

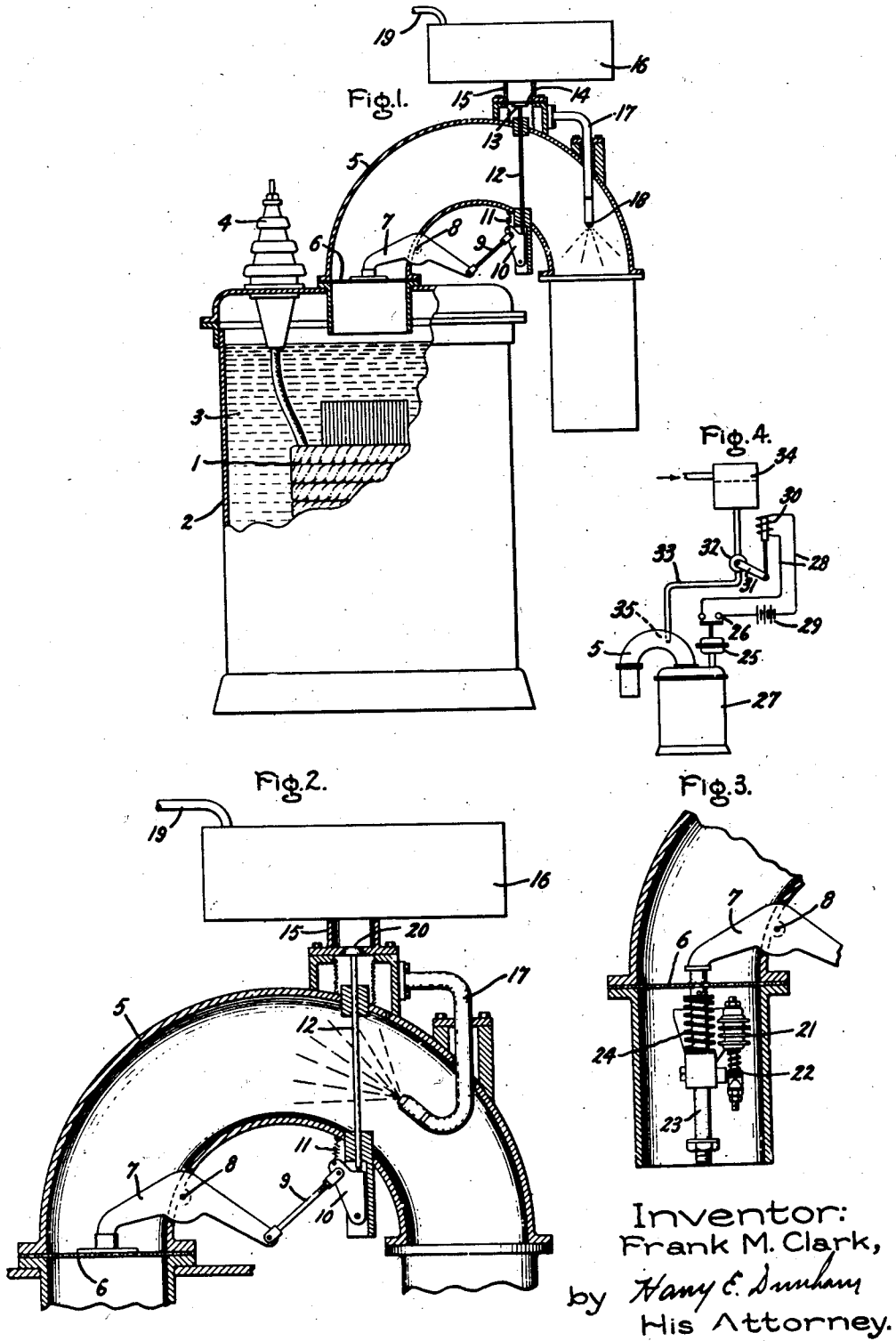
March 8, 1949.

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2,464,026

GAS ELIMINATOR FOR ELECTRIC APPARATUS

Filed June 1, 1945



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UNITED STATES PATENT OFFICE

2,464,026

GAS ELIMINATOR FOR ELECTRIC APPARATUS

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Application June 1, 1945, Serial No. 597,027

4 Claims. (Cl. 174-17)

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The present invention relates to the protection of electrical apparatus which contains cooling and insulating materials consisting of chlorinated, fluorinated, or otherwise halogenated, hydrocarbon products.

When a liquid-filled electrical apparatus fails electrically, irritating gases are formed as a result of the decomposition produced by the action of the electric arc on the solid and liquid insulations present therein. In some types of electrical apparatus, such as transformers, it is customary to provide a frangible diaphragm whereby these decomposition gases are allowed to vent to the atmosphere, thus preventing the accumulation of excessively high pressures within the electrical apparatus, with resulting avoidance of tank explosions and other dangerous effects.

In electrical apparatus such as transformers, halogenated liquid compositions, such as described in my prior U. S. Patent 1,931,373 of October 17, 1933, provide a non-inflammable, non-oxidizing dielectric and cooling medium which, when decomposed by the electric arc, evolves only non-explosive gaseous mixtures. These gaseous mixtures consist largely of hydrogen halide gas. It is one of the features of my invention to provide an eliminator whereby rapid and efficient removal of toxic and irritant gas is accomplished, thereby obviating the hazard to human life should the electric failure of the apparatus occur in a restricted, poorly ventilated location and the decomposition gases be vented to the atmosphere.

The accompanying drawing shows in Fig. 1 a side elevation, partly in section, of a transformer which is provided with a gas absorber of the spray type; Fig. 2 is a somewhat enlarged view of a modified absorber; Fig. 3 illustrates a modification employing a Sylphon bellows trigger apparatus; and Fig. 4 shows another modification which is provided with an electrically-operated spray-release mechanism.

My prior U. S. Patent 1,964,684 of June 26, 1934, describes an electric apparatus of this type which is provided with protective apparatus containing a mass of solid reagent whereby gaseous decomposition products are absorbed. Although the apparatus described in this patent gives satisfactory results when applied to large fixed installations, such as power distribution stations or factories, it is not so well adapted for installations, such, for example, as railroad locomotive transformers in which the conditions are unfavorable as will be described.

Solid absorbents such as soda lime are efficient absorbers of the hydrogen halide gas evolved from

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the halogenated liquid dielectric as a result of electrical failure. Such materials, however, must be used in a specially designed apparatus in order that the resistance to free gas flow through the solid may be reduced to a minimum, thereby preventing the accumulation of excess pressure within the apparatus. Even with the most approved design of absorber, the efficient use of a solid absorbent is restricted to fixed and immobile apparatus.

When absorbers, such as described in U. S. Patent 1,964,684, are used on electrical apparatus subject to motion, as for example on railway locomotive transformers, the vibration which occurs pulverizes the particles, which even though originally carefully screened to remove dust and fine powder, become packed under the vibration of the moving locomotive forming a dense solid mass. This presents high resistance to gas flow through the solid absorbent. The internal resistance may be reduced by supporting the gas-reactive solid material on trays over which the effluent gases are caused to pass. However, even in such case, vibration causes the absorbing action to become inefficient by the crumbling and packing of the particles of the absorbent, thus greatly reducing the total reactive surface presented to the flowing gas. It is another object of my invention to provide a means by which this "dusting" and powdering of the solid absorbent and packing under vibratory motion is completely eliminated, thereby giving increased reliability of absorption and freedom from maintenance and replacement.

The use of a solid absorbent for the removal of the hydrogen halide gases from halogenated liquid dielectrics when decomposed by the electric arc involves chemical reactions which are chiefly limited to the surface of the solid reagent. This is not chemically efficient. It is a further object of my invention to provide a high degree of subdivision of an efficient absorber for the toxic gases whereby a high degree of physical contact between the gas and the absorbent are attained thereby giving rapid and complete elimination of the toxic gases.

In electrical apparatus used on railway locomotives, on shipboard and the like, physical space always is at a premium. In the case of the railway use of electrical transformers, the apparatus is frequently mounted beneath the car floor. In such applications, transformers containing a non-inflammable dielectric liquid are particularly advantageous. Besides the packing difficulty due to the vibration encountered on railway installations, an absorber containing a solid reagent is

too large for practical usage, due to the bulk of the absorbent and the gas spaces necessarily present to provide rapid gas passage through the absorber without excessive gas pressure. It is a further object of my invention to provide a means for rapid and efficient toxic gas absorption in spaces so small that absorbers such as heretofore employed are not available.

The apparatus shown in Fig. 1 of the drawing comprises a transformer 1 which is housed in a sealed tank 2 containing a quantity 3 of liquid halogenated hydrocarbon. The latter may assume various forms, as well understood, and as described in prior U. S. Patent 1,931,373. For example, mixtures of chlorinated benzene and chlorinated diphenyl may be employed. Only one terminal bushing 4 has been illustrated in the transformer, such apparatus being well known. Communicating with the tank holding the liquid-immersed transformer is an elongated conduit 5 which normally is sealed from the main tank 2 by a frangible diaphragm 6. The latter may consist of glass, or other material, which is capable of being ruptured by a moderate gaseous pressure, that is, a pressure of the order of about 12 pounds per square inch.

A lever 7 pivoted at 8 on a support mounted on the conduit 5 is connected by a second lever 9 to a latch 10. The latter normally is held in a vertical position, as shown, by a spring 11. Should an arc occur in the transformer by some catastrophic disturbance, as for example by a violent surge or by a lightning discharge, causing violent gas evolution, the diaphragm 6 is ruptured. The lever 7 thereby is rotatably moved, causing a rod 12 resting on the latch 10 to be released. As the rod 12 drops and the head 13 no longer presses against a diaphragm 14, the unsupported diaphragm in the duct 15 is ruptured by the liquid which is held under pressure in the container 16. Hence, the liquid is discharged into the pipe 17 and delivered as a fine spray through the orifice 18. The liquid may consist of an aqueous solution of sodium hydroxide, sodium carbonate or other alkaline material capable of chemical reaction with hydrogen chloride. The reactive liquid may be maintained under pressure in any convenient way, as by the application of compressed air to the liquid through the pipe 19.

As the atomized liquid absorber encounters the gas, ordinarily hydrogen chloride formed by the decomposition of the chlorinated hydrocarbon, the latter is removed by chemical reaction with the alkaline liquid. For example, when the absorbing liquid consists of an aqueous solution of potassium carbonate, non-inflammable and non-toxic carbon dioxide gas and potassium chloride are formed, the latter going into solution in the water of the absorbing reagent.

By reason of the state of fine subdivision of the absorbing reagent which encounters the hydrogen chloride or other gaseous decomposition products in the conduit 5 and by reason of the solubility of such products in water, a more complete and more rapid absorption of the gaseous products occurs than would be effected by a solid reagent, particularly under conditions subjecting a solid reagent to vibration and consequent packing.

Various modifications may be made in apparatus embodying my invention. For example, in the apparatus shown in Fig. 2, the frangible diaphragm 14 has been omitted and a tightly fitting

valve 20 closes the orifice in the duct 15 of the container 16 which stores the gas-absorbing liquid. When the rod 12 is released, the pressure upon the liquid in the container 16 opens the closure valve 20 thereby releasing the gas-absorbing liquid. In the modification of Fig. 2, the discharge pipe 17 is bent, as shown, so as to discharge the atomized liquid into the conduit 5 in a direction contrary to the direction of motion of the escaping gas thereby increasing the turbulence of the mixture and promoting absorption.

In Fig. 3 is shown a trigger-operated device which is provided with a powerful spring for breaking the diaphragm. This device is provided with a Sylphon bellows 21 which, when compressed by gaseous pressure, operates a trigger 22 thereby releasing a plunger 23 which is driven upwardly by a powerful spring 24. The plunger head breaks the diaphragm 6 and forces upwardly the lever 7, of a release mechanism such as shown in Fig. 1. A trigger device of this type is shown in Vienneau U. S. Patent 2,337,361, patented December 21, 1943. As the structural parts whereby the spring-operated plunger 23 is released by a moderate change in pressure upon the bellows 21 are described in detail in this patent, they need not be described herein. By the operation of this device even a slight accumulation of gas in the transformer tank sets into motion relatively powerful forces for delivering a reagent for absorbing the gas which might otherwise accumulate until it constituted a hazard to human life.

In the modification of my invention shown in Fig. 4, a pressure-activated, electrically-operated contactor 25 closes the contacts 26 when the gaseous pressure in the tank 27 has risen to a predetermined value—say ten pounds per square inch. The closure of these contacts completes the circuit 28 which contains a source of current 29 and an electromagnet 30. The stem of the latter is connected to a lever 31 which is attached to a valve 32. This valve when opened releases the flow of liquid in the pipe 33 which leads from the reservoir 34 to the nozzle 35 in the conduit 5. The absorber reagent in the reservoir 34 is under pressure as explained in connection with other modifications. In practice, circuit relays may be present as is well known.

In the application of my improved absorber, I prefer to use an aqueous solution of an acid-absorbing compound since the efficiency and rapidity of the removal of the corrosive and toxic gases is promoted by the remarkably high solubility of the gas in the water present. Approximately 450 cc. of hydrogen chloride is dissolved in 1 cc. of cold water. However, as electrical apparatus when used on railway locomotives and the like is subject to extremes of low temperature, it is necessary that the aqueous solution must be so selected that it will not solidify within the range of temperature to which it is normally likely to be subjected. Evaporation at the higher range of temperatures to which it may be subjected is prevented by the application of the pressure used to force the reactive solution into the stream of decomposition gases as already described. To prevent solidification within the temperature range normally expected in the operation of electrical apparatus as described, it has been specified that the reactive solution shall not become solid or viscous at temperatures as low as -30°C . I have found that antifreeze aqueous solutions containing sodium or potassium hydroxide or carbonate are particularly well

adapted as absorbents in accordance with my invention. Of these I prefer the use of a 39-40 per cent solution of potassium carbonate or a 23-25 per cent solution of potassium hydroxide. Such solutions are characterized by being chemically reactive to acid vapors, low viscosity and easy flowing properties. They resist freezing at temperatures as low as $-30^{\circ}\text{C}.$, and are capable of efficient use in accordance with my invention:

Aqueous Solutions Containing	Freezing Temperature
	$^{\circ}\text{C}.$
39.5% potassium carbonate.....	-36
23.9% potassium hydroxide.....	-35

If still lower freezing points are desired, they are obtained by varying the concentration of the reactive solution, the following being suitable:

Aqueous Solutions Containing	Freezing Temperature
	$^{\circ}\text{C}.$
25.5% potassium hydroxide.....	-40
44.2% potassium hydroxide.....	-65

In the application of my invention the absorbent liquid solution is forced in a finely divided spray or cloud into the effluent gases formed from the decomposition of the halogenated liquid dielectric. For this purpose, it is desirable that a high pressure gas shall be applied to eject the absorbent liquid. In its application to railway locomotive transformers, this high pressure gas is normally supplied from the high pressure air supply normally used in the braking system. On shipboard an equally convenient gas pressure supply is available.

To one skilled in the art, the substitution of other chemically active absorbents than those illustrated will be immediately evident. In one modification of my invention a finely divided solid absorbent may be atomized in contact with the gases to be removed. Thus, potassium carbonate, dried and powdered to a state of subdivision at least as fine as 300 mesh or finer, may be blown under gas pressure through a nozzle, as illustrated. The rapidity and efficiency of the absorption in this instance is produced as a result of the great contact surface exposed to the effluent gases as a result of the fineness of subdivision of the absorbent solid.

The products of the chemical reaction with the effluent gases resulting from the arc decomposition of the halogenated liquid should be non-toxic and non-inflammable and non-explosive.

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

1. The combination of a sealed tank, an electric device therein which is insulated with a halogenated hydrocarbon, venting means which is op-

erative to permit the escape from said tank of gas derived by decomposition of said hydrocarbon, and means arranged to be activated by the operation of said venting means for introducing into the vent path of said gas an atomized reagent which is capable of combining with said gas to form non-toxic reaction products.

2. The combination of a sealed tank, an electric device therein which is insulated with liquid chlorinated hydrocarbon, normally closed venting means constructed to permit emergency escape of gas formed by violent decomposition of said hydrocarbon by abnormal arc discharges, means for atomizing in contact with escaping gases a liquid reagent which is capable of combining with such gaseous decomposition products, and pressure-controlled means for activating said atomizing means.

3. The combination of an electric device comprising a sealed tank, an energy-transferring device therein, a body of halogenated material in contact with said device, a segregated body of aqueous antifreeze solution under pressure which is capable of reacting with gaseous decomposition products derived from said halogenated material, an absorbing chamber communicating with said sealed tank, an easily frangible diaphragm sealing the communication between said tank and said absorbing chamber, and means put into action by the rupture of said diaphragm for spraying said reactive liquid into said absorbing chamber.

4. The combination of a transformer, an enclosing housing therefor, a body of halogenated hydrocarbon located in said housing and submerging said transformer, an elongated absorption chamber having an opening communicating with said housing, an easily rupturable diaphragm closing the opening communicating between said housing and absorption chamber, means for delivering into said absorption chamber upon the rupture of said diaphragm spray of liquid reagent which has a freezing point as low as about $-30^{\circ}\text{C}.$ and which is capable of fixing gaseous decomposition products derived from said hydrocarbon and means for initiating the delivery of said spray in response to abnormal pressure rise in said transformer housing.

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