

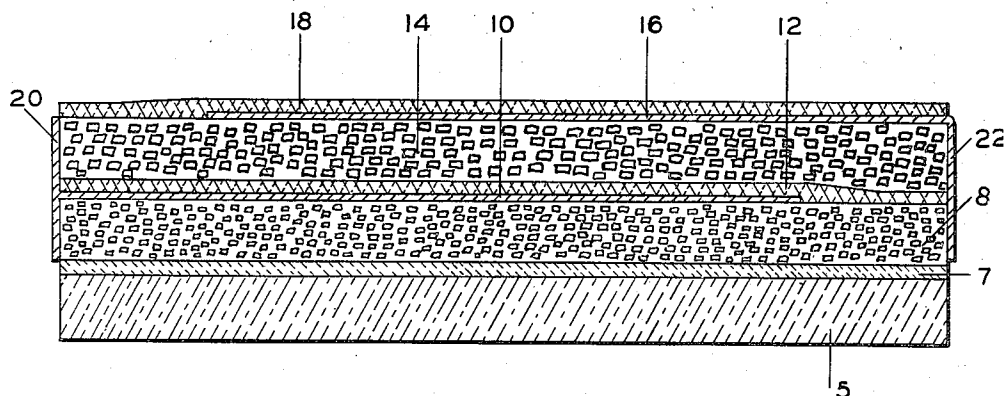
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PROCESS FOR THE MANUFACTURE OF ELECTRICAL CAPACITORS

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PROCESS FOR THE MANUFACTURE OF
ELECTRICAL CAPACITORS

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5 Claims. (Cl. 75—22)

This invention relates to a new and improved method of manufacturing ceramic capacitors of a type suitable for use in electrical, radio, and radar equipment. More particularly, it is concerned with an improved method of manufacturing the novel capacitors wherein the dielectric layers are formed of vitreous enamel and the electrode layers of metallic silver, as more fully disclosed, for example, in the copending applications, Deyrup and Ballard, Serial No. 504,882, filed October 4, 1943; Serial No. 504,883, filed October 4, 1943; and of Deyrup, Serial No. 504,885, filed October 4, 1943; (P. C. 2181, P. C. 2182 and P. C. 2184, respectively, filed simultaneously herewith); and in the copending application of Alden J. Deyrup, Kermit H. Ballard and John J. Strickarz, Serial No. 504,884, filed October 4, 1943.

In preparing ceramic capacitors as described in said copending applications it is usual to spray a suspension of the vitreous enamel in a suitable vehicle on a supporting base, and then apply to said vitreous enamel layer, after the latter has dried, using for the application preferably the screen stencil method, a layer of metallic silver suspended in a suitable vehicle. After the metallic silver layer has dried, a second layer of vitreous enamel having dielectric properties suspended in a suitable vehicle is applied, and this is followed by a second layer of metallic silver suspended in vehicle. In this way alternate layers of vitreous enamel and metallic silver, both in the unfired condition, are built up, one layer drying by evaporation of the suspending solvent before the next layer is applied thereto.

This method differs in two important respects from usual ceramic enamelling processes. First, in the application of the second and all subsequent layers of vitreous enamel dielectric suspended in vehicle, the process requires spraying the vitreous enamel suspension on top of a porous base. Secondly, certain areas of this porous base to which the subsequent layer of enamel is applied are coated with an unfired layer of silver particles. In both respects this procedure differs from the customary application of a vitreous enamel suspension, in the ceramic industry, only to hard, smooth non-porous surfaces.

In practicing the process described in the above-identified copending applications to prepare the ceramic capacitors therein disclosed, a large number of defective units has sometimes resulted. These defective multi-layer vitreous capacitors result from the particular manner in which the various layers constituting the capacitor are applied to the supporting base surface, as will be

apparent from the following explanation. When the second layer of vitreous enamel dielectric suspended in vehicle is applied over the first layer, certain portions of which first layer are coated with an unfired layer of silver particles, the liquid vehicle of the suspension of vitreous enamel particles is drawn by capillary action, to some extent, into the interstices in the first layer of vitreous enamel dielectric. This results in the displacement of air, the air being trapped in the form of fairly large bubbles which tend to escape through the wet second layer of vitreous enamel dielectric suspended in vehicle. The escape of these air bubbles will usually either produce holes in the second dielectric layer, resulting in breakdown of the finished capacitor when tested at relatively low voltages, or they may carry silver particles from the intermediate silver electrode up through the second layer of vitreous enamel dielectric. In the latter case direct short circuiting of the completed capacitor will result or the finished capacitor will be characterized by lowered electrical breakdown resistance.

I have now discovered a process which permits the securing of a much larger percentage of perfect ceramic capacitor units. In practicing my invention I first apply to the supporting base, as in the above-identified copending applications, a layer of vitreous enamel dielectric suspended in a vehicle and, after the latter is dry, I then apply, as disclosed in those applications, the first silver electrode layer. In order to prevent the escape of trapped air from the first dielectric enamel layer into a subsequently applied layer of vitreous enamel suspended in a suitable vehicle I then apply, however, over the exposed portions of the first dielectric layer and the first silver plate or electrode layer, a thin overall spray of lacquer. This produces a continuous organic interlayer of such nature and thickness that air does not escape from the first vitreous enamel layer, and there is no cleavage or separation between adjacent dielectric layers during subsequent drying operations.

Accordingly, it is an object of this invention to render available to the industry a process for producing ceramic capacitors of the type described in the above-identified copending patent applications, which process permits the securing of a much higher proportion of perfect units than previously available procedures. Another object of this invention is to accomplish this purpose by preventing the escape of trapped air from a lower, already applied, dielectric layer, into a later-applied layer of vitreous enamel suspended

ed in a suitable vehicle, by providing a layer of a suitable lacquer over exposed portions of the first dielectric layer and over the intermediate silver electrode layer, said lacquer being of such nature and character that no air bubbles escape from said first dielectric layer into the later-applied suspension of vitreous enamel dielectric. These and still further objects of this invention will be apparent from the ensuing disclosure of certain preferred embodiments thereof.

My invention is best illustrated with reference to the annexed drawing which shows, however, a ceramic capacitor built up of only two vitreous enamel dielectric layers and two silver electrode layers. In the usual commercial practice a ceramic capacitor of this type will contain a much larger number of silver electrode layers, and a much larger number of interposed vitreous enamel dielectric layers. For convenience in illustrating, however, only two dielectric layers have been shown, as the practice of my invention is identical regardless of the number of individual layers applied. It may also be remarked that in this drawing the thickness of the dielectric layers has been greatly increased relative to the thickness of the metallic electrode layers, this distorted thickness serving to permit diagrammatic illustration of the air present in said dielectric layers surrounding the individual particles of solid dielectric enamel.

Referring particularly to said drawing, numeral 5 denotes the temporary rigid supporting base on which the ceramic layers comprising the electrical capacitor are built up, the process being described more fully, for example, in the application Serial No. 504,883, filed October 4, 1943. This temporary rigid supporting base is provided, as shown, with a parting layer 7, which may consist essentially of bentonite, this layer serving to prevent adhesion between the lowermost layer of dielectric enamel and the temporary rigid base 5.

There is then applied on the temporary rigid supporting base 5 coated with the bentonite parting layer 7, the first layer of vitreous enamel suspended in a suitable vehicle, this layer being denoted by the numeral 8. As previously explained, this layer comprises a suspension of powdered vitreous enamel in a suitable vehicle, and in view of its nature there will remain a number of air bubbles therein. By exaggerating the thickness of this layer it is possible to illustrate the layer diagrammatically as a number of individual particles of vitreous enamel surrounded by the air envelope, this air remaining in the interstices but causing no difficulty during later manufacturing steps because of my improved manufacturing procedure.

The first silver electrode layer 10 is applied on top of vitreous enamel layer 8. As shown, this silver electrode area will not necessarily be co-extensive with the upper surface of vitreous enamel layer 8, there being portions of the latter layer which are not covered by the suspension of metallic silver in a suitable vehicle.

On top of the silver electrode layer 10, and over such portions of the vitreous enamel dielectric layer 8 as are not covered by the metallic silver layer 10, there is provided a layer of lacquer 12. This lacquer, as previously explained, serves to prevent the escape of trapped air from the first vitreous enamel dielectric layer 8 into the second vitreous enamel dielectric layer 14, which is then applied on top of the lacquer layer 12. This second vitreous enamel dielectric layer is illustrated,

as the first, much thicker than it actually is relatively, in order to show diagrammatically the air envelope surrounding the individual particles of powdered vitreous enamel suspended in a suitable vehicle, constituting said layer.

On top of second vitreous enamel dielectric layer 14 there is then applied a second layer of metallic silver suspended in a suitable vehicle, this layer constituting the second metallic silver electrode layer 16. As in the case of the first metallic silver electrode layer 10, the second silver electrode layer does not necessarily cover all portions of the second vitreous enamel dielectric layer 14, there being portions of the latter which are left uncovered by the metallic silver.

There is then applied over the metallic silver electrode layer 16, and over exposed portions of the second vitreous enamel dielectric layer 14, a second layer of lacquer 18, this layer serving, as previously explained, to prevent the escape of air bubbles from second vitreous enamel dielectric layer 14 into the subsequently applied layers of wet vitreous enamel dielectric. Although such subsequent layers of vitreous enamel dielectric are not illustrated in the drawing, as they are not necessary to explain my invention, it is evident that any number of vitreous enamel dielectric layers and metallic silver electrode areas, there being provided between adjacent vitreous enamel dielectric layers the layer of lacquer, as illustrated, may be built up on the support 5, depending upon the number of individual vitreous enamel dielectric layers required to constitute the finished ceramic condenser.

As illustrated in the drawing, the first silver electrode layer 10 may be provided with a portion 20 along the edge surface of the built-up layers of the capacitor, said portion 20 serving to permit electrical connection to said first silver electrode layer 10. Similarly, the second silver electrode layer 16 may be provided with a depending portion 22 on the edge surface of the built-up layers constituting the condenser, the said depending portion permitting electrical connection with said second silver electrode layer. It is evident that in the usual practice alternate electrode or plate areas are joined by a conducting member to provide the two electrodes of the completed capacitor. For this purpose the portions 20 and 22 may extend along the entire end or edge surface of the built-up elements constituting the electrical capacitor, whereby alternate silver electrode plate areas may be joined to permit electrical lead wires to be attached thereto, thus constituting a ceramic capacitor with two electrodes and attached lead wires by which the capacitor may be made a part of electrical circuits.

It is, of course, evident that each individual layer of vitreous enamel dielectric, of metallic silver paste, or of lacquer, applied either to the supporting base 5 or over previously applied layers, is preferably dried before the next succeeding layer is applied. Generally, I prefer to apply the vitreous enamel dielectric composition by spraying, the silver electrode areas being applied as a suspension of silver or paste by the squeegee screen stencil method, although, of course, the methods may be used interchangeably as desired.

In practicing my improved process for manufacturing ceramic capacitors of the type described I have secured best results with a lacquer consisting of ethyl cellulose dissolved in methyl alcohol. In order that the thickness of the lacquer interlayer may be accurately controlled in manual spray operations it is preferred,

although not essential, to incorporate a dye in the ethyl cellulose solution, this dye permitting estimation of the thickness of the coating applied by the hue or color imparted thereto. A lacquer suitable for use in a preferred embodiment of my invention may be made up as follows:

	Per cent
Ethyl cellulose	4.150
Dye (du Pont Rodamine "B" extra).....	0.003
Methyl alcohol solvent.....	95.847

All percentages are by weight, based on the total weight of the composition.

In place of this lacquer any other suitable lacquer may of course be utilized, and I have employed with success lacquers containing either nitrocellulose or methyl cellulose, each being dissolved in a suitable solvent such as methanol or water. However ordinarily I prefer to utilize a lacquer comprising ethyl cellulose because by its use there may readily be secured organic interlayers which are practically free from pin holes.

By utilizing my improved process for the production of ceramic capacitors, employing an organic interlayer to prevent migration of air from one vitreous enamel dielectric layer to another subsequently applied vitreous enamel dielectric layer, I have substantially increased the yield of perfect condensers obtainable in manufacturing operations such as those disclosed in the copending application, Serial No. 504,883, filed October 4, 1943. In one instance over 90% of a large lot of capacitors fabricated in accordance with my improved procedure, these capacitors consisting of 19 individual dielectric layers and 20 layers of metallic silver electrodes, successfully passed the customary dielectric breakdown tests with alternating currents of 1000 volts.

It is, of course, evident that in order to complete my improved ceramic capacitors they must be fired to fuse the metallic silver electrode layers or plates and the vitreous enamel dielectric layers to produce a unitary monolithic capacitor structure. This firing is preferably carried out in accordance with the procedure described, for example, in the previously referred-to copending applications.

As many variations may be made in my improved procedure of manufacturing ceramic capacitors, certain preferred embodiments of which have been disclosed herein, without departing from the scope of my invention, it is my intention that such variations shall be regarded as within its scope to the extent that they are comprehended within the appended claims.

I claim:

1. The process of manufacturing electrical capacitors of the type comprising a plurality of vitreous enamel dielectric layers separating fired silver electrode plate layers which comprises:

building up on a temporary supporting base a plurality of layers of powdered dielectric vitreous enamel suspended in a suitable vehicle and a plurality of layers of metallic silver suspended in a suitable vehicle, said enamel layers and said silver layers alternating in position; providing between adjacent vitreous enamel dielectric layers, covering the metallic silver electrode plate layer positioned therebetween, a non-porous lacquer, said lacquer serving to prevent migration of air from one of said vitreous enamel dielectric layers to the other; removing the resulting incomplete capacitor structure from said temporary base and transferring it to a second temporary base; and firing the resulting structure to provide a unitary monolithic electrical capacitor of the type described.

2. The process of manufacturing unitary monolithic electrical capacitors of the type comprising a plurality of vitreous enamel dielectric layers separating fired silver electrode plate layers, which comprises: forming a layer of vitreous enamel dielectric to comprise, when fired, one of the dielectric layers of said capacitor; providing on said vitreous enamel dielectric layer a metallic silver electrode area by applying thereto a suspension of metallic silver suspended in a suitable vehicle; applying over said silver electrode area and the uncovered portions of said first vitreous enamel dielectric layer, a layer of a non-porous lacquer, said non-porous lacquer serving to prevent the escape of air bubbles from said first dielectric layer; positioning on said non-porous lacquer layer a second layer of vitreous enamel suspended in a suitable vehicle; applying over said second vitreous enamel layer a second silver electrode area by applying thereto a suspension of metallic silver suspended in a suitable vehicle; applying on top of the uncoated portions of said second vitreous enamel dielectric layer and on said metallic silver electrode area a second layer of a non-porous lacquer; continuing said process, applying alternate layers of vitreous enamel dielectric suspended in a suitable vehicle, and layers of metallic silver suspended in a suitable vehicle, a non-porous lacquer layer separating adjacent vitreous enamel dielectric layers, until the desired number of metallic silver electrode plates is built up; and firing the resulting structure to provide a unitary monolithic electrical capacitor of the type described.

3. The process described in claim 2 wherein said non-porous lacquer comprises ethyl cellulose dissolved in methanol.

4. The process described in claim 2 wherein said non-porous lacquer comprises nitrocellulose dissolved in a suitable solvent.

5. The process described in claim 2 wherein said non-porous lacquer comprises methyl cellulose dissolved in a suitable solvent.

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