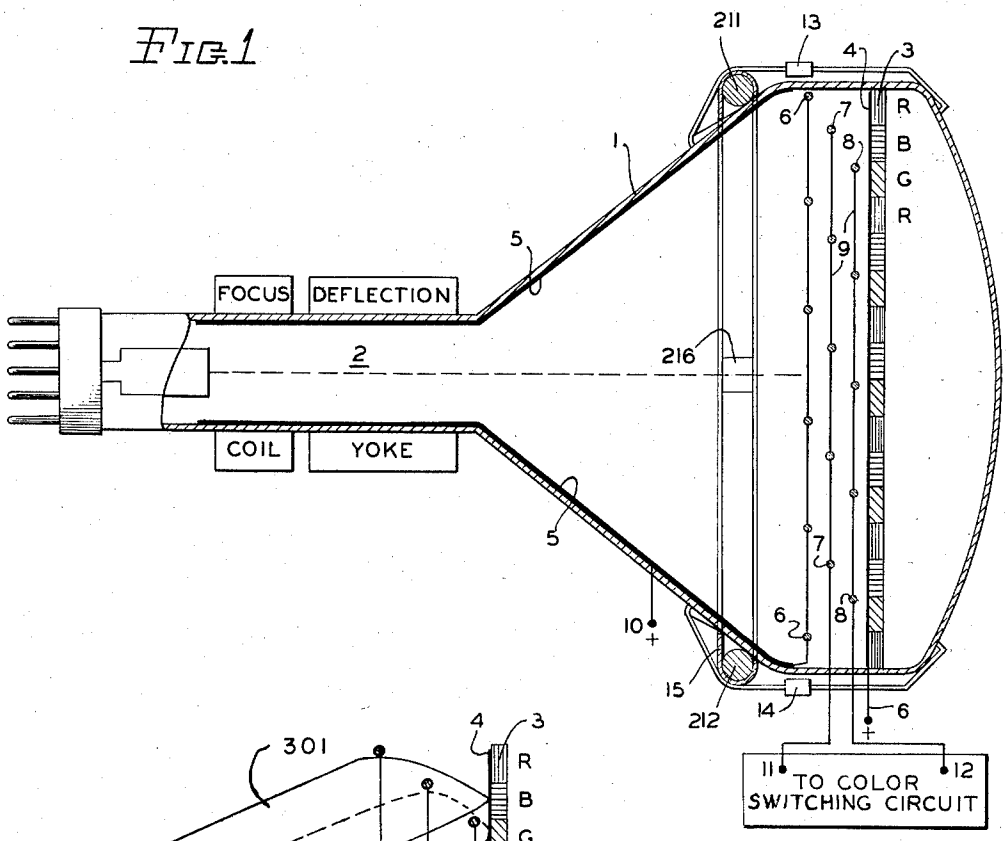
Nov. 11, 1958 A. SANDOR 2,860,271

CATHODE RAY TUBE

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FIG. 1



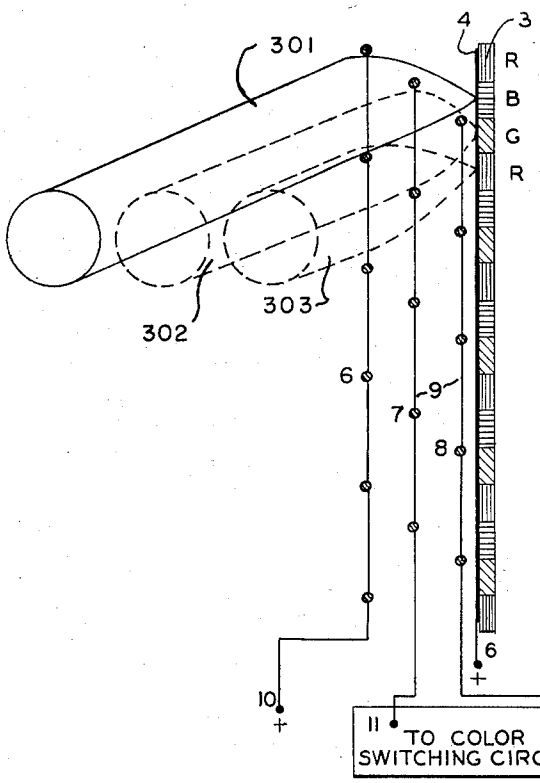


FIG. 2

INVENTOR.
AURELIUS SANDOR

BY Theodore C. Joyce

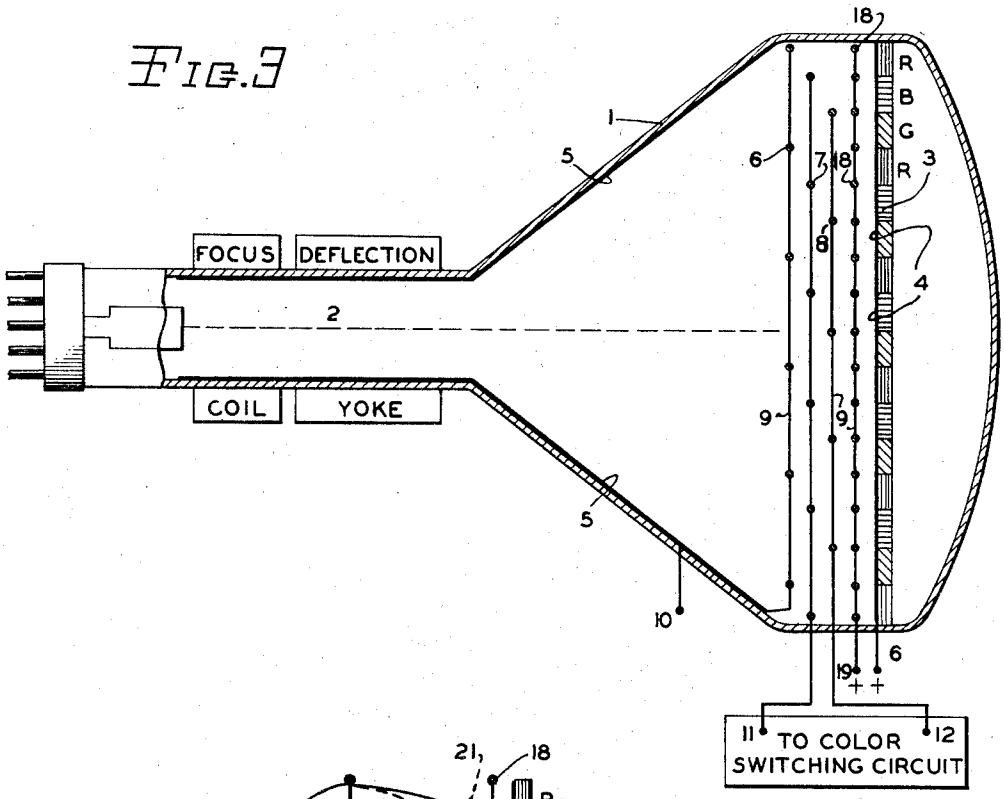
ATTORNEY

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FIG. 3



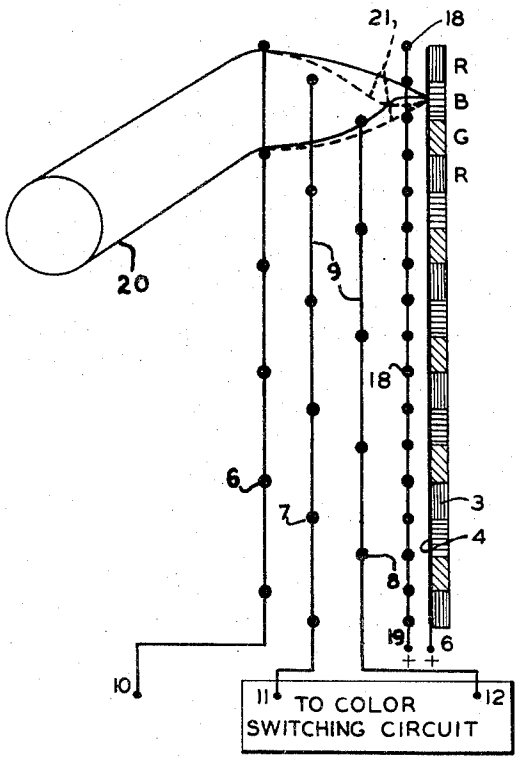


FIG. 4

INVENTOR.
AURELIUS SANDOR

BY Theodor C Joyce

ATTORNEY

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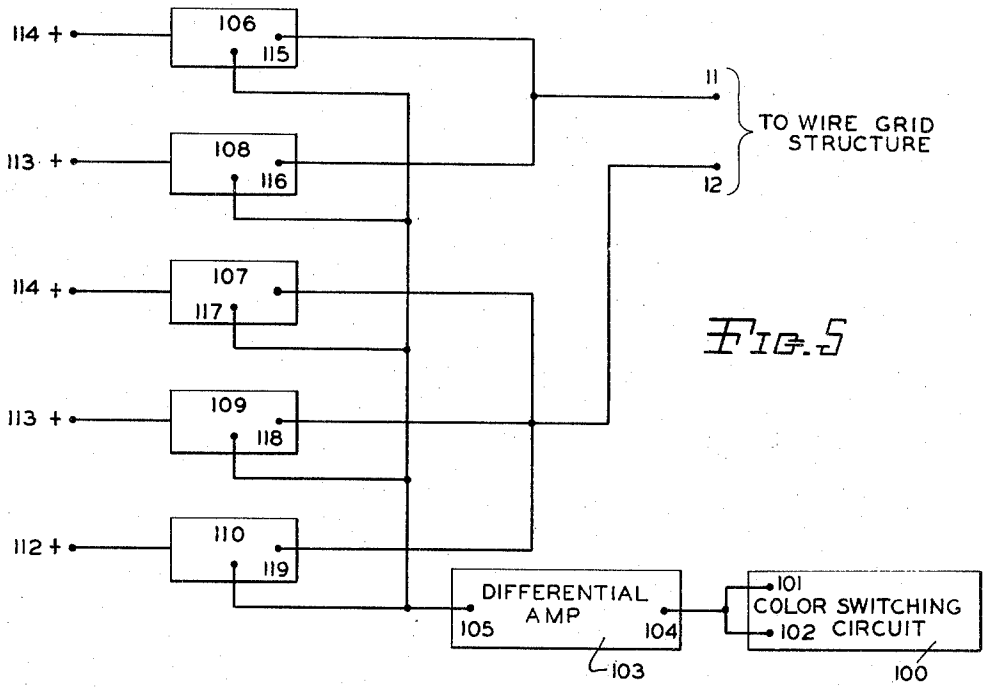


FIG. 5

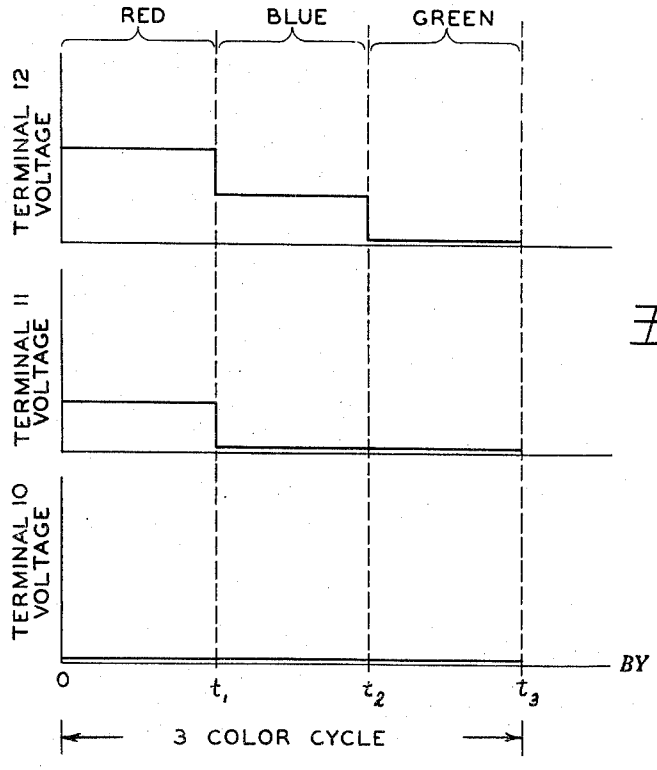


FIG. 6

INVENTOR.
AURELIUS SANDOR

Theodore C. Foyt

ATTORNEY

United States Patent Office

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2,860,271

CATHODE RAY TUBE

Aurelius Sandor, Forest Hills, N. Y., assignor to Sylvania Electric Products Inc., a corporation of Massachusetts

Application June 3, 1955, Serial No. 513,092

9 Claims. (Cl. 313—77)

My invention is directed toward cathode ray tubes for use in color television systems.

In present color television systems, the visual image is formed upon a cathode ray tube screen provided with a plurality of screen areas which are separate from each other and which are covered with a thin electrically conductive coating. Selected groups of these areas are coated with different phosphor materials so as to produce different colored images. The electron beam generated within the tube is deflected upon each area in turn, thus producing, in well known manner, different colored images in such rapid succession that they appear visually to mix and create a composite colored image. Normally, three primary colors are used in these systems.

One type of tube employed in this manner is provided with a flat image plate or screen mounted within the evacuated tube envelope. The coated screen areas are in the form of extremely narrow horizontal or vertical strips which are substantially parallel. The first, fifth, ninth, $(1+4N)$ strips produce one of the primary colors, for example, red. (N can be any positive integer or zero.) The second, fourth, sixth, $(2N)$ strips will produce another color, for example, green. The third, seventh, eleventh, $(3+4N)$ strips will produce the third color, for example, blue. A single electron gun produces an electron beam which, when in its center or zero deflection position, is perpendicular to the image plate.

Interposed between the gun and the coated portion of the image plate is a wire grid containing a plurality of parallel wires which are contained in a plane parallel to that of the image plate. These wires extend along the long dimension of the strips, one wire being associated with each blue or red strip. The wires associated with the red strip are connected together to a first common terminal. Similarly, the wires associated with the blue strip are connected together to a second common terminal. The conductive coating on the screen or image plate is connected to a third terminal.

When the first and second terminals are maintained at the same potential, and the third terminal is maintained at a much higher potential, the potential difference acts to accelerate and focus the electron beam; the electron beam will be directed upon the green strips only, and a green raster is produced. If now the potential difference between the first and second terminals is adjusted so that the potential on the first terminal has a higher positive value than that on the second terminal, the beam will be directed upon the red strips only, and a red raster will be produced. By reversing the potentials on these two terminals, a blue raster can be produced. Color switching circuits coupled to the first and second terminals supply these potentials as required.

This type of tube has been described in the literature. For example, further details on this tube will be found in Proceedings of the I. R. E., July 1953, pages 851–858.

This type of tube suffers from many serious disadvantages. For example, since adjacent grid wires are periodically maintained at different potentials, transverse

electric forces are established therebetween, and the wires tend to "sing" or vibrate with resultant color distortion. Even with the use of ruggedizing structure on the grid wire, this vibration cannot be wholly eliminated. Further, the grid wire separations are necessarily small and as a result, the grid exhibits high internal capacitance with attendant undesirable high frequency radiation effects. Moreover, each grid wire must be carefully insulated to prevent electrical interaction between wires.

It is an object of the present invention to obviate the above enumerated difficulties in this type of multicolor cathode ray tube.

A further object is to provide a new and improved multi-color cathode ray tube in which the wire grid contains three coplanar sets of uninsulated grid wires, the sets being insulated from each other, and is further characterized by a low capacitance between sets.

Still a further object is to linearize the raster scanning characteristics (re provide linear phosphor strips) of multi-color cathode ray tubes of the character indicated.

Yet a further object is to provide a new and improved cathode ray tube of the character indicated which employs a novel wire grid structure and further makes use of an image plate in which an iterative sequence of color strips is used (re red-blue-green, red-blue-green, etc.).

These and other objects of my invention will either be explained or will become apparent to those skilled in the art when this specification is studied in conjunction with the accompanying drawings wherein:

Fig. 1 is a longitudinal section of a cathode ray tube in accordance with one embodiment of my invention;

Fig. 2 is a diagram illustrating the operation of the tube of Fig. 1;

Fig. 3 is a longitudinal section of a cathode ray tube in accordance with another embodiment of my invention;

Fig. 4 is a diagram illustrating the operation of the tube of Fig. 3;

Fig. 5 is a block diagram of the color switching circuitry used with the tubes of Figs. 1 and 2; and

Fig. 6 illustrates graphically the action of the circuitry of Fig. 5.

Briefly stated, my multicolor cathode ray tube is provided with an image screen coated with narrow substantially parallel strips of three different color types arranged in an iterative sequence of first, second and third color types respectively. The screen is scanned in conventional manner (for example either horizontally or vertically) by a single electron beam. Interposed between the beam and the plate is a wire grid structure containing a plurality of grid wires which are parallel to each other and to the color strips. Each wire is associated with a corresponding edge of a corresponding color strip. The first set of wires associated with the first type of color strip falls within a first plane parallel to the image plate; all wires in this set are electrically connected together to a first terminal which in turn is connected to a point of positive potential.

Similarly, the second and third sets of wires associated with the second and third types of color strips fall within separate second and third planes parallel to the image plate. The wires in the second set are electrically connected together to a second terminal, while the wires in the third set are connected together to a third terminal. The wires in each of these sets are equidistantly spaced with respect to each other. The wires need not be insulated.

These sets are arranged with respect to each other so that for a separation d between adjacent wires of one set, there is a separation of $d/3$ between the wire centers of corresponding wires in adjacent wire sets where the separation is projected upon a common plane.

Positive going color switching pulses are supplied sequentially to the second and third terminals in a manner described in more detail hereinafter. As a result, the electron beam is first concentrated between adjacent wires of the first set and directed upon the color strip equidistantly spaced from these wires; a strip of the second color type. Similarly, the beam is then concentrated between adjacent wires of the second set and directed upon the strip in the third color type, and finally is concentrated between adjacent wires of the third set and directed upon a strip of the third color type.

All wires in any set are always at the same potential so that transverse wire vibration in any one set as between sets is eliminated and no color distortion results. Further, the ruggedized techniques referred to previously need not be used. Moreover, because of the separation between wire sets, the capacitance between wire grid sets is greatly reduced compared with the known tube. Further, if the separation between adjacent wires in any set is adjujsted to equal that of the adjacent wire separation of the known tube described previously, it will be seen that the picture resolution (which is a function of the number of color strips included in the space corresponding to this separation) of this known tube is reduced by 50% as compared to my tube; whereas the color phosphor strip width required by my tube is reduced only by 33⅓% as compared to the known tube. Moreover, if my tube is to have a resolution equal to that of the known tube, the color strip width required by my tube is 33⅓% larger than that of the known tube.

However, my tube as thus far described, in common with the known tube, exhibits barrel shape line bowing. This type of distortion can be substantially eliminated by means of a second wire grid interposed between the aforesaid grid structure and the image plate. The fourth grid consists of a like plurality of grid wires which are electrically interconnected to a fourth terminal maintained at a constant positive potential, there being one wire associated with each color strip. These wires are equidistantly spaced and are parallel to each other and to the color strips. Further, these wires fall within a plane parallel and adjacent the image plate.

By adjusting the potential on the fourth terminal to be small as compared to the maximum amplitude of the switching pulses, the electron beam will be prefocused on the fourth wire grid and thereafter strike the desired colored strip in such manner that line bowing is substantially eliminated.

One problem not yet discussed, which confronts both my tube and the known tube described above, results from conventional beam deflection techniques. For example, when the image plate is scanned in a direction perpendicular to the long dimension of the color strips, the angle at which the beam strikes the image plate (the angle of incidence) decreases as the beam is deflected away from the zero deflection position toward either one of the two extreme or maximum beam deflection positions. (Conventionally, the angle of incidence for the zero deflection position is adjusted to 90°.)

In order to insure that the beam, despite this variation in deflection angle, always strikes the designated color strip and no other, it has been found necessary to vary the widths and the shape of all the color strips. More specifically, the widths of the color strips which are to be scanned when the beam approaches either maximum deflection position are normally increased relative to the widths of the color strips which are to be scanned when the beam approaches its zero deflection position. Further, these strips must be somewhat curved to minimize bowing.

One solution to this problem is to increase the widths and shapes of all the color strips to an extent at which the beam will always strike the designated color strip despite this variation in deflection angle. I have found this method satisfactory in certain applications. However, as the width of the color strips is increased, the color resolution is, of course, decreased. Consequently, when a high degree of color resolution is required, another technique must be used.

In my copending application, Serial No. 505,226, filed May 2, 1955, I disclose such a technique. Specifically, I showed that by establishing a non-uniform magnetic field within a multicolor cathode ray tube of the character indicated through the use of electromagnets or permanent magnets externally mounted about opposite sides of the tube, the beam trajectory can be influenced in such manner that the variation of angle of incidence is minimized (essentially 90° incidence on the entire grid area); as a result, narrow uniform color strip widths can be used. Moreover, use of this field results in substantial elimination of line bowing distortion.

As pointed out in the above copending application, the color images produced in accordance with this technique compare favorably with the images produced by conventional methods; for large color images, the correcting effect of the non-uniform field is less pronounced at the corners of the image. Accordingly, the direction and intensity of this field may be adjusted in these corner areas to obtain an acceptable large color image. The adjustment is accomplished by means of a second magnetic field in a manner described hereinafter.

Referring now to Fig. 1, a cathode ray tube **1** is provided with an electron gun assembly **2** including associated focusing and deflection apparatus, and an image plate **3**. A plurality of long narrow parallel phosphor strips with the repetitive red-blue-green, red-blue-green sequence indicated are applied in well known manner to the inner surface of the plate **3**. These strips all have the same width. A very thin electrically conductive layer **4**, for example of aluminum, is applied over the screen. Layer **4** is connected to terminal **6** which in turn is connected to a point of high positive potential with respect to the cathode potential of the gun. The gun assembly **2** is adjusted to produce an electron beam which in its center or zero deflection position strikes the plate essentially with a 90° angle of incidence. A coating **5** of graphite, aquadag or other conductive material is connected to terminal **10** which in turn is connected to a point of high positive potential which, however, is much lower than the potential on terminal **6**.

A wire grid structure is mounted within the tube between assembly **2** and plate **3**, the grid being adjacent the coating **4**. The grid includes first, second, and third sets of wires identified at **6**, **7** and **8** respectively.

The first set **6** includes a plurality of wires **9** which are parallel to each other and parallel to the color strips, these wires falling within a first plane which is parallel to the image plate. Each of these wires is associated with a corresponding red strip; the wires are equidistantly spaced, uninsulated from each other, and electrically connected to terminal **10**.

The second set **7** includes a like plurality of wires **9** positioned and connected together in the same manner to a switch terminal **11**. The wires in the second set fall within a second plane displaced from the first plane and parallel thereto. Each wire in the second set is associated with a corresponding blue strip.

The third set **8** includes a like plurality of wires **9** positioned and connected together in the same manner to a switch terminal **12**. The wires in the third set fall within a third plane displaced from the first and second planes and parallel thereto. Each wire in the third set is associated with a corresponding green strip. The first, second and third coplanar wire sets are equidistantly spaced from each other.

Magnets **211** and **212** (which can be electromagnets or can be of the permanent type) are adjustably contained and equidistantly spaced within a non-magnetic mounting ring **15** secured to tube **1** by adjustable clamps **13** and **14**. The magnets are straight or curved and their longitudinal

axes fall within a common plane. The fields of these magnets have opposed polarities. The intensity of the resultant magnetic field, when measured along a line (the Y axis) contained within this plane and passing through the electron-optical center of the tube in a direction perpendicular to the grid wires, varies in such manner that the field intensity is zero at a point corresponding to the zero deflection position, increases with given polarity in one direction along the Y axis displaced from the zero position and increases with opposed polarity in the direction displaced from the zero position. The zero position of the Y axis corresponds to the electron-optical center of the image. The Y axis represents the common axis of symmetry for magnets **211** and **212**.

When the plate **3** is scanned along the Y axis, the magnetic field constrains the beam in such manner that the angle of incidence measured with respect to this axis is substantially 90° for all beam deflection angles.

When the beam travels in a direction perpendicular to the Y axis, the effect of the non-linear field is less pronounced in positions corresponding to the corners of the image, and the angle of beam incidence on the grid with increasing beam deflection angle, as measured with respect to this perpendicular direction, will vary. For small color images, this variation is insufficient to impair or degrade the image. For larger color images, however, it is necessary to adjust the direction and intensity of the non-linear field in such positions.

In order to accomplish this adjustment, I provide two field correction magnets, also adjustably contained and equidistantly spaced within the mounting ring **15** in such manner that magnets **211**, **212**, and these two magnets, are equidistantly spaced circumferentially with respect to each other. The two field correction magnets (only one of which is shown in the drawing and is identified at **216**) together establish a second non-linear field substantially similar to the first field; however, the common axis of symmetry of magnets **211** and **212** which passes through the optical center of the tube (the X axis) is perpendicular to the similar axis of symmetry of the two correction magnets.

The lengths of the correction magnets are small relative to the lengths of magnets **211** and **212**. This is necessary to provide a sufficient gap between adjacent ends of adjacent magnets to effectively suppress any magnetic interaction between these adjacent ends. As a result, the effects of the second field are confined to adjusting the direction and intensity of the first non-linear field in positions corresponding to the corners of the color image.

Further details on the action of these magnetic fields will be found in the above-mentioned copending application.

As indicated previously, if color resolution requirements permit, the widths of the color strips can be increased as necessary and the magnets need not be used.

The effect of the grid structure on beam position can be readily seen from an examinaiton of Figure 2. When a suitable blue color switch pulse is supplied to terminals **11** and **12**, the electron beam is directed between two adjacent wires on the first wire set **6** to strike a blue strip.

When a green color pulse is sequentially supplied to these terminals, the beam is deflected between the corresponding two adjacent wires of the second wire set **7** to strike a green strip.

When a red color pulse is sequentially supplied to these terminals, the beam is deflected between the corresponding two adjacent wires of the third wire set **8** to strike a red strip. Note that color switching is not accomplished through the use of electric fields transverse to the direction of beam emission as in the known tube, but rather through the use of substantially parallel and physically displaced electric fields.

The apparatus for supplying the switching pulse to the various switch terminals is shown in Fig. 5 and will be described hereinafter.

Fig. 3 shows a cathode ray tube arrangement which is substantially identical with that shown in Fig. 1 except that a fourth wire set **18** is interposed between the third set **8** and the image plate, and the magnets are not used. Set **18** includes a second plurality of equidistantly spaced wires **9** which are parallel to each other and to the color strips and which fall along a plane parallel to the image plate. Each of these wires is associated with a corresponding color strip; the wires are uninsulated and electrically connected together to a terminal **19**. Terminal **19** is connected to a point of positive constant potential with respect to the cathode of the gun which is substantially less than that applied to terminal **6** and is also less than a potential approximately equal to three times the maximum amplitude of the color switching pulse.

Because of these differences in potentials, the electron beam is under-focused on to the plane of the fourth wire set in the manner shown in Fig. 4 and then finally focused on the desired color strip. The under-focused beam exhibits line bowing as indicated by the solid and dotted lines **20** and **21** respectively as the beam is scanned along a particular color strip, in this example a blue strip. However, the final focusing action eliminates this bowing action in the manner shown by displaying an additional cylinder lens focusing action.

The tubes shown in Figs. 1, 2, 3 and 4 have all made use of planar image plates and coplanar wire grid structures. Since each wire set included in the grid structure is parallel to the image plate (which is an equipotential surface) and since the grid wires in each set are all at the same potential, it follows that each wire set falls along an equipotential surface.

I have found that as long as each wire set falls along an equipotential surface in this manner, curved image plates and correspondingly curved wire sets can be successfully used. Consequently, my invention is not limited to the use of planar image plates and wire grid structures.

Referring now to Fig. 5, a conventional color switching circuit identified at **100** produces conventional color switching potentials across its output terminals **101** and **102**. When a green strip is to be scanned, the potential difference between these terminals is substantially zero. When a red strip is to be scanned, the potential difference has a definite value and positive polarity. When a blue strip is to be scanned, the potential difference has the same value, but the polarity is reversed. An amplifier **103** is coupled at its input **104** to terminals **101** and **102** and produces at **105** an output signal proportional to the difference in potential. Therefore this output signal has a positive value, a negative value or a zero value depending upon the color of the strip to be scanned.

The output signal is supplied to the conditioning electrodes **115**, **116**, **117**, **118** and **119** of gates **106**, **107**, **108**, **109** and **110**.

Gates **106** and **107** are connected at their inputs to terminals **114** which is maintained at the same potential as terminal **10**. Gates **108** and **109** are connected at their inputs to terminal **113** which is maintained at a constant direct potential which is higher than that on terminal **10** but lower than that on terminal **6**. Gate **110** is connected at its input to terminal **112** which is maintained at a constant direct potential which is higher than that on terminal **113** but lower than that on terminal **6**.

The output of gates **106** and **108** are connected at their inputs to terminal **114** which is maintained at the same potential as terminal **10**. Gates **108** and **109** are connected at their inputs to terminal **114** which is maintained at a constant direct potential which is higher than that on terminal **10** but lower than that on terminal **6**. Gate **110** is connected at its input to terminal **112** which is maintained at a constant direct potential which is higher than that on termnial **113** but lower than that on terminal **6**.

The outputs of gates **106** and **108** are connected to-

gether to terminal **11**. The outputs of gates **107**, **109** and **110** are connected together to terminal **12**.

Gates **110** and **108** are designed to be opened only when the output signal for amplifier **103** has a positive value (indicating that a red strip is to be scanned). Gate **109** is designed to be opened only when the output signal has a negative value (indicating that a blue strip is to be scanned). Gate **107** is designed to be opened only when the output signal has a zero value (indicating that a green strip is to be scanned). Gate **106** is designed to be opened when the output signal has a negative or zero value (indicating that a blue or green strip is to be scanned).

The resulting color switching pulses supplied to the terminals **11** and **12** of the wire grid structure have the wave forms indicated in Fig. 6. Thus sequential red, blue and green switching pulses are supplied to the wire grid structure and the operation proceeds in the manner described above.

While I have shown and pointed out and described my invention in one preferred embodiment, it will be apparent to those skilled in the art that many modifications can be made within the scope and sphere of my invention as defined in the claims which follow.

What is claimed is:

1. In combination, a cathode ray tube envelope; a planar image plate mounted within said envelope and coated with a plurality of first, second and third types of long narrow parallel phosphor strips having substantially equal widths, said strips being arranged in a repetitive pattern such that the (N) strip is of the first type, the (2N) strip is of the second type and the (3N) strip is of the third type, N being any positive integer; and a wire grid structure mounted within said envelope adjacent the coated side of said plate, said structure including first, second and third separated coplanar sets of parallel grid wires lying in corresponding first, second, and third separated planes, the number of grid wires in any set being equal to the number of strips of a corresponding color type, each grid wire being parallel to its corresponding color type, said planes being equidistantly spaced from each other and being parallel both to said plate and to each other.

2. The combination as set forth in claim 1 wherein the wires in any set are electrically interconnected to a corresponding common terminal.

3. The combination as set forth in claim 2 further including a fourth set of coplanar parallel grid wires interposed between said structure and said plate and lying in a fourth plane separated from and parallel to said first, second, and third planes, there being a grid wire in said fourth set associated with and parallel to each color strip.

4. The combination as set forth in claim 3 wherein the wires in said fourth set are electrically interconnected to a corresponding common terminal.

5. In combination, a cathode ray tube envelope; an image plate mounted within said envelope and coated with a plurality of first, second and third types of long narrow parallel phosphor strips having substantially equal widths, said strips being arranged in a repetitive pattern such that the (N) strip is of the first type, the (2N) strip is of the second type and the (3N) strip is of the third type, N being any positive integer; a wire grid structure mounted within said envelope adjacent the coated side of said plate, said structure including first, second and third separated coplanar sets of parallel grid wires lying in corresponding first, second, and third separated planes, the number of grid wires in any set being equal to the number of strips of a corresponding color type, each grid wire being parallel to its corresponding color strip, said planes being equidistantly spaced from each other and being parallel both to said plate and to each other; and a pair of magnets equidistantly spaced apart and mounted about the outside of the envelope at positions adjacent the grid structure, said magnets having a common axis of symmetry which passes through the electron-optical center axis of the envelope and which extends in a direction perpendicular to the long dimension of the strips.

6. The combination as set forth in claim 5 further including a second pair of magnets mounted around the outside of the envelope at positions adjacent the wire grid and having a second common axis of symmetry which extends through said central axis and which is perpendicular to the axis of symmetry of the other pair of magnets.

7. In combination, a cathode ray tube envelope; an image plate mounted within said envelope and coated with a plurality of first, second and third types of long narrow parallel phosphor strips having substantially equal widths, said strips being arranged in a repetitive pattern such that the (N) strip is of the first type, the (2N) strip is of the second type and the (3N) strip is of the third type, N being any positive integer; a wire grid structure mounted within said envelope adjacent the coated side of said plate, said structure including first, second and third separated coplanar sets of parallel grid wires lying in corresponding first, second, and third separated planes, the number of grid wires in any set being equal to the number of strips of a corresponding color type, each grid wire being parallel to its corresponding color strip, said planes being equidistantly spaced from each other and being parallel both to said plate and to each other; and means external to said envelope to establish a magnetic field within said envelope about the region of said grid structure, said field exhibiting a non-uniform field intensity within said grid structure along a path perpendicular to said wires which is substantially zero for a central position in said grid structure, said intensity gradually increasing with one polarity for positions upwardly displaced from said central position and gradually increasing with opposite polarity for positions downwardly displaced from central position.

8. In combination, a cathode ray tube envelope; an image plate mounted within said envelope and coated with a plurality of first, second and third types of long narrow parallel phosphor strips having substantially equal widths, said strips being arranged in a repetitive pattern such that the (N) strip is of the first type, the (2N) strip is of the second type and the (3N) strip is of the third type, N being any positive integer; a wire grid structure mounted within said envelope adjacent the coated side of said plate, said structure including first, second and third separated coplanar sets of parallel grid wires lying in corresponding first, second, and third separated planes, the number of grid wires in any one set being equal to the number of strips of any one color type, each grid wire being parallel to its corresponding color strip, said planes being equidistantly spaced from each other and being parallel both to said plate and to each other, the wires in the first set being interconnected to a first terminal, the wires in the second set to a second terminal, the wires in the third set to a third terminal; an electron gun for emitting an electron beam which is adapted to scan said plate; and means to supply color switching pulses sequentially to said terminals whereby said beam is sequentially directed upon strips of the second, third and first types.

9. In combination, a cathode ray tube envelope; an image plate mounted within said envelope and coated with a plurality of first, second and third types of long narrow parallel phosphor strips having substantially equal widths, said strips being arranged in a repetitive pattern such that the (N) strip is of the first type, the (2N) strip is of the second type and the (3N) strip is of the third type, N being any positive integer; a wire grid structure mounted within said envelope adjacent the coated side of said plate, said structure including first, second and third separated sets of parallel grid wires, the number

of grid wires in any set being equal to the number of strips of a corresponding color type, each grid being parallel to its corresponding color strip, said sets being equidistantly spaced from each other and being parallel both to said plate and to each other; and a fourth set of parallel grid wires interposed between said structure and said plate, said fourth set being parallel both to said plate and to said first, second and third sets, the number of grid wires in said fourth set being equal to said plurality of the first, second and third types of color strips, each grid wire in said fourth set being parallel to this corresponding strip.

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