

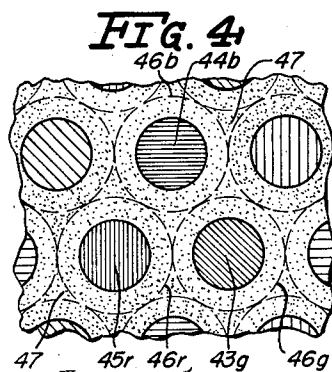
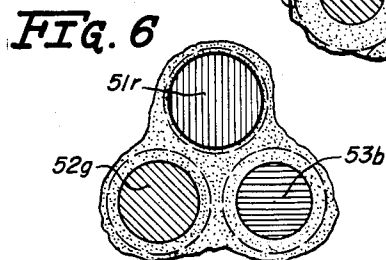
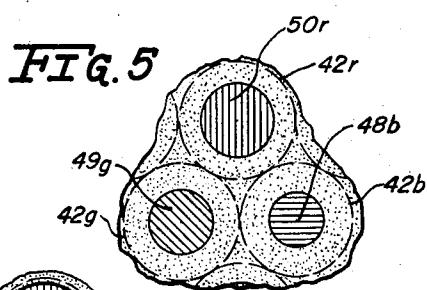
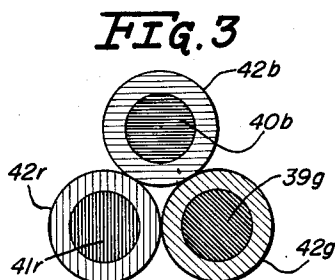
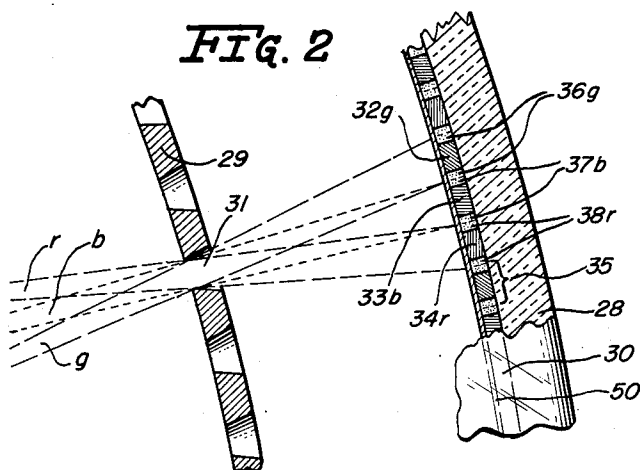
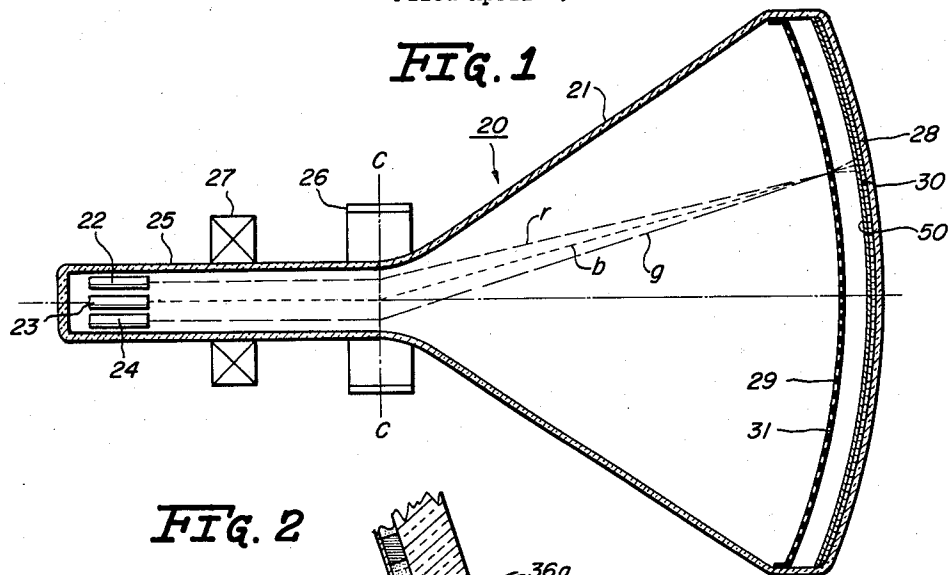
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J. P. FIORE ET AL

3,146,368

CATHODE-RAY TUBE WITH COLOR DOTS SPACED BY LIGHT ABSORBING AREAS

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3,146,368

CATHODE-RAY TUBE WITH COLOR DOTS SPACED BY LIGHT ABSORBING AREAS

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9 Claims. (Cl. 313-92)

The present invention relates generally to cathode-ray tubes used in color reproduction and more particularly to color reproducing cathode-ray tubes affording improved brightness and contrast.

In color reproducing cathode-ray tubes of the type with which the present invention is concerned, it is common to provide an evacuated envelope made of glass, metal or any other suitable material having an enlarged end carrying a frontplate, and at its opposite end a neck portion with an electrode arrangement formed of one or more electron guns for projecting a beam or beams of electrons toward the frontplate. Similar to the arrangement of black and white cathode-ray tubes, the energy of the electrons is converted into light by a suitable phosphor layer provided on the inside surface of the frontplate, or on a separate screen structure provided within the envelope just behind and visible through the frontplate. The color reproducing cathode-ray tube is preferably provided with a phosphor screen which is differentiated from point to point in that adjacent areas of different phosphor material produce light of different colors. A color-selection electrode, usually a multi-apertured mask and conventionally made of a very thin metal sheet which is opaque to the passage of electrons, is disposed between the electron gun assembly and the phosphor screen and adjacent to the screen. The mask is provided with a large number of small, closely spaced apertures geometrically related to the different phosphor areas on the screen in a predetermined manner. The relation of the apertures to the phosphor areas is such that, by controlling the direction of the electron beam, different phosphor areas, producing predetermined color emission, can be selectively energized to produce a visible picture corresponding to the original scene.

In conventional color tubes, the apertures of the mask are of such size and the operating voltages are of such magnitudes, that the electron beam impinges only a portion of the respective phosphor areas. The difference between the actual size of the phosphor area and the area not impinged by the electron beam constitutes a tolerance or a guard ring which provides a safety factor for preventing color contamination owing to various mechanical, thermal and electrical errors. However, full utilization of the phosphor is not achieved, a fact which contributes to the undesirable shortcomings of inadequate brightness and contrast characteristic of present day color tubes.

Accordingly, it is a general object of the present invention to provide a new and improved color reproducing cathode-ray tube.

A more specific object of the invention is to provide a new color reproducing cathode-ray tube with substantially improved brightness of the reproduced image.

A further object of this invention is to provide an improved color reproducing cathode-ray tube with improved contrast ratios, obtainable in the reproduced image, without impairing the image brightness.

It is a more specific object of this invention to provide a new and improved color reproducing cathode-ray tube having a multi-color image screen which will effectively absorb much of the ambient light at the image screen, but will not attenuate the light emitted by the screen.

It is another object of this invention to provide an im-

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proved multicolor image screen for the color reproducing cathode-ray tube with substantially reduced color desaturation effects attributable to reflected ambient light, but without reducing the efficiency of the tube.

A still further object of this invention is to provide an improved color reproducing cathode-ray tube in which the differences in conversion efficiency of the different phosphors are effectively compensated to improve the uniformity of the light output of the color image.

A color reproducing cathode-ray tube, constructed in accordance with the present invention, comprises within an evacuated envelope a multi-color image screen including, a plurality of interspersed groups of similarly shaped elemental phosphor areas, each of the elemental phosphor areas being spaced from all adjacent such areas by intermediate light absorbing areas; electron gun means for projecting a corresponding plurality of electron beam components towards the image screen; and means, including a color-selection electrode provided with a plurality of apertures individually larger than elemental phosphor areas and disposed between the screen and the electron gun means, for selectively directing the electron beam components onto areas of respective ones of the groups.

The inventive arrangement is applicable to color tubes of various types, including, for example, post deflection acceleration mask type tubes, but for convenience will be described as embodied in a three-gun dot-screen shadow-mask tube in which mask and screen are operated at a common potential.

The image screen can be planar, spherical or of any other configuration, and may be mounted either on the face-plate of the tube or on a transparent target-plate behind the face-plate.

The features of the present invention, which are believed to be novel, are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may be best understood, however, by reference to the following description of exemplary embodiments of this invention taken in connection with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIGURE 1 is a cross-sectional view, partly schematic, showing in general certain of the basic components of a color-reproducing cathode-ray tube, comprising a spherical aperture mask and a spherical image screen.

FIGURE 2 is a cross-sectional view of a color tube embodying the invention, showing portions of the screen and the mask at an enlarged scale, illustrating the relative positioning of the apertures in the mask and of the respective phosphor areas on the multi-color image screen.

FIGURE 3 is a schematic view, showing the arrangement of a triad of phosphor areas relative to the areas of impingement of the electron beams from the aperture mask in prior art color tubes.

FIGURE 4 is a schematic view, showing the arrangement of a triad of phosphor areas relative to the areas of impingement of the electron beams from the aperture mask in a color tube embodying the present invention.

FIGURE 5 is a schematic view, showing a modification of this invention in which the phosphor areas of different colors on the image screen are of different size.

FIGURE 6 is a schematic view, showing a further modification of the present invention.

A color reproducing cathode-ray tube 20 having a glass envelope 21 is shown in FIGURE 1. For clarity, most of the physical details which do not relate to the present invention are omitted. The three electron guns are indicated by the rectangular 22, 23 and 24 which are disposed in the neck portion 25 of the cathode-ray tube en-

velope 21 and are arranged to emit respective electron beam components, in this case separate electron beams, designated *g*, *b* and *r* respectively. The electron guns are preferably disposed in a triangular array but can be arranged in other suitable interrelationships, such as a collinear array, depending upon the other structural features of the tube construction. Alternatively a single electron gun can be used in conjunction with an auxiliary color-switching deflection system for deflecting the electron beam to sequentially produce three separate electron beam components.

The electron beam components *g*, *b* and *r* are accelerated in known manner to pass through a deflection field produced by scanning signals applied to a yoke member 26. This deflection field changes the courses of the electron beam components in accordance with the instantaneous sweep signals applied to the yoke member 26. Such course change of the electron beam components is gradual within the deflection field; for purposes of illustration and explanation, however, the change of the course of the electron beams is shown as occurring at a plane *c-c* passing through the yoke member 26 and hereinafter designated the color-center plane. After being deflected, the electron beam components *g*, *b*, *r* are directed through the apertures in the color-selection electrode or shadow mask 29 to impinge on the scanning side (the side on which the electron beam components are incident) of a multi-color image screen 30, disposed on the inside surface of the frontplate 28 of the envelope 21. The cathode-ray tube 20 also requires a convergence system, represented in the drawing by a convergence yoke assembly 27, for converging the electron beam components *g*, *b*, *r* in the plane of the shadow mask 29.

The apertured shadow mask structure 29 may include a plurality of circular apertures 31, the screen 30 being covered accordingly with a plurality of circular phosphor areas (dots). Three interspersed similar groups of phosphor dots, one for each primary color, are provided in the usual manner. Adjacent phosphor areas, one from each group, constitute triads or clusters, and one such triad is positioned in relation to each aperture in the mask 29 in such a manner that the electron beam components *g*, *b*, *r* selectively impinge upon corresponding groups of phosphor areas. Other forms than circular apertures in the mask and circular phosphor areas (dots) on the screen are feasible, as for instance, apertures of rectangular shape, slits in the form of thin rectangular openings etc. Regardless of the particular configuration of the mask and of the image screen, the phosphor areas are disposed on the scanning side of the image screen 30 so that the electron beam components *g*, *b*, *r* are directed through the apertures in the mask structure 29 to impinge selectively upon the respective groups of phosphor areas of the screen 30.

The different groups of phosphor areas on the screen 30, regardless of the configuration of same, possess different color-response characteristics, each group emitting light of a different one of the elemental or primary colors when excited by the incidence of an electron beam. Different phosphor materials are used for producing the component colors green, blue and red.

The relative positioning of the apertures 31 in the mask 30 with regard to the arrangement of the phosphor areas 32*g*, 33*b* and 34*r* on the multi-color screen 30 is shown at larger scale, in FIGURE 2 of the drawings. These phosphor areas (dots) are arranged in triads, with each triad centered relative to an aperture in the mask. Preferably an electron-transparent aluminum or other conductive layer 50 covers the entire rear surface of the screen to provide increased brightness as well as to provide convenient means for maintaining the screen at the operational potential.

The construction of the tube as thus far described, including the phosphor materials, the exposure techniques

and the photo-resist materials used in the production of the screen, is well known in the art.

According to the present invention, the apertures 31 in mask 29 are dimensioned and the relative mask and screen potentials selected so as to have the electron spots 35 on screen 30 larger than the size of phosphor areas 32*g*, 33*b*, 34*r*, and the intermediate areas 36*g*, 37*b*, 38*r* are made of or coated with a light absorbing material in a manner to be described. The geometry of the conventional arrangement of the phosphor areas on the image screen is shown in FIGURE 3, in which the apertures in the mask are of such size and the mask and screen potentials of such magnitude that the electron spots 39*g*, 40*b*, 41*r* are of smaller size than the phosphor areas 42*g*, 42*b*, 42*r* on the image screen.

In distinct contrast in a tube embodying the present invention, as shown in FIGURE 4, the apertures in the mask are made larger than the elemental phosphor areas on the screen, while the mask and screen potentials are of such magnitudes that the electron spots 46*g*, 46*b*, 46*r* on the screen are larger than the phosphor areas 43*g*, 44*b*, 45*r*. In accordance with a further feature of this invention the whole surface of the image screen, excluding the elemental phosphor areas, is formed of or coated with a light absorbing material 47; this may be most conveniently accomplished by coating the intermediate areas with a material such as black manganese dioxide. Thus the relation between the size of the actual phosphor areas 43*g*, 44*b* and 45*r* and the size of the electron spots 46*g*, 46*b*, 46*r*, as shown in FIGURE 4, is exactly reversed as compared with prior art color tubes.

The blackened intermediate areas 47 of the image screen substantially reduce ambient light reflections since these blackened areas effectively absorb the ambient light, but do not attenuate the light emitted by the image screen. To achieve the maximum benefit of the invention in this respect, the face-plate of the cathode-ray tube and the safety-plate bonded thereto or superposed thereover may be formed of clear glass rather than the darkened or reduced-transmission glass ordinarily used in such devices. The combination of blackened areas intermediate the phosphor areas with electron spots larger than the individual elemental phosphor areas, and clear glass face-plate and safety-plate, provides materially greater brightness without loss of contrast and, in many instances, with improved contrast as well.

A further advantage of a tube, embodying the present invention, consists in that the desaturation effects caused by the reflected ambient light, are reduced by the increased effective absorption in the blackened intermediate areas 36*g*, 37*b*, 38*r*; this also improves the contrast ratios obtainable in the reproduced image, without reducing the efficiency of the cathode-ray tube.

Different methods for producing the light absorbing surfaces between the phosphor areas of the image screen may be employed. Two basic methods are possible: one in which the black area is produced first, and another method in which the different color phosphor areas are produced first and subsequently the intermediate black areas.

In the first mentioned method, it is necessary to produce an image which is the reverse of that usually applied in photo-screening color tubes. Whereas each aperture normally produces three phosphor areas (dots) images, now there is required an image everywhere except where the phosphor areas are to be. It is therefore necessary to use some kind of photographic reversal process. While different reversal methods are well known using silver halide emulsions, a more economical method involves the use of a reversal type photo-resist, that is, a photo-resist which becomes soluble where exposed by light and remains insoluble elsewhere. Such a resist is disclosed, for instance, in U.S. Patent No. 2,533,530 to H. C. Staebler. Another reversal type resist, based on a diazo-type material, is disclosed in U.S. Patent No. 2,929,708 to D. Straw.

To make the black areas, a black powder such as manganese dioxide may be settled over the whole area of the screen by a water sedimentation process. The water is removed and the screen is dried and then coated with the reversal type photo-resist. The sensitized screen is exposed to light, either successively or simultaneously, from the color centers to be later used to expose the color phosphor areas. The size of the light exposing source is selected to be such that because of penumbra effects, well known in the photoengraving art, a proper size area can be secured by controlling the exposure time. By this means phosphor areas (dots) smaller than the mask apertures are readily obtained. After exposure, the screen is developed in a resin solvent, which development also removes the black pigment in those areas where light has struck. Following the application of the black area, the three color phosphor areas may be put on using any conventional screening process. If desired, the phosphor areas can be made larger than the openings in the black area; in this way, the exposure time need not be critically regulated. Even though the phosphor areas are larger than openings in the black area, only the light generated in the clear areas of the black surface can reach the observer, the rest being absorbed by the black opaque coating.

A second method of making the screen consists in that the color phosphor areas are first made on the screen surface in conventional manner except that the phosphor areas are made smaller than the apertures in the mask, utilizing the above described method of controlling the exposure time.

The resin with the respective phosphors dispersed therein is then dyed in known manner with a dye which absorbs actinic light. The whole area of the screen is subsequently coated with a dichromated photo-sensitive colloid, and the whole screen is then exposed, from the side opposite to that used in exposing the phosphor areas, to a source of diffuse actinic light. The clear areas between the dyed phosphor areas, which are coated with the dichromated photo-sensitive colloid, are thus exposed and hardened, while the dyed phosphor areas do not transmit any light to the photo-sensitive colloid.

The unexposed dichromated photo-sensitive colloid is then washed away and a black pigment slurry is applied to the screen; the black pigment adheres only to the exposed and hardened colloid areas between the phosphor areas, as is well known in the art.

The rear surface of the screen is then aluminized and baked in conventional manner. The baking also removes the organic coating and the dyes from the phosphor areas, as well as the organic coating from the areas between the phosphor dots.

In the screen of FIGURE 4, all phosphor areas of each triad are of the same size. Because the conversion efficiency of the three different phosphors varies to a substantial degree, it has previously been the practice to dilute the blue phosphor by approximately 35% with a white inert material in order to cut or reduce the brightness of the blue phosphor areas. To obtain further improved performance in a tube embodying the invention, the screen of the color tube of FIGURES 1 and 2 may be modified by making the blue phosphor area and the green phosphor area substantially smaller than the red phosphor area in each triad, the red phosphor being the least efficient. This results in improved color balance without substantial loss in overall brightness since the intermediate blackened areas are correspondingly enlarged. At the same time the possibility of color contamination attributable to landing errors of the electron beam components is still further reduced. Such a modification is shown in FIGURE 5, in which the blue phosphor area 48b is made substantially smaller than the green phosphor area 49g, while the red phosphor area 50r is made substantially larger than the green and blue

phosphor areas, thus improving the color balance of the light output from the image screen.

In an illustrative color reproducing cathode-ray tube having an image screen as shown in FIGURE 5, the diameter of the red phosphor area was 0.013 inch, the diameter of the green phosphor area was 0.0115 inch, and the diameter of the blue phosphor area was 0.01 inch, the diameter of the apertures 31 of shadow-mask 29 being 0.016 inch. The image screen as shown in FIGURE 4, having phosphor areas of equal size in any one triad of 0.013 inch, the apertures in the shadow-mask being 0.016 inch, has a black, light absorbing area of 43.8% of the total area of the image screen. The image screen of the embodiment shown in FIGURE 5, in which the phosphor areas are of unequal size within any triad, and having the red phosphor area of 0.13 inch, the green phosphor area of 0.0115 inch and the blue phosphor area of 0.01 inch, has a black, light absorbing area of 56.3% of the total area of the image screen. Moreover, the embodiment of FIGURE 5 provides improved appearance of the red phosphor areas on the image screen, since the electron beam component, impinging the red phosphor areas, is separated from the adjacent blue and green phosphor areas by a greater amount. Since the commonly used blue and green phosphors are substantially more efficient than the red phosphor, even a small overlap of the blue and green phosphor areas by the electron beam component intended for the red phosphor leads to substantial color contamination and the increased separation is especially significant as it affects the red component of the reproduced image.

For still further improvement in a tube embodying the invention, to not only improve the contrast ratios but also enable an increase of the direct light output of the image screen, the relative dimensions may be modified as shown in FIGURE 6. For example, the diameter of the apertures 31 in the mask 29 may be reduced from 0.016 inch to 0.015 inch, and the diameter of the red phosphor area 51r increased from 0.013 to 0.014 inch (an increase of approximately 8%; the diameter of the green phosphor area 52g may be increased from 0.0115 inch to 0.012 inch, and that of the blue phosphor area 53b from 0.01 inch to 0.011 inch. These larger phosphor areas increase the overall brightness of the image by approximately 16% as compared to the pattern of phosphor areas shown in FIGURE 5.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made therein without departing from the invention in its broader aspects, and therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

We claim:

1. A color reproducing cathode-ray tube comprising within an evacuated envelope: a multi-color image screen including a plurality of interspersed groups of elemental phosphor areas, each of said elemental phosphor areas being spaced from all adjacent such areas by intermediate light absorbing areas; electron gun means for projecting a corresponding plurality of electron beam components towards said image screen; and means including a color-selection electrode, provided with a plurality of apertures individually larger than said elemental phosphor areas and disposed between said screen and said electron gun means for selectively directing said electron beam components onto areas of respective ones of said groups.

2. A color reproducing cathode-ray tube as in claim 1, in which said image screen is formed on a transparent face-plate constituting a portion of said envelope.

3. A color reproducing cathode-ray tube as in claim 2, in which said face-plate is composed of clear glass.

4. A color reproducing cathode-ray tube in accordance with claim 1, in which said apertures in said mask, as

well as said elemental phosphor areas on said image screen, are substantially circular.

5 5. A color reproducing cathode-ray tube comprising within an evacuated envelope: a multi-color image screen including a plurality of interspersed groups of elemental phosphor areas, each of said elemental phosphor areas being spaced from all adjacent such areas by intermediate areas, a coating of light absorbing material on said intermediate areas; electron gun means for projecting a corresponding plurality of electron beam components towards said image screen, and means including a color-selection electrode, provided with a plurality of apertures, individually larger than said elemental phosphor areas and disposed between said screen and said electron gun means for selectively directing said electron beam components onto areas of respective ones of said groups.

10 6. A color reproducing cathode-ray tube comprising within an evacuated envelope: a multi-color image screen including a plurality of interspersed groups of substantially circular elemental phosphor areas; a corresponding plurality of electron guns for projecting a corresponding plurality of electron beams onto said image screen; and means including a shadow-mask, provided with a plurality of apertures individually larger than said elemental phosphor areas and disposed between said screen and said electron guns for selectively directing said electron beams onto areas of respective ones of said groups, the whole surface of said image screen except said phosphor areas being coated with black pigment material.

15 7. A color reproducing cathode-ray tube comprising within an evacuated envelope: a multi-color image screen including a plurality of interspersed groups of elemental phosphor areas, each group exhibiting different color radiation characteristics and one group having a conversion efficiency smaller than that of the others, each of such elemental phosphor areas being spaced from all adjacent such areas by intermediate light absorbing areas; electron gun means for projecting a corresponding plurality of electron beam components towards said image screen; and means including a multi-apertured color selection electrode disposed between said screen and said electron gun means for selectively directing said electron beam components onto areas of respective ones of said groups.

groups, the apertures in said color-selection electrode being individually larger than said elemental phosphor areas, and the elemental phosphor areas of said one of said groups being of larger size than those of the remaining groups.

8. A color reproducing cathode-ray tube comprising within an evacuated envelope: a multi-color image screen including a plurality of interspersed groups of elemental phosphor areas, each group exhibiting different color radiation characteristics and having a conversion efficiency different than those of the other groups, each of said elemental phosphor areas being spaced from all adjacent such areas by intermediate light absorbing areas; electron gun means for projecting a corresponding plurality of electron beam components toward said image screen; and means including a multi-apertured color-selection electrode disposed between said screen and said electron gun means for selectively directing said electron beam components onto areas of respective ones of said groups, the apertures in said color-selection electrode being individually larger than said elemental phosphor areas, and the individual elemental phosphor areas of each group being of different size than those of each of the remaining groups the relative sizes of the areas of the different groups being substantially inversely proportional to the respective conversion efficiencies.

9. In combination, a multi-color screen and a multi-apertured color-selection electrode for color reproducing cathode-ray tubes, said image screen including a plurality of interspersed groups of elemental phosphor areas, each of said elemental phosphor areas being spaced from all adjacent such areas by intermediate light absorbing areas; and said color-selection electrode including a plurality of apertures, individually larger than said elemental phosphor areas, for selectively directing electron beam components onto phosphor areas of respective ones of said groups.

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