

March 24, 1959

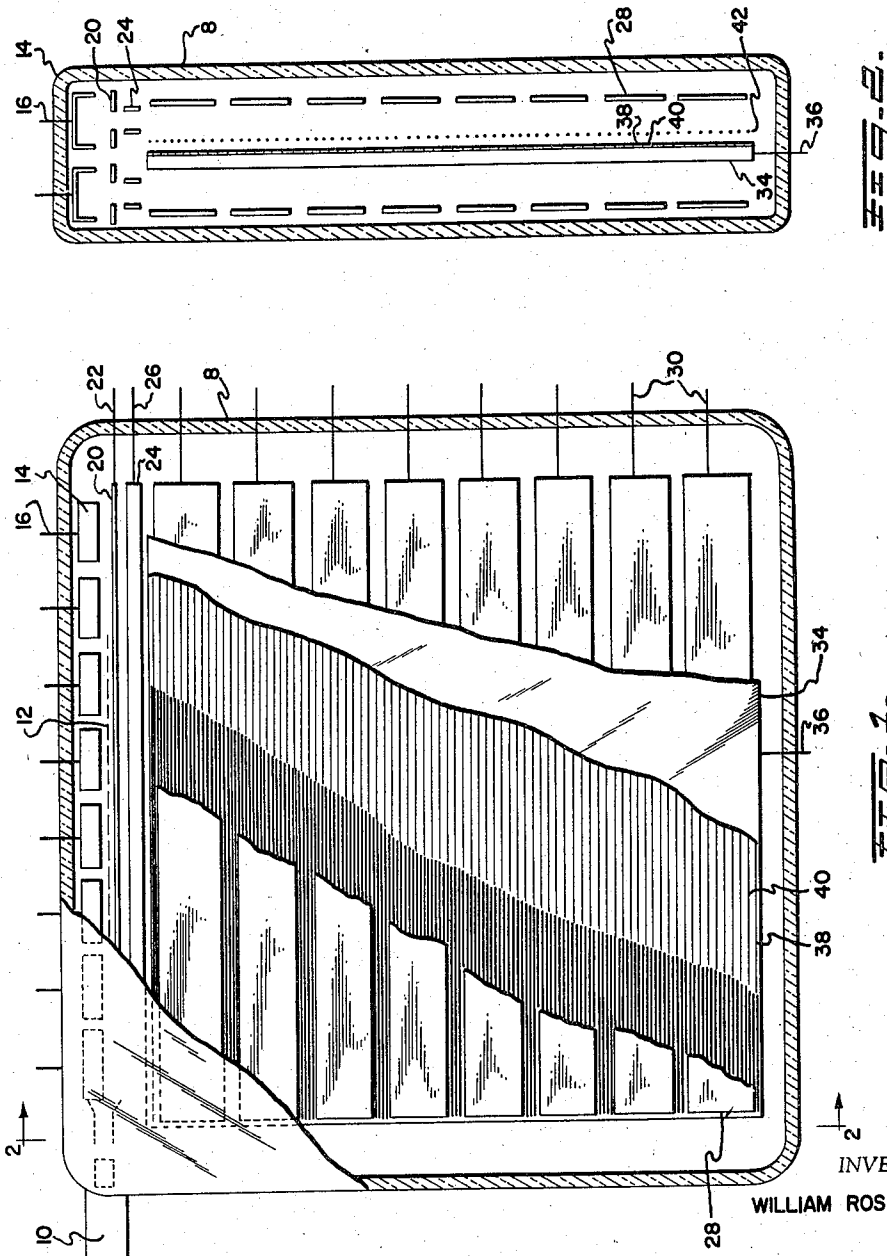
W. R. AIKEN

2,879,446

ELECTRONIC DEVICE

Filed Feb. 8, 1956

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

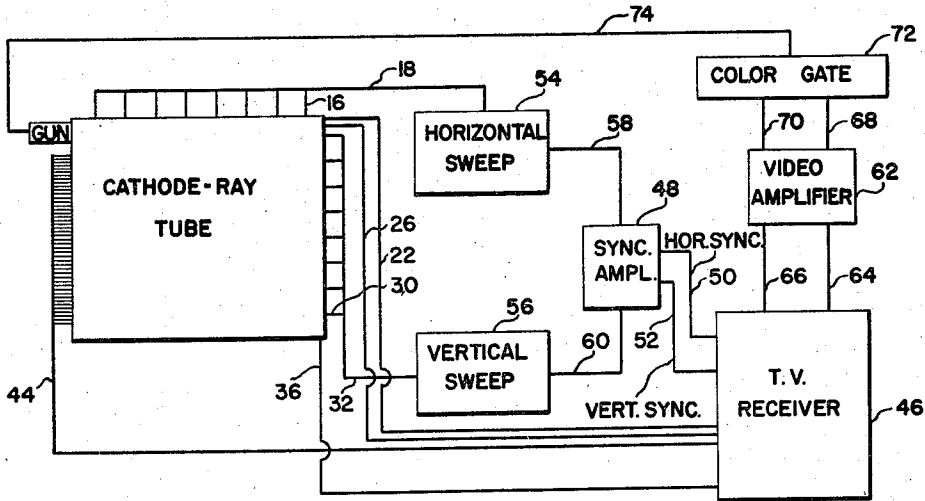
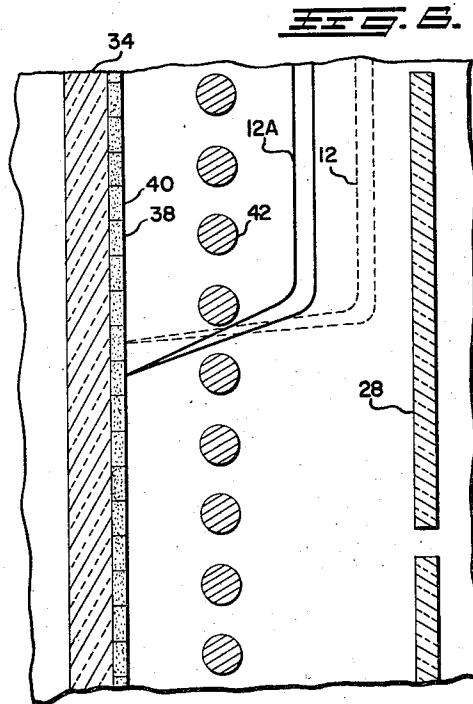
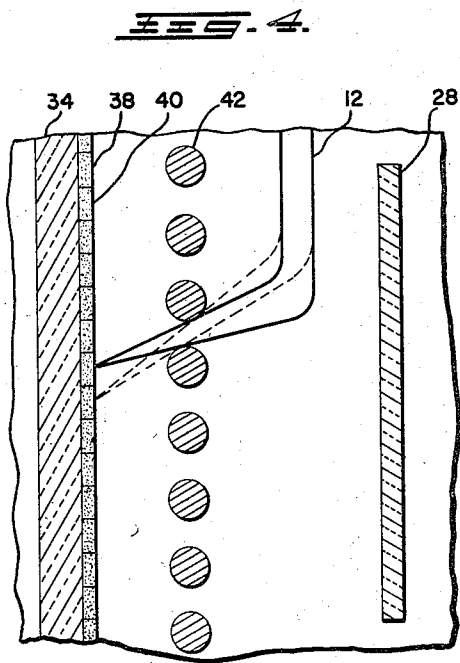


FIG. 3.



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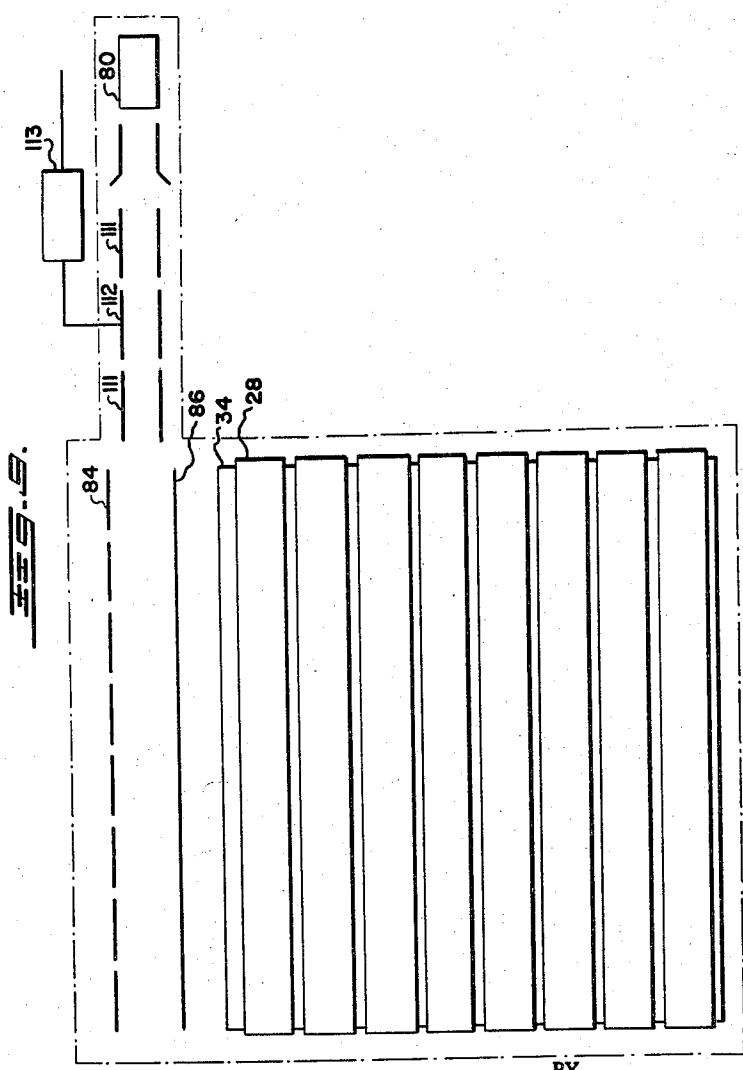
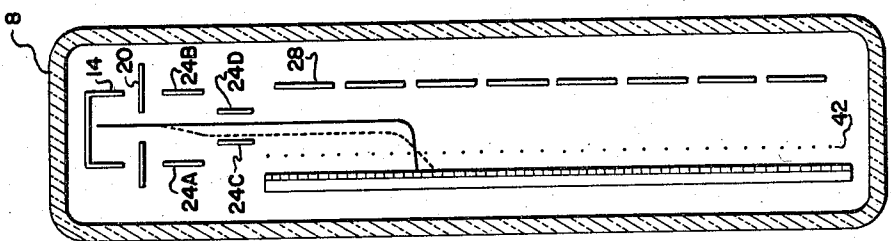
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4 Sheets-Sheet 4

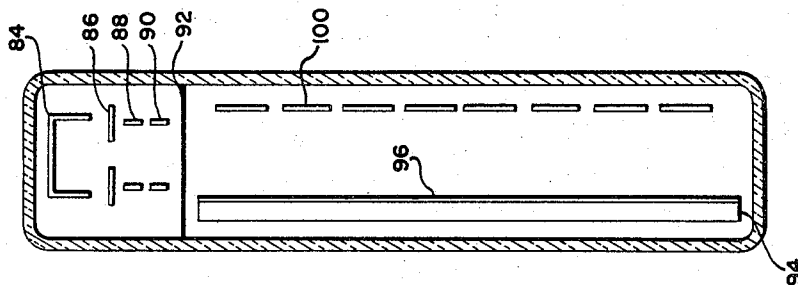


Fig. 6.

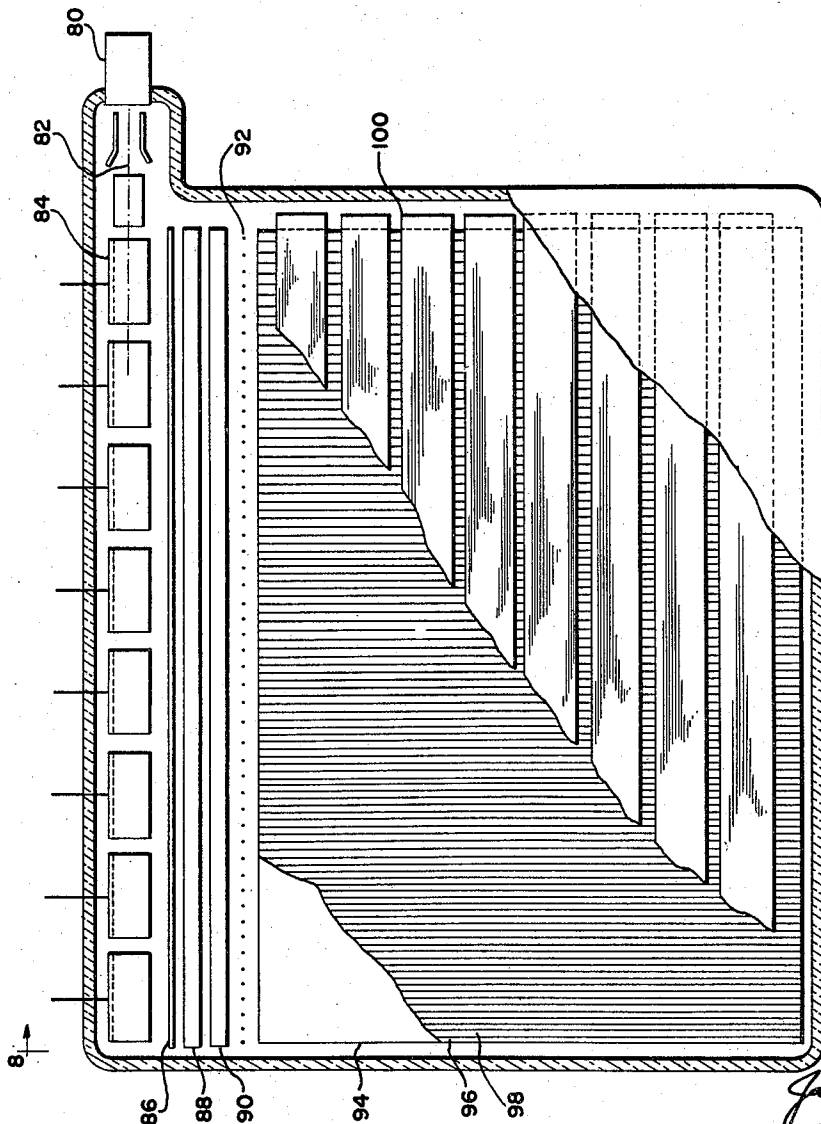


Fig. 7.

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2,879,446

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Application February 8, 1956, Serial No. 564,166

15 Claims. (Cl. 315—21)

The present invention relates to electron discharge devices and more particularly to thin cathode-ray tubes of the general type set forth in co-pending application Serial No. 355,965, filed May 19, 1953, now abandoned; copending application Serial No. 504,281, filed April 27, 1955; copending application Serial No. 656,874, filed May 3, 1957; copending application Serial No. 703,340, filed December 12, 1957; and Patent No. 2,795,731 which issued June 11, 1957, which are capable of polychrome operation.

In the prior art, it has been proposed to display the television image signal by means of a cathode-ray tube using one or three electron guns directed at a target screen comprising discrete sensitized areas of electron sensitive fluorescent materials which are capable of emitting the desired color component elements such as red, blue, and green. These sensitized areas have assumed a variety of configurations such as dots, lines, and pyramids. Various combinations have been proposed to provide means for scanning the target screen in accordance with the scan of the transmitted image, and for modulating, controlling and orienting the electron beam to produce the desired luminous color and to limit the impingement thereof to only the desired sensitized area. The electron beam or beams may be caused to scan the three primary color areas either in sequence or simultaneously so that the luminosity of the three color values are additive to the human eye to thereby reproduce the hue and saturation of the particular color signal or to produce black and white image areas. Numerous systems and structures have been proposed to control and modulate the electron beam so as to thereby produce the desired scanning of the sensitized areas and to prevent the impingement of the electron beam, or any portion thereof, upon undesired color sensitized areas. The display arrangements proposed by the prior art include many relatively complicated and expensive deflecting grid and masking arrangements which are designed to limit the impingement of the electron beam on only the desired primary color area.

The prior art attempts to employ a masking arrangement disposed immediately in front of and slightly spaced from the target screen have been confronted with the problem of picture brightness due to the extreme current loss of the electron beam in passing through the mask. In certain instances, the current lost or absorbed by electron impingement on the mask has been as much as eighty-seven percent of the entire beam current. In attempts to effect a picture brightness which would be commercially acceptable, higher voltages have been employed. High voltages have inherent disadvantages and limits due to their dangerous nature and an expense beyond the range which is commercially feasible.

Accordingly, it is an object of the instant invention to produce a cathode-ray tube having a masking arrangement capable of permitting the passage of only the desired electrons of the electron beam while at the same time absorbing a minimum of beam current.

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Another object of the instant invention is to produce a cathode-ray tube capable of exhibiting a polychrome display and utilizing a small number of components so as to be inexpensive to manufacture and operate.

5 A further object is to produce a cathode-ray tube capable of effecting polychrome displays on the target screen thereof and having a relatively small depth dimension as compared with its length and width.

A still further object is to produce an electron discharge device having extreme stability and color fidelity for exhibiting polychrome displays.

In accordance with one embodiment of the instant invention, the cathode-ray tube comprises a target screen having a plurality of strips of fluorescent material capable of emitting light of different primary colors which are cyclically repeated across a surface thereof. An electron gun is provided to deliver a beam of electrons along a marginal edge of the target. The linear set of deflection electrodes, which is used to selectively deflect the beam to a zone adjacent the surface of the target, is positioned in adjacently spaced relation with respect to the marginal edge of the target along which the electron beam is initially delivered. A set of deflection electrodes adapted to selectively deflect the beam into registration with the target strips is provided adjacent the surface of the target and spaced therefrom an amount sufficient to permit passage of an electron beam therebetween. A grid wire assembly is disposed within a zone intermediate the first-mentioned set of deflection electrodes and the region defined by the target. In this arrangement, the angle through which the beam is deflected by the deflection electrodes determines the fluorescent strip with which the beam will register.

Objects and advantages other than those hereinabove set forth will be apparent to those skilled in the art upon reading the following description in connection with the attached drawings, in which:

Figure 1 is a front view of the cathode-ray tube with sections thereof partly broken away to more clearly illustrate the internal components,

Figure 2 is a sectional view of the cathode-ray tube illustrated in Figure 1 taken along line 2—2 thereof,

Figure 3 is a schematic illustration of a suitable system employing the instant cathode-ray tube for the polychrome display of television programming,

Figure 4 is an enlarged side view of a portion of the high voltage section of the tube to more clearly illustrate the electron beam deflection angles of the embodiment shown in Figures 1 and 2,

Figure 5 is a side view of a modified version of the tube shown in Figures 1, 2 and 4,

Figure 6 shows another modified version of the tube wherein two electron beams are employed,

Figure 7 is a front view of an embodiment of the invention,

Figure 8 is a sectional view of the cathode-ray tube shown in Figure 7 taken along line 8—8, and

Figure 9 is a front view of an embodiment of the invention shown in diagrammatic form.

There is shown in Figures 1 and 2 an envelope 8 which is adapted to completely house the internal components of the instant tube and maintain the desired vacuum therewithin. An electron gun 10 of any of the conventional types employing, preferably, an integral electrostatic deflection system, such as that described in an article entitled, "Improved Electron Gun for Cathode-Ray Tubes," by L. E. Swedlund in Electronics for March 1946, is disposed within the envelope 8. The electron gun 10 is adapted to deliver an electron beam 12. A linear array of horizontal deflection electrodes 14 is disposed within the envelope 8 along the upper marginal edge thereof. Each of the electrodes 14 is

provided with an electrical conductor 16 which is adapted to pass through the wall of the envelope 8 and the entire group of conductors may be assembled and positioned within suitable cable means 18 and in turn connected to a horizontal sweep generator 54, as clearly illustrated in connection with Figure 3.

A slotted accelerating electrode 20 is disposed in spaced and substantially parallel relation with respect to the entire array of deflection electrodes 14. The electrode 20 is suitably energized through a conductor 22 adapted to electrically couple the electrode 20 to a suitable power supply within a television receiver 46, as clearly illustrated in Figure 3. The aforementioned group of components may be referred to as the "primary section" of the tube.

Disposed beneath and extending substantially the entire length of the primary section, there is a pair of focusing and accelerating electrodes 24 provided with a suitable electrical conductor 26 which is adapted to pass through the wall of the envelope 8 to a power supply within the television receiver 46, as clearly shown in Figure 3. It is to be understood that, in certain applications, it may be desirable to employ an additional pair of focusing and accelerating electrodes similar to the pair of electrodes 24. In such event, these additional electrodes could be disposed beneath and slightly spaced from the electrodes 24 and connected to the same power supply employed to energize the electrodes 24 or to a separate power supply to operate at potential different from that of electrodes 24. The electrodes 24 and any additional similar electrodes which may be desired may be referred to as the "transition section" of the tube.

The "high voltage" or "secondary section" of the tube comprises an electrically conductive transparent panel 34 having a coating thereon of a material which when struck by impinging electrons will become excited and fluoresce an amount in proportion to the energy of the impinging beam of the electrons. The fluorescent coating or target screen is comprised of alternate strips 38 and 40 of fluorescent material cyclically repeated across one entire surface of the panel 34. The strips 38 are of a fluorescent material, such as zinc phosphate, manganese activated $[Zn_3(PO_4)_2:Mn]$, which will emit red light when excited by an impinging beam of electrons and the strips 40 are of a fluorescent material, such as zinc sulfide, silver activated ($ZnS:Ag$), which will emit blue light when excited by impinging electrons. It has been found advisable to make each strip 38 and 40 of a width of approximately thirty (30) mils. Accordingly, if four hundred eighty-seven strips ($243\frac{1}{2}$ of the strips 38 and $243\frac{1}{2}$ of the strips 40) are employed, the resultant display area will have a vertical dimension of fifteen (15) inches.

It will be noted that the electrically conductive panel 34 is provided with a conducting wire 36 which is adapted to be electrically connected to a source of potential which is positive with respect to the potential of the electron beam 12. The potential is obtained from the power supply within the television receiver 46, shown in Figure 3.

Opposite and spaced from the phosphor coating comprised of the strips 38 and 40, there is a plurality of deflection electrodes 28. Each of the electrodes 28 is provided with an electrical conductor 30 adapted to pass through the tube envelope 8 to a vertical sweep generator 56, as shown in Figure 3. The various conductors 30 may be cabled together outside of the tube envelope 8 within a cable 32.

In certain applications of the instant tube, it may be deemed necessary to view the display presented on the target screen from two sides. In such event, the vertical deflection electrodes 28 are formed of a transparent conducting material such as, for example, glass treated with stannic chloride ($SnCl_4$).

Within the zone defined by the target screen and the vertical deflection electrodes 28, there is disposed a grid wire assembly comprised of a plurality of grid wires 42 having a common conductor 44 leading to a power supply within the television receiver 46, as illustrated in Figure 3. The number of grid wires 42 is only one-half that of the number of strips of fluorescent material affixed to the panel 34; or, in other words, there are as many individual grid wires 42 in the grid wire assembly as there are strips 38 of red light emitting phosphors. The grid wire assembly is disposed in such a manner relative to the phosphor strips 38 and 40 that a single wire 42 is directly opposite and spaced from each of the strips 38 which emits red light. The diameter of each of the grid wires 42 is of the order of thirty (30) mils; therefore, the diameter of the wires 42 is substantially equal to the width of each of the phosphor strips 38 and 40.

Figure 3 illustrates a system employing the instant cathode-ray tube in connection with the reception of a television display in color. A standard RCA color receiver circuit may be employed such as, for example, RCA Model CT100, Chassis No. CTC2. For purposes of simplification, the above referred to receiver is shown in diagrammatic form by reference numeral 46. The color TV receiver 46 includes a power supply capable of energizing the various components of the instant tube as will be hereinafter be set forth in detail.

The horizontal and vertical sweep sync signals are fed to a sync amplifier 48 through their respective coupling conductors 50 and 52. The sync amplifier 48 amplifies the horizontal and vertical sync signals which are then fed to the horizontal and vertical sweep generators 54 and 56 through electrical conductors 58 and 60, respectively. The horizontal sweep generator 54 is coupled to the horizontal deflection electrodes 14 through the conductors 16 which are housed within the cable 18. The vertical sweep generator 56 is coupled to the vertical deflection electrodes 28 through the conductors 30 which are housed within the cable 32.

The grid wires 42 are coupled to the power supply within the receiver 46 by the conductor 44.

The video signals carrying the information to be displayed by the instant tube are fed from the receiver 46 to a video amplifier 62 through a suitable electrical conductor 64 for conducting the red color control signals and an electrical conductor 66 for conducting the blue color control signals. The video amplifier 62 amplifies the red and the blue signals and they are then fed through conductors 68 and 70, respectively, to a color gating circuit, diagrammatically shown and generally indicated by reference numeral 72. The gating circuit 72 is operative to selectively feed the signals carrying the appropriate color information to the electron gun 10 through an electrical conductor 74.

In the operation of the instant invention, the electron gun 10, upon suitable energization by an incoming video signal (television use), causes an electron beam 12 to be delivered along a path which is in substantially parallel alignment with the longitudinal axis of the linear array of horizontal deflection electrodes 14. Initially, all the horizontal deflection electrodes 14 are maintained at some potential positive with respect to the cathode potential of the electron gun 10 and negative with respect to the potential of the slotted accelerator electrode 20. As the electron beam 12 enters the region of electrostatic field established by the first horizontal deflection electrode 14 most adjacent to the source of the electrons, the repelling force of said field causes the beam 12 to be deflected downwardly in a direction away from said electrode. The equal potential lines established within the horizontal deflection electrodes 14 deflect the electrons through the open side of the electrodes 14 toward and through the slot formed in the slotted electrode 20 and hence into the "transition" and "high voltage" sections of the tube.

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In obtaining a display, the horizontal deflection electrodes 14 are, as mentioned above, initially maintained at their maximum negative value with respect to the slotted accelerator electrode 20, and then selectively driven in a positive direction toward said potential value. This display may also be achieved in the opposite manner; in other words, all the horizontal deflection electrodes 14 may be initially maintained in their fully charged state and then discharged or driven toward a negative potential value. Whichever method is used, the frequency of change (from negative to positive or charged to discharged) is controlled by the horizontal sweep generator 54.

It was found that satisfactory results were obtained by initially impressing on the horizontal deflection electrodes 14 a potential of 400 volts positive with respect to the cathode potential of the electron gun 10. The slotted electrode 20 is maintained at 800 volts potential positive with respect to the cathode potential of the electron gun 10.

In achieving a line scan, energizing signals are applied to the horizontal deflection electrodes 14, preferably in a successive overlapping manner. That is, a signal is applied to the deflection electrode closest to the source of electrons, which drives that electrode in a positive direction approaching the value of the potential on the slotted electrode 20. However, prior to the instant the potential value on the first electrode reaches a value substantially equal to the potential of the slotted electrode 20 (800 volt positive potential), a positive going signal is applied to the next adjacent deflection electrode 14. Obviously, when the potential on the first of these electrodes reaches the approximate value of the potential on the slotted electrode 20, a field-free zone is established within the region defined by the slotted electrode 20 and the horizontal deflection electrode 14, thereby permitting the electron beam 12 to travel unaffected to the next adjacent horizontal deflection electrode 14. This procedure is repeated along the entire array of electrode 14 in such a manner that the charge on at least two of the electrodes is always changing at the same time.

The electron beam 12 after being deflected, accelerated and focused in the primary and transition sections, is caused to travel along a path in close proximity to the vertical deflection electrodes 28. The vertical deflection system is operated in much the same manner in which the horizontal deflection system is operated. The signals applied to the vertical deflection electrodes 28 are preferably applied in overlapping manner so that the potential value on at least two adjacent electrodes 28 is changing at the same time. Initially, the vertical deflection electrodes 28, the grid wires 42, and the fluorescent target comprised of the phosphor strips 38 and 40 are maintained in the order of 16 kv. potential positive with respect to the cathode potential of the electron gun 10. By virtue of the fact that each of the elements of this portion of the high voltage section is maintained at an equal potential value, a field-free region is established therewithin permitting the electron beam 12 to travel unobstructively within the field-free region until a suitable negative potential with respect to the potential of the target strips 38 and 40 is applied to one or more of the vertical deflection electrodes 28.

As one electrode 28 is driven negative with respect to the cathode potential of the target, it exerts a deflecting force on the beam 12, causing it to be deflected toward the fluorescent target through the grid wire assembly 42. The impingement of the electrons upon the proper color strip of the target, as hereinafter described, causes it to give off luminescence of an intensity which is directly proportional to the intensity of the impinging electron beam 12.

In order to obtain a full polychrome display, the surface of the panel 34 opposite the surface coated with the target strips of phosphor 38 and 40 may be coated with

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a phosphor of the type which emits green light upon the impingement of an electron beam. For instance, such a phosphor as zinc orthosilicate manganese activated ($\text{Zn}_2\text{SiO}_4:\text{Mn}$) may be used. In such an embodiment, an additional electron gun modulated by the signal carrying the information to be displayed in green is positioned adjacent that other surface of panel 34 and is deflected by another set of vertical deflection electrodes. In the alternative, the target strips 38 and 40 may be separated by a phosphor strip of green light emitting phosphor. Beam switching means would then be employed to cause the electron beam to selectively sweep the desired fluorescent material upon receipt of the corresponding color information so that the device would be operated with but a single electron gun modulated by the red, blue, and green signals.

In order to present an image in color, the individual pictures which have been sent from the transmitter in each of the primary colors must be reassembled at the receiver. In order to simplify the following discussion, we will assume that the first of the three color embodiments described above is used so that the green primary color is produced by a separate electron gun upon a separate target, whereas the red and blue signals are reproduced by the modulation of a single electron gun acting upon a target having strips of alternate red and blue phosphors. In such an embodiment, the color picture may be produced by a field-sequential method. In such a method, the electron beam is first caused to scan the entire face of the target screen in a manner whereby only the phosphor strips 38 emitting red light are struck and thereby excited by the beam, forming a red raster. During the next succeeding scanning operation, the beam will be caused to impinge only on those phosphor strips 40 which emit blue light, thereby forming a blue raster. Acting under the control of the transmitted signal, the beam 12 changes in intensity and thereby causes the spot of light emitted by the excited phosphor to effect a corresponding change in brightness as it moves along each strip and thus recreates the light and shadows of the original scene. Since the light spot on the target screen moves in precise step with the scanning process of the television camera at the transmitting station, each dot of light falls in its proper place and has its proper value of light or shade. Obviously, the reassembling process at the receiver is accomplished so rapidly—a single primary color being emitted during each period of the beam sweep of the individual strips of phosphor—that these strips are not perceived separately one after the other, but appear to the viewer as a blend of colors existing simultaneously.

In the alternative, a polychrome display may be produced by a line-sequential method. In this method and in somewhat similar fashion to that used in the conventional black and white television picture tube, the persistence of the eye to retention of light images is utilized to reduce the flicker of transmission. Alternate lines are first scanned and then the picture is retraced on the remaining lines, so that the entire picture is covered twice during the one-thirtieth of a second raster. In this system, the lines are scanned so that after each line of red, there is a scan of a line of blue and then of a line of red and a line of blue, alternatively, and when the bottom line is reached, the electron beam retraces the face of the target, utilizing the remaining color strips. Simultaneously, of course, the green target is scanned and, since only two of the three primary colors are interlaced, the crawling which is experienced in the line interlace or line-sequential system is inherently reduced to such a degree that it is unnoticed, as in conventional black and white TV receivers.

At this point in the description of the invention, the exact nature and function of the grid wire assembly must be explained. As briefly pointed out in a preceding section of the description in connection with the disposition of the individual wires 42 with respect to the individual

strips 38 and 40 of fluorescent material, there is a wire 42 disposed in spaced coextensive parallel relation directly in front of each of the strips 38.

The function of the grid wire assembly is that of a mask which effectively blocks the passage of all but a desired group of electrons of the electron beam which has been deflected toward the target screen by the vertical deflection electrodes 28. The manner in which the grid wires 42 operate is best illustrated in connection with Figure 4 which shows the electron beam 12, shown in full line, deflected so as to impinge on only the phosphor strips 38 which give off red light. When the electron beam 12 is deflected so as to pass through the opening between adjacent grid wires 42, it impinges on the phosphor strips 40, as shown in Figure 4 in broken lines. It will be understood that the angle through which the beam is bent by the force applied by the deflection electrodes 28 determines whether the beam will impinge on the phosphor strip 38 or 40.

As mentioned above, the point of beam registration on the target screen is determined by the angle through which the beam is caused to bend under the influence of the deflecting force established by the vertical deflection electrodes 28. In the instant embodiment of the invention, it is necessary to cause the beam 12 to bend through one angle in order to impinge upon the strips 38 to achieve a red raster, and to bend through another angle to impinge upon the strips 40 to achieve a blue raster. It will be readily apparent that if the energizing signals impressed on the vertical deflection electrodes 28 are maintained within the same range, the energy or velocity of the electron beam 12 as it travels in the high voltage section must be of a constant energy in order to bend and pass through the space between adjacent grid wires 42 and impinge on the phosphor strips 38. The beam 12 must rapidly then assume another energy to be deflected by the deflection electrodes 28 through the space between adjacent grid wires 42 and impinge on the phosphor strips 40.

It should be noted here that the angle of the deflected beam is dependent upon the ratio of the energy of the beam to the deflecting forces acting upon it. In order to obtain the desired color change, it is only necessary to change this ratio in any convenient manner. For instance, the deflecting forces acting upon the beam in both the primary and the secondary section of the beam may be kept constant and the energy of the beam varied independently, as by raising the voltage of the transition section. A beam with a higher energy component will be deflected through a lesser angle than that of a smaller energy component when acted upon by the same deflecting force. For another example, the desired result may be had by changing the energy of the beam in the secondary section by increasing the voltage on both the vertical deflection electrodes 28 and upon the targets 38 and 40. The beam is aligned on one of the two colors by utilizing a voltage of, for example, +10 kv. upon the target plate and a potential of +1 kv. on the deflection electrodes 28. Then, for the other color, the target is run at +11 kv. and the deflection electrodes at +2 kv. In this example, no over-all change is made in the voltage drop between the target and the deflecting electrodes so that, therefore, the deflecting force remains constant at 9 kv. but, however, the energy of the beam in the secondary section is sufficiently varied by the 1 kv. change so that it is deflected through a different angle and therefore registers upon a different color. In another example, the opposite technique is used and the deflection forces are changed rather than the energy of the beam, for any specific color selection. In another instance, the energy of the beam is varied by modulating the cathode potential. As previously explained, the higher energy beam is deflected less by a given deflection field than a lower energy beam.

In yet another example, the overlapping action of

the deflection plates is increased for one color and decreased for another. By increasing or decreasing the area of field overlap in the deflection system, the deflection angle of the beam is changed by the changing action of the deflecting electrodes. It should be explained at this point that if the dot sequential method is used in forming the color picture, then the change from one color to the other must be effected very rapidly, whereas if the line sequential method is used, then the change need not be quite so rapid and, of course, if the field sequential method is used, then the color change need only be made once for each complete raster field.

In addition, as shown in Figure 5, the position of the electron beam in the secondary section may be shifted to achieve different color registrations. The electron beam is deflected, focused, and accelerated in the primary and transition sections by horizontal deflection plates 14, slotted accelerator 20, and focusing and accelerating electrodes 24. The side portions of each pair of electrodes 24A-B are normally operated at one potential positive with respect to the potential of the cathode of the electron gun 10, for example +5 kv. Similarly, both sides of the pair of electrodes 24C and 24D are operated at the same potential, in this example +3 kv., with respect to the potential of said cathode. After passing through the transition section, the electron beam is then in the secondary section and is ready to be deflected by vertical deflection electrodes 28. As shown in Figure 5, if the potential on 24B is made slightly more negative, say of the order of 200 volts, from that on 24A, the electron beam will be caused to pass closer to the surface of electrode 24A than to the surface of electrode 24B. Correspondingly, if the potential on accelerating and focusing electrode 24C is similarly made more negative with respect to the potential of the electron beam than the potential of electrode 24D, the electron beam will be caused to straighten its path and pass close to but not impinge on electrode 24C. As is shown in Figure 5, this gives a shifted path to the electron beam as it passes through the transition section and serves to pass the electron beam closer to the grid wire assembly 42. Accordingly, when the electron beam is deflected by one of the electrodes 28, if it is closer to the grid wire assembly 42 it will not be acted upon with as much force and, correspondingly, will be deflected through a smaller angle than the electron beam passing normally between the transition section which will be deflected through a larger angle and impinge upon the color strip adjacent to that impinged on by the electron beam whose path was shifted. By switching the potentials on electrodes 24B and 24C to correspond to the color modulation of the signal, the electron beam will be caused to fall upon the red phosphor strips and the blue phosphor strips, alternatively and in the proper order.

The target screen may be coated or deposited with a film of aluminum by the well-known process of "aluminizing" to absorb any secondary electrons which may be emitted from the phosphor material of the strips 38 and 40. Also, any secondary electrons emitted from the grid wires 42 in a direction toward the target screen will also be absorbed by this film of aluminum.

The double-bend deflection of the electron beam, as set forth above, reduces beam "blow-up" and thereby provides powerful inherent focusing ability. Specifically, the beam is not brought down to a small spot until the second deflection force is applied to the beam (the force applied by the vertical deflection electrodes 28). Due to the very nature of the double-bend deflection system, it is possible and relatively simple to effect focus of the electron beam in the horizontal dimension separately from focus in the vertical dimension. Accordingly, and in the shadow mask device described herein, it may be advantageous to use astigmatic focusing of the electron beam to overcome any problems of misregistration due

to slippage of the pattern or raster. For instance, if a slight slippage occurred which would cause a misregistration of the electron beam in relation to the shadow mask, it is possible that a thin beam of the ordinary size would create a black or blank spot on the phosphor target. Since either of these results would be noticeably objectionable, it would be well to astigmatically focus the beam so that it is narrow in its horizontal dimension but long in its vertical dimension. A beam of this type will give sharp definition but will also simultaneously impinge upon both of the limiting grid wires of the shadow mask to insure that a good portion of the beam passes through the grid wires in the proper fashion, regardless of any minor misregistration of the electron beam upon the shadow mask. While some loss of brilliance occurs, due to the fact that a certain portion of the electron beam is masked by the grid wires and does not pass through to excite the phosphor screen, this is compatible with the situation in the conventional color tubes wherein a substantial portion of the electron beam is always lost at the color mask. However, this type of cathode-ray tube has the advantage over the conventional cathode-ray tube in that the beam current can be increased to make up for any electron losses. In any case, the amount of astigmatic focusing will, of course, depend upon the seriousness of the misregistration problem.

In certain applications of the instant cathode-ray tube, it may be deemed advisable to maintain the grid wires 42 at substantially the same voltage as the voltage impressed on the vertical deflection electrodes 28 at their maximum charged value, while the target screen is maintained at some voltage value positive with respect thereto. For example, one may employ a corresponding maximum value of +10 kv. for the vertical deflection electrodes 28, a substantially equal potential on the grid wires 42, and a potential of the order of +20 kv. on the target strips 38 and 40. Inasmuch as the electrodes 28 and the grid wires 42 are of substantially the same voltage value, there will be no potential gradient between them, thereby establishing a field-free zone within which the electron beam 12 may travel unaffected until deflected.

By maintaining the above set forth voltage values on the respective components, the electron beam 12, after passing through the space between the adjacent grid wires 42, will be accelerated toward the relatively positive target area and be very sharply focused on the phosphor target strips 38 and 40. This focusing, which is sometimes called, "post-deflection focusing," is the result of the acceleration of the electron beam in the area between the grid wires and the target and can readily be shown by a vector analysis. In other words, if the beam has any cross sectional area at all, this area will be decreased since the outer edges of the beam will be turned inwardly toward its center. The advantages of this post-deflection focusing are, of course, obvious, since a beam with greater energy is concentrated at a smaller point of impact on the target to give greater brilliance and definition than otherwise.

Figure 6 illustrates another method of achieving color selection by employing two electron beams 12 and 12a of the same energy and velocity. It will be noted that the electron beam 12 is caused to travel within the high voltage or secondary section of the tube along a path which is closed to the vertical deflection electrodes 28 than the electron beam 12a. As described above, the angle through which the beam is deflected determines the color selection. In the instant embodiment, the deflecting force established by the deflection electrodes 28 acts to a different degree on each of the beams 12 and 12a. The beam 12, which is closer to the array of vertical deflection electrodes 28, is deflected through a larger angle than the beam 12a. This result is achieved due to the fact that the force imparted on the beam 12 is considerably greater than the force imparted on the beam 12a.

Accordingly, it will be noted that the beam 12 is deflected through an angle causing the beam to bend and travel through the space between adjacent grid wires 42 toward the phosphor strips 38, while the beam 12a is caused to be deflected through a smaller angle and travel through the space between adjacent grid wires 42 toward the phosphor strips 40.

Another modification of the cathode-ray tube is shown diagrammatically in connection with Figures 7 and 8. It will be noted that the modified version employs a grid wire assembly between the transition section and the high voltage section of the tube. Its function is similar to that of the grid wire assembly shown and described in the embodiment shown in Figures 1 and 2, being in the nature of a mask which acts to permit the passage therethrough of only those electrons which have been deflected through a predetermined angle, while all others impinge on the surface of one or more of the individual wires of the assembly. Further, it will be noted that the target screen is comprised of vertically disposed strips of fluorescent material which are parallel to one another and extend across the entire surface thereof.

There is shown in Figures 7 and 8, an electron gun 80 adapted to deliver an electron beam 82 in spaced and parallel relation with respect to the upper marginal edge of a target screen. Said target screen is comprised of a conducting glass panel 94, one surface of which is provided with a plurality of vertically disposed phosphor strips 96 and 98. A linear array of horizontal deflection electrodes 84 is disposed along and spaced from the upper marginal edge of the target screen so as to apply deflecting forces to the beam 82 upon suitable energization. A slotted accelerating electrode 86 is disposed in spaced coextensive relation with respect to the linear array of deflection electrodes 84, enabling the electron beam 82 to pass therebetween. The linear array of horizontal deflection electrodes 84 and the slotted accelerating electrode 86 comprise the so-called primary section of the tube which is substantially identical with the corresponding section of the embodiment shown and described in connection with Figures 1 and 2.

The transition section of the tube comprises two pairs of accelerating and focusing electrodes 88 and 90. These electrodes are disposed in coextensive and spaced relation with respect to the slotted accelerating electrode 86.

Disposed beneath the pair of electrodes 90, there is a grid wire or mask assembly comprising a plurality of grid wires 92 which are disposed in parallel relation with respect to one another.

An electrically conductive glass panel 94 having a plurality of strips 96 and 98 of fluorescent material cyclically repeated across a surface thereof, is disposed beneath the assembly of grid wires 92. The strips 96 are composed of a phosphor such as zinc phosphate, manganese activated, which is capable of emitting red light when excited by an impinging beam of electrons. The strips 98 are composed of a phosphor such as zinc sulfide, silver activated, which is capable of emitting blue light when excited by an impinging beam of electrons. The strips 96 and 98 are formed in a width of approximately thirty (30) mils.

A set of vertical deflection electrodes 100 is disposed in adjacently spaced relation with respect to the surface of the panel 94 which is provided with the fluorescent strips 96 and 98. In certain applications of the cathode-ray tube, it may be desirable to view the display presented on the target screen from two diametrically opposed directions and, in such event, the deflection electrodes 100 may be formed of an electrically conductive transparent material such as, for example, glass. The aforementioned combination of elements, including the panel 94 having the fluorescent strips 96 and 98 and the set of deflection electrodes 100, comprise the so-called secondary or high voltage section of the tube.

It must be understood that the modification shown in

Figures 7 and 8 is merely diagrammatic and that for purposes of simplicity, the electrically conductive wires for the respective electrodes of the tube are not shown. The glass envelope enclosing the entire assembly which is necessary to provide a vacuum environment is likewise not shown.

In operation, initially, all the horizontal deflection electrodes 84 are maintained at a potential of approximately 400 volts positive with respect to the cathode potential of the electron gun 80. The slotted accelerating electrode 86 is maintained throughout the entire operation of the tube at substantially 800 volts potential positive with respect to the electron gun 80. Accordingly, the electron beam 82 delivered by the electron gun 80 is initially deflected by the electric field established by the deflection electrode 84 closest to the gun. The deflected beam 82 is caused to travel downwardly through the slot formed in the slotted accelerating electrode 86 and is then successively focused and accelerated by the accelerating and focusing electrodes 88 and 90. The pair of electrodes 88 may be satisfactorily maintained at +2 kv. potential positive with respect to the cathode potential of the electron gun 80, and the pair of electrodes 90 may be maintained at substantially +8 kv. potential positive with respect to said cathode potential.

Due to the fact that the electron beam 82 has a velocity component in a direction away from the electron gun 80, it may approach the assembly of grid wires 92 at an angle of less than ninety degrees.

Color selection is achieved by the grid wires 92 much in the same manner as color selection is achieved by the grid wires 42 of the embodiment shown in connection with Figures 1 and 2. Accordingly, the specific strip of fluorescent material of the target screen on which the beam 82 registers is determined by the angle of incidence of the beam with the assembly of grid wires 92. It will be noted that if the beam 82 arrives at the grid wire assembly at one angle, only certain of the electrons of the beam are permitted to pass through the space between the adjacent wires 92, while the other electrons are blocked. On the other hand, if the beam is deflected through a larger angle, thereby having a larger angle of incidence, only certain of the electrons of the beam 82 will be permitted to pass through the space between the same adjacent wires 92, while other electrons of the beam will be effectively blocked. Obviously, it will be seen that in the first instance, the beam 92 will effectively impinge on the phosphor strip 96 which will emit red light, while in the second case, the beam 82 will impinge on the phosphor strip 98 which will emit blue light.

In this embodiment, the assembly of grid wires 92 is maintained within the range of from fourteen (14) to sixteen (16) kv. potential positive with respect to the cathode potential of the electron gun 80. The high voltage section, including the target panel 94 and the vertical deflection electrodes 100, are maintained initially at substantially sixteen (16) kv. potential positive with respect to the cathode potential. Accordingly, it will be readily understood that if the potential impressed on the grid wires 92 is substantially the same as the potential of the high voltage section, there will be no supplemental focusing effected on the electron beam between the grid wires and the high voltage section. But, if the potential impressed on the grid wires 92 is lower than that of the high voltage section, additional focusing will be effected.

As the electron beam 82 enters the high voltage section of the tube, it will travel unaffected downwardly through the field-free zone defined by and established between the target screen and the vertical deflection electrodes 100, until one of the electrodes 100 is caused to be driven toward zero potential. Upon being so driven, that deflection electrode will establish a relatively negative electric field, thereby imparting a force to the electron beam causing it to bend toward and impinge on the

target panel. The particular phosphor strip impinged by the beam is determined by the angle of incidence with the assembly of grid wires 92 or, in other words, the angle through which the beam is bent by the deflecting forces established by the horizontal deflection electrodes 84 of the primary section of the tube.

The horizontal and vertical deflection electrodes 84 and 100, respectively, are energized by suitable sweep generators in a manner substantially identical to that described in connection with the previous embodiment.

The angle through which the electron beam 82 is bent within the primary section of the tube is determined by the relative energy or velocity of the electron beam 82 and the forces exerted thereon by the electric field established by the horizontal deflection electrodes 84. It is deemed advisable to maintain the forces of the electric field substantially constant and to vary the energy or velocity of the electron beam 82 by modulating the cathode of the electron gun 80. In accordance therewith, upon the receipt by the gun of the red information containing signal, the cathode is energized to lower the energy or velocity of the emergent beam so as to be deflected by the horizontal deflection electrodes through an angle to pass through the grid wire assembly in registration with the phosphor strips 96. Accordingly, upon the receipt of the blue information, the cathode is so modulated as to raise or increase the velocity of the emergent beam. The increased energy or velocity beam will be deflected through a smaller angle by the deflection electrodes 84 so as to travel in the high voltage section in registration with the phosphor strips 98.

The preceding description has been directed to the use of phosphor strips of only two of the primary colors, red and blue; however, it must be understood that other combinations of phosphors could likewise be employed. Certain combinations may include the employment of strips of fluorescent material capable of emitting red and green light or in other applications it may be desirable to employ fluorescent strips with red, blue, and green light emitting characteristics.

In the embodiment shown in Figure 9, the electron beam is passed through a "drift tube" section before passing into the field-free region of the primary section. The principle of drift tube acceleration is well-known in nuclear experimentation work where it is used in linear accelerators for quantizing an electronic beam in order to divide the beam into discrete energy units. In this fashion, an electron beam may be divided so that it contains groups of electrons at different but definite energy levels. In the embodiment diagrammatically shown in Figure 9, the drift tube principle is used to impart different energy levels to the electron beam to obtain the result accomplished in the embodiment described in Figures 7 and 8 by modulating the cathode of the electron gun. The electron beam emanates from electron gun 80 and before reaching the primary section and the region between the horizontal deflection electrodes 84 and the slotted accelerating electrodes 86, passes through a drift tube device comprised of the two pairs of plates 111 and the oscillating pair of plates 112. The two pairs of plates 111 are connected to the power supply of the unit and are maintained at 1-kv. potential positive with respect to the cathode potential of the electron gun 80. The pair of plates 112 are connected to an RF oscillator 113 which, in turn, is controlled by the color information signal. Thus, the voltage on the drift tube is increased and decreased responsive to the color signals and thereby imparts to those electrons passing through the tube an increase or decrease in energy. Thus, as the electron beam leaves the drift tube apparatus, it will have a definite energy level dependent upon the voltage characteristics of the pair of plates 112. By operating the oscillator 113 to impart either a high or low voltage to the pair of plates 112, the electron beam may be divided into bunches of electrons of two

different energy levels. Thus, as the electron beam is deflected in the primary section by the electrodes 84, it is deflected at two distinct angles resultant from the two different and distinct energy levels of the electron beam. Accordingly, the angle through which the electron beam is deflected is distinctly different upon the receipt of blue information than upon the receipt of red information and, therefore, the proper registration with the phosphor strips 96 and 98 is accomplished.

It will be obvious to those skilled in the art that a drift tube apparatus may be placed in an embodiment such as that shown in Figures 3 and 4 in the area just before the secondary section. Accordingly, the electron beam will be imparted with two different and distinct energy levels prior to the time that it is deflected in the secondary section. Thus, if the oscillation of the drift tube device is co-ordinated with the color signal information, the beam will be properly deflected to impinge upon the corresponding phosphor color strip. In such case, the drift tube would have a long and flat configuration rather than the short and round configuration described in Figure 9.

Other combinations of the invention will be obvious to those skilled in the art to provide other embodiments of a polychrome electron discharge display device operated in accordance with the invention set forth hereinabove.

I claim:

1. A cathode-ray tube having a target comprising a plurality of strips of fluorescent material arranged in a predetermined pattern, means for delivering a beam of electrons along a path substantially parallel to said target, means for modulating the velocity of the electrons in said beam of electrons prior to its delivery along said path, means for selectively deflecting said beam from different intervals on said path into registration with correspondingly different intervals on said target, and masking means for discriminately permitting registration with predetermined different target strips responsive to variations in the velocity of the electrons in said beam of electrons.

2. An electron space discharge device having a target provided with a plurality of strips of fluorescent material, an electron beam source for delivering a beam along a path in adjacent, substantially parallel relation with the marginal edge of said target, means for imparting discrete velocities to said electron beam as it passes along said path, means for selectively deflecting the beam from different intervals on said path into a zone adjacent said target, masking means comprising a plurality of grids disposed in parallel and adjacent relation with said strips of fluorescent material to mask certain of said strips from said beam as delivered toward said masking means at a first predetermined angle of incidence relative thereto, and to mask other predetermined ones of said strips from said beam as delivered at a second predetermined angle of incidence relative thereto, and means for deflecting the beam from said zone toward said masking means at said first and second predetermined angles of incidence to effect registration thereof with said other of said certain strips in said respective deliveries.

3. A cathode-ray tube for reproducing polychromatic images comprising an electron sensitive target having a plurality of fluorescent strips capable of emitting light of the primary colors arranged in a predetermined pattern, an electron beam source means for delivering a beam along a path adjacent and substantially parallel to a marginal edge of said target, means for selectively applying deflecting forces to said beam causing it to be deflected to a zone in spaced and parallel relation with said target, masking means comprising a grid wire assembly in adjacent spaced relation with respect to said target to present certain predetermined areas to said beam and to mask other predetermined areas from said beam as delivered at a predetermined angle of incidence relative

to said masking means, and means for selectively applying deflecting forces to said beam to cause same to be bent in the direction of said grid wire assembly at said predetermined angle of incidence.

4. A cathode-ray tube as defined in claim 3 wherein said grid wire assembly comprises a plurality of parallel and electrically conductive elements disposed in coextensive relation with respect to alternate ones of said strips to mask said alternate strips from said beam responsive to direction of the beam toward said mask at said predetermined angle of incidence, and to mask the other strips from said beam responsive to direction of the beam toward said mask at a second angle of incidence, and means for adjusting the angle of incidence of the beam relative to said mask.

5. A cathode-ray tube for reproducing polychromatic images comprising an electron sensitive target having a plurality of fluorescent strips capable of emitting light of at least two of the primary colors arranged in a predetermined pattern, an electron beam source means for delivering a beam along paths substantially parallel to a surface of said target and to a zone adjacent and parallel to a surface of said target, masking means including a grid wire assembly disposed in adjacently spaced and parallel relation with respect to said target to mask certain predetermined strips from said beam as delivered toward said masking means at a first predetermined angle of incidence relative thereto and to mask different ones of said strips from said beam responsive to delivery of the beam in the direction thereof at a second given angle of incidence, and means for selectively applying deflecting forces to said beam causing it to be directed in the direction of said grid wire assembly at said first and second angles of incidence and into impingement with said different and said certain ones of said strips in said respective deliveries on said target.

6. A cathode-ray tube for reproducing polychromatic images comprising an electron sensitive target having a plurality of fluorescent strips capable of emitting light of the primary colors arranged in a predetermined pattern, an electron beam source means for delivering a beam along a path adjacent and substantially parallel to a marginal edge of said target, means for selectively applying deflecting forces to said beam causing it to be deflected to a zone in spaced and parallel relation with said target, masking means disposed between said path and said target for selectively discriminating electron impingement on said target whereby only electrons deflected through a predetermined angle may pass through said masking means and into registration with predetermined ones of said strips, and means for selectively applying deflecting forces to said beam causing it to travel through said masking means into registration with said predetermined strips.

7. A method of presenting a polychromatic display on an electron sensitive target comprising the steps of delivering a beam along a marginal edge of said target, applying deflecting forces to said beam causing it to be directed to a zone parallel to and spaced from a surface of said target, maintaining said zone free from spurious electric fields, applying deflecting forces to said beam causing it to be deflected in a direction toward said target, and effectively discriminating the flow of electrons by masking steps prior to their impingement on said target.

8. A cathode-ray tube comprising a target wherein at least one surface thereof is coated with a plurality of strips of electron sensitive material arranged in a recurrent pattern across said surface, an electron beam source means for delivering a beam of electrons along a marginal edge of said target, means for applying deflecting forces to said beam causing it to be deflected to a zone adjacent to and spaced from said target, means for applying deflecting forces to said beam causing it to be deflected toward and into impingement with said target,

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and masking means comprising a grid wire assembly for effectively discriminating the passage of said beam there-through wherein only the electrons of said beam deflected through certain predetermined angles will pass through said masking means into registration with predetermined ones of said strips.

9. An electron discharge device comprising: a target having at least one surface thereof coated with a plurality of vertically disposed parallel strips of electron sensitive material arranged in a recurrent pattern, an electron beam source means for delivering a beam of electrons along a marginal edge of said target, means for applying deflecting forces to said beam causing said beam to travel toward a region adjacent to and spaced from said surface, discriminating masking means disposed to effectively permit passage therethrough of only those electrons of said beam deflected through a predetermined angle, and means for imparting forces to said beam causing said beam to be deflected through said angle and into registration with predetermined ones of said strips.

10. A cathode-ray tube for reproducing polychromatic images, an electron sensitive target, means for delivering a beam of electrons to a zone adjacent and parallel to a surface of said target, masking means comprising a plurality of grid wire members disposed between said last mentioned means and said target to effectively discriminate the flow of electrons therethrough, and means for selectively applying deflecting forces to said beam causing same to pass through said masking means into registration with predetermined areas on said target.

11. A cathode ray tube comprising an electron sensitive target, means for delivering a beam of electrons to a zone adjacent and substantially parallel to said target, means for selectively applying deflecting forces to different intervals of said beam to deflect same into registration with correspondingly different areas on said target and means for modulating the velocity of said beam prior to the delivery thereof into said zone adjacent said target to vary the angle of incidence of registration of the beam with said target.

12. In a cathode ray tube as set forth in claim 11 in which said means for delivering a beam of electrons to the zone adjacent said target includes an electron gun having a cathode element, and said means for modulating the velocity of said beam includes means for coupling

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potential signals to said cathode of different values to vary the angle of incidence of registration of the beam with the target to different values.

13. A cathode ray tube comprising an electron sensitive target, means for delivering a beam of electrons to a zone adjacent and substantially parallel to said target, means for selectively applying deflecting forces to different intervals of said beam to deflect same into registration with correspondingly different areas on said target, and means for modulating the energy level of said beam prior to the delivery thereof into registration with said target including potential responsive means disposed along the beam path, and means for coupling signals of different predetermined potential values to the potential responsive means to adjust the energy level of the beam and the angle of incidence of the beam with the target to correspondingly different values.

14. In a cathode ray tube as set forth in claim 13 in which said potential responsive means includes a drift tube accelerator unit disposed along the beam path having at least a set of control elements, and means for coupling a potential of different values to the control elements of the drift tube responsive to the coupling of different sets of color information thereto, whereby the energy of the beam and the angle of incidence thereof with the target is varied with changes in the color information signals coupled thereto.

15. In a cathode ray tube as set forth in claim 13 in which said means for delivering the beam to a zone adjacent the target includes an electron beam source, a transition deflection set positioned adjacent the beam path prior to delivery of the beam into said zone, and means for coupling signals of variable predetermined potential values to said transition deflection set to vary the energy level of the beam and the angle of incidence of the beam with said target.

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