

UNITED STATES PATENT OFFICE

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METHOD OF MAINTAINING DIELECTRIC
STABILITY OF INSULATING OILSLeo J. Berberich, Pittsburgh, Pa., assignor to So-
cony-Vacuum Oil Company, Incorporated, New
York, N. Y., a corporation of New YorkNo Drawing. Application September 1, 1937,
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8 Claims. (Cl. 252—1)

This invention is directed to a method of improving and maintaining the dielectric stability of insulating oils such as are used in high voltage power cables, capacitors, and the like.

It has been known that such oils, under conditions of use, are prone to decomposition of some form, with the resultant formation of gas, "cable wax", and eventual loss of dielectric properties of the combination of oil with paper or other structural insulating material used. It is known that one of the major causes of failure has been traceable to "void" formation, i. e., to the presence of small pockets in the structure, actually filled with gas under very low pressure, which may have been caused by the attendant expansion and contraction of the insulating structure when in use under a normal load-temperature cycle, or by the incomplete impregnation of paper or other insulating structural material with oil, or voids may be formed by handling, as by bending of a cable, causing parting of insulation. These pockets or "voids" are filled with gases at low pressure, some being residual air, and some originating from the dielectric material. It has been found highly impracticable to minimize "void" formation to a point where failures resulting therefrom will be inconsequential. This invention is directed to a method of protection of the insulating oil in a cable, capacitor, or other insulated structure containing the usual "voids" in the usual amount and distribution found in practice.

It has been found that the deterioration referred to above most probably has its origin as the result of the electrical bombardment of the surrounding oil, and structural material by high speed electrons formed within the "void" under conditions such as to stress the gas therein, at its reduced pressure, above its critical voltage. Such bombardment effects disintegration of the materials, particularly of the oils. This manifests itself by the splitting out from the hydrocarbon molecule of hydrogen and gaseous hydrocarbons, and the formation of the insoluble waxy material called "x-wax" or "cable-wax" of unknown composition possibly formed by the condensation of highly activated molecular residues. It is possible, if the discharges are severe enough, or prolonged enough, that the whole of the oil may be converted to gases and "wax". It is evident that once a discharge has started, the action becomes cumulative by spreading of the gases throughout the insulation, with the formation of more "voids" and ultimate electrical breakdown. Even in the early stages, the effect of such dis-

charge is to increase the conductivity and, hence, the loss in the insulation, thus resulting in a local temperature rise which accelerates breakdown.

This invention has for its object the maintenance of the dielectric stability of insulating oils under conditions of use by protection of those oils from the deteriorating effect of electron bombardment from "voids" under conditions of use.

This invention is based upon the discovery that certain materials, when present in the insulating oil, under conditions otherwise known to result in the formation of gases and "x-wax", appear to be able to substantially inhibit the formation of such products, and to enable the insulating oil to maintain its dielectric properties for a much greater length of time.

The substances capable of being so used are those oil-soluble organic compounds, capable of being further combined with hydrogen, not of themselves capable of substantially decreasing the dielectric strength of oil when present therein to extent of a few per cent, of sufficiently low volatility to remain in the oil in proper quantity under conditions of use, and not prone to otherwise degrade the oil under conditions of use. As examples of such compounds there may be named dibenzyl disulphide, benzophenone, diphenyl, and diphenyl oxide.

All of these are organic compounds containing two cyclic nuclei joined to each other at one point of attachment only, either directly as in diphenyl, or through a linkage such as oxygen, sulphur, nitrogen, carbonyl, etc. or by an organic chain containing these and/or other groups. The cyclic nuclei may be either substituted or unsubstituted. Of compounds of this class, preference is given to those consisting of two cyclic nuclei, joined to each other at one point of attachment only, either directly as in diphenyl or by a linkage group containing oxygen, sulphur, nitrogen, or carbonyl, which linkage group is relatively compact and of relatively low molecular weight. These compounds do not, under these circumstances, show as a principal activity that of an antioxidant. A collateral antioxidant effect of relatively minor importance may be present under certain conditions for some of these compounds. Many compounds highly effective as "gas-proofing" agents are quite ineffective as antioxidants, and even to some degree are pro-oxidants. Others may act as antioxidants in hydrocarbon oils of one degree of refinement, may be quite useless as antioxidants in oils differently refined, and yet be quite help-

ful to both oils as dielectric quality stabilizers or "gas-proofers". Further, the deterioration spoken of, and the protection spoken of as well, can both occur in the known absence of oxygen. Of these compounds, those believed to be most effective and at present preferred are dibenzyl disulphide, diphenyl, and benzophenone.

The effectiveness of such ingredients in oils may be tested by the following procedure:

- 10 A discharge chamber is arranged, consisting of two co-axial glass cylinders, the annular space between which is sealed from the atmosphere, the outside of the outer cylinder being coated with a conducting paint, and the inner cylinder
- 15 filled with mercury, thus providing two conductors, with an insulating space between. The space is evacuated to less than 0.05 mm. mercury, absolute pressure, and then partially filled with oil while maintaining the vacuum to insure
- 20 removal of entrained and dissolved air from the oil. Then the space at a pressure of less than 0.05 mm. mercury absolute is sealed, and voltage of about 20 kv. is applied over a two-hour period. The evolution of gas is noted, measured,
- 25 and reduced to standard conditions.

The following table shows the results of several of such tests:

Table I

Material and per cent added by weight	Gas evolution in cubic centimeters from 25 cc. of oil	
	Highly refined light oil	Moderately refined heavy oil
None	26.8	29.2
1% benzophenone	11.4	
5% benzophenone		10.7
5% diphenyl		13.6
1% dibenzyl disulphide	10.0	16.8
5% dibenzyl disulphide		6.5

In the above tables the highly refined oil is one having a viscosity of 255" Saybolt Universal at 100° F., and the moderately refined oil is one having a viscosity of 140" at 210° F.

From the above data it will be observed that the compounds cited are quite effective in reducing the formation of gas under such conditions. The gas formed was found in all instances to be composed of about 80% hydrogen, the remainder being mostly hydrocarbon gases, with less than 1% total amount of oxygen, carbon dioxide, carbon monoxide, and the like.

The percentage of such compounds to be used in oil varies with the nature of the oil and the effectiveness of the compound. In general, from 1 to 5% by weight of the oil will be sufficient for conditions encountered in normal usage. Since the additive compound appears to be consumed,

or altered to an ineffective form while exercising its protective function, higher concentrations are indicated where the insulating oil must have a long effective life, as in cables, and the like.

I claim:

1. Method of maintaining dielectric stability of oil in electrical insulating structures comprising adding to the oil a small amount, from about 1% to 5%, of dibenzyl disulphide.

2. Method of maintaining dielectric stability of oil in electrical insulating structures comprising adding to the oil a small amount, from about 1% to about 5%, of diphenyl.

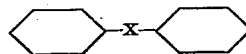
3. Method of maintaining dielectric stability of oil in electrical insulating structures comprising adding to the oil a small amount, from about 1% to about 5%, of benzophenone.

4. A dielectric structure comprising an insulating material impregnated with a mineral oil having low tendency to loss of dielectric stability secured by the addition to said oil of from about 1 to about 5% of dibenzyl disulphide.

5. A dielectric structure comprising an insulating material impregnated with a mineral oil having low tendency to loss of dielectric stability secured by the addition to said oil of from about 1 to about 5% of diphenyl.

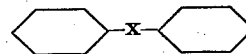
6. A dielectric structure comprising an insulating material impregnated with a mineral oil having low tendency to loss of dielectric stability secured by the addition to said oil of from about 1 to about 5% of benzophenone.

7. A dielectric structure comprising an insulating material impregnated with a mineral oil having low tendency to loss of dielectric stability secured by the addition to said oil of from 1% to about 5% of its weight of an organic compound selected from the group consisting of diphenyl, dibenzyl-disulphide, and compounds of the general formula



in which X denotes a linkage selected from the group consisting of oxygen, sulphur, and the carbonyl group.

8. A method of maintaining dielectric stability of oil in electrical insulating structures comprising adding to the oil from 1% to about 5% of its weight of an organic compound selected from the group consisting of diphenyl, dibenzyl-disulphide, and compounds of the general formula



in which X denotes a linkage selected from the group consisting of oxygen, sulphur, and the carbonyl group.

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