Jan. 11, 1944. J. CARDELL 2,338,701

INSULATING COATING FOR ELECTRICAL SPACE DISCHARGE TUBE ELEMENTS

Filed June 20, 1938

Fig. 1.

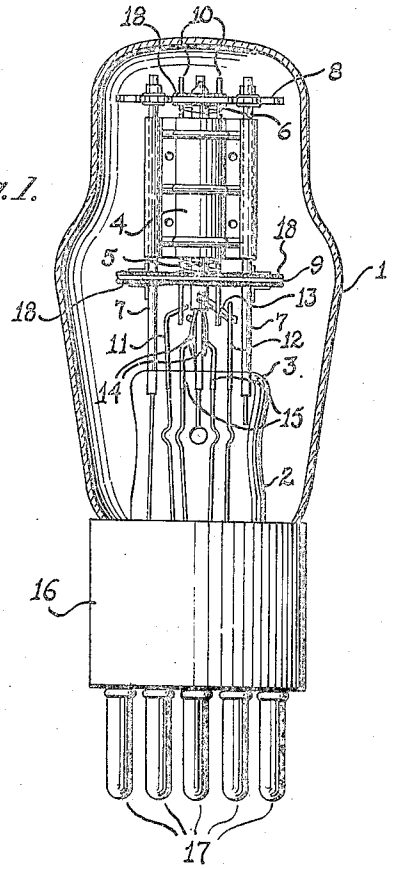


Fig. 2.

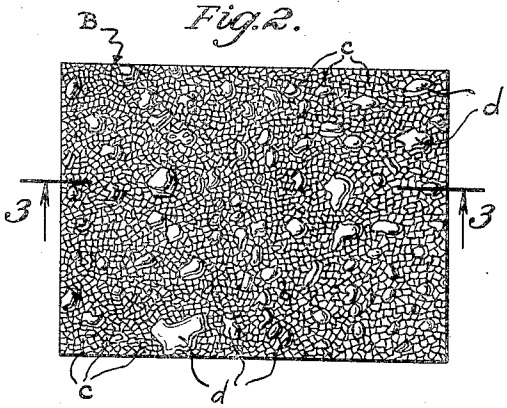


Fig. 3.

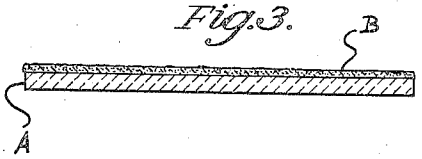
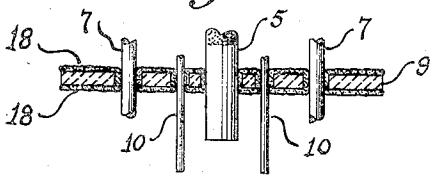


Fig. 4.



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INSULATING COATING FOR ELECTRICAL SPACE DISCHARGE TUBE ELEMENTS

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3 Claims. (Cl. 117—123)

This invention relates to an insulating coating for electrical space discharge tube elements, and more particularly to such a coating which is adapted to be sprayed on insulating spacers of such a tube for the purpose of decreasing the leakage of electricity along the surface of said insulating spacers.

In the art of electrical space discharge tubes, the various electrode elements are mounted in and supported by various insulating members, such as mica spacers and the glass stem of such tubes. When high voltages are impressed upon the electrodes, leakage currents tend to flow along the surfaces of such insulating members. This tendency is increased in those tubes in which a metallic getter is vaporized inasmuch as slight films of such getter tend to form on such insulating surfaces, producing conductive paths between electrode elements of different voltages. The art has attempted to cope with this problem in various ways, as, for example, by mechanically roughening the surface of the insulators and by spraying said insulators with an insulating coating. However, heretofore such means have not been completely successful. For example, it has been difficult to make previous insulating coatings adhere firmly to the underlying insulating member, and also such insulating coatings have not entirely eliminated leakage currents.

My present invention deals with the foregoing problem, and has for its object the production of an insulating coating which adheres very tenaciously to the underlying member, and which also substantially entirely eliminates leakage currents.

The foregoing and other objects of my invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein:

Fig. 1 is a tube with the envelope thereof in cross-section showing a construction to which my novel insulating coating may be applied;

Fig. 2 is a magnified surface view of my novel coating in which the magnification is roughly one hundred times the actual size;

Fig. 3 is a section taken along line 3—3 of Fig. 2, with a much smaller degree of amplification; and

Fig. 4 is a cross-section taken through the lower insulating spacer of Fig. 1.

My present invention accomplishes the objects recited above as well as other novel results by a novel mixture of elements. An example of such a mixture and the process of preparing it which I have used is substantially as follows. To 19,000 cubic centimeters of distilled water, at room temperature, 600 grams of heavy magnesium oxide consisting of relatively large particles which hydrolyze with difficulty and 2000 grams of light magnesium oxide consisting of very fine particles which are easily hydrolyzed, are added. This is mixed together and agitated until smooth. This may take approximately one-half hour. About 55 grams of starch are boiled in water to make 2750 cubic centimeters of boiled starch solution which is then added to the above mixture. The container is then covered and let stand for a considerable period of time in order to permit as complete a hydrolyzation of the magnesium oxide as possible. This period is preferably twenty-four hours or longer. At the end of that time the easily hydrolyzed magnesium oxide has been converted to very fine magnesium hydroxide substantially in colloidal form suspended in the water while the magnesium oxide which hydrolyzes with difficulty remains largely in that form dispersed in larger particles in the mixture. Finally there is added about 28,000 cubic centimeters of 91% isopropanol. The exact amount of isopropanol is varied so that the resulting mixture should have a specific gravity of about 0.965 to 0.975 at room temperature. The exact quantities specified above may be varied. However, it is desirable that the resulting solution should contain approximately 7.2% of magnesium hydroxide by weight. The mixture as prepared above is strained through a cheesecloth in order to remove any foreign particles which might interfere with spraying the mixture. The strained mixture is then bottled, and is then ready to be used as a spray in order to form insulating coatings.

The material as prepared above is then sprayed on the surface of an insulating member, such as represented at A in Fig. 3, producing an insulating coating B. In the usual electrical space discharge tube, the member A is made of mica. The member A carrying the coating B is then heated in an atmosphere of hydrogen to 1000° C. for about a minute. When this heating is finished, the coating assumes its final form. The coating as completed has the form as shown in Fig. 2. This consists of a two-phase structure having a major matrix consisting of very fine crystal grains *c* and larger evenly dispersed crystallites *d*. The small crystal grains probably consist of crystals of magnesium oxide which were formed from similar crystals of magnesium hydroxide which were converted to the oxide during the hydrogen heating. The larger crystallites are probably

unhydrolyzed particles of magnesium oxide which have persisted in oxide form throughout the process. The major matrix consisting of fine grains shows excellent cohesive and adhesive properties; that is, the individual grains cohere among themselves and adhere very strongly to the underlying mica. Such adhesion is probably not only one due to physical forces but seems also to be somewhat of a chemical nature since mica is acidic and the insulating coating is basic in nature. Also the larger crystallites *d*, I believe, serve to anchor the coating even more firmly. The actual mechanism of adhesion is not perfectly known, yet I have found that it is a fact that this type of coating is much more tenacious than those heretofore known in this art.

The recrystallization which accounts for the appearance of the large evenly dispersed crystallites *d* makes such crystallites stand out in relief, which produces a very rough surface and introduces interruptions of any leakage currents along the surface of the material. In prior coatings such interruptions either do not appear or are strongly localized. However, the substantially entire absence of any leakage currents along the surface of the insulating coating appears to be due primarily to the major matrix consisting of the small crystal grains *c*. This matrix has a very large percentage of grain boundary area. These grain boundaries also serve to interrupt the conductivity of the surface and likewise of any adsorbed film of getter material or other materials which tend to produce a conducting surface. It is known that grain boundaries in bulk material show much lower conductivity than the grain material itself. These grain boundaries also exhibit different physical chemical properties than the interior of the grain. Therefore, it appears that the grain boundary areas likewise tend to inhibit the deposition of a conducting film at said boundaries. Since the grain boundaries are present in such an enormously large percentage, the present insulating coating possesses the property of substantially entirely preventing leakage currents.

It appears that the novel aspects of my coating are due primarily to the addition of the starch to the coating material. While the real function of said starch is somewhat obscure, yet my present theory is that it acts to prevent the union of many fine particles of magnesium hydroxide into large agglomerates. Thus the magnesium hydroxide is forced to crystallize out into the small crystal grains as described above. Although any type of starch may be used, yet I prefer to use arrowroot starch. Other materials of a physical and chemical nature similar to that of starch may likewise be used to prevent the formation of large agglomerates and to cause the formation of the fine crystal grains as described above.

It appears that the present invention is the first to produce a strong adherence of the insulating coating to the underlying material and a substantially complete elimination of leakage currents by depositing the insulating material on the underlying member in the form of very finely-divided crystal grains having a relatively large percentage of grain boundaries. These crystal grains have an average diameter of the order of magnitude of about .001 of an inch or less. The thickness of the coating is preferably of the same order of magnitude as the crystal grain diameter so that said coating consists of substantially a single layer of said crystal grains. Larger thicknesses could also be used.

In Figs. 1 and 4 I have shown a structure to which such an insulating coating as I have described above may be applied. This structure consists of a sealed envelope 1 having a reentrant stem 2 at the upper end of which is a glass press 3. The press supports an anode 4, a cathode 5, and a control grid 6. The anode is supported by a pair of anode standards 7 which likewise support an upper insulating spacer 8 and a lower insulating spacer 9. These spacers in the usual tube structure are made preferably of mica. The spacers 8 and 9 also support a pair of grid standards 10 upon which the grid 6 is formed. The insulating spacers likewise support the cathode 5. The grid 6 is provided with a lead-in wire 11 sealed in the press 3 and electrically connected to one of the grid spacers 10. The cathode 5 is provided with a lead-in conductor 12 likewise sealed in the press 3 conducted to the cathode by a cathode connector 13. The cathode 5 may be of the indirectly-heated type having an interior filamentary heater which is provided with two ends 14 connected in turn to a pair of heater lead-in wires 15 likewise sealed in the press 3. The tube may be provided with the usual base 16 carrying contact prongs 17 to which the various lead-in wires are connected, whereby external electrical connections may be made to the elements within the envelope 1.

The insulating coating which I have described above may be applied to the insulating spacers 8 and 9 at 18. As shown in the enlarged view of Fig. 4, the cathode and the standards 7 and 10 pass through openings in the spacer 9 which are slightly larger than the diameter of said elements. The coating 18 is sprayed on both sides of the spacer 9. When the tube is heated during the exhaust thereof, the coating 18 is raised to a relatively high temperature. I have found that the coating which I have described above has the property of softening slightly under such heat, whereupon said coating flows in around the elements passing through the spacer 9, as indicated in Fig. 4. Thus the insulating coating fills the spaces between the members passing through the spacer 9, and prevents any relative motion between these various elements. Inasmuch as any such motion is undesirable in a vacuum tube, due to the fact that it has a tendency to introduce noise, the foregoing property of my insulating coating is a very valuable one.

Of course it is to be understood that this invention is not limited to the particular details as described above as many equivalents will suggest themselves to those skilled in the art. For example, in addition to the variations which I have suggested above, instead of using a two-phase insulating coating in which both magnesium oxide and magnesium hydroxide are presented, the coating could be prepared with only magnesium hydroxide. The larger crystallites could be formed of other insulating particles, such as aluminum oxide, instead of magnesium oxide. Likewise other finely-divided insulating materials which in the presence of a dispersing medium, such as starch, tend to crystallize out into finely-divided crystal grains such as I have described above, could be used to form the main matrix. The material in some instances may be applied to conducting as well as insulating members and also to a wide variety of tube structures. Various other changes and uses for my present invention will readily suggest themselves to those

skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of this invention.

What is claimed is:

1. A supporting structure of mica, an electrically insulating coating on a surface of said structure, an electrically insulating material taken from the group consisting of magnesium oxide and aluminum oxide and crystallized in situ to form finely divided crystal grains having a large number of crystal boundaries interrupting the surface of said layer.

2. A supporting structure of mica, an electrically insulating coating on a surface of said structure, an electrically insulating material comprising magnesium oxide crystallized in situ to form finely divided crystal grains having a large number of crystal boundaries interrupting the surface of said layer.

3. A supporting structure of mica, an electrically insulating coating on a surface of said structure, an electrically insulating material comprising aluminum oxide crystallized in situ to form finely divided crystal grains having a large number of crystal boundaries interrupting the surface of said layer.

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