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CATHODE-RAY TUBE AND METHOD OF MAKING SAME

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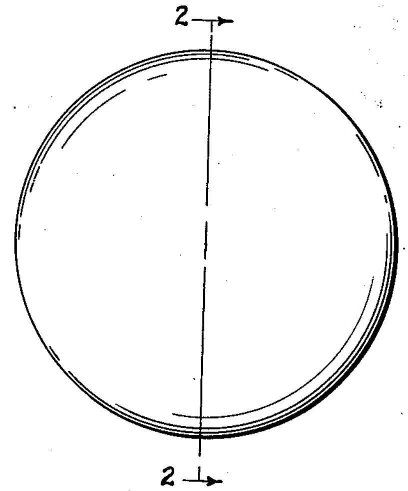

Fig. 1

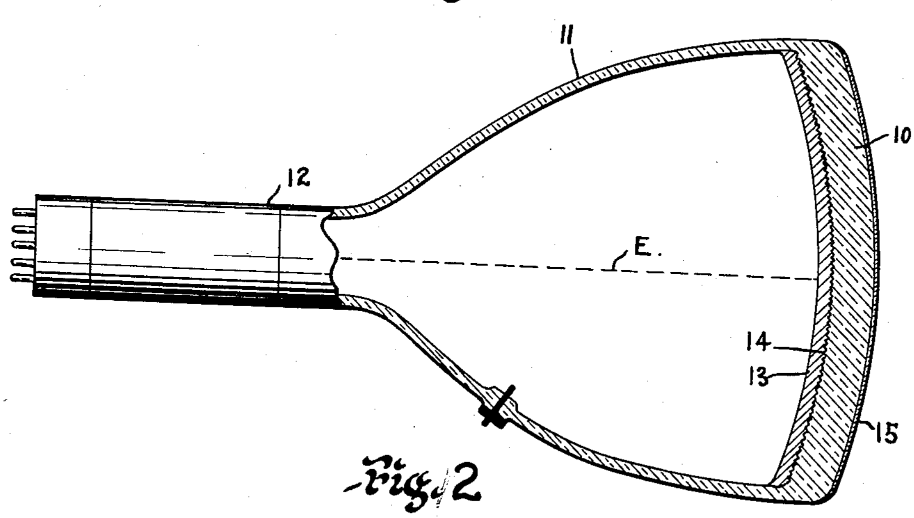

Fig. 2

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CATHODE-RAY TUBE AND METHOD OF MAKING SAME

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4 Claims. (Cl. 313—92)

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This invention relates to improvements in devices of the type wherein illuminated images are produced on a viewing screen and relates particularly to the provision of novel means and method of improving the observation qualities of such images.

One of the principal objects is to provide novel means and method of effectively eliminating specular and other reflections from the image-producing portion of a cathode ray tube or the like while increasing or effectively introducing no change as to contrast discrimination of the image produced by the inner phosphor layer of such a tube.

Another object is to provide a cathode ray tube or the like with an outer surface reflection-reduction coating and an inner light diffusing surface on which is superimposed a layer of phosphor responsive to and adapted to fluoresce when bombarded by an electron stream whereby the said outer reflection-reduction coating will function to reduce reflections from light sources externally of the tube as well as to simultaneously eliminate specular reflections from such sources and the inner light diffusing surface will function to eliminate specular reflection from said inner surface while effectively introducing no change as to definition of image.

Another object is to provide a tube of the above character with a light diffusing surface substantially in the plane of the image-producing surface whereby the definition of the image visible through the diffusing surface will be effectively unaltered.

Other objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawings and it will be apparent that many changes may be made in the details of construction, arrangement of parts, and steps of the method shown and described without departing from the spirit of the invention as expressed in the accompanying claims. I, therefore, do not wish to be limited to the exact details of construction, arrangement of parts and steps of the method shown and described as the preferred form only has been given by way of illustration.

Referring to the drawings:

Fig. 1 is a front elevational view of the cathode ray tube embodying the invention; and

Fig. 2 is an enlarged sectional view taken as on line 2—2 of Fig. 1 and looking in the direction indicated by the arrows.

One of the major problems encountered in the use of cathode ray tubes, for example, in television has been the presence of annoying surface reflections as well as specular reflections of outside sources of illumination from the outer and inner surfaces of the tube.

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Many attempts have been made to obviate such reflections as, for example, by placing an outer light diffusing surface on the face of the tube. Although a light diffusing surface of this nature did effectively reduce specular reflection, its distance forwardly of the plane of the image produced by the fluorescence of the inner phosphor coating when bombarded by the electron stream of the tube, due to the inherent thickness of the material of the face of the tube, was greatly deteriorated and was much less discriminating than with tubes having no such light diffusing surface thereon. This deterioration was such as to render the placing of an outer light diffusing surface on tubes of this nature undesirable and impractical for use.

One of the primary objects of this invention, therefore, is to provide novel means and methods of eliminating such annoying reflections while introducing effectively no deterioration as to the definition or discrimination of image.

This has been accomplished by providing the front surface of the tube with a coating so controlled as to effectively eliminate surface reflections as well as specular reflections from light sources externally of the tube and through which the image produced by the bombarded phosphor coating of the tube will be substantially unaltered as to its definition and discrimination. Such coatings, while extremely efficient as to reduction of surface reflections and specular reflections from the outer surface of the tube, do increase the light-transmitting characteristics of said outer surface whereby a secondary specular image may be reflected by the inner surface of the tube. In following the teachings of the present invention and in order to eliminate such secondary specular image from the inner surface of the tube, the said inner surface is provided with light-diffusing characteristics. By forming the inner surface light-diffusing and due to the fact that it is substantially in the plane of the image produced by the fluorescing phosphor coating inwardly of the tube the said image will be effectively unaltered as to its definition, discrimination and contrast.

It is well-known that such independent surface treatments are not new but the essence of the present invention resides in the combining of an outer reflection-reduction coating with an inner light-diffusing coating to overcome the difficulties of the prior art as set forth above and which have been found to provide very simple, efficient and economical means for accomplishing the desired results while introducing effectively no change as to the definition, discrimination and contrast of image.

Referring to the drawings wherein like characters of reference designate like parts throughout the several views, in Figs. 1 and 2 there is illustrated a cathode ray tube embodying a transparent face portion 10, conical side walls 11 and a neck portion 12. The side walls 11 may be formed either of glass or metal as desired. The neck 12 contains a conventional electrical discharge device (not shown) which is adapted to direct a moving beam of electrons E toward the face portion of the tube 10 so that the electrons will engage a fluorescent screen 13 deposited by conventional methods upon the inner surface 14 of the face of the tube. The fluorescent screen 13 is formed of a plurality of tiny phosphor particles each of which is capable of fluorescing when contacted by the electron beam E.

In following the teachings of the present invention, the inner surface 14 of the face of the tube 10 is initially provided with a light diffusing surface whether by grinding, sand blasting, acid etching, or by any other known method prior to the depositing of the phosphor coating 13 thereon. The light diffusing surface 14, therefore, is in substantially the same plane as the image produced by the phosphor coating 13 when bombarded by the electron stream E and therefore avoids deterioration of the definition of the resultant image as would be the case if the light diffusing surface were placed on the outer surface of the face 10 and spaced considerably from the plane of the image by the inherent thickness of the material of the face. This light diffusing surface eliminates spherical reflections which might result from light from an outside source.

To further eliminate specular reflection as well as other surface reflections from outside sources, the outer surface of the face 10 is provided with a reflection-reduction coating 15. This coating may be formed as follows:

By evaporation of calcium or other fluorides on the outer surface of the glass face 10 or by wetting the face with silicic acid and treating with hydrochloric acid to precipitate the silicic acid; another type is made as a film of barium stearate which is produced by dipping the face in water containing barium salts and having a layer of stearic acid on top; others are films of magnesium fluoride, calcium fluoride, sodium fluoride or sodium aluminum fluorides; still others are chemical decompositions of salts.

The preferred reflection-reduction coatings, however, are formed in accordance with the teachings of Moulton Patent No. 2,432,484, issued December 9, 1947, and Moulton application Serial No. 739,545, filed April 5, 1947, and comprising compositions consisting of colloidal suspensions containing from about 0.1 to 6.0 per cent by weight of submicroscopic, microgranular, discrete particles of solid anhydrous transparent material such as silica, magnesium fluoride, lithium fluoride, strontium fluoride, calcium fluoride, barium fluoride or cryolite substantially uniformly dispersed in a volatile liquid inert to the particles, with the particles being approximately spherical in shape and substantially less than one-quarter of the wave length of light in diameter.

The glass surface can be provided with the reflection-reduction coating by applying to the surface a thin layer of the above composition and causing it to dry, leaving a dry coating of very minute ultra-microscopic particles on the surface. It is desirable to control the concentration of the particles in the suspension to produce a reflection-reduction coating having a resultant thickness of approximately one-quarter wave length of light.

The reflection-reduction coating thus formed will comprise sub-microscopic, discrete, microgranular, transparent solid particles which are so deposited on the surface as to form minute projecting irregularities on said surface, the concentration of the particles in the irregularities decreasing from the surface of the glass outwardly and the material of the particles being such that the effective index of refraction of the reflection-reduction coating varies from substantially unity at the layer-air interface to an index value which progressively increases as it approaches the surface of the glass where it substantially approximates the index of refraction of said glass.

In order to render the above coating more resistant to abrasion, a small amount of tetraethylorthosilicate may be incorporated in the colloidal sub-microscopic suspension.

Other reflection-reduction coatings can be formed by following the teachings of Cartwright et al. Patent Nos. 2,207,656 issued July 9, 1940, 2,281,474 issued April 28, 1942, and 2,281,475 issued April 28, 1942.

For example, a reflection-reduction coating suitable for the purpose can be formed in accordance with the above patents by applying to the glass surface a layer of a suitable substance having an index of refraction intermediate the index of refraction of the optical element and the index of refraction of air and having an optical thickness approximately $x/4$ of the wave length of preselected light, x being a positive odd integer not greater than 9 and preferably being 1. A film of lithium fluoride, sodium fluoride, sodium aluminum fluoride, calcium fluoride, or the like, of the appropriate optical thickness and appropriate index of refraction, on the surface of the glass will very greatly diminish light reflection from the surface. Such a film can be deposited by evaporation onto the glass, with the evaporation being controlled so as to produce a layer with an optical thickness of approximately one-quarter of a wave length of the light and with an effective index of refraction approaching the square root of that of the glass to which it is applied. The film can be improved with respect to ruggedness and tenacity by subsequently baking at a temperature between 300° C. and 500° C. for a period of time sufficient to effect the desired improvement.

Still another method for reducing reflections from the surface of the glass is the skeletonizing process wherein the surface is treated with a solution of fluosilicic acid having a quantity of silica dissolved therein ranging from saturation to about 3 millimoles supersaturation per liter, the treatment being for such a length of time as will produce on the surface a skeletonized film of substantially pure silica of desired depth and index of refraction, whereby the desired reduction in reflection is accomplished, the depth being indicated by the wave length of light predominantly reflected by the surface. The treatment is preferably accomplished by immersing the glass surface in the solution while the solution is maintained under agitation.

Another method of forming a reflection-reduction coating is by providing a solution of fluosilicic acid having a molar concentration of between about 1.25 and about 4 at a temperature not exceeding about 70° C., said solution being supersaturated with respect to silica to the extent of from about 4 to 16 millimoles per liter. Immersing the glass surface in the solution will form a transparent hard film of silica on the surface, the time of immersion being controlled in accordance with the thickness desired of the coating. The resultant coating will substantially reduce the reflectivity of the surface to which it is applied.

The above reflection-reduction coatings, while being efficient as to the elimination of specular reflections and other reflections from outside sources, are particularly desirable because they introduce substantially no deterioration in the definition of the image. On the other hand, they have been found to introduce an overall increase in the discrimination of image. This effect is due partly to the reduction of halation which might result from light passing through the material of the face 10 of the tube from the fluorescing phosphor particles and thence being internally and rearwardly reflected by the outer surface of the tube whereby other spaced and normally non-fluorescing particles of the phosphor will be illuminated and result in the introduction of halation. The reflection-reduction coating, therefore, in addition to reducing the reflection of light from outside sources also functions to reduce the reflections of light emanating from the fluorescing particles of phosphor when bombarded by the electron stream and, therefore, greatly increases the definition of the resultant image.

The difficulties inherent to such internal reflections are clearly set forth in co-pending application Serial No. 155,514 filed April 12, 1950 by Robert Bowling Barnes.

Although it has been described that the inner light diffusing surface may be formed by sand blasting, acid etching or other known methods, the said inner surface 14 of the tube may be provided with a coating of a composition comprising a transparent liquid bonding agent having uniformly dispersed therein small nearly spherical transparent particles or may be provided with any other desired light diffusing layer. Such coatings may be applied by painting, spraying, dipping or other suitable method and when the liquid is dry and hard or becomes polymerized, the surface will have a texture simulating a multitude of small contiguously related spherical elements with partially filled depressions therebetween whereby light impinging thereon and which would normally cause specular reflections will be diffused and the image forming characteristics thereof destroyed.

It is particularly pointed out that the liquid and particles used must be of the known type having no detrimental effect upon the phosphor.

From the foregoing, therefore, it will be seen that specular reflection from both the inner and outer surfaces of the face of the tube will be eliminated while introducing substantially no detrimental deterioration of the definition of the image. This is due primarily to the fact that the light diffusing surface is placed internally of the tube and in adjacent relation with the plane of the image produced by the closely related particles of phosphor which are in superimposed relation with the light diffusing surface and which produce the image when bombarded by the electron stream E. The fact that the outer surface is provided with a reflection-reduction coating rather than a light diffusing surface and that such reflection-reduction coatings tend to increase the definition of the image rather than to deteriorate the same, results in a tube having a better overall performance.

It might be said that slight deterioration of the image which might result from the inner light diffusing surface is more than compensated for by the increase in definition resulting from the outer reflection-reduction coating so that the resultant tube, therefore, will not only cause the image to be more clearly visible but will further eliminate annoying specular reflections and as well as other undesirable surface reflections from external sources.

I claim:

1. The tube face of a cathode ray tube of the type having a fluorescent screen and an electron gun for bombarding said fluorescent screen to produce a luminous image to be viewed by an observer, said tube face comprising a portion of relatively rigid transparent material supporting on the inner side surface thereof the fluorescent screen whereby, when in use, light from said luminous image may be transmitted therethrough to be visible to the observer's eyes, said tube face having, on the outer side surface thereof, a coating of transparent material having an effective index of refraction and optical thickness such as to substantially increase transmission of light rays striking said outer surface from a light source exteriorly thereof and whereby the reflection of said light rays to the observer's eyes will be materially reduced, and said tube face further having light-diffusing means on said inner side surface which is such as to break up specular reflection of light from said light source exteriorly thereof which might otherwise be visible to the observer's eyes, said light-diffusing means being disposed between said inner side of the tube face and the fluorescent screen and in intimate contact therewith whereby it is in such close proximity with the luminous image produced on bombardment of the fluorescent screen, when the tube is in use, as to have substantially no effect upon the definition of the image, said transparent coating on said outer surface of the tube face simultaneously increasing the transmission of light from said luminous image through said outer surface whereby the amount of light from said image reflected back toward the inner surface of the tube face is reduced, and said reduced amount reflected back being broken up by the light-diffusing means on said inner surface whereby halation is substantially eliminated and increased definition and contrast of the image as viewed by the observer is obtained.

2. A cathode ray tube of the character described having a light-diffusing surface on the inner side of the face thereof for breaking up specular images normally reflected by said side from externally of the tube, a layer of fluorescent material disposed over said light-diffusing surface in intimate contact therewith and adapted when bombarded by an electron stream to emit a luminous image for transmission through the face of the tube, said light-diffusing surface being located adjacent the image produced by bombardment of the fluorescent material so as to have substantially no effect on the definition of said image as it is transmitted therethrough, and a transparent coating on the outer side of the face of the tube, said transparent coating comprising sub-microscopic, discrete, micro-granular, transparent solid particles arranged on said

outer side in the form of minute projecting irregularities with the material of the particles being such that the effective index of refraction of the reflection-reduction coating formed thereby varies from substantially unity at its air interface to an index value which progressively increases as it approaches the outer surface of said face where it substantially approximates the index of refraction of said face whereby simultaneously transmission of said luminous image through the outer side of the face of the tube is increased and the amount of light from said luminous image reflected back is decreased, and with the amount reflected back being diffused by said light so as to substantially increase contrast and definition of the image when viewed by an observer, and said coating on the outer side of the tube face simultaneously reducing the reflection of light, by said surface, from exteriorly of the tube.

3. A cathode ray tube of the character described having a layer of fluorescent material disposed on its inner surface in intimate contact therewith and adapted when bombarded by an electron stream to emit a luminous image for transmission through the face of the tube, said inner surface in intimate contact with the layer of fluorescent material embodying a plurality of contiguously related irregularities forming light-diffusing means located substantially in the same plane as said image emitted by the fluorescent material for breaking up specular images normally reflected by said side from exteriorly of the tube while not substantially affecting said image as it is transmitted therethrough, and a transparent coating on the outer side of the face of the tube, said transparent coating being of a character and having an optical thickness such as to increase the transmission of said luminous image through the outer side of the face of the tube and said light-diffusing means breaking up the portion not transmitted and reflected back whereby the definition of the luminous image emitted by the fluorescent material is substantially improved, and said outer coating simultaneously reducing the reflection of light from exteriorly of the tube.

4. A cathode ray tube of the character described having an acid etched surface on the inner side of the face thereof forming light-diffusing means for breaking up specular images normally reflected by said side from externally of the tube, a layer of fluorescent material disposed over said light-diffusing surface in intimate contact therewith and adapted when bombarded by an electron stream to emit a luminous image for transmission through the face of the tube, said light-diffusing surface by reason of its close proximity to the fluorescent material having substantially no effect upon the definition of said image as it is transmitted therethrough, and a transparent coating on the outer side of the face of the tube, said transparent coating having an effective optical thickness and refractive index such as to increase the transmission of said luminous image through the outer side of the face of the tube, and said light-diffusing surface breaking up the portion reflected back by said outer surface whereby improved contrast and definition of the luminous image emitted by the fluorescent material is had and said transparent coating further functioning to simultaneously reduce the reflection of light from exteriorly of the tube.

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