachlorodifluoroethane and trichlorobenzene.
13. A transformer having coils immersed in di-

electric comprising approximately ten parts of tetrachlorodifluoroethane to ninety parts of trichlorobenzene.

14. An electric cable having as insulation tetra-  
5 chlorodifluoroethane.

15. A process of transferring heat from an electrical conductor comprising thermally contacting the conductor with dielectric cooling liquid in admixture with fluorinated hydrocarbon.

10 16. A process of transferring heat from a transformer coil comprising circulating in thermal contact with the coil halogenated aromatic hydrocarbon in admixture with fluorinated straight chain hydrocarbon.

15 17. A process comprising treating trichlorobenzene containing straight chain chlorinated hydrocarbons by heating in the presence of reactive metals comprising iron, sodium, calcium or magnesium, distilling, mixing the product with dielectric material, and insulating electric  
20 conductors with the mixture.

18. As a new composition of matter diphenyl compound in admixture with fluorinated straight chain hydrocarbon.

25 19. As a new composition of matter a fluorinated mixture of hydrocarbons that is liquid at ordinary temperatures and solidifies below approximately  $-1^{\circ}\text{C}$ .

30 20. As a new composition of matter a mixture of trichlorobenzene and tetrachlorodifluoroethane.

21. A new composition of matter comprising a fluorinated hydrocarbon and chlorinated derivative of diphenyl containing approximately 50 to 60 percent of chlorine.

22. A new composition of matter comprising  
80 fluorinated ethane, chlorinated derivative of diphenyl containing approximately 50 to 60 percent of chlorine, and trichlorobenzene.

23. A new composition of matter comprising  
85 approximately 2 parts tetrachlorodifluoroethane, 44 parts trichlorobenzene and 54 parts of diphenyl derivative containing approximately 40 to 60 percent of chlorine.

24. A new composition of matter comprising  
90 pentachlorodifluoroethane in admixture with insulating material.

25. Electric apparatus having electrically conducting elements operative and being in dielectric consisting substantially of cyclic compounds comprising fluorinated cyclic compounds.  
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26. Electric apparatus having electrically conducting elements operative and being in dielectric consisting substantially of halogenated compounds comprising fluorinated cyclic compounds.  
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27. Electric apparatus having electrically conducting elements operative and being in dielectric consisting substantially of halogenated cyclic compounds comprising fluorinated cyclic compounds.  
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HOWARD M. ELSEY.

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