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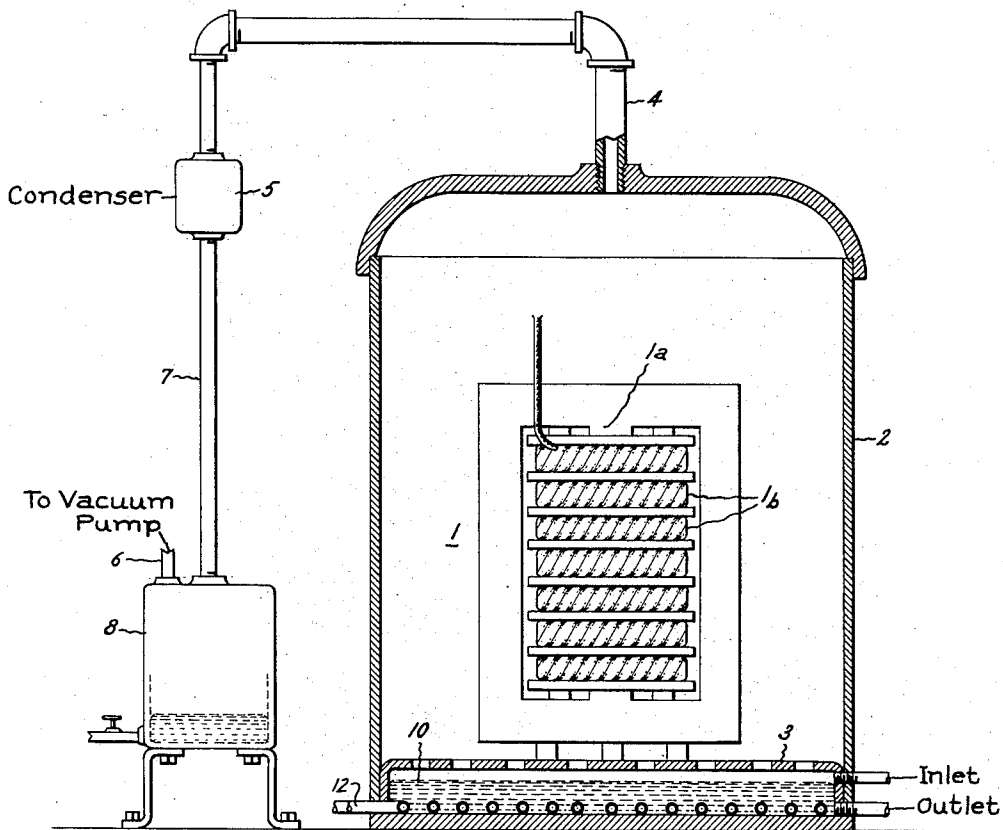
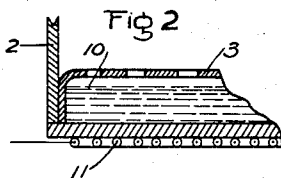
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2,293,453

DEHYDRATING TREATMENT

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Fig. 1.



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DEHYDRATING TREATMENT

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9 Claims. (Cl. 34—15)

The present invention comprises an improved method of removing moisture, trapped gas and other impurities from bulky objects consisting in part of metal such, for example, as electrical windings, cables, capacitors, and in particular objects which are to be rendered dehydrated preliminary to being impregnated with a fluid. My invention is not limited in its scope to the treatment of electrical devices.

In accordance with my prior Patent 1,866,346, objects preliminary to their impregnation with insulating materials have been subjected in a closed chamber to a dry gas followed by evacuation, these steps ordinarily being repeated as may be required. Heat has been applied externally to the chamber in which the treatment is carried out. In some cases electrical devices, or other objects, have been dried simply by heating such objects in an evacuated chamber by the application of external heat. In some instances the electrical device has been dried by passing electrical current through the short-circuited conductors. Not only are such processes relatively slow, but there is danger of local overheating of the object being evacuated or of the external container in which the process is being carried out. This local overheating is dangerous since it leads to the decomposition of the electrical insulation with resulting increase in power losses under voltage and a decrease in the dielectric strength.

It is the object of my present invention to provide a more rapid and more efficient method of dehydration which is free from the danger of overheating. In accordance with my invention the object to be dried and otherwise purified is subject to a current of vapor of a substance which has a boiling point materially above the boiling of water, but below the decomposition temperature of substances which form a part of the object being treated. The reflux condensation of such vapor on the object being treated rapidly heats such object to the temperature of such vapor by the liberation of the latent heat of vaporization without danger of overheating any part of such object or of the container.

The novel features of my invention will be pointed out with greater particularity by the appended claims and will be further explained in connection with the accompanying drawing in which Fig. 1 shows a treating apparatus, somewhat diagrammatically, in side elevation and partly in section, and Fig. 2 is a sectional fragmental view of an apparatus constructed to be heated electrically.

The device to be freed from moisture and

other deleterious impurities is represented in the drawing by the transformer assembly 1 (including a core 1a and windings 1b). It is placed within a sealed treating tank 2 which is provided with a perforated partition 3 near its base on which the transformer assembly rests. The tank 2 also is provided with an outlet conduit 4 which leads to a condenser 5 which in turn communicates with a vacuum pump (not shown) by an evacuation conduit 6. Condensation products accumulating in the condenser 5 may be discharged into a storage tank 8 through a conduit 7.

In carrying out the dehydrating and degasifying treatment a quantity of chosen liquid or solid is introduced into the space in the treating tank below the partition 3. A liquid or solid is selected which is stable under the boiling conditions applied, has a desired boiling point well above the boiling point of water, and which has no deleterious effect on the object to be treated. Ordinarily, vacuum boiling temperatures within a range of 80 to 200° C. are effective. For example, if a transformer, capacitor or cable is to be treated, a liquid or solid should be selected which has no deleterious effect on decomposable materials incorporated into such devices, for example, such as paper, cotton, resins, varnishes, pitches, or other organic material. I may use, for example, a chlorinated aromatic compound such as trichlorobenzene which, at atmospheric pressure, boils at 200 to 220° C., pentachlorodiphenyl which boils at about 350 to 400° C. at atmospheric pressure, or other chlorinated compound of diphenyl such as trichlor or tetrachlor diphenyl which boil respectively at a temperature of 300 to 325° C. and 325 to 350° C. Other halogenated hydrocarbons of particular utility are the various chlorinated diphenyl oxides, chlorinated diphenyl methanes, chlor benzotrifluorides, chlorinated toluenes, chlorinated ethyl benzenes, chlorinated benzo nitriles, chlorinated phenyl benzoates, and chlorinated diphenyl ketones. In some cases chemically stable unchlorinated compounds may be employed such, for example, as diphenyl and diphenyl oxide. Mineral oil is also of utility. The use of this material is best accomplished by selecting a highly refined distillate boiling over a narrow range of temperature, preferably with not more than a 25° C. difference between its initial and final boiling temperature. In general, the solid or liquid hydrocarbons may be of the aliphatic or aromatic type. When halogenated hydrocarbons are used, I prefer to employ organic compounds having the aromatic type of molecule in order to avoid

chemical decomposition and the corrosion resulting from the generation of hydrogen chloride which would result from the decomposition of the chlorinated aliphatic hydrocarbons at the reflux temperature. Long chain aliphatic hydrocarbons are to be avoided because of the tendency for such molecules to "crack" or otherwise chemically change with resulting change in the boiling point.

The liquid or solid is heated in any suitable manner as, for example, as shown in Fig. 2, by means of an electric heater 11 which is applied to the exterior of the treating tank, or, as shown in Fig. 1 by a heating medium conveyed by the pipe 12 which is immersed in the vaporizable substance 10. The heating means should be adequate to rapidly raise the temperature of the treating liquid to the boiling point under the pressure conditions set up. When the treating tank has been sealed and the pressure of the air or other gas therein has been reduced by evacuating means to a desired low pressure, for example, has been reduced to a pressure as low as about 10 millimeters of mercury pressure, and preferably below one millimeter, then the material 10 is heated to the boiling point causing its vapors to come into contact with the transformer assembly or other device. The condensation of the vapors to the liquid state on the relatively cool surface of the device being treated and the accompanying liberation of heat rapidly raises the temperature of this device to the temperature of the vapor.

In a vacuum having a partial pressure below 10 microns, water boils below room temperature. Trichlorobenzene, on the other hand, under the same conditions boils at a temperature of about 115° C. The hot vapors of trichlorobenzene condensing on the object to be treated, which initially may be at room temperature or even colder, rapidly cause it to heat to the temperature of the vapor, no danger of overheating being involved. The water content and other volatilizable impurities are rapidly gasified and removed from the object as it becomes heated. Even non-volatilizable impurities which are soluble in trichlorobenzene are removed by the washing effect of the condensed liquid although such action is incidental.

When the object being treated becomes heated to the temperature of the vapor, that is, to a temperature within a range of 80 to 200° C. or higher, then condensation of vapor on the object of course ceases. If by this time the tank 2 has become heated throughout, refluxing of the liquid ceases and vapor leaves the tank 2 by the conduit 4 and condenses in the condenser 5. As the condenser 5 is placed between the treating tank and the evacuating means, the load on the evacuating means is very light and of course in all cases lighter than would be the case were heating in a vacuum carried out by former methods. The distillation of the liquid from the treating tank 2 is continued. The transformer or other apparatus to be dried thus is exposed to a continuous current of dry vapor, whereby water vapor is carried away. When the vaporization treatment has been carried on sufficiently long to produce the desired results, the excess of the vaporizing liquid in the tank may be drawn off. Any residue of such liquid accidentally remaining in the tank readily may be removed by vaporization accompanied by a continuation of the evacuation of gases through the vacuum conduit 6. The apparatus finally may be impregnated

with any desired material in liquid form in accordance with known practice.

By the practice of my invention, the time required for the object to be freed from water and other vaporizable material is materially reduced. The process as carried out in a practical manner in treating a commercial transformer requires only approximately one-half to three-quarters of an hour to cause the temperature of the transformer to rise from 20 to 100° C. The same temperature rise under vacuum conditions required at least about six hours. When the process of heating and dehydration has been applied to the treatment of capacitors, it has been found that the rise of temperature of the capacitors from about 20° up to 105° C. required approximately two hours. In accordance with a vacuum process formerly used, about five hours were required for the same temperature rise.

When the process of my invention has been carried out with pentachlor diphenyl as the vaporizing liquid, the interior of such capacitors can be heated to about 200° C. in two hours. In general, it may be said that if the temperature of an object to be dehydrated and degasified should be carried to approximately 100° C., then trichlorobenzene is satisfactory for use as the vaporizing liquid; in case the final temperature should be about 160° C., diphenyl or diphenyl oxide or a mixture of diphenyl oxide and diphenyl (3:1 proportion by weight) may be used. The mixture has greater utility because of its liquidity at room temperature. When the maximum desired temperature is about 200° C., then various chlorinated diphenyl compounds, such as the tri-, tetra-, or pentachlor compounds of diphenyl, may be used. When a mineral oil distillate is used as the heating and drying liquid, any specified maximum temperature up to 200° C. or even higher can easily be obtained by the proper selection of the distillate boiling range.

One particularly advantageous and novel result accruing from the use of my improved process is its automatic and flexible nature. No expensive temperature control devices or manual supervision are necessary since the temperature obtained is a direct function of the pressure conditions existing and may be determined by a simple reading of the pressure. Pressure increase is automatically compensated by an increase in the liquid refluxing temperature.

Another important and novel result obtained by the use of my improved heating, drying and degassing treatment is the freedom from gas pocket or void formation in the dielectric assembly. Gas pockets are dangerous to the successful operation of high voltage equipment such as transformers, cables, bushings, and capacitors because of the ionization which results when high voltage stresses are applied. The ionization subjects the insulation to electric discharge bombardment with resulting chemical and dielectric deterioration and eventual dielectric breakdown. When liquids or solids are vaporized, preferably under a pressure of less than 10 millimeters, the air or other gases contained in and adhering to the dielectric fibers and surfaces is effectively displaced along with the moisture. At the end of the cycle residual vapors of the refluxing liquid or solid if still present in the dielectric are dissolved in the liquid or solid impregnating material which is introduced or are condensed when the pressure is finally allowed to revert to atmospheric pressure at the end of the treating cycle.

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

1. The method of dehydrating an electric device containing paper insulation which consists in causing condensation on said device in a highly evacuated space of the vapor of a normally liquid hydrocarbon having a condensation temperature in said evacuated space materially above the boiling temperature of water, evacuating from said space water vapor and other gases which are expelled from said device when said device becomes heated by the heat liberated from said vapor, exposing said device to a current of dry vapor of said hydrocarbon, and continuing evacuation and the vaporization of said hydrocarbon until said device has been dehydrated to a desired degree.

2. The method of degasifying an electric device containing materials whose physical characteristics would be deleteriously affected by heating to 200° C. which consists in evacuating the space about said device to a residual pressure below about ten millimeters of mercury, exposing said device to the vapor of a diphenyl compound having a boiling temperature higher than water but no higher than about 200° C. at said pressure, thereby heating said device by the condensation of said vapor thereon, evacuating gases evolved from said device, and continuing the exposure of said device to a current of dry vapor of said diphenyl compound for a period of about two hours.

3. The method of degasifying an originally unheated electric device containing paper which consists in evacuating gas from the space about said device to a residual gas pressure below about ten millimeters of mercury pressure, admitting to said space the vapor of trichlorobenzene, permitting said vapors to condense upon and heat said device, evacuating gases evolved from said device and when said device has attained by said condensation a temperature of about 200° C., continuing the exposure of said device to a current of dry vapor of trichlorobenzene until sufficiently purified.

4. The method of drying an electric transformer containing insulating materials which ordinarily are deleteriously affected by heating to 100 to 200° C. preliminary to impregnation with insulating material, which consists in evacuating the space surrounding said transformer to a residual pressure of about ten millimeters of mercury, subjecting said transformer while unheated to the vapor of an aromatic organic compound having a boiling temperature at said residual pressure within a range of 80 to 200° C., whereby condensation of said vapor on the surfaces of said cooler transformer occurs, water held therein is expelled and impurities are washed therefrom, and subjecting said transformer to a current of dry vapor of said compound until such transformer is sufficiently dried.

5. The method of removing impurities including water from a device comprising electrical insulation, components of which are susceptible to deterioration when heated to a temperature in excess of 200° C., which consists in introducing said device into a sealed enclosure together with a vaporizable organic material having a boiling temperature materially higher than

water but not exceeding about 200° C. at a low pressure as hereinafter specified, evacuating said space to a pressure of the order of about one to ten millimeters of mercury, boiling said material and continuing evacuation of said space until said object has been freed from impurities to a desired degree.

6. The method of removing water from an electric device containing components susceptible to injury when heated under ordinary conditions to temperatures in a range of about 100 to 200° C., which consists in evacuating a space surrounding said device to a residual pressure equal to a small fraction of atmospheric pressure, exposing said device to the vapor of an organic substance having a boiling temperature materially higher than water in said evacuated space but not materially exceeding 200° C., thereby causing expulsion of water from said device and continuing evacuation of said space while supplying said vapor until a desired condition of dehydration of said device has been attained.

7. The method of removing water from an electrical device containing components whose physical characteristics would be materially changed at a temperature in excess of about 200° C., which consists in evacuating a space surrounding said device to a pressure at least as low as about ten millimeters of mercury, introducing into said space the vapor of an organic material having a boiling temperature materially higher than water under the same reduced pressure, thereby causing heat to be imparted to said device and water to be expelled therefrom, and continuing evacuation while exposing said device to dry vapor of said material until said device has been dried to a desired extent.

8. The method of removing water from an electrical device whose physical characteristics are susceptible to change by heating to elevated temperatures which consists in evacuating a space surrounding said device to a pressure at least as low as about ten millimeters of mercury, introducing into said space the vapor of an aromatic organic compound having a boiling temperature at said reduced pressure higher than that of water but below 200° C., thereby causing heat to be imparted to said device by said vapor and water to be expelled therefrom, and condensing and refluxing said organic compound while exposing said device to vapor of said organic compound until said device has been dried to a desired extent.

9. The method of drying preliminary to impregnation with insulating material an electric transformer containing insulating materials which ordinarily are deleteriously affected by heating to 100 to 200° C. which consists in evacuating the space surrounding said transformer to a residual pressure of about ten millimeters of mercury, subjecting said transformer while unheated to the vapor of mineral oil having a boiling temperature at said residual pressure within a range of 80 to 200° C., whereby condensation of said vapor on the surfaces of said cooler transformer occurs, water held therein is expelled and impurities are washed therefrom, and subjecting said transformer to a current of dry vapor of said oil until such transformer is sufficiently dried.

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