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Kuzminski et al.

[11] **3,878,428**

[45] **Apr. 15, 1975**

[54] **CATHODE RAY TUBE HAVING SHADOW MASK AND SCREEN WITH TAILORED HEAT TRANSFER PROPERTIES**

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[73] Assignee: **RCA Corporation**, New York, N.Y.

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[21] Appl. No.: **319,375**

[52] **U.S. Cl.** **313/408;** 313/470
[51] **Int. Cl.** **H01j 29/16**
[58] **Field of Search** 313/408, 470

[56] **References Cited**

UNITED STATES PATENTS

2,728,008 12/1955 Burnside .... 313/85 S
3,392,297 7/1968 Schwartz .... 313/92 B

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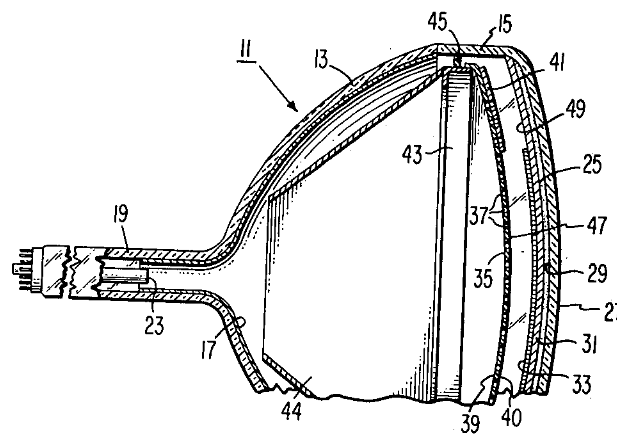
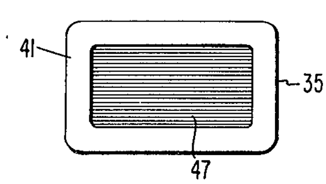
Assistant Examiner—Lawrence J. Dahl
Attorney, Agent, or Firm—G. H. Bruestle, L. Greenspan

[57] **ABSTRACT**

Cathode-ray tube comprising an evacuated envelope including a viewing window and a viewing screen comprised of a mosaic of phosphor areas of different emission colors supported on the inner surface of the viewing window. Closely spaced from the screen is a shadow mask having two opposed major surfaces and an array of apertures therein registered with the phosphor areas of said screen. At least one of the major surfaces of the mask and the inner surface of said screen have surface means for effecting faster radiative heat transfer from the central portion of the mask than from peripheral portions of the mask.

10 Claims, 10 Drawing Figures





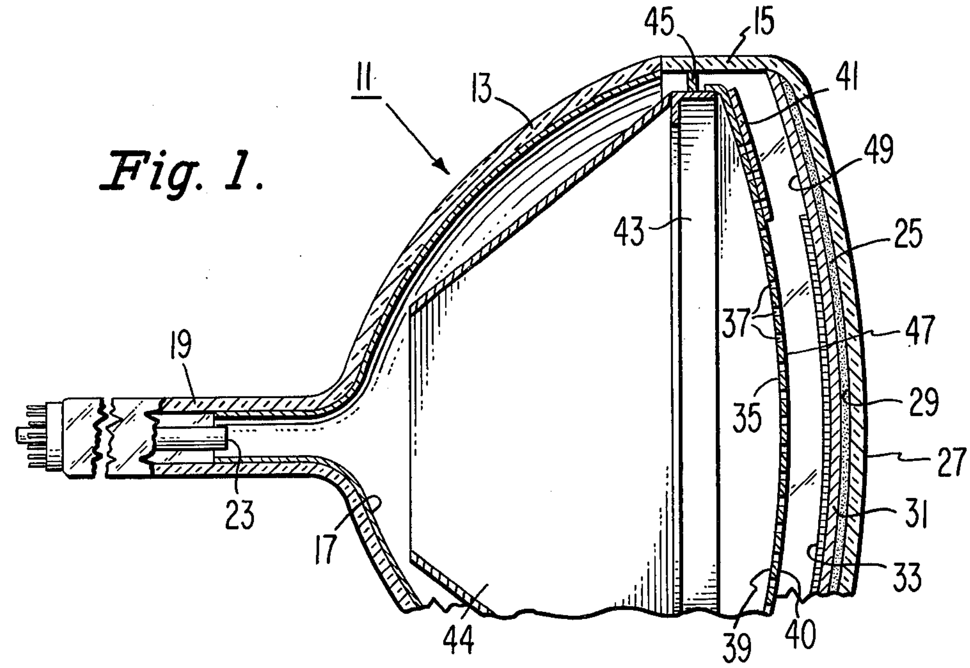


Fig. 1.

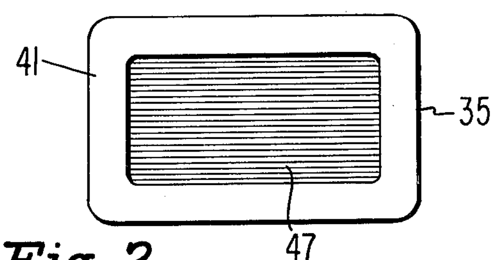


Fig. 2.

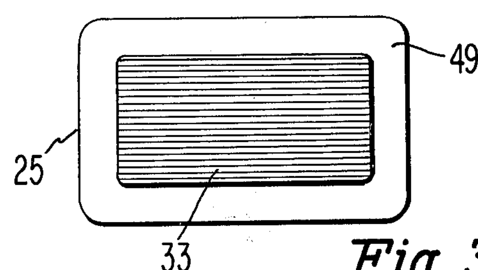


Fig. 3.

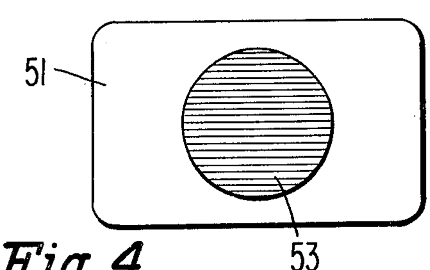


Fig. 4.

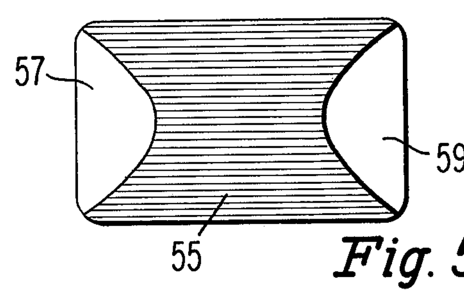


Fig. 5.

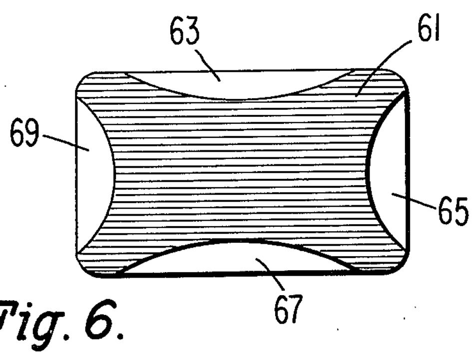


Fig. 6.

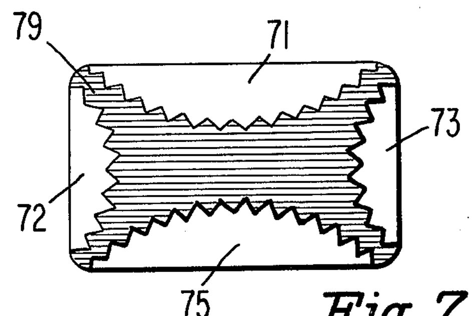


Fig. 7.

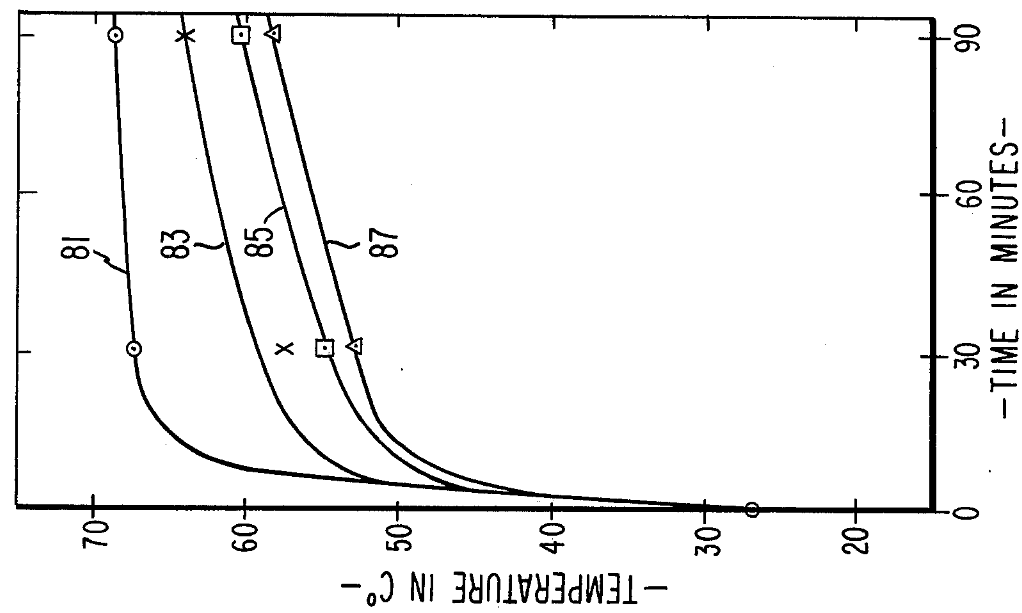
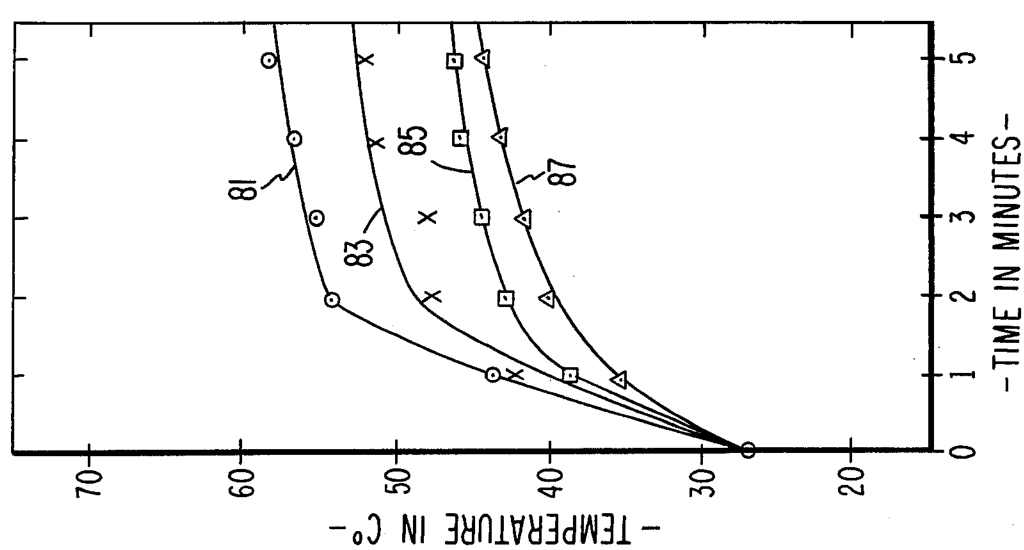

—TEMPERATURE IN C°—
70
60
50
40
30
20
—TIME IN MINUTES—
0
30
60
90
81
83
85
87

Fig. 8.


—TEMPERATURE IN C°—
70
60
50
40
30
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—TIME IN MINUTES—
0
1
2
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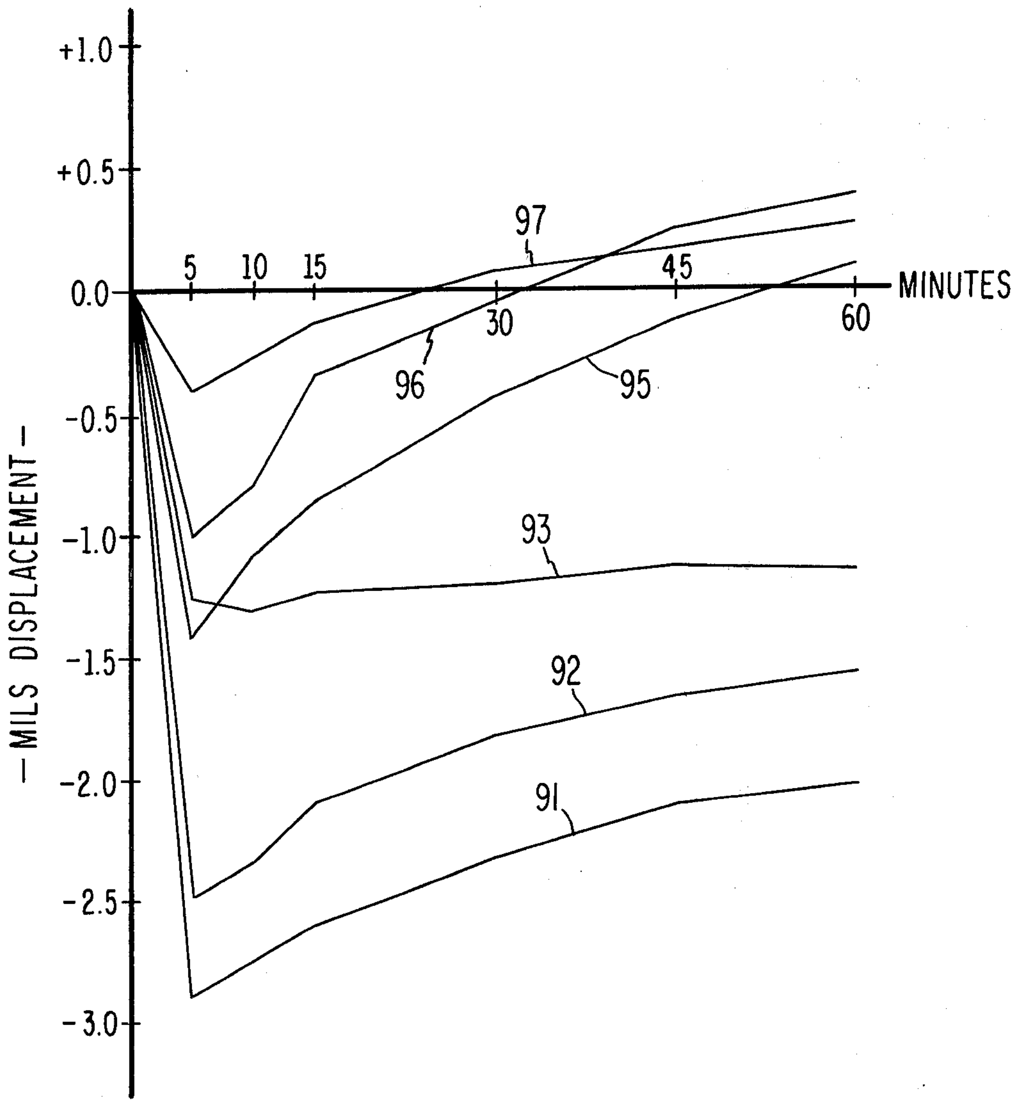
Fig. 9.


+1.0
+0.5
0.0
-0.5
-1.0
-1.5
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-2.5
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— MILS DISPLACEMENT —
5
10
15
30
45
60
MINUTES
97
96
95
93
92
91

Fig. 10.

CATHODE RAY TUBE HAVING SHADOW MASK AND SCREEN WITH TAILORED HEAT TRANSFER PROPERTIES

BACKGROUND OF THE INVENTION

This invention relates to a novel cathode-ray tube having a shadow mask and screen with tailored heat-transfer properties.

One type of cathode-ray tube that is used for television displays is referred to as a shadow-mask tube. This tube is comprised of an evacuated envelope having a viewing window, a viewing screen comprised of a mosaic of phosphor areas (usually dots) of different emission colors supported on the inner surface of the viewing window, a shadow mask having an array of apertures therein in register with the phosphor areas and mounted in the tube in adjacent spaced relation with the window, and means for projecting one or more (usually three) electron beams towards the screen for selectively exciting the phosphor areas of the mosaic. The mask has the general shape of the viewing window, which is usually spherical. The mask is mounted on a heavier frame, which in turn is mounted to the envelope with springs attached to the mask frame.

In operating a shadow-mask tube, the electron beams are made to scan a raster in a fixed pattern. As the beams are made to scan, portions of the beams are intercepted by the mask, and other portions, referred to herein as beamlets, pass through the mask apertures and excite the desired phosphor areas. The energy in the intercepted portions of the electron beams heats the mask causing the mask material to expand. During the initial heating-up period, the central portion of the mask heats up faster than both the frame and the peripheral portions of the mask. This causes the mask to dome, so that the central portion of the mask moves toward the screen, while the edge of the mask maintains its spacing with the screen. If the heating of the mask is not uniform, as where a test pattern or other non-moving image is displayed, the mask may become distorted. In any of these situations, the movement of the mask may adversely affect the position of the beams which pass through the mask apertures to cause misregister, that is, to cause some or all of the beamlets to miss their associated phosphor areas.

Some of the heat in the mask is removed by radiation back to a black coating on the funnel of the tube. Normally, the viewing-screen structure includes a thin layer of a highly reflective metal, usually aluminum. Heat from the mask that has been radiated forward towards the screen is reflected back by the metal layer, and insufficient heat is removed by radiation to the screen. U.S. Pat. No. 3,392,297 to J. W. Schwartz suggests applying to the entire reflective layer an overcoating of a heat-absorptive material by evaporation and vapor deposition in a vacuum. Lithium nitride, boron carbide and nickel oxide are examples of such materials. The purpose of the heat-absorptive overcoating is to increase the rate of the radiative heat-transfer between the mask and the screen. U.S. Pat. No. 3,703,401 issued Nov. 21, 1972 to S. B. Deal et al. discloses a sprayed-on overall overcoating of carbon particles for the same purpose. The prior art also suggests employing a temperature-compensating mask mounting comprising bimetallic or other means for moving the mask-frame assembly toward the screen. However, such mounting is only effective at a later stage of the heating-up period, when the frame supporting the mask or the mounting supporting the frame has heated up.

SUMMARY OF THE INVENTION

The novel cathode-ray tube comprises an evacuated envelope, a viewing screen comprised of a mosaic of phosphor areas of different emission colors, and a shadow mask mounted in the envelope closely spaced from the screen. The mask has two opposed major surfaces and an array of apertures therein in register with the phosphor areas of said screen. At least one of the major surfaces of the mask and the inner surface of the screen include surface means, such as surface portions that are selectively reflective and surface portions that are selectively absorptive of infrared radiation, for effecting faster radiative heat transfer from the central portion of the mask than from peripheral portions of the mask.

In some embodiments, one or more of the major surfaces of the mask and screen each carry a central surface portion that is dark colored and rough textured to enhance radiative heat transfer. The central portion is partially or entirely surrounded by peripheral surface portions that are light colored or metallic and smooth textured to reduce radiative heat transfer.

By providing surface means for effecting faster heat removal from the central portion of the mask than from peripheral portions of the mask, doming of the mask during the initial heating-up period is reduced. By tailoring the shape and thickness of these portions, doming and distortion of the mask may be reduced to further reduce misregister of the electron beamlets on the phosphor areas.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal, partially broken away sectional view of a three beam tricolor cathode-ray tube of the shadow mask, dot screen variety which employs one form of the invention.

FIG. **2** is a plan view, viewed from the screen side, of the shadow mask of the tube of FIG. **1** showing the location of surface areas having greater absorptivity and areas having greater reflectivity of infrared radiation.

FIG. **3** is a plan view, viewed from the gun side, of the viewing screen of the tube of FIG. **1** showing the location of surface areas with greater infrared absorptivity and areas having greater infrared reflectivity.

FIGS. **4** to **7** are plan views of some different patterns of infrared absorptive and emissive areas that may be used on any of the surfaces of the mask, screen, and/or funnel of a cathode-ray tube.

FIG. **8** is a family of curves showing the temperature changes, during the initial **90** minutes of heating up, at various points in a tube similar to that illustrated in FIG. **1** except that all surfaces of the mask and screen are uniformly blackened.

FIG. **9** is the same family of curves as shown in FIG. **8** but on a different time scale for the initial five minutes of heating up.

FIG. **10** contains two families of curves showing average displacements in the radial direction of electron spots with respect to the associated phosphor dots they are exciting during the initial period of operation of a tube of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

EXAMPLE 1

A typical structure for the novel tube, shown in FIGS. **1** and **2**, is a rectangular color television picture tube comprised of evacuated glass envelope **11** including a funnel **13** and a faceplate panel **15**. The interior surface of the funnel is coated with an electrically-conductive coating **17** which is entirely of a heat-absorbing material such as graphite particles in a silicate binder. One end of the funnel **13** terminates in a neck **19** which houses an electron-gun assembly **23** so adapted to project three electron beams at a target structure at the opposite side of the envelope **11**. The target structure includes a luminescent viewing screen **25** supported on a glass viewing window **27**, which window is part of the faceplate panel **15**. The screen **25** is comprised of a multiplicity of red-emitting, green-emitting and blue-emitting phosphor dots, R, B, and G respectively, adhered to the inner surface **29** viewing window **27**. The dots generally are round and arranged in a regular repetitive order of triads of three dots, one dot of each triad being of each color-emission characteristic. The dot structure is overlaid with a reflective coating **31** of aluminum. The reflective coating **31** carries a rectangular infrared absorptive layer **33** in the central portion thereof as will be described in detail below. Closely spaced from the viewing window **27** toward the gun assembly **23** is a metal shadow mask **35** having a multiplicity of generally round apertures **37** in regular cyclic array therein, one aperture for each triad. The apertures are graded in size, with the largest being in the central portion of the mask **35** and the smallest being in the peripheral portions of the mask **35**. The mask **35** is spot-welded at various points along its margins to a frame **43**. A magnetic shield **44** in the shape of a hollow truncated pyramid is welded to the gun side of the frame **43**. The frame **43**, the magnetic shield **44**, and the gun-side **39** of the mask **35** are blackened. The screen-side **40** of the mask **35** is blackened and carries a peripheral coating **41** of vapor-deposited aluminum metal defining a rectangular infrared emissive area in the central portion thereof as will be described in more detail below. The frame **43** is supported on studs **45** attached to the faceplate panel **15** by four springs attached to the mask **39**. The apertured mask **35** is so positioned between the gun assembly **23** and the viewing window **27** that, during tube operation, an electron beamlet from each of the three beams passes through each aperture **37** of the mask **35** at a different angle and excites a different one of the three phosphor dots of the triad of the screen **25**. Thus, a first electron beam can excite all of the red-emitting dots, a second electron beam can excite all of the green-emitting dots, and a third electron beam can excite all of the blue-emitting dots. The blue-emitting dots preferably consist essentially of a silver-activated zinc-sulfide phosphor. The green-emitting dots preferably consist of a copper-and-aluminum-activated zinc-cadmium-sulfide phosphor, and the red-emitting dots preferably consist essentially of an europium-activated yttrium-oxysulfide phosphor. Other phosphor compositions may be used in place of the phosphors mentioned.

In this example, the mask **35**, which is of cold rolled steel, is blackened on both the screen-side **40** and the gun-side **39**, as by controlled oxidation of the surfaces

thereof. An infrared-reflective layer **41** of aluminum metal is deposited on all of the peripheral areas of the screen-side of the mask, as shown in FIG. **2**, providing an infrared-reflective area around a rectangular infrared-absorptive area **47**. In this example, the screen carries the usual light-reflective (and infrared-reflective) layer **31** of aluminum metal. A central rectangular area of the light-reflective layer **31** carries an overcoating **33** of carbon particles as shown in FIG. **3**, thereby providing an infrared-absorptive area **33** and leaving an infrared-reflective peripheral area **49** around the margin of infrared-absorptive area **33**. The two infrared-absorptive areas **47** and **33** are about the same size and shape and are closely spaced from one another in confronting or facing relationship. For a 25-inch, 110° deflection picture tube, the screen is about 15 inches high and 20 inches wide. The infrared-absorptive area **33** on the screen **25** is about 10 inches high and about 15 inches wide leaving a 2½-inch margin of infrared-reflective aluminum metal. The infrared-absorptive area **47** on the screen-side **40** of the mask **35** is also about 10 inches high and about 15 inches wide. Because the mask **35** is somewhat smaller than the screen **25**, it has a smaller margin **41** of infrared-reflective material. When the tube **11** is turned on for operation, the electron beams heat the mask **35** as described above. Heat is removed by infrared radiation from central areas of the mask **35** by radiative transfer from the hotter black central area **47** on the mask **35** to the cooler black central area **33** on the screen **25**. However, the peripheral areas **41** and **49** of the mask **35** and the screen **25** respectively are infrared reflective with relatively low infrared emissivity, resulting in a retarded heat transfer. The relative effect compared to prior tubes is to heat up the peripheral areas of the mask and to cool down the central area of the mask. The mask, due to its coefficient of expansion, expands at its peripheral areas, drawing the center of the mask in a direction opposite to doming (away from the screen). Measurements have shown a reduction in movement of the mask **35** toward the screen **25** of up to about 2 mils, and reductions of beamlet movement (measured 6 to 8 inches from the screen center) of up to about 2 mils.

EXAMPLE 2

In this example, the tube is identical in structure with the tube of Example 1 except that the gun-side **39** of the mask **35**, instead of being uniformly infrared absorbing, carries infrared-absorbing and infrared-reflecting portions which are the mirror-image of the pattern shown in FIG. **2**. This is achieved by vapor depositing a band of aluminum metal on the peripheral portions of the gun side of the mask. In so doing, the effects described in Example 1 are realized faster during the initial operation of the tube.

EXAMPLE 3

In this example, the tube is identical in structure with the tube of Example 2 except that the magnetic shield is omitted and the inner surfaces of the funnel **17**, instead of being uniformly infrared absorbing, carry a pattern of infrared-absorbing and infrared-reflecting portions. The projection of this pattern upon the screen **31** is a mirror image of the pattern shown in FIG. **3** when viewed along the longitudinal axis of the tube. This may be achieved by replacing the conductive coating 17 of graphite with an overall conductive coating of vapor-deposited aluminum metal and providing thereon, in the central portions thereof, a graphite overcoating of the desired shape.

GENERAL CONSIDERATIONS AND ALTERNATIVES

The invention may be embodied in any cathode-ray tube which employs a shadow mask and a mosaic screen. The mosaic may be continuous lines of narrow width, or round, oval or rectangular islands. Tubes with screens comprised of round islands or dots find widespread use as color television picture tubes.

In all of the embodiments of the invention at least one of the infrared radiating or receiving surfaces of the tube carries the desired pattern of infrared-absorbing and infrared-reflecting areas. These surfaces are the two major surfaces of the mask and the screen surface that faces the screen side of the mask. The inner surface of the funnel which faces the gun side of the mask may also carry such a pattern. For the purposes of the invention, an infrared-absorbing area is an area that exhibits relatively high emissivity and absorptivity. This follows from the fact that the radiative process employed is to transfer heat by infrared radiation from the higher temperature mask (which requires high emissivity of infrared) to or through the lower temperature envelope (which requires a good heat sink by absorption of infrared).

Relatively high reflectivity of infrared radiation is exhibited by a surface with a mirror finish, which is smooth, shiny and metallic. High reflectivity is achieved to a lesser degree with any surface that is smooth or light-colored, and preferably both smooth and light-colored. Vapor-deposited aluminum layers are preferred. But, coatings of aluminum oxide, titanium dioxide and magnesium oxide may also be used.

Relatively high absorptivity of infrared radiation is exhibited by surfaces with a rough or matte black finish. Such surfaces also have a high emissivity of infrared radiation. High absorptivity of infrared radiation is achieved to a lesser degree with any surface that is rough or dark colored and preferably both rough and dark colored. Optimum absorption is achieved when the thickness of the infrared absorbing material is at least 0.1 of peak wavelength of the emission from a "black body." At 80°C, which is higher than the normal operating temperature of the mask. mask, wavelength is about 8440 nanometers. Coatings of black particles of materials such as graphite, carbon, nickel oxide, and black iron oxide are preferred. Dark-colored materials which are brown, gray, blue, green and purple may be used. Evaporable coatings such as those disclosed in the cited Schwartz patent may be used. Where the material allows for it, such as an iron-bearing shadow mask, the surface may be treated as by controlled oxidation to produce a dark-colored finish. Also, the surface may be roughened as by sandblasting or other abrasion technique.

Various patterns of areas that are selectively infrared absorptive and reflective may be used. FIGS. 2 and 3 show rectangular areas with rounded corners. FIG. 4 shows a circular central absorptive area 53 symmetrically disposed within a reflective peripheral surrounding area 51. FIG. 5 discloses an absorptive field 55 (including the central portion and the upper and lower peripheral portion) having symmetrically notched out peripheral reflective areas 57 and 59 on the left and right of the field. FIG. 6 shows an absorptive field 61 having symmetrically notched out reflective portions 63, 65, 67 and 69 on all four sides of the total surface. FIG. 7 is similar to FIG. 6 except that the boundaries between the reflective areas 71, 72, 75, 77 and the absorptive field 79 follow a zigzag path.

Any of the patterns may be provided on one or more of the inner screen surfaces 25, the screen-side of the mask 40, and the gun-side of the mask 39. The inner surface 17 of the funnel 13 may also carry such a pattern. Where patterns appear on two or more of the surfaces, then the same patterns may be used which are the same or different sizes, or different patterns may be used. Thus, the pattern of FIG. 2 may be used in combination with a similar but smaller pattern, or may be used in combination with the pattern of FIG. 4, and/or FIG. 5, and/or FIG. 6, and/or FIG. 7.

Whether used singly or in combination with other patterns, the total combination in the tube is the means for providing relatively faster radiative heat transfer from the central portion of the heated mask to the cooler screen surface and funnel surface, and relatively slower radiative heat transfer from peripheral portions of the mask. The shaping of the pattern or patterns used provides a means for tailoring the doming or distortion which results from expansion of the mask due to changes in temperature.

The pattern or patterns used may be produced by fabricating separate, adjacent areas, or by fabricating an overall infrared absorbing surface and then depositing an area or areas of infrared reflecting material which masks the surface below, or by fabricating an overall infrared reflecting surface and then depositing an area or areas of infrared absorbing material which masks the surface below. By any of these structures, the pattern may be further modified by feathering or grading the infrared absorbing and/or reflecting property of an area or of areas. This may be achieved by feathering the thickness of a layer along its normal boundary, or by providing an interdigitated boundary such as a sawtooth or a zigzag.

It is preferred that the pattern on the screen provide substantially uniform attenuation to the electron beamlet. This may be achieved by adjusting the thicknesses of the various layers on the mosaic so that the total mass of material is substantially constant across the mosaic. For example, this may be achieved in the tube of FIG. 1 by making the reflective coating 31 thinner under the absorptive layer 33 and thicker elsewhere.

FIG. 8 is a family of curves showing the temperature changes during the first 90 minutes of operation at various points on the mask 35 and one point on the internal magnetic shield 44 of a tube similar to that shown in FIG. 1, except that all internal parts were uniformly blackened. The curve 81 is for several points at about the center of the mask 35. The curve 83 is for several locations on the mask 44 at about 6.5 inches from the center, and the curve 85 is for several locations on the mask at about 11.0 inches from the center. The curve 87 is for several points on the internal magnetic shield 44. Readings were made with thermocouples in contact with the point measured. These curves illustrate the differential of average temperatures which occur across the mask, the rapid temperature changes that occur during the first 5 minutes of tube operation, and that temperatures have not equalized after 90 minutes of operation. Such differentials and rapid temperature changes cause the mask to warp temporarily, resulting in a temporary displacement of the apertures **37** with respect to their associated phosphor areas on the screen **25.** FIG. **9** shows the same family of curves **81,** 83, 85 and **87** during the first 5 minutes of tube operation.

FIG. **10** includes a family of curves **91, 92** and **93** showing the displacement of the electron beam spot with respect to the associated phosphor dot that it is exciting during the initial minutes of operation, for a prior-art tube similar to that shown in FIG. **1,** except that all of the mask and screen surfaces were uniformly blackened. The tube was operated with a white field at 25 kilovolts using 1500 microamperes of beam current. The curves **91, 92** and **93** are the averages of at least four points that are located about 6 inches, about 8 inches and about 11 inches respectively from the center of the screen **25** (12 points total). The measurements are made optically by viewing excited phosphor areas through a microscope and noticing the movement in the radial direction of the edge of the excited area with respect to the edge of the phosphor area. Movement away from the screen center is considered positive and toward the center is considered negative. Nonuniform movements of electron spots of more than 1.0 mil toward the center were observed, which are attributed to changes in shape and location of the mask apertures **37.** The curves **95, 96** and **97** are a corresponding family of curves for the tube shown in FIG. **1** except that the screen carried a pincushion pattern, such as shown in FIG. **6,** wherein the reflecting areas **63, 65, 67** and **69** are about 2.5 inches wide at their widest point, and the legs of absorbing material separating them in the corners are about 2.0 inches wide. The curves **95,** 96 and 97 illustrate that the presence of the selectively absorbing areas and selectively reflecting areas on the screen dramatically reduces the electron spot - phosphor dot displacement.

We claim:

1. A cathode-ray tube comprising an evacuated envelope including a viewing window, an electron gun mounted within said envelope, a viewing screen comprised of a mosaic of phosphor areas of different emission colors supported on the inner surface of said viewing window, and shadow mask mounted in the envelope closely spaced from said screen, said mask having two opposed major surfaces and having therein an array of apertures in register with the phosphor areas of said screen, at least one of the major surfaces of said mask and the inner surface of said screen including surface means for effecting faster radiative heat transfer from the central portion of said mask than from peripheral portions of said mask.

2. The tube defined in claim **1** wherein said at least one major surface has a central portion that is selectively absorptive of infrared radiation and peripheral portions that are selectively reflective of infrared radiation.

3. The tube defined in claim **1** wherein said inner surface of said screen and said major surface of said mask facing said screen each have a central portion that is selectively absorptive of infrared radiation and all surrounding peripheral portions that are selectively reflective of infrared radiation.

4. The tube defined in claim **1** wherein said inner surface of said screen and said major surface of said mask facing said screen each have a central portion and some peripheral portions that are selectively absorptive of infrared radiation, and remaining peripheral portions that are selectively reflective of infrared radiation.

5. The tube defined in claim **2** wherein said selectively infrared absorptive surface portions are dark colored and rough and said selectively infrared reflective surface portions are light colored and smooth.

6. A cathode-ray tube comprising an evacuated envelope including a rectangular viewing window, an electron gun mounted within said envelope, a rectangular viewing screen comprised of a mosaic of phosphor areas of different emission colors supported on the inner surface of said viewing window, and a rectangular shadow mask mounted in the envelope in adjacent spaced relation with said screen, said mask having an array of apertures in register with phosphor areas of said screen, the facing surfaces of said mask and said screen having surface means including a metallic layer that is selectively reflective of heat and a coating that is selectively absorptive of heat arranged to provide relatively faster radiative heat transfer from said mask to said screen in the central portion of said mask than at peripheral portions thereof.

7. The tube defined in claim **6** including an overall metallic reflective layer on said mosaic of phosphor areas and an infrared absorptive coating on at least the central portion of said reflective layer.

8. The tube defined in claim **6** wherein substantially all of both major surfaces of said mask are black and there is a metallic reflective layer on peripheral surface portions of said blackened mask facing said screen.

9. The tube defined in claim **8** including an overall metallic reflective layer on said mosaic of phosphor areas and an infrared absorptive black coating only on the central portions and each of the corner peripheral portions of said reflective layer.

10. The tube defined in claim **8** including an overall metallic reflective layer on said mosaic of phosphor areas and an infrared absorptive black coating only on the central portion of said reflective layer.

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