March 27, 1945. J. C. COOK 2,372,359

LUMINESCENT TARGET

Filed July 31, 1941

FIG. 1

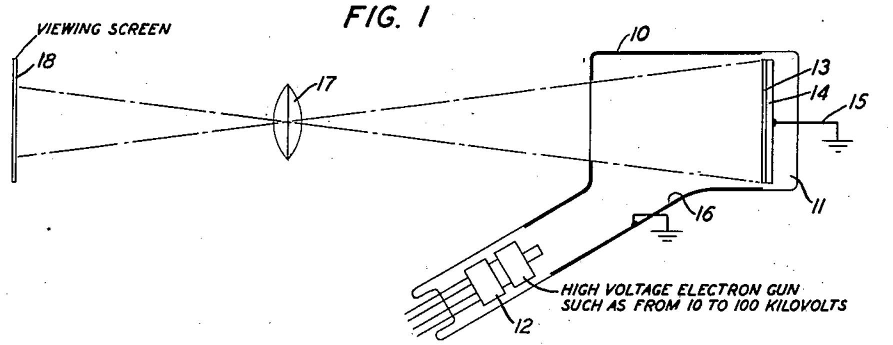


FIG. 2

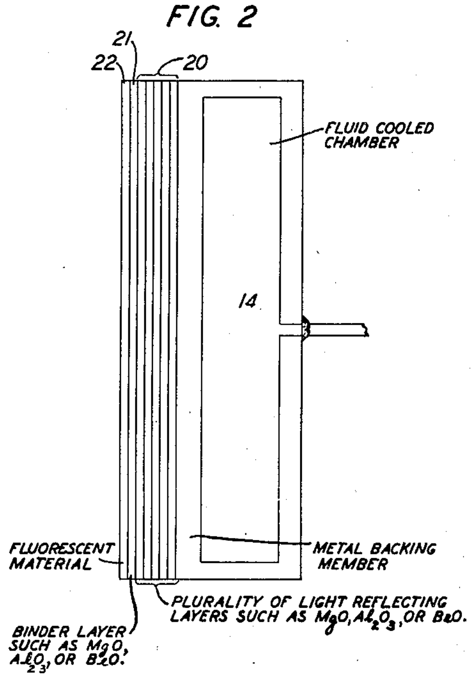
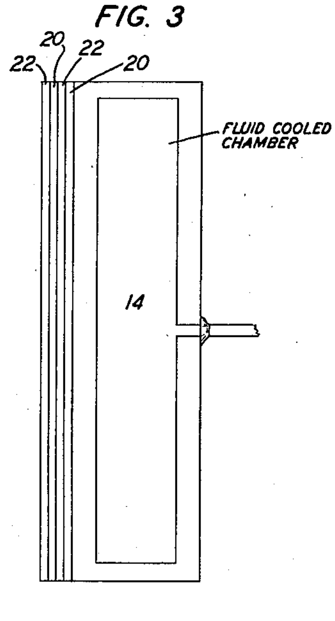


FIG. 3



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LUMINESCENT TARGET

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8 Claims. (Cl. 250—164)

This invention relates to luminescent screens or coatings and more particularly to fluorescent screens or targets for cathode ray tubes.

It is an object of the present invention to provide novel fluorescent screens or coatings suitable for producing intense light under cathode ray bombardment.

In order to obtain large television images, a projection cathode ray tube has been used. In such a tube, the voltage applied to the final accelerating member is, in many cases, as high as 50 or 100 kilovolts or more and the power in the beam is of the order of 500 to 1000 watts. This high voltage and power is necessary to obtain sufficient light for projection purposes where large bright images are desired. The present invention relates primarily to screens or targets for projection cathode ray tubes.

A luminescent element made in accordance with this invention comprises, in one form hereinafter more fully described, a metal backing serving the triple purpose of a support member, a means for transmitting heat away from the screen (it may be fluid cooled), and a means to conduct away charges imparted to the screen by the electron beam, a thick reflecting layer of light colored material, a binding cement (which may be of the same material as the reflecting layer), and one or more layers of fluorescent material. The thick reflecting layer is preferably made up of a plurality of thin layers. In a modified form, alternate layers of reflecting and fluorescent material are applied to the supporting member. A preferred material for the layer to serve as the reflecting and binding means is magnesium oxide, which is a good binder, a transmitter of light to and from the lower layers, and a reflector of light, and which does not have a deleterious effect on the phosphors used. This material in a layer of just sufficient thickness to be continuous is a better reflector than transmitter of light. Other suitable reflecting and cementing materials are aluminum oxide and beryllium oxide.

The depth of penetration of an electron beam in a target has been shown by several investigators to vary directly with the square of the voltage of the impinging beam and inversely with the density of the target material. A screen structure made in accordance with this invention (not including the metallic supporting element) of about 5 to 15 mils in thickness has been found to be sufficient for beam voltages up to about 100 kilovolts. The screen can be slightly thinner than this and still operate satisfactorily (if it is too thin, however, only a fraction of the energy of the beam will be absorbed) or it may be somewhat thicker, the limiting thickness being determined by the heat and electricity transmitting ability of the reflecting material which is not as good for very thick layers as for layers of, for example, 10 mils in thickness.

A preferred method of making a screen of this type comprises coating a metal backing plate with a continuous coating of, for example, magnesium oxide, applying a second coating after the first coating is dry, applying a binding cement of magnesium oxide to the reflecting layer of magnesium oxide and immediately sifting uniformly over the wet surface the fluorescent powder. If desired, a small amount of sodium silicate in water can be added to the binding mixture or the reflecting mixture or both, the sodium silicate resulting in a higher resistance to abrasion. Alkali silicate alone is not suitable for thick coatings because on heating, water is evolved and causes the glassy silicate to "froth" and swell up. Moisture can get out of the thin film of silicate or from thick ones which have a large amount of filler. Addition of the silicate, however, improves the magnesium oxide binder.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawing forming a part thereof in which:

Fig. 1 shows a cathode ray tube containing a fluorescent screen in accordance with this invention;

Fig. 2 is an enlarged view of a fluorescent screen and its supporting member; and

Fig. 3 shows a modification of the screen shown in Fig. 2.

Referring more specifically to the drawing, Fig. 1 shows, by way of example for purposes of illustration, a cathode ray tube of the projection television receiver type. The tube 10 comprises an evacuated container 11 containing a high potential cathode ray gun 12 of any suitable form but which is preferably of the type that will produce a high current beam at a high voltage, for example, of the order of 10,000 to 100,000 volts, at the surface of the fluorescent screen 13 which is mounted on a conducting supporting member 14. The supporting member 14 is connected by means of a lead 15 to ground which is also preferably the potential of the highest anode in the electron gun 12, which anode may be a conducting coating 16 within the walls of the tube 10, although one or more other gun elements may be at ground potential also. The container 11 is so shaped that the picture developed on the fluorescent screen 13 by the scanning of the beam of electrons generated by the gun 12 and deflected over a field thereon by any suitable deflecting means (not shown), is projected by means of a suitable lens system, represented by the single lens 17, upon a viewing screen 18.

Reference will now be made to Fig. 2 which shows in greater detail the structure of a luminescent screen made in accordance with this invention. Smooth layers are shown in Fig. 2 but this is merely for simplicity in description as it will be understood that these layers, formed from successive coatings of material, are in some degree, at least, interlocking, due to the composition and structure of the particles making up the individual layers.

The screen or target of this invention preferably comprises one or more reflecting layers on a metallic backing plate, these reflecting layers being of a material which has the following properties: (1) it has a relatively high (compared to such substances as glass which have been used in the prior art) reflectivity in the visible and ultra-violet portions of the spectrum; (2) it has a low vapor pressure in vacuum so that it is stable over a long period of time at temperatures up to 450° C. and when exposed to electron bombardment and ultra-violet light; (3) it is inert at ordinary temperatures and with respect to the fluorescent material used, which in a preferred arrangement is a combination of metallic sulphides with suitable metal activators therein; (4) it has good mechanical adherence and coherence; and (5) it does not discolor, evolute gases or contaminate the phosphors. Upon this layer is bound the fluorescent material by a suitable cement which may be of the same material as the reflecting coating or a mixture of this material with other materials.

Suitable reflecting materials which have all of the above properties are magnesium oxide (MgO), aluminum oxide (Al_2O_3) and beryllium oxide (BeO). These materials are also suitable as binding materials to cement the fluorescent material to the reflecting coating. Other white powders could be used instead of these but these have been found to be best because (1) they are chemically very inert; (2) they have desirable reflecting properties to an unusual degree; and (3) they all have forms which are somewhat gelatinous when suspended in water and which when dried provide a coherent coating.

In order to utilize substantially all of the large beam energy which is provided in television projection tubes, a relatively thick coating of fluorescent material. A high reflectivity of the binding material in the under reflecting layer or layers is also necessary. The thickness of the fluorescent material should be sufficient to absorb all or at least substantially all of the energy of the electrons in the beam. This coating generally varies form a few mils to 10 to 15 mils of thickness. By way of comparison, the average size fluorescent screen crystal is around 1 mil to an edge. The most intense fluorescence occurs on the side where the beam first strikes it but the beam, however, penetrates to the under layers of the fluorescent material and a portion of the resulting light is transmitted through the material and is of some importance in adding to the intensity of the final spot of light. By far the brightest spots are those from screens which are adapted to be viewed from the same side that receives the electrons from the scanning beam, as in the arrangement of Fig. 1. In order to increase the amount of light obtained from the under layers of the fluorescent material, the relatively high reflecting layer 20 is used. This reflecting layer 20 is coated on a metal backing 14 which is preferably a heat conducting disc of copper or any other suitable material. This disc or metal backing member serves the triple purpose of a support member, a means for transmitting heat away from the screen (that is, it may be cooled by water, oil, air or any other suitable fluid caused to flow adjacent thereto or therein by any suitable means), and as a means to conduct away charges imparted to the fluorescent screen by the electron beam inasmuch at it is placed at the same potential as the conducting coating 16 in the tube 10. The reflecting layer 20, which may be as shown in Fig. 2 a plurality of layers, is thick enough to be continuous and thus is a good reflecting surface, and thin enough so that there is a minimum heat insulation between the fluorescent particles and the metal backing layer. These requirements determine the thickness as between a lower limit of about 1 mil and an upper limit which may be as high as an inch. Below 1 mil the material tends to be discontinuous while the maximum thickness is fixed by the heat conductivity which, of course, varies with the particular material used. A white reflecting under-surface is desirable in order to redirect the light to the front of the screen. While a metal backing may be used as a reflecting material it also has certain disadvantages. Copper has been used but this tends to shift the color of the luminescence towards the red portion of the spectrum. Also, metals have a fairly high reflectivity in the visible portion of the spectrum and a very high reflectivity for infra-red (heat) radiations. White or other light colored crystalline powders typically possess a very high reflectivity for visible radiations and very low reflectivity (i e., high absorption) for the infra-red radiations. These latter properties are ideal for the type of tube for which this invention is primarily adapted. Moreover, metals such as silver and aluminum tend to discolor the fluorescent particles and are not for this reason entirely suitable for reflecting materials. Furthermore, the metals themselves are not suitable as binders.

A preferred method of making the screen in accordance with this invention, given by way of example, comprises coating the metal backing plate 14 with a continuous coating of a three per cent suspension of magnesium oxide, allowing this coating to dry, applying a second coating 20, allowing this coating to dry, applying a third coating 20, allowing this to dry, and applying additional coatings and allowing them to dry until there is built up a reflecting coating of the desired thickness. A binding cement 21 made by suspending 3 grams of light calcined magnesium oxide in 100 cubic centimeters of water, is then applied to the reflecting layer or layers 20 and immediately thereafter the fluorescent powder is sifted uniformly over this wet surface. The fluorescent powder 22, which may be of any well-known material capable of very high light intensity and which is preferably a mixture of zinc and cadmium sulphides activated with copper and manganese (in order to produce a white luminescence), is then sifted uniformly over the cementing surface of magnesium oxide. A suitable fluorescent powder, best known to the trade as Patterson No. 66 powder, is manufactured by the Patterson Screen Company. Other suitable fluorescent powders are calcium tungstate, synthetic willemite, or a silicate. The fluorescent powder is cemented in a thick layer by the fine, semicolloidal MgO, Al_2O_3 or BeO suspension. The sulfide particles are large (1 mil) and cannot be reduced in size so a rather large bulk of cement is needed in a thick film. These materials are very suitable because they are not vitreous and consequently are difficult to degas in thick films. The excess fluorescent powder may be removed after the drying process, which may be at room temperatures or by baking the tube at about 100° C., by inverting the screen and tapping.

In preparing the screen for the cathode ray tube, the conducting layer 16 of aquadag or any other suitable material is put on first and heated in air at a temperature of about 450° C., and in some cases even higher, to remove carbonaceous volatile materials. If the fluorescent screen is mounted within the tube before the conducting coating is put on and the tube and screen then baked at 450° C., the fluorescent screen tends to oxidize. Hence the aquadag or other conducting layer is put on first. After the screen is mounted within the tube, dried, and the excess fluorescent material removed, the bulb is then baked at from 300° C. to 400° C. and perhaps even as high as 450° C. for a period of about one hour to remove gas from the glass, metal, etc. The time and temperatures given are not very critical, however.

The neck of the tube containing the gun is then sealed on to the glass member containing the screen and the tube baked in a gentle stream of nitrogen at about 300° C. for from ten to sixty minutes. The tube is then evacuated and may be, if desired, baked after evacuation although the latter step is not essential. The electron gun is then sealed into the tube which is then pumped to the required degree of vacuum, as well known in the art.

If desired, a small amount (say 3 cubic centimeters) of 20 per cent solution of sodium or potassium silicate in water can be added to 100 cubic centimeters of the binding mixture, the sodium silicate in the binder (or in the reflecting coating or both) resulting in a higher resistance to abrasion. While sodium and potassium silicates are well-known binders, they are not suitable when used alone to bind thick screens as they swell up when baked but when used in combination with magnesium oxide or other suitable binding materials they act as very good hardeners. Other glass-like materials (with a suitable porous material filler such as MgO so that water and gases can escape from the thick coating) can be used instead of the alkali silicates.

A feature of this method of forming the fluorescent screen is that all steps can be conducted at room temperatures, if desired, although the final fluorescent screen may be baked at temperatures of about 100° C. if quicker drying is desired. The method is particularly suitable for screens of the sulphide type, that is, for example, screens using powders made of mixtures of zinc and cadmium sulphides plus activator materials which are usually copper, silver or manganese, depending upon the color of the luminescence desired.

If a silicate is used as the fluorescent material, magnesium oxide is not needed as a binder although the reflecting coating of magnesium oxide is used. If silicate particles are about of 1 mil size, exactly the same method as with a sulfide is used. As it is possible to grind silicates to very small sizes without destroying their fluorescent properties, coatings of these materials can be applied with no permanent binder. Thick coatings, however, require a binder of some sort. The nature of willemite is such that no reflector is needed as it is a white reflecting powder. A thick coating with a small amount of a silicate as a binder will provide a satisfactory screen but the brilliance is less than from sulfides.

In the case where an oxygen-containing phosphor, such as willemite or calcium tungstate, is used, an interesting condition exists in that these materials are fair reflectors. Also they can be ground to very fine powders and will bond well with a small amount of an alkali silicate in thick layers and provide the "filler" porosity effect themselves so the silicate can be outgassed. A thick screen of these materials using a small amount of a silicate binder is superior mechanically to that in which the silicate is mixed with MgO, for example, but the maximum luminous intensity and conversion efficiency of these phosphors is not as good as the sulfide type. Thick coatings of these materials have been found in practice to require a binder, although the thin translucent screens used for the oscillograph type cathode ray tube, that is, where the screen is viewed from the rear, do not require a binder.

While in the arrangement shown in Fig. 2, a plurality of reflecting layers **20** of magesium, aluminum, or beryllium oxides is shown (and this is the most satisfactory way of forming a thick coat of material on metal), it is possible to make this reflecting coating in one thick layer. The binding cement is then applied to this reflecting coating or the thick reflecting coating can also comprise the binding cement, the fluorescent material being in this case applied to the reflecting coating before it is dried. In another modification, shown in Fig. 3, a thick and highly reflective screen can be obtained by applying successive layers of binder **20** and fluorescent material **22** to the conducting backing member **14**. As both the layers **20** and **22** are translucent, there is a penetration of the light rays from the lower levels of fluorescent material out into the tube through the upper layers. The number of alternate layers of fluorescent material and reflecting material is determined by the penetration of the electron beam which, of course, is dependent on the square of the voltage of the beam at the screen.

The screens or targets made in accordance with this invention produce intense light and have excellent mechanical properties and the methods of preparing them are simple and easily reproducible. Various modifications may be made in the screen structures and the methods of forming them without departing from the spirit of the invention, the scope of which is indicated by the appended claims.

What is claimed is:

1. A target for electrons having a luminous surface which is adapted to be viewed from the same side on which it is activated comprising a supporting member, a continuous light-colored reflecting member in the form of a coating on said supporting member, and a coating of fluorescent material bound to said reflecting member by a binder comprising a moist coating of an oxide of one of the group of elements consisting of magnesium, aluminum and beryllium.

2. The combination of elements as in claim 1

and being further characterized in that said light-colored reflecting member comprises an oxide of one of the group of elements consisting of magnesium, aluminum and beryllium.

3. The combination of elements as in claim 1 and being further characterized in that said light-colored reflecting member comprises an oxide of one of the group of elements consisting of magnesium, aluminum and beryllium, said reflecting member being of a thickness of at least 1 mil.

4. A luminous surface which is adapted to be viewed from the same side on which it is activated comprising a supporting member, a continuous light-colored reflecting member in the form of a coating on said supporting member, and a coating of fluorescent material bound to said reflecting member by a binder comprising a moist coating of an oxide of one of the group of elements consisting of magnesium, aluminum and beryllium, and an alkali silicate.

5. In a cathode ray tube, a target, and means for generating a cathode ray having a voltage between 10 and 100 kilovolts at said target, said target comprising a metal supporting member, a coating of light-colored non-metallic reflecting material on said supporting member, and a fluorescent coating on said reflecting material, said reflecting material and said fluorescent coating together being from 1 to 15 mils in thickness.

6. In a cathode ray tube, a target, and means for generating a cathode ray having a voltage between 10 and 100 kilovolts at said target, said target comprising a metal supporting member, a coating of light-colored non-metallic reflecting material on said supporting member, and a fluorescent coating on said reflecting material, said reflecting material and said fluorescent coating together being from 1 to 15 mils in thickness, said reflecting material comprising one of the group consisting of magnesium oxide, beryllium oxide and aluminum oxide.

7. In a cathode ray tube, a target, and means for generating a cathode ray having a voltage between 10 and 100 kilovolts at said target, said target comprising a fluid-cooled metal supporting member, a coating of light-colored non-metallic reflecting material on said supporting member, and a fluorescent coating on said reflecting material comprising one of the group consisting of magnesium oxide, beryllium oxide and aluminum oxide, said reflecting material and said fluorescent coating together being from 1 to 15 mils in thickness.

8. An element for transforming energy imparted to it by electronic bombardment into light radiated from the surface of the element receiving the electrons comprising a backing element having good electric and heat conductivity, a light-reflecting coating on a surface of said backing element, and fluorescent material on said coating capable of emitting rays both in and above the infra-red region of the spectrum when bombarded either by electrons or by light rays above the infra-red region, said coating being predominately of material from the group consisting of the oxides of magnesium, aluminum and beryllium, and having the property of reflecting a large portion at least of the light received by it from the fluorescent layer in the region above the infra-red portion of the spectrum and dissipating to said conductive backing element a large portion at least of the received energy in the infra-red region, said fluorescent material being in the form of discrete particles distributed within said coating near the surface thereof and held in place thereby, the portion of said coating underneath said fluorescent material being thick enough to be continuous.

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