

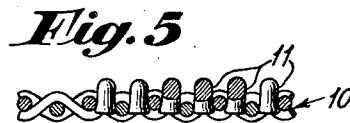
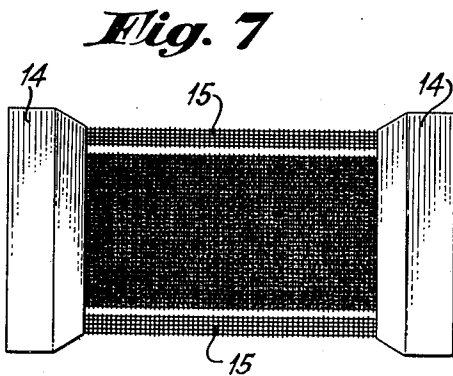
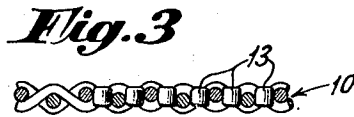
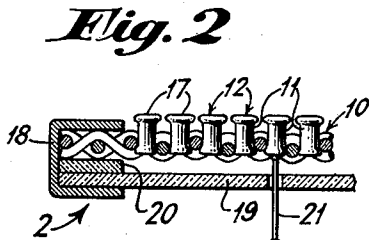
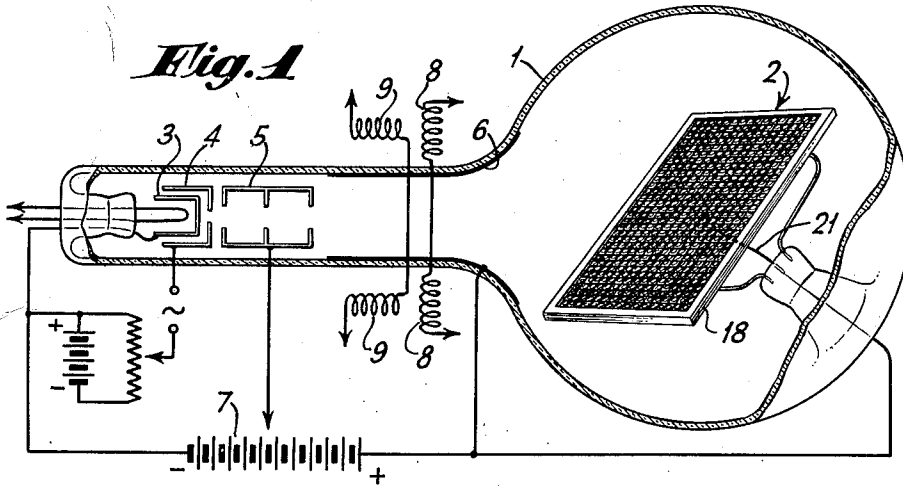
May 30, 1939.

H. W. KAUFMANN

2,160,022

SCREEN FOR CATHODE RAY TUBES

Filed Aug. 31, 1937



INVENTOR.
HENRY W. KAUFMANN
BY *Charles McClair*
ATTORNEY.

UNITED STATES PATENT OFFICE

2,160,022

SCREEN FOR CATHODE RAY TUBES

Henry W. Kaufmann, East Orange, N. J., assignor, by mesne assignments, to Radio Corporation of America, New York, N. Y., a corporation of Delaware

Application August 31, 1937, Serial No. 161,732

9 Claims. (Cl. 250—27.5)

My invention relates to luminescent screens for use in cathode ray apparatus, such as oscillograph tubes and television receiving tubes.

In the conventional cathode ray tube the fluorescent screen is often made of such materials as zinc ortho-silicate which when suitably activated, such as by the addition of manganese, produce a screen having high luminous efficiency with low input power. When a cathode ray beam of relatively low current density impinges on such a screen with moderate velocity the luminous trace is clearly visible even under conditions of moderate external illumination. To obtain a luminous trace of greater light intensity the beam current, the beam velocity, or both, must be increased, but the resulting increase in luminosity is not proportional to the increase in current density and velocity of the beam, as the screen becomes saturated at a point beyond which it is difficult to obtain greater luminosity. Moreover, the input power, which is determined by the beam current and beam velocity, must be limited, as overheating and loss of screen efficiency by decomposition of such a screen occurs with relatively low input power. The conventional screen usually does not produce a white light, a screen of zinc ortho-silicate activated by manganese having a greenish tinge which makes it undesirable for television use where a definite esthetic effect is desired.

The principal object of my invention is to provide a luminescent screen giving a pure white light and of greater luminosity than screens of the conventional type. A further object is to provide a screen which will withstand intense bombardment, and is stable and of relatively long life.

In accordance with my invention I provide a screen for cathode ray tubes or similar use, comprising a mechanically strong foundation, preferably of metal, having thereon a multiplicity of minute rodlets made of refractory material of low heat conductivity, projecting side by side and supported at their proximal ends by the foundation. The free or distal ends of the rodlets may be enlarged to form a multiplicity of minute mushroom-shaped projections from the foundation. The rodlets or mushroom-shaped projections are mounted with their free ends spaced so that the ends may be heated almost instantaneously to incandescence by the cathode ray beam without appreciable loss of heat by conduction to adjacent areas of the screen. When the cathode ray beam is removed the incandescence decreases rapidly because of loss of heat by

radiation. The incandescent ends of the rodlets give a pure white light of great intensity.

The above objects and other objects, features and advantages of my invention will appear from the following description taken in connection with the accompanying drawing in which,

Figure 1 is a longitudinal view, partially in cross section, illustrating my improved luminescent screen incorporated in a cathode ray tube;

Figure 2 is a fragmentary view, in cross section and on a greatly enlarged scale, of the screen;

Figures 3, 4, 5, and 6 are sectional views of a portion of the screen shown in Figure 2 illustrating four steps of preparation; and

Figure 7 is a view showing a preferred method of carrying out a step in the manufacture of the luminescent screen.

In the illustrative embodiment of my invention shown in Fig. 1 the tube incorporating my new and improved luminescent screen comprises a highly evacuated glass envelope 1 with a tubular arm or neck section enclosing a conventional type electron gun and a spherical section enclosing a luminescent screen assembly 2 so positioned that its front surface may be scanned by a beam of electrons from an electron gun and that the luminescent image produced by the scansion of the electron beam over the surface of the screen may be viewed or projected through a portion of the spherical section. It is therefore desirable to construct that portion of the spherical section opposite the luminescent screen of transparent optically uniform material.

The electron gun assembly is of the conventional type and comprises a cathode 3 from which an electron stream may be drawn, a control electrode 4 connected to the usual biasing battery through a source of fluctuating potential whereby the intensity of the electron stream may be modulated, and a first anode 5 maintained positive with respect to the cathode 3. The electron stream leaving the first anode 5 is accelerated and concentrated into an electron scanning beam focused on the front surface of the luminescent screen 2 by a second anode 6 which is preferably a conductive coating on the surface of the envelope 1 near the neck of the bulb, but removed from that portion of the spherical section through which the image produced on the luminescent screen may be viewed or projected. The first anode 5 and the second anode 6 are maintained at the required positive potentials with respect to the cathode 3 by the battery 7. The type of electron gun here described is highly efficient and is capable of producing a cathode ray beam car-

rying as much as 10 ma. In practice the battery 8 supplies an anode potential of 6,000-10,000 volts so that the beam may be considered as capable of delivering from 60-100 watts at the surface of the luminescent screen 2. Conventional deflecting means, such as deflection coils 8 and 9, may be used to sweep the beam in a horizontal and vertical plane to scan the luminescent screen, but it is obvious that conventional electrostatic deflection plates may be substituted for the deflection coils, if desired.

In accordance with my invention the luminescent screen which is scanned by an electron beam to produce a highly luminescent image includes, as shown in Figure 2, a foundation member 10 which is mechanically strong and which has a multiplicity of minute rodlets or projections 11 of some refractory material, such as a refractory oxide, with their distal ends out of contact with one another. The foundation member 10, preferably is foraminous, with a multiplicity of small apertures, and may conveniently be a thin foraminous metal plate or a wire mesh netting having a woof and warp of wires spaced from one another to provide a multiplicity of apertures or interstices in which the proximal ends of the refractory oxide projections are supported. I have found that a netting having 100-200 interstices per linear inch is satisfactory for this purpose. The rodlets 11 are firmly fixed in the interstices of the foundation member 10. For some applications of my device I have found it desirable to provide these rodlets with refractory caps 12, as shown in Figs. 2 and 7.

As examples of materials which may be used for the purpose of forming the oxide rodlets 11 and the caps 12 are salts, such as the nitrates of thorium, cerium, calcium, and manganese, which upon heating are converted into the oxide with increase in volume. When such salts are decomposed by heat they will produce a porous mass which is stable when raised to incandescence by bombardment of the cathode ray beam. The preferred material, however, is thorium nitrate, which may be easily decomposed by heat into thorium oxide. I have used with satisfactory results a solution of 100 grams of thorium nitrate in 100 cubic centimeters of water, to which is added some material which will serve as a flux, such as approximately $\frac{1}{2}$ gram of boric oxide. The use of such a flux produces a finished screen which is more rugged under mechanical shock. The solution is then applied to the foundation member 10 by painting, dipping, spraying or any convenient method, whereby the apertures or interstices of the foundation are filled or substantially filled with the solution. The interstices are so small that they hold the solution by capillary attraction, little or none of the material remaining on the metal foundation between the interstices. The foundation member is painted, sprayed or dipped repeatedly, and dried in air until the interstices of the foundation member 10 are completely filled. The foundation member 10, with individually supported and separate plugs of nitrate 13 in the interstices, is then rapidly heated, preferably by heat generated by an electric current passing directly through the wires constituting the mesh member, as the best results are obtained when the nitrate plugs are heated from the metal of the foundation. This may be accomplished conveniently, as shown in Fig. 7, by clamping heavy copper electrodes 14 to the opposite sides of the foundation member and passing an electric current

through the mesh between the oppositely disposed electrodes. It is desirable that the foundation member 10 be brought to a high and uniform temperature, such as about 1000° C., in as short a time as possible, which causes the individual nitrate plugs 13 to decompose into the corresponding oxides. For the purposes of obtaining uniform heat distribution throughout the mesh and especially near the edges of the mesh not held by the electrodes, I prefer to use metal guard strips 15 co-planar with and close to each edge of the member 10. These strips may be formed from the same material as the foundation member 10 and are clamped between the electrodes 15 and heated to the same temperature as the foundation member 10 by the current supplied to the electrodes.

When the wires constituting the foundation member 10 are heated, such as by passing an electric current through these wires, the nitrate plugs are converted into oxides, as indicated in Figs. 4 and 5. The portion of the nitrate plugs contacting the walls of the interstices is immediately melted and decomposed into the oxide. Heat is conducted through the oxide thus formed to the inner portion of the plugs and causes the nitrate constituting the inner portion of the plugs to be melted and decomposed. The nitrate plugs are in this way progressively decomposed into thorium oxide from those portions of the plugs which are in contact with the foundation inwardly of the plugs. Simultaneously with this action the plugs expand as the nitrate is converted into the oxide and form the rodlike members which contain in their tips a small portion of melted nitrate 16 which, as the process continues, is converted into the oxide. By such rapid heating it is possible to obtain, in a few seconds, from the plugs of nitrate 13 rodlets 11 of porous oxide (Fig. 5) which are supported at their proximal ends by the foundation member 10.

Luminescent screens made in this manner have the desired characteristics, but for certain purposes I prefer to form on the distal ends of the rodlets 11 cap portions 12 which tend to overlap those portions of the foundation member 10 between its interstices. The caps 12 may be provided by spraying the nitrate solution mentioned above over the exposed ends of the rodlets 11 formed as above described. In spraying the nitrate solution the foundation member carrying the individual oxide rodlets is preferably inclined at an angle to the direction of the spray to minimize the deposition of the material on the foundation member between the oxide rodlets. The caps 12 are then formed by decomposing the nitrate on the ends of the rodlets into the oxide by heating the assembly for a few minutes in a furnace operated at a temperature of approximately 1000° C. This heating causes the nitrates to be converted into oxides, thereby converting the rodlets 11 to mushroom-shaped projections 17 with the individually supported and mutually separated caps 12. Any nitrate which has been inadvertently deposited on the foundation member 10 between the individual plugs of oxide by the spraying process is also converted into the oxide, but this is immaterial, inasmuch as the caps 12 are sufficiently close together as to shield this portion of the screen from the cathode ray beam during operation.

A screen made in accordance with my invention may be conveniently mounted in a frame 18 so that the distal ends of the rodlets or projec-

tions face the electron gun. The frame 18 extends around the edges of the screen 2, supporting it in such a manner that it will be substantially flat over its entire surface. For purposes of rigidity I prefer to mount within this frame and behind the screen 2 a relatively thick sheet 19 of mica or other heat insulating material corresponding in area and shape to the screen 2. The mica sheet 19 may be spaced from the screen 2 by strips of mica 20 to decrease thermal conductivity from the screen 2. This assembly is mounted in the cathode ray tube, as shown in Fig. 1, by support wires 21, at least one of which serves as an electrical conductor and is connected to the foundation member 10 and to the second anode 8.

The beam is deflected to fall upon the distal ends of the rodlets in succession and to trace a pattern on the screen by the deflecting coils 8 and 9. Since the screen 2, as shown in Fig. 1, has its effective surface in a plane which is at an acute angle to the electron gun axis for the purpose of viewing the scanned side of the screen, the pattern swept out by the beam will be in the form of a quadrilateral having two opposite sides parallel and the other sides inclined toward each other at a slight angle. This effect is known as keystoneing and may be obviated in ways well known in the art as, for example, by properly shaping the magnetic pole pieces about which the coils 8 and 9 are wound. Since the individual rodlets or projections of the screen 2 are spaced from those which are adjacent, the heat generated in these rodlets or projections by the impact of the beam is lost almost entirely by radiation, the conduction from one to another being necessarily through the rodlets or projections and through the foundation member 10. This conduction is very small due to both the low thermal conductivity of the porous oxide and to its small cross sectional area transverse to the direction of the heat flow. Since radiation is practically the only channel of heat loss and since a large amount of power is expended in the small mass comprising the ends of the individual elements, the distal ends of the rodlets or projections are excited to incandescence almost instantly. Once excited they continue to be incandescent until the loss of heat by radiation, which continues over a materially greater period than the excitation period, reduces them to darkness. In the use of luminescent screens made in accordance with the present invention, the beam is constantly moving from one elemental area to another and the mass of material in the area scanned by the beam is so small at any one time that the mass becomes incandescent almost instantly. Furthermore, conduction to adjacent elements is so restricted that heat loss by radiation cools the bombarded area before the heat can spread to adjacent areas thereby limiting the spreading of the luminescent area to a minimum. With screens of the type illustrated, it is possible to obtain an efficiency of approximately 39 lumens/watt at a brightness of approximately 300 candle power/square centimeter. Thus with an input power of around 60 watts, the image produced on a screen of this type is so intense that it cannot be viewed directly. It may, however, be projected by a suitable lens system upon a projection surface having a high coefficient of reflection. It is, therefore, possible when using screens of this type to project white light images on a distant projection surface even under conditions of rel-

atively high external illumination. Such a luminescent screen is therefore entirely suitable for projection of television images.

From the foregoing description it will be apparent that various other modifications may be made in my invention without departing from the spirit and scope thereof and I desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art and set forth in the appended claims.

I claim:

1. A luminescent screen comprising a metal foundation member having a multiplicity of perforations, and rodlets of a refractory oxide fixed in said perforations to project extending substantially from a surface of said foundation member with their distal ends spaced from one another and leaving voids therebetween.

2. A luminescent screen comprising a foraminous foundation member, and projections of a refractory oxide secured in a foramina of said member to extend beyond the surface of said foundation with their distal ends spaced from one another and leaving voids between the said distal ends.

3. A luminescent screen comprising a perforated metal mesh foundation, and a multiplicity of projections of a refractory oxide with their proximal ends enclosed in and supported by the mesh and their distal ends spaced from one another and extending from the said foundation for a substantial distance.

4. A luminescent screen comprising an intersticed metal foundation, and a multiplicity of refractory oxide projections supported by their proximal ends in the interstices of said foundation and their distal ends extending substantially beyond the surface of said foundation.

5. A luminescent screen comprising an intersticed metal foundation, a multiplicity of rodlets of refractory oxide supported at one end in the interstices of said foundation and extending substantially from said foundation, and a cap of refractory oxide on the distal ends of each of said rodlets.

6. The method of forming a luminescent screen including a perforated foundation comprising substantially filling the perforations of said foundation with a readily oxidizable material selected from the group consisting of salts of thorium, cerium, calcium, and manganese decomposable into oxides by heat, and forming a multiplicity of rodlets extending from said foundation by rapidly heating said foundation.

7. The method of forming a luminescent screen including a perforated metal foundation comprising substantially filling the perforations of said foundation with thorium nitrate to form plugs of the nitrate in the perforations and progressively decomposing the plugs inwardly from the surface of the plugs in contact with the foundation by passing electric current through said foundation to heat said foundation rapidly.

8. The method of forming a luminescent screen including a perforated metal foundation comprising substantially filling the perforations with a solution of thorium nitrate, heating the foundation at a low temperature to form solid plugs of thorium nitrate in said perforations and progressively decomposing the plugs of thorium nitrate to porous thorium oxide inwardly from the surface of the plugs in contact with the foundation by subjecting said plugs to a higher temperature.

9. The method of forming a luminescent screen including a perforated metal foundation comprising substantially filling the perforations with a solution of thorium nitrate, heating the foundation at a low temperature to form solid plugs of thorium nitrate in said perforations and subjecting said plugs to a high temperature to cause

said plugs to be converted into porous thorium oxide rodlets, applying thorium nitrate to the distal ends of said rodlets and heating said ends to convert said last applied thorium nitrate into porous thorium oxide.

HENRY W. KAUFMANN.