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METHOD OF FABRICATING ELECTRICAL APPARATUS

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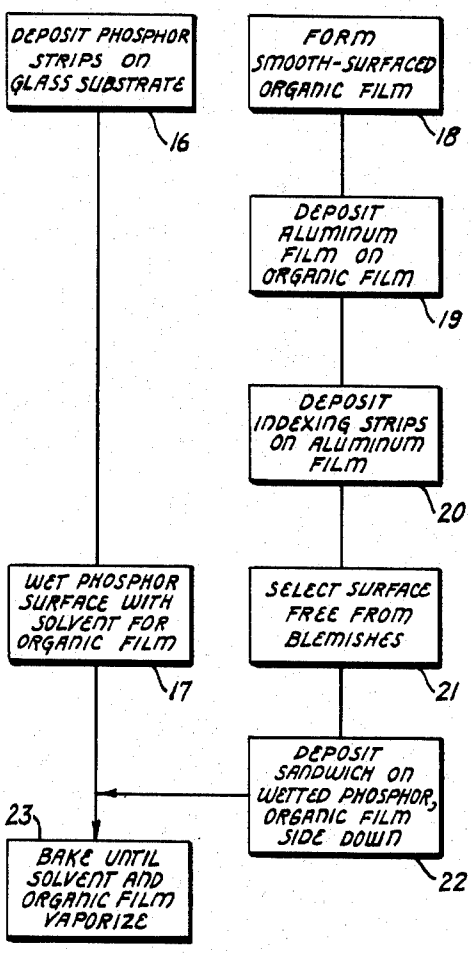


FIG. 2.

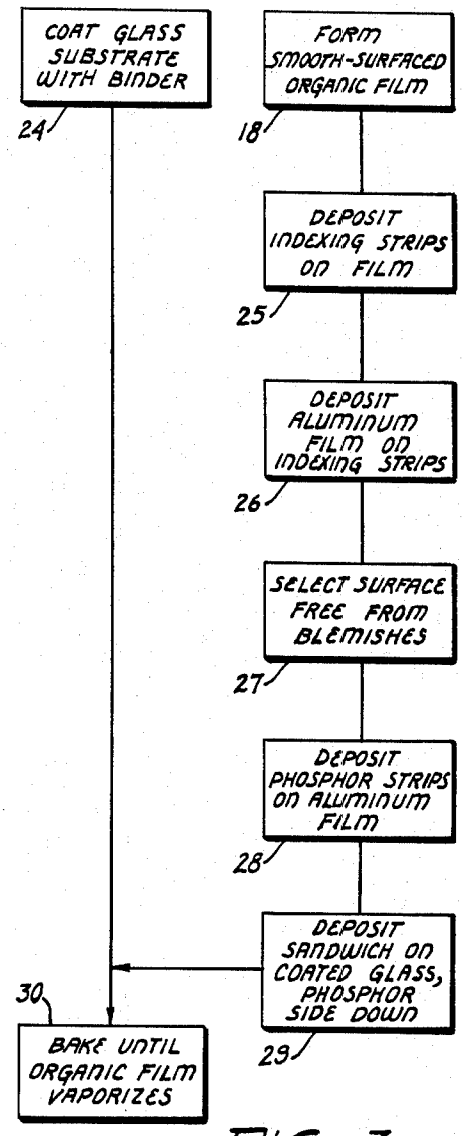


FIG. 3.

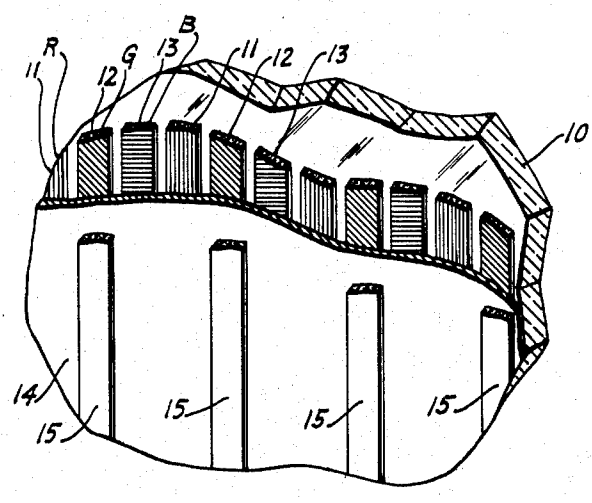


FIG. 1.

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METHOD OF FABRICATING ELECTRICAL APPARATUS

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5 Claims. (Cl. 154—95)

The present invention relates to improvements in the manufacture of cathode ray tubes and, more particularly, to improved methods of fabricating the screen structures of such tubes.

In the past it has been the practice to form cathode ray tube screens by consecutively depositing, on a transparent substrate, the several different constituents of the screen. In the case of a cathode ray tube for black and white television reception, these constituents may be the phosphor and the conventional aluminum backing. In the case of a cathode ray tube adapted for color television reception, there may be a plurality of phosphors emissive of light of different colors, together with an aluminum backing and additional elements, such as strips of a material having a secondary electron emissivity substantially different from the secondary electron emissivities of the phosphors and/or the aluminum, for producing electrical indications of cathode ray beam impingement upon predetermined portions of the screen area. The latter form of screen structure is fully described in the copending U. S. patent application of Carlo V. Bocciarelli, Serial No. 198,709, filed December 1, 1950, and assigned to the assignee of the present invention.

Although each step in these consecutive deposition processes was critical and required great care and skill for satisfactory performance, none was more delicate than that of aluminum filming. For, no matter how closely controlled were the conditions under which this step was carried out, there was still no way of guaranteeing a uniformly successful result. As is well known, the aluminum films of which I speak must be extremely thin; in fact so that that the electron beam of the cathode ray tube can penetrate the conductive material without substantial attenuation. Since this film serves as a light reflecting mirror for the fluorescent screen, it must also be substantially free of blemishes. Since bubbles, tears, variations in thickness and like deformations occur uncontrollably in the process of depositing such a thin film, the manufacture of aluminized cathode ray tube screens has heretofore been inefficient in the extreme, for it has been common to have to discard an otherwise completed screen structure because of the appearance of one of the aforementioned defects in the aluminum film. The resulting waste is serious even in black-and-white tubes, wherein the entire fluorescent screen area is usually made of a uniform layer of phosphor. But in color television tubes, wherein the formation of the multi-colored screen involves the deposition of many minute elements of different phosphors in accurate registry by methods costly in both manpower and materials, the danger of wasting these efforts by reason of a defect in the superimposed aluminum film has actually been a serious deterrent to the use of such films in spite of their well known advantages.

It will be understood that similar dangers arise, with varying degrees of urgency, whenever it is necessary to form a sandwich-like structure such as a cathode ray tube screen by the successive deposition of different materials.

It is, accordingly, a primary object of the invention to provide an improved method of depositing a layer of one material on the surface of another material with substantial reduction of the danger that failure of the deposited material will destroy the usefulness of the entire structure.

It is another object of the invention to deposit a thin metallic film on an inorganic surface by a method which minimizes the likelihood of structural failure of the film.

It is still another object of the invention to provide an improved method of aluminizing cathode ray tube screens, which method substantially reduces the likelihood of producing a defective screen.

In practicing my invention, the most conspicuous departure from the prior art resides in the formation of the aluminum film on a separate substrate, preferably of organic material, this formation being carried out externally of the cathode ray tube. The far reaching improvements which this modification produces will be better appreciated from a consideration of the following detailed discussion in conjunction with the accompanying drawings wherein:

Figure 1 is an enlarged fragmentary view of a typical cathode ray tube screen for color television reception;

Figure 2 is a flow diagram outlining a method of fabricating the screen of Figure 1 in accordance with my invention; and

Figure 3 is a flow diagram outlining another method of fabricating the screen of Figure 1 in accordance with my invention.

The structure of the cathode ray tube screen illustrated in Figure 1 of the drawings, to which more particular reference may now be had, is entirely conventional in all respects, consisting, as it does, of a glass substrate **10** which may be either the face plate of the cathode ray tube itself or else a separate glass plate supported within the tube envelope. Upon this glass substrate there are disposed a plurality of parallel vertical phosphor strips, of which those designated **11** are made of a fluorescent material emissive of red light in response to impingement by the electron beam of the cathode ray tube. Those strips designated **12** are made of a fluorescent material responsive to electron beam impingement to emit green light, while those designated **13** are similarly responsive to emit blue light. As is also conventional, the entire surface area of these strips **11, 12** and **13** is covered by a film **14** made of a highly light reflective material such as aluminum and sufficiently thin so as to be electron permeable. On the electron beam confronting side of this aluminum film **14** there are, in turn, disposed a plurality of so-called indexing strips **15**, which are arranged in a predetermined geometrical relationship with respect to the phosphor strips **11, 12** and **13** and which are characterized by having a secondary electron emission ratio which differs substantially from that of the aluminum film. In practice, the indexing strips **15** will frequently be disposed in alignment with phosphor strips emissive of light of one particular color, say green. There will then be an indexing strip superimposed upon every third phosphor strip and separated therefrom by the aluminum film **14**. However, it will be understood that this particular arrangement of indexing strips is not essential to my inventive concept, having been disclosed in the aforementioned copending application. Suitable materials of which these indexing strips may be made, include principally those having high secondary electron emission ratios relative to that of the aluminum film. A variety of materials, such as magnesium oxide, silver, gold, tungsten and various other high atomic weight materials have this property.

Again, as fully explained in the above-identified copending application, the cathode ray beam is conventional-

ly swept across the screen structure illustrated in Figure 1 so as to trace across the phosphor strips approximately at right angles, thus causing emission of red, green and blue light in rapid succession. The beam intensity is then successively controlled in accordance with received red, green and blue color information, the timing of this control being such that impingement of the electron beam upon a strip emissive of light of one particular color, say green, coincides with control of the electron beam intensity by green color information. It is in order to assure this coincidence that the indexing strips 15 are provided on top of aluminum film 14. For, as the electron beam sweeps perpendicularly across consecutive phosphor strips, it will also traverse successive indexing strips, thereby producing periodic changes in the secondary emission current from the screen. Conventional means of the type described in detail in the aforementioned copending application may then be connected to the screen for the purpose of deriving therefrom a signal corresponding to these variations in secondary emission current. This signal provides indications of beam impingement upon particular portions of the screen and may therefore be utilized to control the rate of beam intensity modulation with color information to coincide with beam impingement upon particular light emissive phosphor strips. Inasmuch as the means for so utilizing the indexing signal are not directly related to my inventive concept, which resides in the improved method of fabrication of the screen itself, and inasmuch as these utilization means are fully described in the aforementioned copending application, no showing thereof is made in the present instance.

One particular manner of practicing the method which constitutes my invention is illustrated in the flow diagram of Figure 2, to which more particular reference may now be had. The salient characteristic of this method, as will be seen by inspection of Figure 2, is the separate carrying out of certain steps of the method followed by the combination of the sub-assemblies produced by the separate processes with subsequent joint processing of the entire assembly. One of the aforementioned separate processes starts with the deposition of the phosphor strips on the glass substrate 10 of Figure 1. This operation is symbolized by rectangle 16 of Figure 2. It may be carried out in a variety of well known ways, as, for example, by settling, silk screening, or photographically depositing the various phosphor strips. In practice, I prefer to use the latter method, which consists of first applying a uniform coating of one of the fluorescent materials to the entire glass substrate, together with a photosensitive emulsion, then exposing portions of this fluorescent material through slits in an otherwise opaque mask, these slits having been cut at positions corresponding to the desired location of strips of that particular phosphor. This exposure fixes the phosphor of the exposed portions and the remainder of the unexposed phosphor can be simply washed off. This process is repeated successively with each of the other two phosphors, the mask being, of course, relocated each time so as to permit exposure of the proper portions of the phosphor which it is desired to have remain on the glass substrate. A variety of phosphors are known which lend themselves to this process of manufacture. Particular phosphors which I have used with success in forming the fluorescent portions of my screen are zinc phosphate for the red light emissive strips, zinc orthosilicate for the green light emissive strips and calcium magnesium silicate for the blue light emissive strips. The next step in processing the assembly of glass substrate and phosphor strips consists of wetting the exposed surface of the phosphor strips with a material which will act as a solvent for organic substances. A material suitable for this purpose is acetone. Others are toluene and xylene. This step is symbolized by rectangle 17 of Figure 2 and concludes the formation of one of the sub-assemblies of which my screen structure is constituted. The formation of the other sub-assembly begins with the formation of a smooth-surfaced organic film, symbolized by rectangle 18 of Figure 2. This organic material is preferably characterized by being adapted to be baked out completely at temperatures below 400° centigrade without leaving a residue. Numerous substances are known which fulfill this requirement. I have had good success with isobutyl methacrylate and nitrocellulose, each of which can readily be formed into a film of as little as one mil thickness and still be capable of supporting a substantial layer of other material such as aluminum. On one surface of this organic film there is then deposited the aluminum film required by the screen structure illustrated in Figure 1 of the drawings, this step being symbolized by rectangle 19 of Figure 2. Next, there is deposited, on the exposed surface of the aluminum film, a plurality of strips made of an indexing material such as magnesium oxide, or gold, and corresponding to the indexing strips 15 of Figure 1. In the deposition of these indexing strips the necessary precautions will, of course, have to be taken to maintain their proper spacing relative to the phosphor strips deposited on the glass substrate so that they will be capable of fulfilling their role of providing indications of beam impingement upon these phosphor strips. The next step in the formation of this sub-assembly, which is symbolized by rectangle 21 of Figure 2, and which consists of selecting a portion of the sandwich consisting of organic film, aluminum film and indexing strips that is free from blemish, does not constitute an essential step of the inventive process inasmuch as inspection of the sub-assembly may take place at each step of its formation. However, the fact that inspection of the formed aluminum film prior to its application to the phosphor strips is possible when practicing my method, emphasizes one of the principal advantages thereof over the prior art, wherein the aluminum film was formed directly on the phosphor strips so that, by the time blemishes occurring in the process of formation became visible, it was too late to save the phosphor strip sub-assembly. The first sub-assembly formed by steps 16 and 17 and the second sub-assembly formed by steps 18, 19, 20, the latter having been preferably inspected for defects in the aluminum film, are now combined, as symbolized by rectangle 22, by depositing the sandwich-like structure of organic film, aluminum film and indexing strips jointly on the phosphor strips which have previously been wet with solvent, this deposition being carried out so that the organic film is in contact with the solvent. The final step of my process, which is symbolized by rectangle 23 of Figure 2, consists of baking the final assembly, preferably at a temperature below 400° centigrade, until the organic film dissolved by the solvent has completely vaporized, at which point there is left only the structure of Figure 1. The use of temperatures below 400° centigrade is prompted by the fact that the phosphors hereinbefore listed and others which may be suitable for the colored light emissive strips of the structure tend to lose efficiency at higher temperatures. If more heat resistant phosphors are used, the baking temperature may, of course, also be raised.

It will be understood that my inventive process of forming the screen structure is complete even without baking out of the organic film. If this is not done at this point, however, there is the danger that heating due to impingement by the electron beam, during actual operation of a completely assembled tube incorporating that screen, will cause vaporization of the organic film which will then contaminate other elements of the tube such as the electron emissive cathode, for example. Alternatively, the organic film may carbonize, leaving a layer of carbon which is light absorbent and also has low secondary electron emissivity.

While the invention is not limited to any particular manner of carrying out the aforementioned steps, certain of the inherent advantages of my novel method over those of the prior art will become apparent from a detailed consideration of the preferred mode of practicing steps 19, 20 and 21, which, respectively, relate to the deposition of the aluminum film, the deposition of the indexing strips

and the selection of a surface free from blemishes for combination with the phosphor strips. The organic film formed in step **18** may, for example, be supplied in the form of a roll of sufficient width to cover the greatest vertical dimension of the phosphor strip lined glass substrate. This roll may be unwound through a continuously evacuated bell jar containing an aluminum evaporator from which the aluminum necessary for the formation of the aluminum film on the organic film is continuously evaporated. The rate of evaporation of the aluminum and the rate of traversal of the organic layer may be so adjusted relatively to each other that aluminum of the desired thickness is continuously formed on the organic film. After the combined organic and aluminum films have left the evacuated bell jar, the exposed surface of the aluminum may be uniformly coated, for example by spraying, with the material of the indexing strips, together with a photosensitive emulsion. The assembly thus produced is then passed behind an opaque mask having a narrow slit through which a strip the width of an indexing strip is exposed to illumination at such intervals, relative to the rate of film displacement under the opaque mask, that portions spaced in accordance with the requirements of the indexing strip spacing disposition are exposed and fixed, after which the entire sub-assembly is passed through a bath in which unexposed portions of the index material are washed away, leaving deposits of indexing material in the appointed locations. The final inspection of this product can be carried out by passing it between a source of light and a photoelectric cell so that light transmission to the photoelectric cell occurs only at discontinuities in the aluminum film, thereby giving automatic warning of defects in this film. Portions of the proper size for application to the phosphor strip assembly are then cut and applied thereto in accordance with step **22**.

Note the tremendous advantage of practicing my method in the manner outlined hereinabove and which resides not only in the formation of a screen having a flawless aluminum film backing without danger of ruining the expensive phosphor sub-assembly, but which also permits the formation of the major portions of the assembly by a completely automatic process which is continuous and requires no human supervision. Evidently, the aforementioned steps can also be carried out by hand.

Where it is desired to avail oneself still further of automatic machinery in the fabrication of a screen structure in accordance with my invention, the process diagrammed in Figure 2 may be somewhat modified, principally with respect to the order of occurrence of the various steps, in the manner diagrammatically represented in Figure 3, to which more detailed reference may now be had. Again it is an important characteristic of my process that two sub-assemblies are first separately formed, then appropriately combined and submitted to final joint processing. The formation of one sub-assembly, in accordance with my invention, involves the coating of the glass substrate upon which the remaining portions of the screen are to be supported with a material adapted to bind fluorescent phosphors to this glass substrate. Such a binder material may be potassium silicate, the step of coating the substrate therewith being symbolized by rectangle **24** of Figure 3. Other silicates may also be used. The formation of the other sub-assembly begins with the formation of a smooth-surfaced organic film, just as it did in the case of Figure 2. Accordingly, this step is symbolized by a rectangle similarly designated by reference numeral **18**. Instead of depositing the aluminum film on this organic film, as was done in the process of Figure 2, the first deposit formed on the organic film consists of the appropriately disposed indexing strips, as symbolized by rectangle **25**. On top of these indexing strips, the aluminum film is then deposited, as symbolized by rectangle **26**. At this point in the process, the inspection of the previously formed aluminum film is preferably carried out to insure its freedom from blemishes, and perfectly formed portions are selected for subsequent utilization. This step which is, again, not essential to the practice of the invention, is symbolized by rectangle **27** of Figure 3. On the exposed surface of the aluminum film there are next deposited the phosphor strips which constitute the light emissive portions of the cathode ray tube screen structure, this operation being symbolized by rectangle **28**. The sub-assembly heretofore produced thus comprises a sandwich-like arrangement of an organic film, indexing strips, aluminum film and phosphor strips adjacently disposed in the order named. In the next step, symbolized by rectangle **29** of Figure 3, this sub-assembly is deposited on the binder-coated glass substrate formed in step **24**, so that the phosphor strips will be in contact with the binder. Finally the entire structure so formed is baked until the organic film has been substantially completely vaporized, as indicated by rectangle **30**.

Note that in the process diagrammed in Figure 3 the deposition of indexing strips and aluminum film on top of the organic film may be carried out automatically in exactly the same way as in the process of Figure 2, except that the order in which these two operations are carried out is reversed. Similarly, the inspection and surface selection may be carried out automatically as explained in the discussion of Figure 2. The additional deposition of the phosphor strips on this sub-assembly, prior to its combination with the glass substrate to form the complete screen structure, permits the deposition of these phosphor strips by automatic processes similar to those by which the indexing strips are deposited. That is, the organic film, after having been coated with indexing strips and aluminum film may be continuously sprayed, first with a phosphor emissive of red light, for example, together with a photosensitive emulsion, then with a phosphor emissive of green light, again with a photosensitive emulsion and finally with a phosphor emissive of blue light and a photosensitive emulsion. Between applications of any two successive ones of these different phosphors, the film is passed beneath an opaque mask, slit so as to permit illumination of a region corresponding to one phosphor strip, successive illuminations being produced at such a rate, relative to the rate of passage of the film under the slit, that portions spaced in accordance with the requirements of phosphor strip configuration of that particular color become developed and fixed, after which the remainder of the undeveloped phosphor of that particular color is washed off.

It will be understood that still further modifications of the method will occur to those skilled in the art without departing from my inventive concept. Therefore, I desire the latter to be limited only by the appended claims.

I claim:

1. The method of forming a screen structure for cathode ray tubes, said method comprising the steps of: forming a first sandwich-like assembly of a solid transparent substrate and a layer of fluoroscent materials, forming a film of organic material having approximately the same surface area as said layer of fluoroscent materials, depositing on said organic film a metal film of electron permeable thickness to form a second sandwich-like assembly of organic material and metal, depositing said second assembly on said layer of fluorescent materials, and baking the structure so formed until said organic film has been substantially completely vaporized.

2. The method of forming a screen structure for cathode ray tubes on a glass substrate coated with a binder for phosphor materials and including a face-plate, said method comprising the steps of: forming externally of said substrate a film of organic material, depositing a layer of aluminum on said organic film and a layer of phosphor materials on said aluminum film to form a sandwich-like assembly of organic film, aluminum and phosphor materials, depositing said assembly on said

binder coated substrate with said phosphor materials in contact with said binder and baking the structure so formed until said organic film has been substantially completely vaporized.

3. The method of forming a screen structure for cathode ray tubes on a glass substrate coated with a binder for phosphor materials and including a face-plate, said method comprising the steps of: forming externally of said substrate a film of organic material, depositing spaced parallel strips of indexing materials on said organic film, depositing a layer of aluminum on said strips of indexing materials and on said organic film in the spaces between said strips, and depositing a layer of phosphor materials on said aluminum film to form a sandwich-like assembly of organic film, indexing materials, aluminum and phosphor materials, depositing said assembly on said binder coated substrate with said phosphor materials in contact with said binder and baking the structure so formed until said organic film has been substantially completely vaporized.

4. The method of forming a screen structure for cathode ray tubes on a glass substrate coated with a binder for phosphor materials and including a face-plate, said method comprising the steps of: forming externally of said substrate a film of organic material, depositing a layer of spaced parallel strips of indexing materials on said organic film, depositing a layer of aluminum on said strips of indexing materials and on said organic film in the spaces between said strips, and depositing on said

aluminum film spaced strips of phosphor materials in predetermined geometrical configuration relative to said strips of indexing material to form a sandwich-like assembly of organic film, indexing materials, aluminum and phosphor materials, different ones of said phosphor strips being made of materials responsive to electron impingement to emit light of different primary colors, depositing said assembly on said binder coated substrate with said phosphor strips in contact with said binder and baking the structure so formed until said organic film has been substantially completely vaporized.

5. In the method of forming a screen structure for cathode ray tubes on the surface of a first inorganic material, the steps of: forming a smooth-surfaced film of organic material, depositing on said organic film a film of a second inorganic material of electron permeable thickness, thereby rendering said film susceptible of inspection for flaws after formation but prior to deposition on said surface, and depositing the assembly of organic material and second inorganic material on said surface of said first inorganic material as a step in the manufacture of said screen structure.

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