Inventor:
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His Attorney.
The present invention relates to electrical discharge devices. It is particularly concerned with, and has as its principal object, the treatment of the exterior surfaces of electrical discharge devices of the type desired to have an accurately predeterminable breakdown voltage, to prevent surface electrical leakage under varying and extreme atmospheric conditions.

Other objects of my invention will become apparent from the following description of my invention taken in connection with the accompanying drawings in which Fig. 1 is a sectional view of a discharge device or tube of the type with which the present invention is concerned and Fig. 2 shows, in curve form, the results of tests to determine the amount of electrical leakage on the surfaces of untreated tubes and tubes treated in accordance with my invention.

It is well known that with many electrical discharge devices the presence of moisture, usually in the form of humidity in the atmosphere, may cause needless annoyance in the form of electrical leakage paths over the surfaces of insulating materials. In some instances, as where the device is destined to have an accurately predetermined and controlled breakdown voltage, success or failure of a project depends mainly on eliminating this source of trouble. Due to the fact that in many cases space is at a premium, one cannot always build suitable heated enclosures or evacuated chambers to dispel the troublesome moisture because of the complications and expense involved.

A discharge device of this type is shown in Fig. 1. This device, which is more fully described and claimed in the copending application of Kenneth H. Kingdon and Elliott J. Lawton, S. N. 414,710, filed October 13, 1941, and assigned to the same assignee as the present invention, comprises a pair of glass cylinders 1 and 2 which are separated by a metal ring 3 sealed between them and which are closed at their respective extremities by means of transverse headers 4 and 5. The glass and metal parts are sealed together in vacuum-tight relation. The upper metal header 4, which forms the anode electrode, is provided centrally with a sealed-off metal tubulation 6 adapted to be used during fabrication of the tube for evacuating it and for introducing a suitable gaseous fillings, such, for example, as argon or neon at a pressure of a few microns to a few millimeters of mercury. When sealed, the tubulation provides means for attaching a terminal 7 used to connect the anode 4 to a suitable potential source.

The intermediate ring 3 is provided with a transversely extending mesh 8 adapted to serve as a control grid. Control potential is applied to the mesh through terminal conductor 9 connected externally to the ring 3. The header 5, in addition to serving as a closure member and base for the tube, further provides a support or composite cathode structure having a filamentary part 10 formed of an uncoated metal, such as tungsten, capable of being maintained at a temperature of effective thermionic emission without excessive voltage applied to it. An auxiliary part 11 to be described more fully at a later point. The filament is mounted between a bracket 12 secured to header 5 and a relatively rigid support rod 13 which is insulatingly sealed through the header by means of a glass-to-metal seal indicated at 14. A terminal connection for header 5 is provided by securing to it a conductor 15.

The auxiliary cathode portion 11 comprises a folded piece of nickel 16 welded to the upper end of bracket 12 and embracing a tab of anodized aluminum foil 17. The foil may be pricked or perforated at a number of points in order to assure contact between the foil and the nickel clamping means 18.

In the use of this tube, as is more fully described in the aforementioned Kingdon and Lawton application, the heating current is passed through the filament 10 by the application of potential between the support rod 13 and the header 5. As a consequence, the filament is maintained in emissive condition, although the resulting electron supply is relatively limited because of the small size of the wire. As long as the potential of the grid 8 is maintained below a predetermined level, no current is permitted to flow to the anode 4. However, as soon as the grid potential exceeds this value, current flow begins, and ionization of the gas filling of the tube ensues. Some of the positive ions thus produced in the discharge space are drawn to the negatively charged cathode surfaces, including the insulated surfaces of the part 11, and produce intense local gradients on the anodized surface. These gradients quickly become so great as to initiate cold cathode emission. This emission tends to increase rapidly in a cumulative fashion so that as soon as it is once initiated, an intense arc strikes almost immediately to the affected region of the cathode part 11. The abundant electron emission thus realized completes the ionization of the discharge space and thus leads to complete breakdown of the tube.

The results obtained under the conditions specified in the foregoing are extremely consistent and are reproducible with different tubes of similar design. This is a consequence of the fact
that initiation of the discharge depends almost entirely upon emission from the tungsten filament and, since the characteristics of such filaments vary very little from sample to sample, one tube may be expected to perform in substantially the same manner as another.

However, when tubes of this type wherein the conductive parts are separated by externally exposed insulating members are subjected to extreme atmospheric conditions of temperature and humidity, accurate operation of the tube is often impossible due to leakage paths resulting from the presence of imperceptible amounts of moisture on the surfaces of the insulating members. For example, in certain applications, the circumstances under which the tubes must function properly may be quite exacting. The temperature range over which the tubes are expected to perform satisfactorily may spread from -60°C to +50°C with accompanying degrees of moisture in the atmosphere up to 100 per cent relative humidity. This means that some precautions must be taken to protect the tube against moisture. The moistureproofing means must of course meet the same requirements as the tube itself.

The present invention is based on my discovery that the effect of moisture on the operation of electrical discharge devices of the above-mentioned type, i.e., surface electrical leakage, may be completely eliminated without the use of space-consuming heated or evacuated enclosures or similar protective measures by treating the surface with organo-silicon derivatives which are in themselves water-repellent or which become so on contact with the atmosphere. I prefer to coat the entire or a part of the surface of the device with the oily, resinous product obtained by hydrolyzing a methyldihalogenosilane of the formula

\[ \text{CH}_3\text{SiHX} \]

wherein \( X \) represents a halogen atom, preferably a bromine or chlorine atom or a mixture of low boiling partially methylated and halogenated silanes consisting substantially of methyldihalogenosilane. The preparation of the hydrolysis product, which is a heat-hardenable, oily or resinous liquid, is more fully described in the co-pending application of Francis J. Norton, S. N. 452,885, filed concurrently herewith, now Patent No. 2,366,259, issued October 9, 1945, and assigned to the same assignee as the present invention, and broadly covering the application of the oily hydrolysis product in waterproofing fibrous and similar water-non-repellent materials. An alternative treatment for tubes intended for use under humidity and temperature conditions normally encountered in temperature climates comprises treating the tubes with an organo-silicon halide in the vapor state, in a manner more fully described and claimed in the applications of Winlow T. Finch, S. N. 365,983, filed November 16, 1940 (now Patent 2,306,222), and of S. N. 433,527, filed March 4, 1942, as a continuation-in-part of the earlier application. These applications, both of which were assigned to the same assignee as the present invention cover the treatment of non-water-repellent bodies with vapors or solutions of organo-silicon halides to render said bodies water-repellent. Illustrative examples of such organo-silicon halides are the alkyl silicon halides (e.g., ethyl, propyl, butyl, etc., silicon halides), the aryl silicon halides (e.g., phenyl silicon halides, etc.), aralkyl silicon halides (e.g., phenethyl silicon halides, etc.), alkyaryl sili-
form a myriad of small droplets evenly distributed over the tube surface. During this period the surface of the tube appeared to the unaided eye to be completely frosted. However, observation under a magnifying glass revealed the fact that each tiny droplet was actually completely isolated one from another, thus preventing the formation of any continuous leakage path. Untreated tubes will not operate under satisfactory grid control at a relative humidity above 50 per cent at room temperature.

The very thin, tightly adherent, water-repellent film formed when a preconditioned tube is brought into contact with the vapors of an organo-silicon halide, preferably a methyl silicone chloride, or mixtures of methyl silicone chlorides, will effectively prevent electrical leakage under ordinary atmospheric conditions. For example, a tube which had been treated with the vapor of a mixture of methyl silicone chlorides consisting chiefly of methyltrichlorosiliane and dimethyl dichlorosilane operated satisfactorily when suspended at room temperature in 100 per cent relative humidity for 18 hours. Another tube treated with vapors of the same mixture of methyl silicone chlorides continued to function properly and normally for over 16 hours while suspended in an atmosphere having 100 per cent relative humidity at 50° C. However, if the vapor-treated tubes are subjected to such extreme conditions for several days, the metal parts corrode and electrical leakage develops.

The results of surface leakage tests on treated and untreated tubes are shown in Fig. 2 of the accompanying drawing. The curves were obtained by measuring the resistance in megohms of a 1/4 inch path on the glass surface of the tube under an applied potential of 500 volts D. C. and plotting these values against time of exposure of the tube to various temperature and humidity conditions.

The apparatus used for these tests was not capable of measuring resistances greater than 55,000 megohms which therefore represents the maximum resistance value that could be recorded and plotted.

Tube A, which was untreated, was cooled to −30° C. while suspended in an atmosphere having a 100 per cent relative humidity, and immediately tested at room temperature. After about 1 minute the frost melted. The resistance dropped to 0.4 megohm within the next twenty seconds. Tube B was also an untreated tube. It was tested at room temperature in an atmosphere having a 100 per cent relative humidity. Within 10 minutes the resistance dropped to about 210 megohms. The maximum recordable resistance values were obtained under similar conditions with tubes C and D which were coated with the resinous hydrolyzed methyl dichlorosilane. Tube C was tested under the same conditions as tube A. Tube D was tested under the same conditions as tube B except that the temperature was varied from room temperature to 85° C. during the test. These tests on treated tubes have been run for as long as 96 hours. At the end of this time, no measurable decrease in the resistance has been noted.

The organo-silicon coating materials I employ in preparing the leak-proof coatings appear to be unique in their property of effectively protecting the metal within the range of temperature and under varying conditions of humidity. Well known waterproofing materials such as phenol aldehyde condensation products, asphaltic com-

pounds, polystyrene, alkyd resins, and various waxes, such as paraffin, have been tried but have not been found in general to be ineffective or at the best only partially effective, in preventing corrosion and electrical leakage under normal or extreme atmospheric conditions.

Although I have described my invention in its application to a three-element discharge device, it is to be understood that it is equally applicable to any discharge device comprising two or more elements separated by an insulating member a surface of which is exposed to the atmosphere.

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

1. In a discharge device of a type desired to have a predetermined breakdown voltage, the combination which comprises conductive parts separated by externally exposed insulating members and a water-repellent coating on the externally exposed insulating members, said coating comprising a hydrolyzed organo-silicon halide.

2. In a discharge device of a type desired to have a predetermined breakdown voltage, the combination which comprises conductive parts separated by externally exposed insulating members and a water-repellent coating on the externally exposed insulating members, said coating comprising a hydrolyzed methyl silicone halide.

3. In a discharge device of a type desired to have a predetermined breakdown voltage, the combination which comprises conductive parts separated by externally exposed insulating members and a water-repellent coating on the externally exposed insulating members, said coating comprising a hydrolyzed methyl silicone halide.

4. In a discharge device of a type desired to have a predetermined breakdown voltage, the combination which comprises conductive parts separated by externally exposed insulating members and a water-repellent coating on the externally exposed insulating members, said coating comprising a baked film of the product of hydrolysis of a methyl dichlorosilane.

5. A discharge device comprising conductive parts separated by an insulating member, the externally exposed surface portions of which have been rendered water-repellent by treatment with vapors of an organo-silicon halide.

6. In a discharge device of the type desired to have a predetermined breakdown voltage, the combination which comprises conductive parts separated by an insulating member having a portion of its surface exposed to the atmosphere and a coating on at least the exposed surfaces of said insulating member, said coating consisting of the product of hydrolysis of methyl dichlorosilane.

7. A discharge device comprising at least two conductive parts separated by an insulating member having an externally exposed surface portion coated with a water-repellent film consisting of the cured resinous product of hydrolysis of methyl dichlorosilane.

8. A discharge device comprising at least two conductive parts separated by an insulating member having a water-repellent, externally exposed surface portion obtained by treating the externally exposed surface portion of said member with a methyl-silicon halide in vapor form.

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