

Sept. 13, 1949.

A. N. GOLDSMITH

2,481,839

COLOR TELEVISION

Filed Aug. 5, 1944

7 Sheets-Sheet 1

Fig. 1.

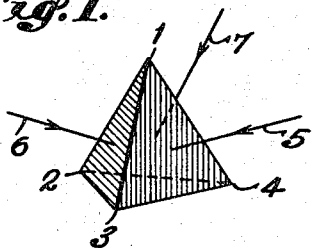


Fig. 2.

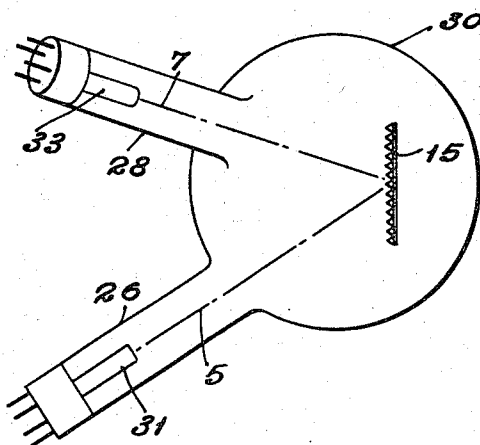


Fig. 3.

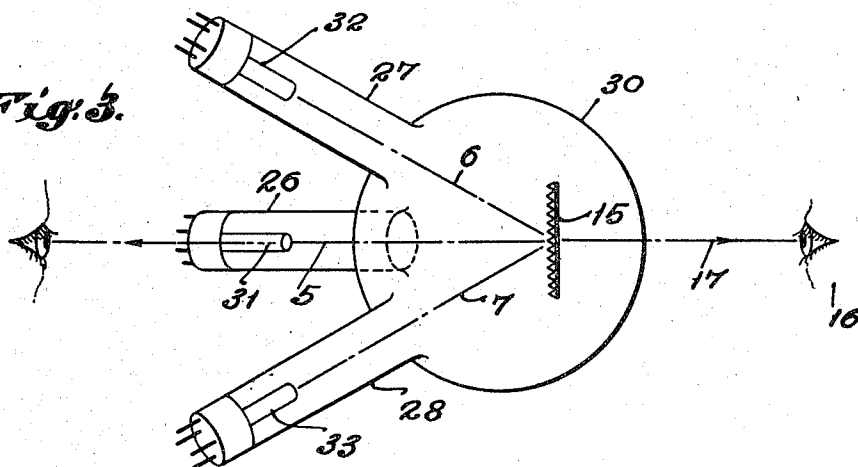
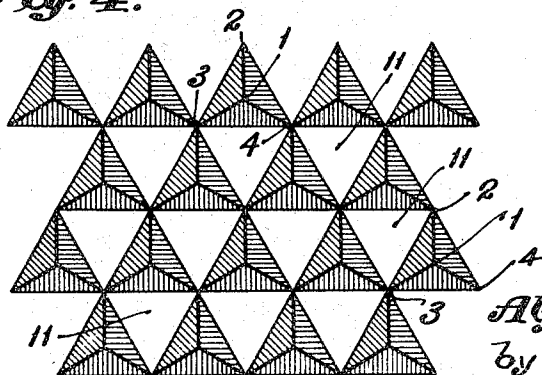


Fig. 4.



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Fig. 5.

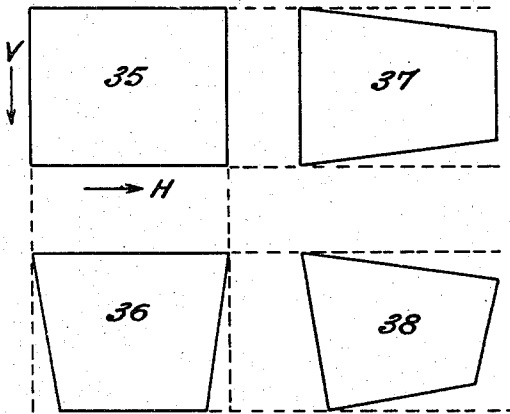


Fig. 6.

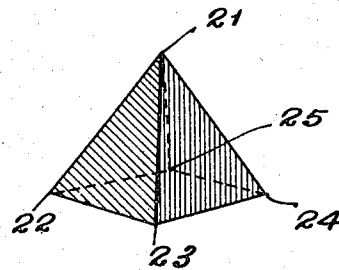


Fig. 7.

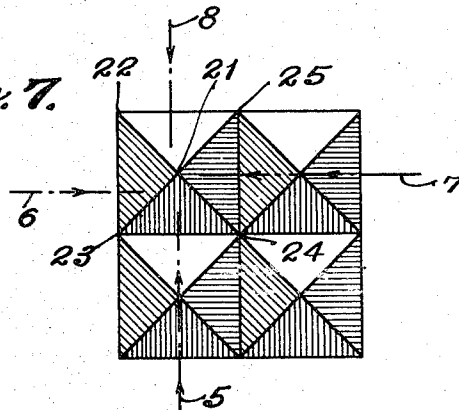
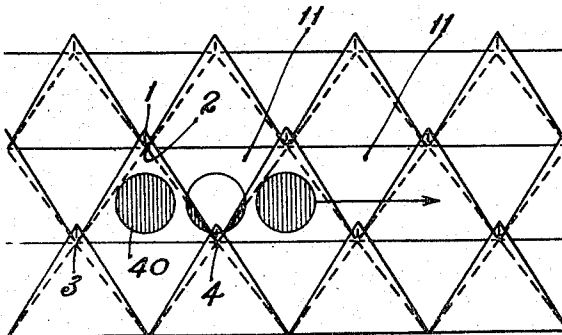


Fig. 8.



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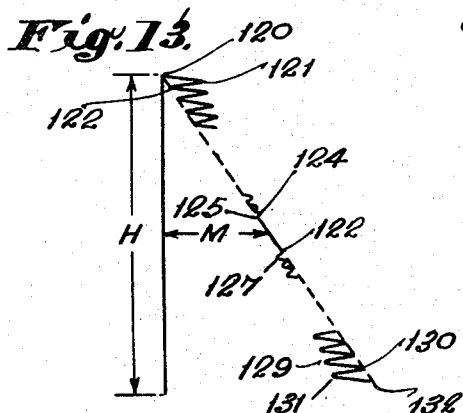
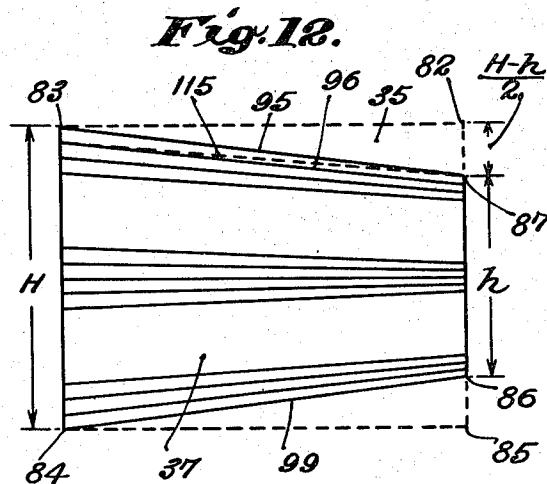
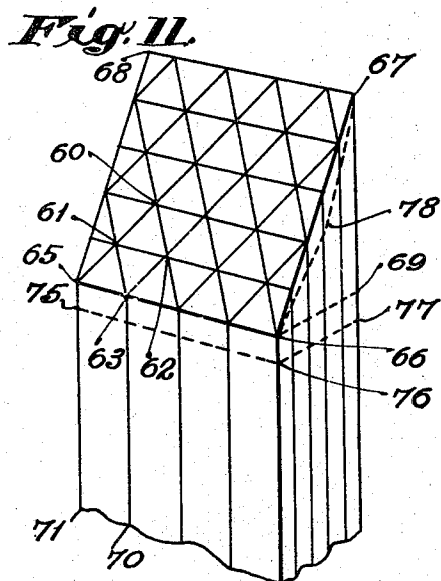
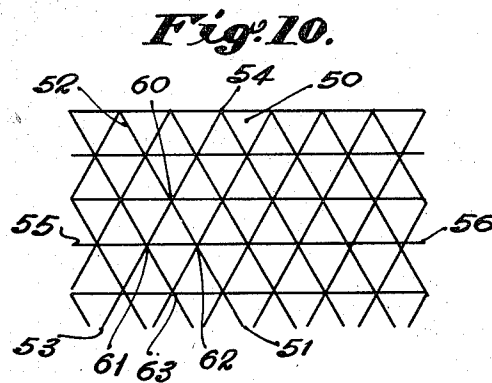
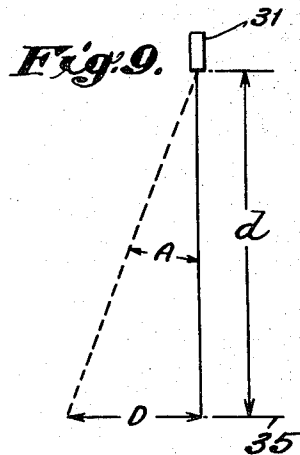
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Fig. 14.

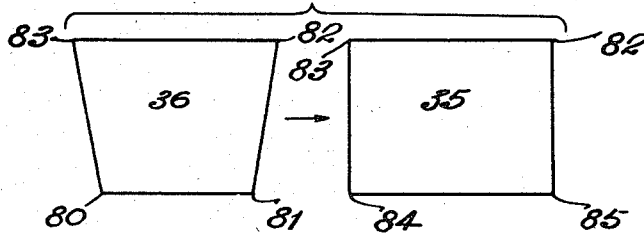


Fig. 16.

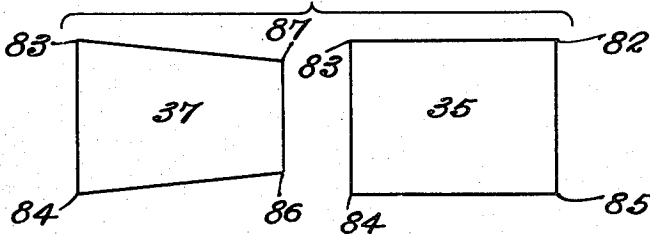
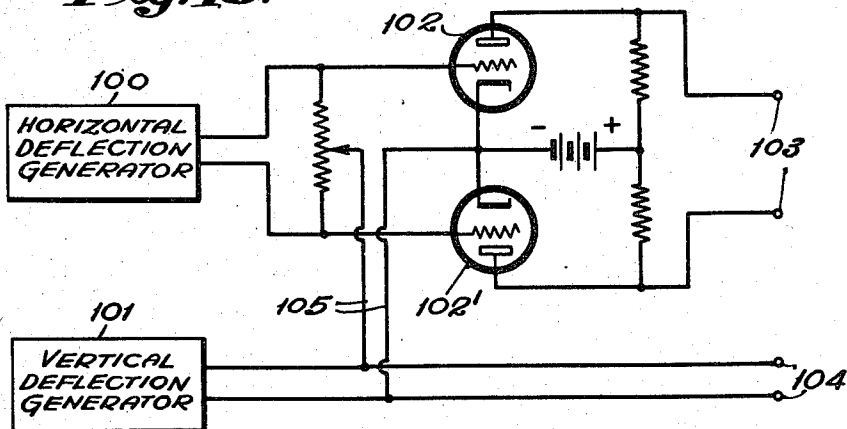


Fig. 15.



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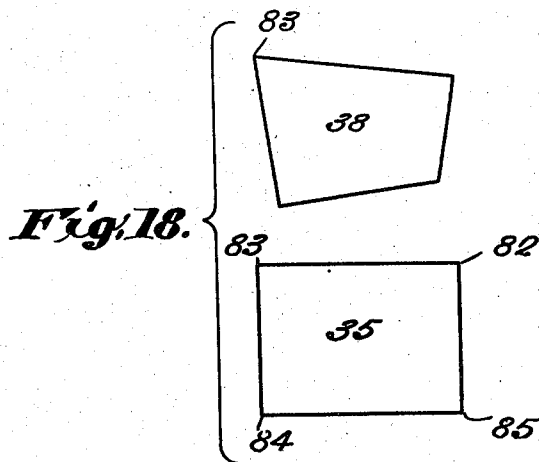
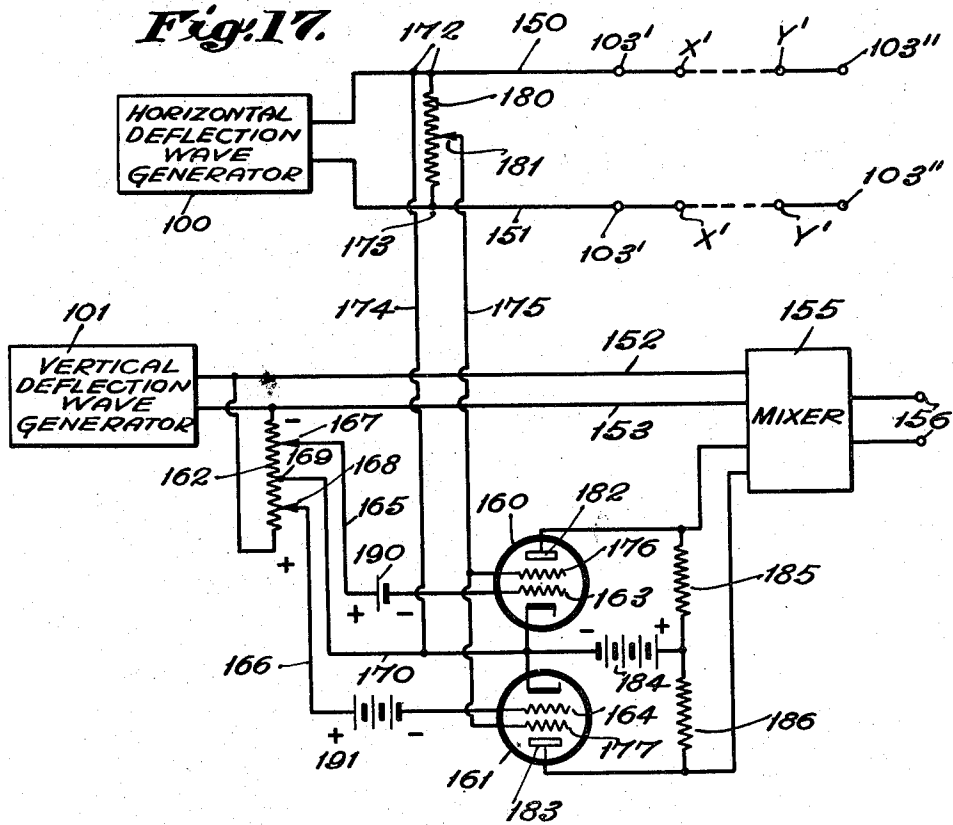
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A. N. GOLDSMITH
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7 Sheets-Sheet 5



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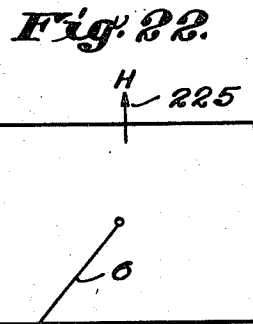
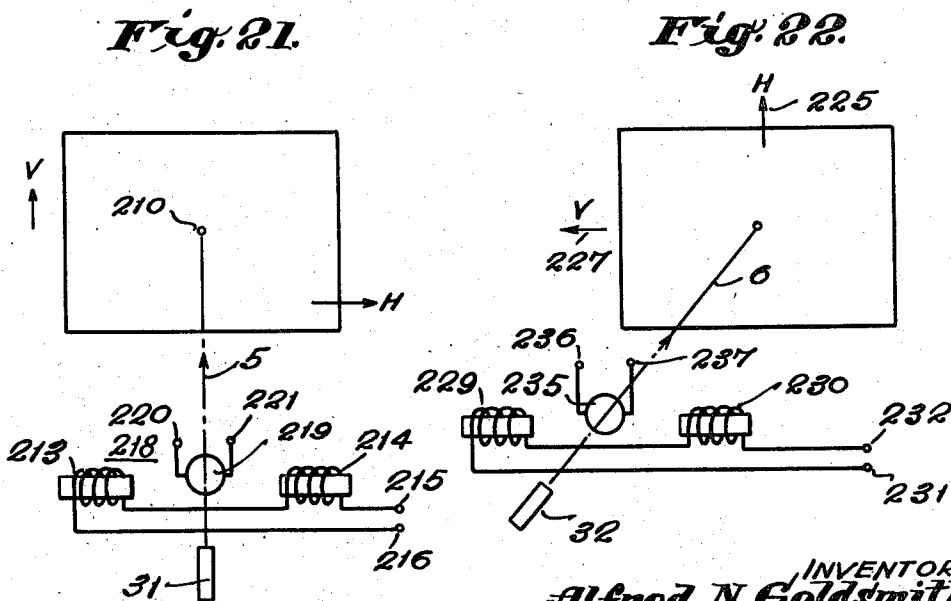
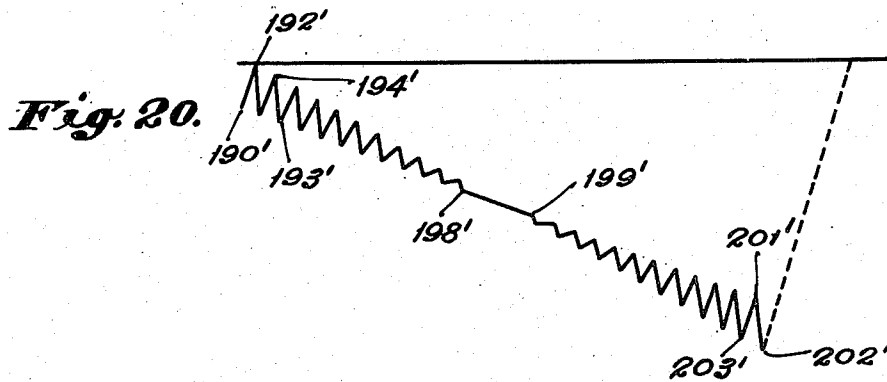
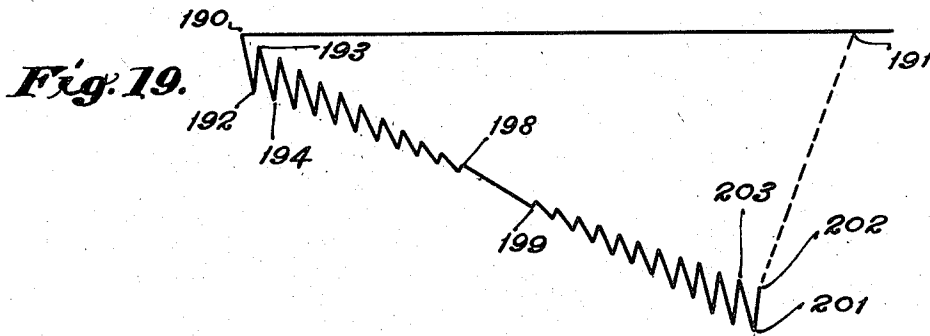
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COLOR TELEVISION

Filed Aug. 5, 1944

7 Sheets-Sheet 6



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COLOR TELEVISION

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Fig. 23.

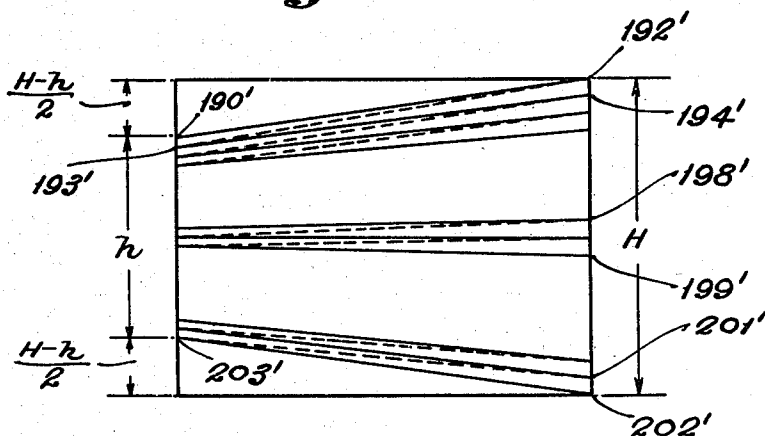


Fig. 24.

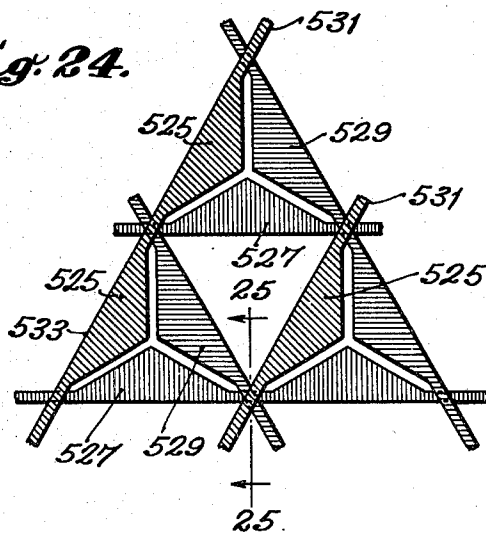
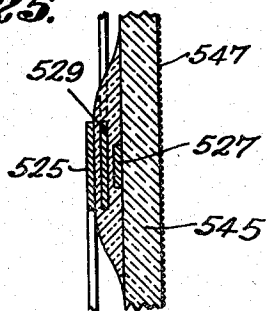


Fig. 25.



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UNITED STATES PATENT OFFICE

2,481,839

COLOR TELEVISION

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Application August 5, 1944, Serial No. 548,238

29 Claims. (Cl. 178—5.4)

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This invention relates to television, and particularly to forms of electronic television systems using cathode ray image scanning or reproducing tubes for such images, where the images are scanned and/or reproduced in colors closely approximating those of the scanned image at the transmission scanning points.

Broadly speaking, the invention is directed primarily to television systems wherein the image reproduction is accomplished by the superpositioning, in registry, of a group of color component images by multicolor, tricolor or bicolor reproduction in selected primary, supplementary, or key colors which, together, add to produce resultant images in substantially their natural colors and with a reasonably acceptable approach to the natural luminous gradations. In the reference above to the so-called "key colors" it is to be understood that such terminology is intended essentially to constitute the neutral shades, such, for example, as gray, since images in key colors have been found to contribute quite materially, in many cases, to the accuracy of gradation rather than only to the actual color value.

In a more specific application, the present invention is directed to a form of television system wherein the image producing tube is provided with a target or screen area based upon a focal or quasi-focal plane upon which one or more electron beams are substantially focused and upon which the images, as produced, are made to appear directly in substantially their natural colors. Such a system incorporates, as well, an appropriate color selective scanning system for the several component colors of the composite image. Under such circumstances, provision is made for geometrically and otherwise relating the separate scanings to the multicolor fluorescent, luminescent or phosphorescent target or screen area.

In one form of the invention the color images result from the impact of a plurality of separately controlled electron scanning beams upon a target or screen area from somewhat different directions of scanning. The invention provides ways and means for correcting any boundary distortions in the component color images which result from such forms of scanning and which would otherwise militate against accurate registry of the component colors.

In another form of the invention, provision has been made for an image scanning or camera type tube for translating the light values of the scene or object into electrical currents or volt-

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ages, where such tube comprises substantially or equivalently the counterparts of the image reproducing device or tube hereinabove referred to. Essentially, therefore, the image scanning or camera tube comprises a focal or quasi-focal plane upon which are positioned groups of multiplicities of light responsive materials with suitable light filtering means for segregating the different component colors of light from different correlated multiplicities of light sensitive elements. The light sensitive elements are supported upon the so-called quasi-focal (or focal) plane which, in this instance, may constitute a dielectric surface which separates the light sensitive elements from the so-called signal plate. Accordingly, electrostatic charges may be built up across the dielectric element with the magnitude of the charges proportional or related to both the intensity of the light and the color of the light to which the related element is subjected.

In one of its broadest senses the invention furthermore may be considered as involving a system wherein provision is made for simultaneously or, under some circumstances, sequentially reproducing television images in color upon a focal or quasi-focal plane of a target or luminescent screen of a cathode ray image reproducing tube. The impacted areas upon which the produced cathode ray beams impinge are formed in different sections or areas, later to be described in more detail, which, generally speaking, comprise groups of multiplicities of rudimentary or elementary surfaces comprising contiguous elements systematically located relative to the focal or quasi-focal plane of the tube, with each of the multiplicities of elements being sensitized to luminesce, fluoresce or phosphoresce when activated by the scanning cathode ray beam, for instance, to radiate light in one of the colors corresponding to the selected primary colors. In this way, the produced light values when visually added together will produce the picture in substantially its natural coloration. Where the elements or rudimentary surfaces all lay in one plane, it may be regarded as a "focal plane." If the elements extend outwardly to a slight extent from a plane, it may be considered to be a "quasi-focal plane."

To this end the system comprises, for color reproduction purposes, a supporting surface or target, hereinafter termed, for convenience, the "quasi-focal plane" (in the light of the above statement) on which is positioned a group of multiplicities of rudimentary or elementary size surfaces which are systematically located and

where the multiplicities of elementary surfaces are, at least in part, covered by material which becomes fluorescent, luminescent or phosphorescent under electronic impact in approximately one of the component colors for production of additive color images. For activating or energizing the elements, a plurality of electron scanning beams, corresponding in number to the component colors selected, are provided. The operation is so arranged that each of the scanning beams is restricted to scanning substantially only one of the multiplicities of elementary surfaces and, at the same time, provision is made for correcting the boundary distortion of the images thus scanned so as to enable accurate dimensioning and registering of the composite scanned areas.

Still further, the present invention comprises, as one of its component parts, suitable means for providing, in many cases, for the alteration of the focus of the beam in proportion to the deflection thereof from a normal or datum position, e. g., the approximate center of the image, since it is apparent that the greater the angle of deflection and obliquity of scanning (e. g., near the edges or corners of the image) the greater the possible defocusing, which can be overcome to a substantial extent by a suitable control of the focus which will be a measure, at least to some extent, of the actual change in position from the normal position of the beam. The energy for providing such correction of focus which will tend to compensate for defocusing may be derived from one or both of the deflecting energy waves which develop the electrical field actually to cause the deflection of the cathode ray beam across the target areas.

Regarding correction systems and means for such correction of focus and distortion, it will be appreciated that the focusing correction is so constituted that the deflection wave or some derivative thereof is applied to one or more of the beam focusing electrodes or other suitable electron beam focusing components in such a way as to avoid any defocusing effects at the remote and oblique scanned portions of the image area. The distortion correction systems are so constituted that a deflection wave or waves is used in an appropriate manner in combination with suitable electron beam deflecting arrangements or components to bring the image areas back to rectangular dimensions of the desired aspect ratio.

It is known, in television systems, that to produce a tricolor additive process image (which will herein be mentioned as one example) requires, at the transmitting station, the resolving of the image or field scanned into preferably three component fields or images which will usually be the red, the green, and the blue versions of each separate image. These separate color versions may be scanned either simultaneously, cyclically or sequentially, and the process may be either continuous or intermittent to produce a composite resultant image. The scanned fields or color versions or color component images are then resolved into electrical signal energy which is transmitted to receiving points to produce the desired color component image signals which are suitably separated one from the other and caused to control the energization or activation of the impacted surface or target areas.

In simultaneous three-color systems to which this invention is particularly thought not exclusively directed, it is desirable to provide three

completely separated electron guns for developing electron beams which are to be directed upon the target areas whereat the separate color versions of the image shall result. Under such circumstances, the different electron guns direct electron beams upon the target area from oblique angles, as well as from, or in place of, paths substantially normal to the surface.

While the three-color additive process has been particularly referred to hereinabove, it will be apparent from what has been above stated that the invention is equally applicable to use with multicolor systems or bicolor systems, or with various numbers of component colors functioning together, either alone or in conjunction with supplementary or key colors. In case the system is applied, however, to a two-color system, it is apparent that co-planar scanning beams, which are oppositely inclined and with which conventional keystone correction for each is substantially oppositely applied, may be resorted to. Under such circumstances, in the case of the image reproduction, one of the two component colors will be a reddish-orange and the other component color will be a greenish-blue, in contrast to the selected red, green, and blue which constitute the primary colors for the selected additive tricolor process.

Accordingly, the present invention makes provision for taking care of the various obliquities of impact of the resultant scanning beams upon the target area so as to compensate for any boundary distortion or foreshortening of the image in one or two dimensions, as would normally result in the absence of the introduction of suitable corrective components into the deflection cycle. Such corrective components are arranged primarily to care for and correct any non-rectangularity of the scanning pattern from each separate electron beam, as well as to provide for an exact matching of the amplitude of the deflections in order that correct and proper registration of the different component elements shall at all times occur.

Still further, the present invention is directed to a system whereby the target area of the receiver image reproducing tube, which is impacted by the electron beams operating simultaneously or in sequence, where desired, shall have certain elements excited by electron impact to produce one color of light, approaching, for instance, as closely as possible to the red component; a second group of elements reacting to the electron beam from another gun, for instance, to produce the same conditions of light as would approximate, as nearly as possible, the green color component of the scanned image of the transmitter; and, a third group of elements acting to produce light approximating, as closely as possible, to produce at the receiver the blue color component of the image which was scanned at the transmitter. It is, of course, apparent that the close approximation of the light radiation emitted by each of the respective multiplicities of elements forming a single color group of the desired primary color component may be increased, to some extent, by surrounding or supporting the impacted material which luminesces, fluoresces or phosphoresces in a medium or underlay having color filtering capabilities of the desired sort, but nevertheless resistive to or shielded from electron impact and capable of maintaining color under impact without the release of gas which would reduce unduly the vacuum within the tube. Such color filtering me-

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dium, when needed and used, must lie at least in part in the path of the light which, after emission from the fluorescent material, passes directly or indirectly to the eyes of the observers.

In one of the systems herein to be described wherein multiplicities of inclined component color fluorescent or luminescent elements are systematically arranged in the target area, it will be appreciated that, generally speaking, it is desirable that each of the groups comprising a multiplicity of elemental areas which produce the different lights in the different given primary component colors shall, as far as possible, be inclined at an angle to the other groups. This is done in order that each activating electron beam, when it strikes the elementary elements of its corresponding multiplicity, shall be exposed on the average as nearly as practicable to a normal impacting electron scanning beam from the corresponding electron gun of the same color component in order that the general effect of substantial shielding or absence of impact from the scanning beams of the other two guns, corresponding to the other color components, shall result. In this connection it may be mentioned that unless precautions are taken, the angle of impact of the beam on the target varies over the entire image area, although, broadly speaking, the angle of change is not excessive so that this disclosure, for simplification, will not discuss specifically various compensating schemes. This is particularly true of the systems herein to be described which will be identified further in their more specific aspects by the monoplane and biplane type of construction or scanning as contrasted with the multicolor scanning with the triply divided scanning type of planar screen such, particularly, as that of the general type and character shown more particularly, as to the specific screen construction, by Leverenz Patent No. 2,310,863, granted on February 9, 1943 which is one example of such a screen structure.

In the last-named form of system including a target of the general type disclosed by Leverenz, the luminescent screen or target consists essentially of long narrow strips of fluorescent material adjacent each other, with one set of such strips having the property of luminescing under electron impact in one primary color, the next set of strips luminescing in a second primary color, and the third luminescing in the third selected primary color, so that when each of the strips is caused to become luminescent the result will be a tri-color additive reproduction of some desired image. Each color strip may be regarded as a series of substantially or actually contiguous colored scanning elements arranged along its length and collectively forming the strip. In this connection it is important to note that strips of like color response are separated one from the other by spacings equal to twice the strip width.

In connection with all of the types of scanning hereinabove referred to, it is apparent that the scanning spot, that is, the cross sectional area of the scanning beam as it impacts any given surface, should preferably be inscribable within one of the substantially contiguous elemental areas and still provide a reasonably practical marginal tolerance in the way of a border area external to the actual beam in order to provide reasonable freedom in alignment of the impacted areas, regardless of minor or incidental variations or errors in the electron gun operation, defects in the deflection system, and the like.

The present invention is also concerned to some

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extent with the specific construction of screen or target areas of the various types hereinabove mentioned, but with regard to the last named general type of tube screen reference to the aforesaid Leverenz patent is made by way of example to cite one suitable form of such screen or target structure. In connection with the present disclosure, it will be understood that the invention is particularly applied to the scanning system, in so far as corrections for obliquities of scanning or beam defocusing are concerned, and so far as the particular area or segmental portion scanned on the target area by each of the separate electron guns forming the separate beams for the tricolor process is concerned.

Accordingly, there are included among the objects of this invention, those of producing color television images by purely electronic means and without the need of any mechanically moving parts, such as color filters of the like heretofore known and used particularly in connection with sequential three-color television.

Another object of the invention is that of producing color television images without mechanically moving parts in either the transmitting or the receiving system.

Another object of the invention is that of producing color television images on cathode ray image producing tubes or kinescopes which can be made responsive either to color television signals transmitted simultaneously, or to systems where the separate color component images are transmitted cyclically or sequentially.

A further object of this invention is to produce colored television pictures or images upon a single cathode ray tube screen by an additive color process so that the images resulting may be viewed directly or by various projection methods known in the art in order to provide enlarged television images. Any suitable enlarging system may be used, but among the systems of the prior art which are generally best adapted to this use are those heretofore suggested by Landis, Ramberg, this applicant and others and fully disclosed in the patented art and elsewhere.

A further object of the invention is that of producing color television images in any desired number of color combinations, and in any desired number of repetitions of the separate colors in the production of one complete television image, so that it is not essential, in one of the forms of the invention, that the rates of scanning be identical for the several colored images, although, with identical rates of scanning and detail for each selected component color, exact registry of the image elements is particularly readily achieved.

A further object of the invention is that of producing multicolor television images upon the target area of a cathode ray image producing tube for either direct viewing or for projection.

A further object is that of producing on a target area of an image producing tube, different component color images in accordance with the angle or angular positioning from the screen at which the particular controlling electron scanning beam emanates, and, at the same time, to provide for the arrangement of a plurality of component electron guns to produce scanning beams each of which will excite the luminescent or fluorescent target in substantially only one of its color components in accordance with the direction or range of directions from which the electron scanning beam emanates.

A further object of the invention is that of

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correcting boundary distortion of foreshortening of the scanned images which would normally be produced because of obliquity of scanning, at least to some extent, by the provision of a plurality of electron guns angularly disposed relative to the impacted target area.

A further object of the invention is that of providing means for accurate dimensioning and registration of the color component images produced by the independent obliquely located scanning beams.

A further object of the invention is that of correcting for beam defocusing which tends to occur in some portions of the image due to the different distances between the electron gun and the scanned surface during certain portions of the scanning process.

All of the foregoing objects likewise apply with equal force to a transmitter type of tube where the light of the image is caused to influence different elemental sections of the tube, as above indicated, to produce electrostatic charges which are a measure of one only of the selected component colors or, also, a key color where such key colors are combined in the transmission.

Still other objects of the invention are those of providing a three-color television system which functions to produce either sequential three-color or multicolor images, or simultaneous of three-color or multicolor images, which will be, considering the general complexities of any form of color scanning system, of relative simplicity and yet high efficiency.

Other objects of the invention are those of providing a system for producing multicolor images, either sequentially, cyclically or simultaneously, which will overcome heretofore known defects in the art and which will provide television images in multicolor which shall accurately portray, in all regards, the image scanned at the point of transmission.

Still further objects of this invention are those of providing a television scanner or camera tube of the electrical variety whereupon optical images may be cast and which, when projected upon a target or mosaic area through appropriate filters, may be caused to produce video or image signals upon scanning of the target which will represent different color visions of the optical image.

Still another object of the invention is that of providing a television scanning or camera tube for separating an optical image into selected image or video signal trains, which signals shall represent the selected primary colors and used to control suitable image reproduction at receiver points so that the optical image may be recreated in substantially its natural colors.

A still further object of the invention is that of providing a multicolor television system in which the principles disclosed are directly applicable either to transmitter or receiver, especially, but not exclusively, in so far as the disclosed systems for correcting for boundary distortion or foreshortening, normally tending to prevent bringing the component images into accurate registration, are concerned.

Other objects and advantages of the invention will become apparent and at once suggest themselves to those skilled in the art to which the invention is directed by reading the following specification and claims in connection with the accompanying drawings, wherein;

Fig. 1 is a schematic illustration of one form of a tetrahedron or pyramid forming a portion of the target area;

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Fig. 2 is an elevational view in schematic form of a scanning tube of one suitable form for multicolor television uses;

Fig. 3 is a view of the tube in Fig. 2 in plan or at 90° relative to the showing of Fig. 2;

Fig. 4 schematically represents a section of a target area constructed from a multiplicity of tetrahedra or pyramids of the general type shown by Fig. 1;

Fig. 5 represents a desired rectangular scanning area with distorted areas resulting from scanning from different directions adjacent thereto and shows the type of pattern scanning which would normally result in the absence of correcting systems disclosed;

Fig. 6 is a modification of Fig. 2 showing a square pyramid replacing the triangular pyramid or tetrahedron of Fig. 1;

Fig. 7 is a schematic representation of a section of a target area formed from a multiplicity of the square pyramids of the type shown by Fig. 6;

Fig. 8 is a schematic representation of a scanned area of the general form shown by Fig. 4;

Fig. 9 illustrates schematically the scanning angle of the electron beam issuing from one of the several electron guns;

Fig. 10 is a schematic showing for illustrating one method of forming the target;

Fig. 11 is to illustrate another step in the process of target formation;

Fig. 12 schematically illustrates one form of distorting pattern traced with a keystone effect resulting in the absence of correction systems;

Fig. 13 shows a modification of the deflecting wave for controlling the traced area of the target;

Fig. 14 represents one pattern which would normally be traced by scanning beams in the absence of deflection correction and also the pattern area which is desired and which results with appropriate correction systems in use;

Fig. 15 shows one form of a compensating circuit particularly adapted for compensation of distortion in one of two dimensions where, for example, the horizontal dimensions is symmetrically shortened;

Fig. 16 illustrates another form of pattern which by correction may be transformed into a rectangular area of desired aspect ratio by virtue of the correction systems shown in connection with Fig. 15, for instance;

Fig. 17 is a further correcting circuit for pattern correction;

Fig. 18 illustrates the distorted pattern normally traced and the transformed rectangular pattern provided by the correction system of Fig. 17;

Figs. 19 and 20 represent two forms of deflection wave patterns to provide image pattern corrections;

Figs. 21 and 22 schematically represent scanning arrangements within a multicolor scanning tube for use with one of the component scanning tracers;

Fig. 23 represents a scanned pattern substantially like that of Fig. 12 but with the scanning distortion recurring in reversed direction;

Fig. 24 represents one manner by which the signal plates of light sensitive elements of a scanning or camera tube may be connected; and,

Fig. 25 is a sectional view taken on the line 25—25 of Fig. 24.

When reference is made particularly to the drawings for a color reproducing system, the term "color element" will be used to some extent

to define a small or elementary area of the target which is coated with material mainly radiating light which will be of a color approximating as closely as possible one of the primary or color components for additive color image production with or without color filtering therein or adjacent thereto. In such applications, the dimensions of such color elements should be of a predetermined size relative to the cross-sectional area of the scanning spot so that during scanning the scanning spot will cover an appropriate number (one or more) of such color elements of a given primary color.

If the color television system is to be set up and operated as a three-color system wherein the assumed primary colors shall be red, green, and blue, it will be appreciated that the various color elements on the fluorescent or luminescent screen or target for any one color component are to be impacted by only one of three selected and separately controlled scanning beams. As a result of such conditions, it naturally follows that in the practical construction and form of the multi-color image producing tube, herein to be described in more detail by what is to follow, in connection with the system by which it is operated and controlled, all of the separate color elements of the given color should be arranged at a like angle (preferably, but not necessarily, normal on the average) to the corresponding scanning beam. Therefore, the separate color elements should be positioned at substantially constant angles relative to the supporting surface, at least as far as the central portion thereof is concerned, in order to avoid distortion or color or brightness changes in the produced image. When any such surface is scanned, it will be apparent that toward the boundaries of the scanned surface the scanning beam is increasingly oblique in its impact and, consequently, the angle between the color elements of any one color and a supporting surface may be gradually increased. However, as a first approximation and for the purposes of this description, it is considered that the angle between the color elements of one color and the supporting surface may be regarded for all practical purposes as being constant. If the distance between the screen and the limited region wherein beam deflection takes place is large compared to the screen dimensions, this condition will be closely approximated. It therefore follows that each group of the color elements, of which the three assumed primary color images are to be formed, will be on the surface or surfaces of a pyramid which will be a substantially right pyramid with its apex turned, generally speaking, in a direction substantially toward the mean position of the sources from which the scanning beams emanate.

By now making reference to the several figures of the drawings by which this invention has been described, it will be seen from Fig. 1 that a triangular pyramid, of the type hereinabove set forth, is depicted, and, in the specific illustration given, the apex 1 of the pyramid is intended to be turned in a general direction toward the electron guns or sources from which the scanning beams originate. The base 2, 3, 4 of the pyramid is intended to rest upon some suitable support area such, for example, as the viewed target plane (not shown specifically by Fig. 1). The pyramid face 1, 3, 4, is intended to be coated with a material which will fluoresce in red, for instance. The face 1, 2, 3 of the pyramid may be assumed to be coated with some suitable material which

will fluoresce in green, while the rear face 1, 2, 4 of the pyramid will be assumed to be coated with material which shall fluoresce in blue.

The particular luminescent materials which are chosen to provide the red, the green, and the blue fluorescent effects may vary widely but, for purposes of illustration, suitable materials may be those which have been disclosed in the aforementioned Leverenz Patent No. 2,310,863, granted February 9, 1943. For instance, to provide the red luminescent effects, use may be made of chromium activated aluminum beryllate or zinc cadmium sulphide activated by silver; the blue effects may result from silver activated zinc sulphide, zinc silicate and zirconium silicate; while the green luminescent effects may be provided by alpha-willemite activated with manganese and zinc cadmium sulphide activated with silver, all as explained in the aforesaid Leverenz patent.

To represent in a conventional manner the several scanning beams which are intended to impinge upon the various pyramid faces, the scanning beams 5, 6, 7 are illustrated for the purpose of indicating the control by which the red, the green and the blue lights or fluorescing areas are produced.

In the fabrication of a tube element for viewing a tricolor additive picture of the type hereinabove described, and which tube is schematically illustrated by the exemplifications of Figs. 2 and 3, the viewed target area will be formed from a multiplicity of the general form of pyramidal elements which were described by Fig. 1. A screen or target of this general character is illustrated by the arrangement of Fig. 4 which is intended to show, in plan, a small portion of the composite surface formed from a multiplicity of pyramidal elements, such as those shown by Fig. 1.

In the arrangement of the composite screen or target of Fig. 4, the apex 1 of each of the pyramids is intended to be pointed in the direction opposite that from which a viewer views the screen (this, however, is not a necessary condition). As the surface is positioned in Fig. 4, it would be assumed that the viewer would look at the composite screen from a position beneath the surface of the sheet of paper and, in Fig. 4, as in Fig. 1, the various pyramid faces are similarly numbered and, when activated, are to provide radiation of light in the three chosen primary colors. Under conditions when the pyramids are mounted and positioned as in Fig. 4, it will be seen that there are a number of small spaces or areas 11 in the space between the several pyramids. These areas, generally speaking, will be triangular, or substantially so, when the pyramids are set up and formed from such elements as those disclosed in Fig. 1.

These areas 11 may be either clear, gray, or black, but in any case should be substantially free from any fluorescent or luminescent coating so that any impingement of any of the scanning beams on the areas 11 will be without significant effect as far as producing light, which will be visible to an observer, is concerned. This condition comes about, generally speaking, because in the composite arrangement of a series of pyramids, such as those shown by Fig. 1, the several scanning beams 5, 6, 7, may impinge to a very slight extent, at least on the overlap areas 11, and thus with the several scanning beams being signal controlled in one only of the several selected component colors, it can be appreciated that sensitization or activation of any of

the areas 11 by fluorescent material could preclude the possibility of obtaining high fidelity color picture representation for the observer.

A slight modification of the arrangement of Figs. 1 and 4 will be found in the structural representations of Figs. 6 and 7. In this connection, Fig. 6 shows a quadrangular pyramidal element which is provided with approximately a square base 22, 23, 24, 25 and from the apex 21 of the pyramid to the various sides of the base, the triangles which are formed are coated with different fluorescent materials so as to produce, when activated, the light in the several different colors. For instance, the triangular face 21, 23, 24 will be assumed to be coated with red fluorescent material; the triangular face 21, 22, 23 may be assumed to be covered with material which fluoresces to radiate green light; the pyramid face 21, 24, 25 will be assumed to be coated with material to fluoresce in blue, while the fourth surface of the pyramid 21, 22, 25 may be either clear, gray, or black or, alternatively, it may be coated with a material which fluoresces to give back and white or so-called "key" images, in which event, the image producing tube would be provided with a fourth electron gun. Generally speaking, an impingement of a scanning beam upon the several areas or pyramid faces 21, 22, 25 would produce black and white key pictures or image representations, which would serve to sharpen the complete image production and at the same time to assist in establishing suitable light gradations.

In the arrangement of Fig. 7, the several scanning beams 5, 6 and 7 are again shown in connection with a composite series of separate pyramidal units of the type of those disclosed by Fig. 6, whereby scanning of the pyramid faces by the exemplified scanning beams will result in the production of the red, green and blue color images, respectively. Clearly, these different color images result from the practically normal impingement of the several scanning beams on the various faces or surfaces so that the individual scanning beams excite fluorescence in one only of the several component colors.

Generally speaking, some of the advantages from the use of the four-sided pyramids, disclosed by Figs. 6 and 7, result in that no gaps or inactive spaces are generally produced between the pyramids, and also, as will be apparent from what is to follow, a double obliquity of scanning may be avoided so that each of the scanned areas in the absence of suitable corrective means is distorted either vertically or horizontally, but not both vertically and horizontally, as is the general case with the three-sided pyramid. The result is that four-sided pyramids simplify the corrective means which will be hereinafter further explained.

It will be explained also, from what is to follow, how the surface covered with the various pyramids may be produced in various ways as well as the method of sensitization of the various pyramid faces with luminescent or fluorescent material which will give off the desired light color when activated.

Under some circumstances, the fluorescent material with which the pyramid faces are activated may not produce light of exactly the color component value desired, so that filtering is required to obtain the correct color. To this end, a suitable filter may be arranged as an underlay on the corresponding pyramid face or surface and the luminescent material deposited

thereupon or, alternatively, the fluorescent material may be applied by means of a bonding or binding agent which contains an inorganic coloring material having the desired filtering characteristics, or the pyramid material which supports the individual fluorescent layer may itself be colored. Except in the last mentioned case the pyramid units themselves shall be substantially transparent to all colors of light so that an observer viewing a composite target or screen structure, for example those of the type shown by Figs. 4 and 7, from the base of the pyramid, shall be able to see readily light in the different primary colors as initiated in the activation of the surfaces by the scanning electron beams 5, 6 and 7.

To this end, a tri-color image producing tube 30 has been conventionally depicted by Figs. 2 and 3 where an observer 16 may view an assemble screen or target structure 15 (such as those shown by Figs. 4 and 7) along a viewing path 17. In the schematic illustration of the screen or target 15 it will be noted that, in the illustrative case, the apex of each pyramid faces away from the observer 16, as was before mentioned. The arrangements of Figs. 2 and 3 are, as above noted, two showings of the same tube 30 with the tube positioned at two 90° viewing points. In this arrangement, it will be seen that the tube proper contains separate neck portions 26, 27 and 28, which include, as conventionally illustrated, several electron gun structures 31, 32, 33 from which the scanning beams 5, 6 and 7 emanate. These scanning beams 5, 6 and 7 are directed toward the target 15 along the paths schematically shown.

If Fig. 3 particularly be considered, it will be noted that the so-called red scanning takes place from below and centrally upward to the target or screen 15. The green scanning may be considered as being from the left above and obliquely downward, while the blue scanning, for illustration purposes, is considered as being from the right above and obliquely downward, with the expressions "right" and "left" being representative of directions from the viewpoint of the person facing the target or screen surface.

While specific detailed illustration has not been made of the various systems by which the deflection of the electron beams emanating from the electron guns contained within the several neck portions of the tube is accomplished, it will be appreciated that electrostatic or electromagnetic systems, or combinations of these, may be utilized. Further, it will be appreciated that while specific illustration of such forms of deflection systems have not been shown, except rather generally herein, the invention contemplates the provision of any necessary and desired types of shielding between the several deflecting systems so as to provide full and complete freedom from the interaction of one deflection system upon another.

With these forms of scanning it will be seen that the angle from which the several scanning beams 5, 6 and 7 strike the target or screen 15 are, generally speaking, greatest at one boundary, at an intermediate value at the center, and least at another boundary. The differences in the angle of incidence of the scanning beam across the target surface 15 is relatively small in the normal type of tube, although to insure accurate image registry compensation may be provided in various ways in order to maintain substantially normal impact of the electron scanning beam for each

of the tricolor component scannings over the entire screen area.

Both theory and experiment indicate that the leeway in permissible angle of scanning beam impact relative to the target or screen area 15 increases as the altitude or elevation of the elementary screen tetrahedra or the pyramidal height increases. It thus becomes evident that the higher the tetrahedra or pyramids the shorter are the permissible side tubulatures of the multi-color scanning tube within which the electron gun is mounted and through which the scanning beam passes. With pyramidal elements or tetrahedra, which are relatively high, the angle A, which is represented particularly in connection with the showing of Fig. 9 (later to be described) may be even twice that which it would be if the height of the tetrahedra were reduced substantially.

Reverting to the theoretical desirability of maintaining equi-angular impact of the scanning beams on the tetrahedral faces throughout their motion over the image area, it is frequently desirable to vary the tetrahedral angles or altitudes systematically over the image or view area. Usually this is not necessary, although it will be appreciated that certain refinements may be obtained from the modification. In cases where there is a variability in the pyramids or tetrahedra, this slight variability in pyramid angles may be taken care of in the manufacture of the screen in order that substantially normal impact may always result. It should, however, be here noted that entirely acceptable operation may be secured with constant pyramid angles over the entire screen surface, provided reasonable beam deflection angles and adequate pyramid heights are used.

In making reference to Fig. 5, the area 35 thereof may be regarded as a rectangular area of normal image aspect ratio which results from a normal electron scanning of a target area by an electron beam scanning the surface or area 35 where the scanning beam is generated in an electron gun positioned normal to the surface and at approximately on a line drawn through the center of the area 35. Neglecting, in the pattern shown, a very slight "pin cushioning" effect, which is extremely small unless the gun is very closely adjacent the target, the scanned area 35 is a rectangle. In the arrangement of Fig. 5, the arrows marked "V" and "H" indicate the vertical and horizontal directions of scanning of the area 35. It will be understood in this connection that, in accordance with now established practice, each of the horizontal and vertical scannings results from a non-symmetrical saw-tooth deflection with the slower component (i. e., the visible scanning and not the suppressed return trace) of each of the vertical and horizontal scannings taking place respectively from left to right for the horizontal scanning and from the top to the bottom for the vertical scanning.

If now, a condition be assumed where the axis of the electron gun is located in a plane perpendicular to the image surface and passing through its vertical central line, and if the gun points toward the center of the image area in this plane and is inclined downward from the normal to this plane, the resulting image, in the absence of correction means, would be foreshortened, as indicated generally by the area 36. To correct this condition, as is well known, a voltage or current of appropriate polarity and magnitude, determined in accordance with the vertical

deflection, may be introduced into the horizontal deflection current or voltage which is producing the lateral deflection or motion in the direction H. In this way, the foreshortening shown by the area 36 is neutralized and, by the usual image dimension controls, the size of the image, as well as its rectangularity, is maintained and brought back to an area such as that shown at 35.

If the axis of the electron gun is in a plane perpendicular to the image area 35, this plane in this instance passing through the center of the image and horizontally (that is parallel to the scanning lines) and if the electron gun points to the center of the image area and is inclined to the right relative to the normal to this plane, the resulting image in the absence of any corrective means will be foreshortened, as indicated by the area 37 of Fig. 5. If a certain amount of the horizontal deflection current or voltage is added in an appropriate polarity to the vertical deflection current or voltage, the foreshortening effect shown in the area 37 may be eliminated and, as before, the rectangular shape of the pattern restored so that the pattern assumes its original dimensions.

The circuits for accomplishing such effects will be hereinafter mentioned in more detail. However, generally speaking, circuits for avoiding the "keystoning" effects in one direction, such as that shown in one direction for the area 36 of Fig. 5, but not for those in another direction, such as that shown by the area 37 of Fig. 5, are known and disclosed both in the literature and in the patented art. That is, "keystoning" resulting from shortening of the horizontal deflection lines can be corrected by known methods, but "keystoning" resulting from shortening of the vertical deflection on one side of the image has not, as far as applicant is aware, been corrected by any previously known means.

If now, a further condition be assumed where the electron gun points toward the center of the image area but does not lie in either of the perpendicular planes above mentioned, the incidence of the electron beam as it is projected toward the area may be said to be "doubly oblique." The result is that the image or scanned area 35 will be found to be distorted both vertically and horizontally, as indicated by the pattern represented as the area 38. In this showing it will be seen that two sides of the pattern 38 slope so as to be similar to those along paths coinciding with the sloping sides of the area 36, while the other two sides of the area 38 slope in a manner resembling the sloping sides of the area 37, and both of these conditions occur simultaneously.

Circuits to provide correction of distortions of this composite or doubly oblique nature, generally speaking, involve at least a combination of the circuits for caring for distortion in the individual patterns or scanned areas represented at 36 and 37 and will be discussed more fully in what is to follow. As far as applicant is aware, such circuits have also been previously absent from the art. It will, of course, be appreciated further that each of the color scannings will have in this way different foreshortening and will each require different correction circuits, although functioning with corresponding constants of operation (vertical and horizontal deflection frequencies and return times). To this end, it will be appreciated that under some circumstances of operation elements of the types shown by Figs. 6 and 7 are to be preferred for some conditions over those of the types shown by Figs. 1 and 4 in order that

the so-called "doubly oblique" conditions represented by the area 38 may not have to be dealt with as would be the case when the three-sided elements of Fig. 4, for instance, are considered. Nevertheless, the doubly oblique foreshortening can be corrected by the practical methods herein to be described and set forth.

Considering, however, further, the type of operation wherein the tetrahedra (pyramids) of the type shown by Fig. 4 are utilized as the screen or target upon which the scanning beams impinge, these tetrahedra may be of the so-called equilateral type, or, in another type, they may have an altitude (that distance measured from the apex 1 to the base 2, 3, 4) which is of the order of two-thirds that of an equilateral tetrahedron, or, in still another type, the altitude may be about 50% greater than that of an equilateral tetrahedron. For present consideration and as illustrative, it will be assumed, however, that the tetrahedra of Fig. 4, used as the target area, are of the equilateral type.

Referring now to Fig. 8, which is a tetrahedral array viewed along the direction of an oblique scanning beam impinging approximately normally on the surfaces 3, 4, and the like, it will be assumed that a scanning beam 5 (see Fig. 2) scans the tetrahedra in such a manner as to impinge upon the red responsive areas or triangles 1, 3, 4. The scanning spot of the beam 5 should preferably cover an area of the impacted triangular tetrahedral face 1, 3, 4, which is represented by that area 40 which is confined within the circular area of impact designated. This, as it will be seen, leaves a small margin on each side of the tetrahedral face when the scanning spot is most centrally located. When the scanning spot, however, moves to the next tetrahedron of the sequence, it tends to occupy a position, which has been indicated within the circular area marked 41, and tends to fall upon the area 11 (see also Fig. 4) which was assumed to constitute a "dead area" between the two tetrahedral faces and is almost exactly inscribed in the forward angle portion of that area, although it can be seen that a very slight and harmless overlap into adjacent like-color tetrahedral faces may occur. It should be understood that in the scanning of the tetrahedral faces of the tetrahedra, the scanning electron beam is directed so that it strikes almost exactly normal at the centermost portion of the combination. While adjacent tetrahedral faces are impacted, to some extent, by the edge portions of the scanning beam, as indicated at 41, so that luminescent effects of like-color result, the brilliance of such luminescent effects is very substantially reduced over that of the scanning electron beam, in a position such as 40, due to the fact that only minute areas of the tetrahedral faces in line between the electron gun and the "dead areas" 11 come within the range of the scanning electron beam. Thus, effectively unique primary color scanning appropriately occurs for each beam.

It will be appreciated, in considering what has herein been stated, that actually all three of the assumed component color scanning spots or beams will fall upon the "dead areas" 11 at certain times during the scanning sequence, although the scanning beams or spots which are to produce the assumed green and blue luminescent effects will strike the "dead" or fluorescently inactive areas 11 from paths substantially 120° spaced from that path along which the assumed scanning spot 40 is directed upon the tetrahedral

faces 1, 3, 4, which faces are assumed, for illustrative purposes, to be red responsive. The direction of impact of the scanning spot 40, as determined by the altitude of the beam (that is, the angle of inclination of the scanning beam to the plane of the target, such as the target plane 15—see Fig. 2 for example) is such that viewed along the scanning beam, the apices of the tetrahedra project slightly, but noticeably, into the next dead or fluorescently inactive area 11. It is, of course, apparent that the tetrahedra may be formed as frustra of tetrahedra so as to have substantially flat top portions which could also serve as fluorescently inactive or "dead" areas. The frustra effect could readily be achieved, for instance, by slightly grinding or polishing the points of the apices of the tetrahedra by any appropriate means.

In the arrangement of Fig. 8, the assumed direction of scanning is, as indicated by the arrow, adjacent the scanning spot whereby the sequence will be from one tetrahedral face to another, with the scanning of a dead area or a fluorescently inactive area, shown by 11 on Fig. 4, for instance, intervening between each successive tetrahedral face impacted.

In connection with the showing, it is desirable to point out that with a multicolor target area of the type herein disclosed, black and white images may be produced as readily as color images in that it will be appreciated that the separate control electrodes of the image reproducing tubes of the general type shown, for instance, by Figs. 2 and 3, and formed from target sections such as shown by Fig. 4, for instance, can all be controlled from the same signal which represents, under these circumstances, a black and white image sequence. Accordingly, if the same control signal is applied to all of the component color gun or electron beam controls, for example, upon the scanning beams 5, 6 and 7 of Figs. 2 and 3, a black and white image sequence will result from the screen or target area 15, irrespective of whether or not the signals are applied to all of the control electrodes or guns simultaneously or sequentially.

To this end, it will be appreciated that a system of the type herein disclosed thus is not, in any way, limited to color image production, but rather is adaptable for use also for black and white image production. In case the black and white image production is relied upon, then it becomes evident that the brilliance of the resulting pattern of viewed image will be enhanced, to some degree, due to the additive effects of light to all of the component color areas.

Furthermore, in connection with scanning of the target area, such as that formed, for instance, according to the showing of Fig. 4, where the areas 11 may be the so-called "dead" areas which represent the triangular spaces between the tetrahedral or pyramidal surfaces, these surface areas may be coated with a suitable luminescent material which luminesces under electronic activation to produce black and white light effects.

Under these conditions, if the scanning beams which would normally strike or impinge upon the red, the green, and the blue responsive fluorescent areas should overlap these respective areas so as to strike the so-called black and white responsive areas or the dead areas, the result will be the formation of a further black and white image in addition to, and in registration with, the separate component color images which normally re-

sult from the scanning beams striking the red, the green, and the blue responsive areas assumed to compose the target.

A black and white image formed in this way will add to the image brightness of the viewed image and, at the same time, will automatically produce a sort of average key image and also increase the efficiency of utilization of the screen or target surface. In many instances it can be appreciated that the increase in efficiency will run to an increase of the order approaching 200% or more.

No illustration of this form of scanning has been applied, but it will be appreciated that the black and white or overlap key image may readily result where the cross sectional area of the scanning beam is slightly enlarged, for instance over what is shown in Fig. 8, so that the spot or beam more readily impinges upon the black and white responsive areas 11 intermediate the tetrahedral or pyramidal surfaces of the target.

In order to avoid possibly false color production, as would result for instance if the scanning beam 5, assumed to impinge upon the red responsive areas or tetrahedral faces 1, 3, 4, were to impact a blue responsive area, such as the area 1, 2, 4, or a green responsive area such as the area 1, 2, 3, it can be appreciated that the obliquity of the scanning direction becomes a material consideration. To this end, Fig. 9 is intended to show the permissible angle of the beam for scanning, in that it indicates the range of angles to the central normal surface 35 within which the scanning beam may impact with reference to the scanned tetrahedral surface without causing false color effects to begin to be observed. This angle is indicated as the angle A; and d indicates the distance from the electron gun to the target area so that at the target area the distance traversed on either side of the normal may be represented as D . Thus, the actual angle within which the scanning beam must lie for correct color impact has a value of twice that of the angle A indicated, in that the beam was assumed to originate from a central location which is essentially the region wherein beam deflection occurs. Likewise, the distance D , shown by Fig. 9, is for approximate grazing incidence of the beam on the desired shielded side of the tetrahedron. Theory and measurement show that the leeway in permissible angle of beam impact will be found to increase as the altitude of the elementary screen tetrahedra increases, or in other words, tetrahedra of the lowest altitudes are more subject to color distortion by grazing incidence of the scanning beam in the outer portions of considerable beam deflection angles on inappropriate color responsive faces which are other than those upon which the beam is intended to impact from more nearly a normal path in order to produce one of the chosen primary color images.

It might be noted, in connection with what has been stated above, that in cases where the distance between the electron gun 31, for instance, and the plane of the target (see Fig. 2) is relatively short so that the target area subtends a considerable solid angle at the location of the electron gun, tetrahedra or pyramids of different altitudes may be used at the center of the target area than are used at the outer edges of the target area with, of course, the greatest height or altitude being used at the outer edges of the target area and the lowest at the centermost portion. Such tetrahedra naturally may be varied in height in steps from the center of the target

area outwardly to its corners, or they may continuously vary in height where so desired. Generally speaking, however, the height of various tetrahedra may be appropriately selected at a single value for use in a tube with reasonable length of electron paths between the electron gun and the target area so that uniformity of the tetrahedra may be retained and yet little or no color distortion from the edge areas will be introduced.

With regard to the manner by which the various target areas may be produced it is, of course, apparent that recourse may be had to various manufacturing methods so long as the resulting product generally conforms with the configuration hereinabove mentioned. Accordingly, it is to be understood that the specific manner of manufacturing the target areas may be varied within wide limits without departing either from the spirit or the scope of this invention or its disclosure. However, for the sake of illustrating one of a number of suitable methods by which the screen or target area may be formed, reference may be had especially to the disclosure of Figs. 10 and 11 of this application.

Referring now to Fig. 10, there is shown, in plan, the top of a block of material which should be transparent and as free as possible from gas emission in vacuo and under electronic bombardment (that is, through the interstices, such as 11, in the fluorescent, luminescent or any other type of coating). The block 50, illustrated by Fig. 10, may initially be of solid nature and then it will be sliced, so to speak, by a slicing machine of microtomic nature by cuts taken at angles at 120° relative to each other in the formation of a target (of the general form shown by Fig. 4, for instance) which slices or cuts are indicated, for instance, by the paths 51, 52, and 53, 54, and 55, 56 respectively, for each of the 120° angles.

After these cuts have been made, the block is reassembled, and Fig. 10 then illustrates the top view thereof. As shown by Fig. 10, the resulting cuts produce triangular elements or areas at the tops of the prismatic elements or splints and it will be noted that two placements of the triangular tops of the splints, of which the block 50 is composed, are possible. One of these arrangements places the units in such a way that one of the splints 60, 61, 62 has its apex turned backward, while another of the type indicated by 63, 61, 62 has its apex turned forward. In the arrangement to be described, half of these units, namely those corresponding to the type shown in plan at 60, 61, 62, will be usable in the procedure to be described further. The other half will require further modification or a different mode of use which need not be here described.

The block shown in Fig. 10 is made up of a side-by-side assembly of a substantial number of splints or prisms of triangular cross sections, which will each be relatively long in comparison with the dimension of the top face. Accordingly, each will have a cross section which corresponds to an equilateral triangle and thus fit together into a sort of tessellated structure which is indicated by Fig. 10. To obtain this formation it is, of course, apparent that small amounts of thinned adhesive material may be used, if desired, to hold the assembly or parts of it together temporarily or permanently, and water glass or a suitable resin may form one of the usable adhesives.

When the tessellated assembly has been made, as above stated, or otherwise, it is caused to have

its top surface inclined to the length of the splints at an angle selected appropriately for the particular desired height of tetrahedra (which angle is of course less than 90° and is determined by the desired altitudinal height of the tetrahedra or pyramids which are ultimately to be produced from the prismatic splints), the inclined top surface of the tetrahedra may be appropriately produced by merely sliding the splints produced, as shown in Fig. 10, so that they rest against a suitably inclined surface, or it may result from obliquely grinding or cutting the desired inclined surface from the clamped tessellated assembly of splints. In either case, however, the resulting production will be of the general formation shown by Fig. 11, where the area indicated as 65, 66, 67, 68 is the tilted surface which corresponds substantially to the surface shown in the plan of Fig. 10. The tops of the triangular prismatic splints are indicated by like reference numerals to those used in Fig. 10. As is indicated, from Fig. 11, the angle designated 67, 66, 69 determines the height of the various tetrahedra, which are to be produced by the assembly in sets of three of the splints in Fig. 11 after they have been appropriately and separately coated with fluorescent or luminescent materials of the desired component color fluorescence (with or without underlying colored filtering media). By way of example, typical splints might be indicated by the formation 61, 63, 70, 71 and 65.

Now, assuming that the surface 65, 66, 67 and 68 has been made flat by grinding and polishing, or otherwise, it is to be coated with the desired component color fluorescent material which, under activation of one of the electron beams, will emit one of the desired primary colors of the tri-color additive group. To this end, the fluorescent coating in question may be directly coated on the tessellated surface, or, if it is desired to correct in any measure the color of the emitted light produced by electronic impact as the light is viewed from the underside of the tri-color tetrahedra which are later to be formed and assembled from the splints, the fluorescent material is coated over a filter layer which has been sprayed or brushed or otherwise deposited on the tessellated surface. Alternatively, the filter material may be appropriately contained within the luminescent compound itself so that when the electronically activated compound is viewed through the proper thicknesses of the splint material from its under or concave side, as will be customary, the desired amount of filtering action will take place.

In the process of fabrication, the next step is to level the complete bundle of splints, as shown by Fig. 11, so that the bases of the coated surfaces all lie in the same plane normal to the length of the splints. After this has been done, the cut indicated by the dotted line 75, 76, 77 is made, thus producing the assembly of coated splints 75, 76, 77, 69, 66, 65. The bottom of this surface is flat, but the top consists of coated triangularly inclined surfaces of which half will be usable in the next step. To this end, the three groups of tessellated component color (that is, the red, green, and blue) splints are formed into a multicolor tetrahedral screen between the tetrahedra of which will be blank or "dead areas" which will be filled with triangular cross section splints having their free ends cut off normal to their lengths and either uncoated or coated with a black and opaque substance of minimum sec-

ondary emission, as shown by way of example in the areas 11 of Fig. 4.

In order that any desired different altitudes for such tetrahedra, as are thus formed, may be provided, such changes may readily be obtained by changing the angle 67, 66, 69, as shown by Fig. 11, or, if a continuously varying angle is desired to provide a continuously variable altitudinal group of tetrahedra, the surface area 65, 66, 67 and 68 may be concavely shaped, as schematically illustrated, for instance, by the concavity of 67, 78, and 66, in which case the tetrahedra of greatest altitude will result from the splints near the back of the area (that is, nearest the edge 67, 68), while the tetrahedra of the least altitude will result from the splints near the front edge 65, 66.

Referring back to the pattern areas 35, 36, 37 and 38 of Fig. 5, various forms of distortion patterns relative to the rectangular pattern 35 were illustrated. These are also more particularly shown again by Figs. 14, 16 and 18.

In the pattern area of Fig. 14, one form of foreshortening is shown which is more or less well known in view of the somewhat extensive use in the art of the "Iconoscope" type image scanning or camera tube, wherein the electron gun is at an angle to the impacted target upon which an optical image is projected. In this way, when the electron beam from the electron gun scans the target or mosaic area, it tends to trace a pattern wherein one of the horizontal dimensions, such as the dimension 80, 81, is symmetrically shortened and the area of the pattern 80, 81, 82, 83, is to be transformed or converted, as indicated by the arrow, into the usual rectangular area 84, 85, 86, 87, which has a generally accepted or standard aspect ratio of 4:3.

To obtain this result and transformation of the pattern from the area 80, 81, 82, 83 into the area 84, 85, 82, 83, a more or less conventional method has been represented by the circuit diagrammatically shown by Fig. 15. To this end, energy for deflecting the cathode ray beam along a horizontal path is shown, for instance, conventionally as being developed from a horizontal deflection generator 100, while the energy to effect vertical deflection may be assumed to be generated by a vertical deflection generator 101. The output from the horizontal deflection generator, which may be such as to produce a saw-tooth deflection pattern, is supplied to each of the tubes 102 and 103 and the output therefrom is delivered at the output terminals 103 to the horizontal deflection means (not shown). The energy from the vertical deflection generator is then fed to the output terminals 104, but is also simultaneously supplied by way of suitable conductors 105 to modulate the horizontal deflection wave symmetrically by the vertical deflection through the aid of the tubes 102 and 103.

The circuit herein illustrated by Fig. 15 is largely schematic in order to aid in understanding the invention, and for further reference to the general type of circuit utilized, reference may be had to the book entitled "Television" published by Drs. Zworykin and Morton (publication by John Wiley & Son, New York) where a circuit of the general nature of Fig. 15 is set forth and described by pages 472, et seq. Accordingly, the description in detail will not herein be repeated, except to state that the disclosed arrangement, by which the pattern at the left hand of Fig. 14 is transformed into the symmetrical rectangular pattern of the right hand portion of Fig. 14, corresponds to a scanning beam in the plane passing

vertically through the centers of the long dimensions 82, 83 and 84, 85 of the area 35 and with its axis inclined to the plane of the picture.

If, however, the electron gun is centered in a plane which passes normally through the center of the short or the vertical sides of the picture (83, 84 and 82, 85) and with its usual axis also inclined to the plane of the picture, a different form of distortion results, as is shown by Fig. 16 or the right hand upper half of Fig. 5. It is believed that no correction means for this type of distortion have been previously disclosed in the art. Such distortion may occur singly or in combination with the type of distortion above explained in connection with Fig. 14. The result is that the area generally represented as 37 in Fig. 16 must be changed into the so-called normal aspect ratio area such as 35.

To accomplish this result, a different type correction circuit, such as that shown by Fig. 17, is required. Before entering into any detailed consideration of the corresponding circuit of Fig. 17, it may be well, however, to consider what is required for operation of this circuit. To this end, reference may be made to Fig. 12 where it will be seen that the area 35, which is desired, is represented in part by the rectangular dotted outline, while the area 37 is represented within the solid outline so that the rectangle corresponding to the area 35 is included within the area 84, 85, 82, 83, while the area 37 would be represented within the area limited by the points 84, 86, 87 and 83.

Under these circumstances, the vertical side of normal length H , represented by the line 83, 84, is the same for each of the areas 35 and 37. The symmetrically foreshortened vertical side of length h is represented as the side 86, 87 in each of Figs. 12 and 16. Accordingly, in order that the area may be scanned, typical scanning lines, which might be designated 95, 96, etc., to 97 are shown, with the return trace formed during the blanking period between these scanning lines being such as that represented by way of example by the single dotted return line 115 (actually the scanning beam is suppressed for this portion of the cycle). When an area such as that indicated at 37 is scanned, it is apparent that the first scanning terminates on the right hand edge of the area at a distance represented by a space 82, 87, or at a distance which is indicated as

$$\frac{(H-h)}{2}$$

below the top of the unshortened vertical dimension H . Similarly, the last scanning line 99 terminates at an identical distance above the bottom of the unshortened vertical dimension H (which would be distance 85, 86 above the line 84, 85). Accordingly, the right hand termination of the n th scanning line falls above or below normal position corresponding to the usual scanning of an undistorted rectangular area by an amount which can be expressed by the expression

$$\frac{(N-2n)(H-h)}{N}$$

where H represents the length of the undistorted edge, h represents the length of the distorted edge, n represents the identifying number of the particular scanning lines in the field scanning sequence, and N represents the total number of lines per image field. It will accordingly be seen from this expression, that the shift at the center

of the image (where n equals $N/2$) is zero since the pattern is symmetrically foreshortened.

The result is that the requirement for making the pattern rectangular results in a peculiar form of vertical deflection wave which is schematically represented in Fig. 13 by the wave form 120, 121, 122—124, 125, 126, 127, 129, 130, 131, 132, which is illustrated by way of example. From this wave it will be seen that the first half of the rising portion of the vertical deflection wave up to its center point, intermediate points 125 and 126, is such that there must be added to the normal deflection wave a further component which includes the horizontal or line deflection wave, although this component is not added with constant amplitude but rather with an amplitude which diminishes linearly from the value

$$\frac{(H-h)}{2}$$

at the beginning of the deflection wave (at point 120) to a value of zero at the center of the deflection wave.

Then, for the second half of the rising portion of the vertical deflection wave starting at its mid-point and ending at point 132, there must be subtracted from the normal linear deflection wave a component which also is based on or a function of the horizontal or line deflection wave. As in connection with the added component, the subtracted component must not be of constant amplitude, but rather must increase linearly from zero value at the beginning of this portion of the deflection wave, that is, between the mid-point and point 132, until a maximum value of

$$\frac{(H-h)}{2}$$

is reached at the end of the deflection wave, as at point 132. The return trace wave form becomes largely immaterial since the scanning beam is suppressed and blanked out in any case during this portion of the wave, and therefore is not discussed in detail. To achieve the results and the wave formation last above mentioned, reference may be had to the circuit shown by Fig. 17.

In its analysis, the elements of the system as herein to be utilized might be considered as embodying a receiving instrumentality, wherein there are suitable circuits for separating output energy signals representative of the different selected component color signal modulations or video energy waves.

In the case of a tri-color system there would, of course, be three signals, but in connection with cases where the so-called "key images" are utilized, there could readily be four separate signals, with the "key image" signal being in addition to the signals representative of the red, green and blue color components.

Similarly, in systems based on primary colors of red, yellow, green and blue, there would be four signals.

In connection with each of these signals, as separated, there is a scanning means for producing a scanning beam arranged to scan a target area and to be controlled in its scanning path to provide compensation for distortion due to obliquity of impact and to provide for electron beam modulation of any character, which shall be in accordance with the segregated component color signals.

To provide the compensation hereinabove mentioned, there must be associated with the controlled scanning beams suitable means to compen-

sate for any obliquity introduced, whereby rectangularity of pattern trace results and superpositioning of the produced light radiations in the several component colors for predetermined points of the traced pattern always results.

The result of this arrangement is naturally that the pattern traces representative of the several component color areas, with or without the addition of "key images" or fourth primary-color images, must be a geometric trace assembly in which there is substantially exact registry for like points of the various individual tracings or pattern which, when viewed collectively, add up to produce the picture in substantially its natural colors as desired.

In the light of what has been stated above, the pattern at the left of Fig. 16 may be transformed into the rectangular area 35 (at the right of Fig. 16) by taking recourse to the schematically illustrated form of the deflection wave generator combination shown by Fig. 17. In this arrangement, the deflection wave generators 100 and 101, for developing the horizontal and the vertical wave deflection energy respectively, are again provided, as with the arrangement of Fig. 15. The horizontal wave deflection energy is supplied by way of conductors 150 and 151 to provide the horizontal wave deflection energy which is made available at the terminals 103' to energize and control the horizontal electron beam deflection. With the system of Fig. 17, the vertical wave deflection generator 101 will be seen to deliver a portion of its output energy by way of conductors 152 and 153 directly to a mixer circuit 155, later to be described in more detail. The output energy from the mixer circuit is supplied at the terminals 156 to energize the means, such as the deflection plates or coils (not shown), which controls the electron beam deflection in a vertical path in the scanning or camera tube or in the image reproducing tube of the type of tube 30, for instance.

To compensate for the distortion of the pattern 37 (Fig. 16), however, another portion of the output of the vertical deflection generator 101 is tapped at points 157 and 158 which are connected to the conductors 152 and 153 respectively, to establish a further control through control tubes 160 and 161.

By virtue of the connection made at points 157 and 158, suitably controlled and oppositely phased energy waves may be fed or supplied by way of the potentiometer 162 to the inner control grids or electrodes 163 and 164 of the tubes 160 and 161. These control voltages are applied by way of conductors 165 and 166 which are connected at appropriately chosen tapping points 167 and 168 on the potentiometer 162, and, by virtue of a third connection made to an intermediate point 169 on the potentiometer 162 by way of conductor 170 which connects to the cathode elements of each of the tubes 160 and 161, oppositely phased and correctly adjusted vertical wave deflection energy is fed or supplied to the control electrodes 163 and 164 of the control tubes 160 and 161. It will be seen that point 167 is negative and point 168 is positive relative to point 169.

In contrast to the arrangement of the circuit conventionally suggested in Fig. 15, where vertical deflection wave energy was introduced into the horizontal deflection control circuit, the circuit arrangement of Fig. 17 provides for introducing horizontal deflection control energy into the generated signal for controlling vertical de-

flection. Accordingly, connections are made at points 172 and 173 on the conductors 150 and 151 to derive horizontal deflection control energy and supply this energy by way of the conductors 174 and 175 to the secondary or outer control electrodes or grids 176 and 177 of the tubes 160 and 161.

This auxiliary control energy is derived by connecting the cathodes of the tubes 160 and 161 directly to one of the connection points from which the horizontal deflection control energy is derived, such as the point 172, and then connecting a potentiometer 180 between the connection points 172 and 173 and deriving a voltage to be supplied to the control electrodes 176 and 177 by virtue of a connection made for the conductor 175 at an intermediate tapping point 181 on the said potentiometer 180.

The control tubes 160 and 161, respectively, have their anode or plate electrodes 182 and 183 connected to receive energizing voltages from a common source 184 fed through the load resistors 185 and 186, respectively, for these two tubes. Depending upon the current flowing the respective tubes will depend the energy or voltage which is supplied by way of the output conductors 187 and 188 which connect tubes 160 and 161, respectively, to the mixer circuit 155.

In this connection it should be noted, from what has been above stated, that the tube 160 may be assumed to provide horizontally controlled deflection wave energy which becomes additive in the mixer circuit 155 with the vertical deflection wave energy supplied to the mixer from the source 101 through conductors 152 and 153, while the tube 161 is to provide horizontally controlled deflection wave energy in the same mixer circuit 155 by way of the voltage supplied through conductor 188 in such a manner that the horizontal deflection wave energy due to the tube 161, which combined with the vertical deflection wave energy, shall be subtractive from the linear deflection wave energy output of the generator 101.

The manner in which the tube 160 is arranged to be inactive only during the first half of the vertical deflection wave in accordance with the above description of Fig. 13, and the manner by which the tube 161 is caused to be active only during the second half of the vertical deflection wave, are brought about by the use of appropriate bias controls on each of these tubes. By virtue of the bias source conventionally shown at 190, negative bias is applied to the control electrode 163 of the tube 160 in such a way that when the vertical deflection wave energy reaches its central value, that is, a value represented by the point intermediate points 125 and 126 on Fig. 13, and this voltage is combined with that derived from the horizontal deflection generator, the tube 160 reaches a cutoff value and becomes inactive during the second half of the rising portion of the vertical deflection wave.

It may be observed, in this connection, that the vertical deflection wave applied to the control electrode 163 of the tube 160 appears as a progressively increasing negative bias on this tube. On the other hand, by virtue of the connection of the control electrode element 164 through the bias source 191 and conductor 166 to the tapping point 168 on the potentiometer 162, it will be apparent that the vertical deflection wave is applied to the control electrode or grid 164 as a progressively increasing positive

bias which is opposed to the negative bias 191 normally serving to control tube 160.

In other words, it might be remarked that the bias provided on tube 160 through the bias source 190, and by virtue of the connection of the control electrode 163 through the bias source and conductor 165 to the potentiometer 162 at point 167, the bias is so set that tube 160 cuts off at the central point of the vertical deflection wave (for instance, half way between points 120 and 132 on Fig. 13), while the bias provided by the bias source 191 and the connection of the control electrode 164 through the bias source of the conductor 166 to the point 168 on the potentiometer 162 is such that tube 161 is supplied with a negative cutoff bias which becomes ineffective at the point in the vertical deflection cycle where tube 160 ceases to draw current (or is cut off) and, at this point in the vertical deflection wave, the tube 161 takes over, so to speak, and the wave formation of Fig. 13, indicated between points 126 and 132, for instance, is obtained as a voltage applied to the mixer 155 through conductor 188.

It thus can be seen that the combination of the two biases applied, as above described, on the tubes 160 and 161 control the operative periods of those tubes and, by virtue of the introduction of some of the horizontal deflection controlled energy upon the tubes through conductor 175, proper combination of the horizontal and vertical deflection controlled energy results. If, of course, some undesired vertical deflection control energy wave component appears in the conductors 187 and 188 supplying energy to the mixer circuit 155, this component of energy can readily be eliminated by well known filter means or potentiometric arrangements which are well known in the art and are therefore neither illustrated nor described in detail.

The mixer circuit 155 comprises a tube of the usual mixer type in which there is a plurality of control electrodes which, in this instance, may be energized in accordance with the output of all of the deflection controlled generator 101 and the tubes 160 and 161. Thus, the current output of the mixer 155, as it appears at the output terminals 156 to be supplied to the vertical deflection coils, is of the general wave formation exemplified by Fig. 13. This is then indicative of the form of wave energy which is supplied to the deflection plates or coils (not shown) to control the deflection of the electron beam (which would normally tend to trace the pattern 37 across the target 15 in the absence of separate deflection control) so that the scanned pattern is transformed into a rectangular pattern area 35.

In this connection it should be pointed out that the vertical deflection control system must be so designed as to be capable of controlling vertical deflection at frequencies as high as the horizontal deflection frequency (or a suitable multiple thereof in accordance with the usual practice) in order that the corrective deviations in the vertical deflection wave from its linear normal form shall be effective. In the absence of providing main deflection coils for the vertical deflections which shall respond at frequencies as high as the horizontal deflection frequency, it is, of course, evident that the scanning beam normally tending to trace the pattern 37, in the absence of correction, may be controlled both by the usual type of deflection coil and by an auxiliary deflection coil which will be responsive at the relatively high line frequency and which

would then preferably derive its energy from the output of the tubes 160 and 161 with or without the inclusion of the mixer element 155 in the circuit.

Conditions can readily arise where the area represented at 37 in Fig. 16, for instance, is reversed from left to right so that its shortened edge is at the left rather than the right and, under these circumstances, the correction of the distortion may be carried forward by the same circuit arrangement as is schematically illustrated by Fig. 17 except, for instance, that an appropriate phase delay, corresponding to the time represented between points 120 and 121 of Fig. 13, must be introduced into the circuit included in the conductors 150 and 151 which supply energy to the horizontal deflection coils so that when the horizontal deflection of the first line starts, points 121 of the deflection wave will already have been reached. It might be pointed out also that, for best operation under these conditions, the energy appearing in the conductors 174 and 175 may be supplied from a second modified horizontal deflection wave generator (not shown) which is arranged to operate synchronously with the horizontal deflection wave generator 100 but which produces a wave output with a relatively rapid rise and a relatively slow drop, or, in other words, a wave which is substantially the left to right mirror image of the wave produced by the horizontal deflection generator 100.

It is possible to avoid some of the aforesaid difficulties, for example, by designing and arranging the horizontal scanning direction of some of the component color images in reverse order to present conventional scanning in order that the horizontal and vertical deflection waves may always start in the same direction or instantaneous phase so to speak. Recourse may be had to such an arrangement, where desired.

In Fig. 12, reference was made to one form of image distortion, and that form of distortion was further particularly exemplified in the showing of Fig. 16 and the compensating circuit of Fig. 15 to correct such distortion. It is, of course, apparent however, that conditions might occur where the distortion, such as that shown by Fig. 12, is completely in the reverse order. In other words, if the scanning pattern is assumed to be from left to right and from top to bottom of the area of Fig. 12 or the left half of Fig. 16, then it can be appreciated that the left hand edge of the pattern might, in some conditions, be represented by the line dimension h and the right hand of the area represented by the line or edge dimension H .

Under these circumstances, the vertical deflection wave, that is, a normal deflection of sawtooth configuration, would have added to it another component to correct for such distortion.

A wave of this general character is particularly represented by the showing in Figs. 19 and 20, respectively. The diagram showing of Fig. 19 is, in many respects, very close to that represented by Fig. 13, except, of course, that the distortion of the deflection wave is different in that the showing of Fig. 13 had to provide adequate horizontal compensation distortion in contrast to the vertical compensation distortion represented by Figs. 19 and 20.

To this end, the vertical deflection wave with a scanning pattern shown by Fig. 12, for instance, where the lines of the pattern trace vary from the first line 83—87 to the last line 84—86, may

be considered as being a wave trace of the form extending between the points 190 and 191, and this is of a serrated formation with the deflection between the points 83—87 being taken care of by the portion 190, 192, and with a return to the last line of scanning being represented by the wave trace 192, 193; then the last line of scanning following 83—87 of Fig. 12 is produced by the deflection wave 193—194. This follows until the centermost portion of the pattern occupied within the boundary points 83, 84, 86, and 87 of Fig. 12 is traced; whereat it will be seen that the vertical deflection wave of Fig. 19 follows a substantially linear configuration or uniform deflection between points 198 and 199.

If the centermost point or line of the area to be traced is produced, it can be seen that for the lower half of the image (in contrast to the upper half), the vertical wave must be slowed down if the trace moves from left to right, rather than speeded up as was the case of the upper half of the image. Consequently, the vertical deflection wave is slowed down by the introduction of a negative component after each line of the image is traced, and this is in contrast to the addition of a component for the upper half.

Accordingly, if reference is made now again to Fig. 12, it will be appreciated that in tracing the line between point 84 and 86, the produced vertical deflection wave will be that represented between points 201 and 202, with a snap-back occurring between the second last line and the line 84—86 being represented in the vertical deflection pattern between the points 203 and 201. The return trace for starting the next image field will then occupy a pattern between points 86 and 83, and may be represented by that portion of the vertical deflection wave between the points 202 and 191. Naturally, this occupies several line periods, but due to the suppression of the scanning beam during such portions of time, the scanning wave in the vertical direction between 202 and 191 in Fig. 19 is merely represented in dotted outline.

It, of course, becomes apparent from what is shown on Fig. 19, that if the pattern of Fig. 12 were reversed from left to right, the wave formation represented by Fig. 20 would apply for such a deflection, and that in tracing from the first line of the pattern down to the centermost portion of the pattern, the trapezoidal distortion would have to be compensated for in exactly the reverse manner than that explained in Fig. 19, so that the vertical deflection wave would have subtracted from it horizontal-deflection-wave components of linearly progressively decreasing amplitude down to zero value as the deflection takes place from the topmost line of the pattern to the centermost line of the pattern. After the centermost line of the image has been scanned, the vertical pattern must have added to it certain components for each line which equal a maximum value for the last line of the image.

In Fig. 20 the various scanning traces are represented by the same means as for Fig. 19, except that a prime has been added in each instance so that the scanning pattern, as it is traced, extends from the point 190' to 191'.

In line with what has been disclosed, it can be seen that, for one form of distortion, correction may be provided by the addition of a positive bias of decreasing value and change according to a saw-tooth pattern between the top line of the image and the centermost line; and then negative bias added, according to a saw-tooth change

of pattern, is applied to the vertical deflection wave from the centermost line to the lowest or bottom line.

For distortions where the pattern is reversed from left to right, the reverse conditions take place and negative bias is first applied and then, after the centermost portion of the image is scanned, positive bias is applied. Various ways and means of taking care of these effects through the use of delay circuits and other appropriate elements may be relied upon. To this end, the deflection wave pattern shown by Fig. 20 may be utilized.

As will later be pointed out more particularly, the normal deflection wave, that is, a linear deflection wave which is capable of carrying the spot of the scanning electron beam vertically from the top to the bottom of the narrowest portion of the distorted field such, for example, as between points 87 and 86 of Fig. 12, corresponding to the normal deflection between the points 192' and 202' for instance, as in Fig. 23, must have added thereto a constant positive bias which is equal to the amount represented by

$$\frac{(H-h)}{2}$$

and also have added thereto a line deflection, the amplitude of which starts with a negative maximum and decreases in amplitude to 0° and then increases progressively to a positive maximum on the other side of the deflection wave, all as indicated by Fig. 20.

The mode of variation of such a wave has already been explained in connection with Fig. 15, except that the constant positive bias above referred to must be added and the polarity of connection between the horizontal generator and the cathodes of the control tubes must be reversed, and this is necessary because it can be seen from a comparison of Figs. 19 and 20 that the added line deflection component in Fig. 20 is in the opposite phase from that of Fig. 19, but is varied in amplitude between two maxima in opposite directions in the same way.

In the arrangement shown by Fig. 18 and also shown in the lower right hand view of Fig. 5, the area 38 represents one in which distortion of the scanning pattern took place in a combination of two directions, in contrast to those distortions which were explained and discussed in connection with Figs. 14 and 16 above where explanation was given of suitable circuits for correcting the distortion of such patterns as the trapezoidal patterns 36 and 37 and transforming these patterns into rectangular areas of scanning of desired and normal aspect as represented, for instance, by the area 35. Distortion of the type shown in the left hand half of Fig. 18 is that type which results from "doubly oblique" scanning of the image or target area and, in order that accurate registration of the final image which is viewed in the target area 15 may result, it is, of course, evident that adequate compensation for the bi-directional distortion must be provided. To this end, a circuit for correcting the distortion and for introducing a modified deflection pattern is provided by virtue of the combination of circuits of Figs. 15 and 17.

Referring now to Fig. 17, it will be seen that the output terminal points 103' and 103'' are indicated, and intermediate these points other terminal points marked X' and Y' have been shown and are represented as connected by dotted outlines. Also, by referring to Fig. 15, it will be seen

that the terminal points 103' there shown are designated also as Y, and terminal points X are shown closely adjacent the horizontal deflection wave generator source 100.

If reference is again made to Fig. 15, it will be seen that the circuit there shown was to compensate for distortion which transformed the area 84, 85, 86, 87 into an area 80, 81, 82, 83, so that the sides thereof were sloping inwardly and in such a manner that the sides 80, 81 corresponded substantially to the parallel sloping sides of area 38 of Fig. 18, while the circuit of Fig. 17 took care of distortion in the vertical direction and transformed the area 37 into one such as that shown by area 35.

Accordingly, it is evident that the area 38 is one in which distortion has occurred in such a way that both the vertical and horizontal distortions are present. To this end, to compensate for the distortion of the left hand half of Fig. 18 that is shown by area 38 and to provide a scanning pattern which again becomes rectangular, the portion of the circuit shown by Fig. 15 intermediate terminal points X and Y may be included and connected between the points marked X' and Y' in Fig. 17 and, under such circumstances, output energy to energize the horizontal deflection plates or coils (not shown) will be derived at the right hand output terminals 108'.

The connections of conductors 105 of Fig. 15 to the vertical deflection wave generator 101 may be provided by connecting these conductors 105 of Fig. 15 now to the conductors 152 and 153 of the circuit of Fig. 17 and thus output energy derived at the right hand output terminals 103' will be the energy of the horizontal deflection wave generator 100 as modified by the influence thereupon of the vertical deflection wave generator 101, while the simultaneously active vertical deflection wave energy, as derived at the output terminals 156, will be influenced and modified by the output from the horizontal deflection wave generator 100, all as was above explained in the description of Figs. 15 and 17. In this connection it should be pointed out that no changes in the circuits above described are necessary to transform area 37 to that shown at 35 by Fig. 18 other than those expressed above, except those conventionally required in any circuit connection to provide adequate and proper ground connection and to eliminate short circuits.

Now, referring to the arrangements shown by Figs. 21 and 22, and first to Fig. 21, there is shown a representation of a section of a monoplane screen section of the general nature shown by Fig. 4. While in the arrangement of Fig. 21, the various tetrahedral elements are not shown in detail, a general relationship which substantially corresponds to that of Fig. 4, where the tetrahedral faces or areas 1, 3, and 4 are each identified by way of example as producing the red image; the tetrahedral faces 1, 4, and 2 are assumed to produce the blue image; and the tetrahedral faces 1, 3, and 2 assumed to produce the green image. The intervening areas, such as those represented at 11 of Fig. 4, for instance, will be assumed to produce the key image or consist of blank areas, as was explained in connection with the arrangement of Fig. 4.

In Fig. 21 the electron gun 31 which, in Fig. 3 was assumed to produce red image, directs electron beam 5 in the direction shown by the scanning path with the arrow designation, so that the beam 5 impacts at a scanning spot conventionally represented at 210 on the red responsive faces of

the various tetrahedra or pyramids. Actually, the beam 5 is not strictly horizontal, as would appear from Fig. 21, but impacts the red responsive tetrahedra faces, such as the areas 1, 3 and 4, for instance, along paths more nearly normal to the tetrahedra faces.

By way of example, in a case where the tetrahedra are of substantially the equilateral variety, it has been found that the angle of impact should be of the general order of 50 degrees to the plane of the target support, although wide variance may be relied upon where desired and without any appreciable undesired effects, and it should be understood that the exact value of this angle of impact of the beam relative to any tetrahedral face is merely illustrative and constitutes no specific limitation relative to the invention. It may also be added that the angle of impact is influenced by the inclination of the tetrahedral faces.

Further, by way of reference, it may be pointed out that the size of the scanning spot, as diagrammatically indicated at 210, the size of the tetrahedral faces and the impact of the scanning spot within the non-responsive or inactive areas 11 (or, where desired, these may be such as to produce the key-image), will determine the preferred angle of the beam impact on the tetrahedral faces.

The path of horizontal scanning which would correspond, for instance, to one scanning path, such as that indicated by way of example as the line between the points 83 and 87 of Fig. 12 (although it may be that the electron gun for the red scanning traces a substantially rectangular pattern so that the line scanned might be that between points 82 and 83 of Fig. 12, for instance), will follow the path indicated by the arrow "H."

If it be assumed that magnetic deflection of the cathode ray beam 5 is to be relied upon, the vertical deflection of the beam shown as occurring in the direction indicated by the arrow and the legend "V" (the scanning being from bottom to top and right to left due to the assumed vertical and lateral inversion of the optical image by the lens element forming a real inverted image on the photosensitive screen of a transmitter tube, or the scanning may be in the opposite direction to that shown by the arrow and legend "V" for a receiver tube) will be provided by the vertical deflection coils represented by the legend "V" and also conventionally by the coils 213 and 214 which receive energy from a suitable source of deflecting energy which is connected to terminal points 215 and 216 with the electron beam 5 being so positioned as to pass through the field of the coils.

A horizontal deflection of the beam in the direction indicated by the arrow "H" is provided by the coils conventionally represented at 218, of which only the pole piece 219 is shown (it being understood that the upper horizontal coil is omitted for illustrative purposes). Suitable energy for providing for the horizontal deflection of the scanning beam is applied from a suitable energy source (not shown) at terminal points 220 and 221.

If the pattern traced on the target area when the beam impacts the tetrahedral faces is distorted, as shown, by any of the patterns 36, 37, or 38 (see Fig. 5), it is apparent that the deflection energy supplied for vertical deflection at the terminal points 215-216 must be corrected in a manner explained in connection with the description of the corresponding distortion correction systems, exemplified particularly by the circuit arrangements of all of Figs. 15, 16 and 17, as well

as the wave forms traced and exemplified by Figs. 13, 19 and 20, so that further comment regarding such deflection control would, at this point, be merely repetitious, in that the obliquity of scanning may be corrected by any of the methods hereinabove described, depending upon the form and type of distortion which is to be met.

If reference is now made to Fig. 22, there is provided an electron gun 32 to produce a scanning beam or cathode ray 6 which is directed toward the target area formed of tetrahedral faces (as more particularly shown by Fig. 4), and as also represented by Fig. 21, wherein the beam or ray 6 is assumed to be projected along a path such that it impacts or impinges upon substantially only the green responsive area 132 of the various tetrahedra or pyramids comprising the impacted target area.

Accordingly, as was represented by the tube of Fig. 3, the scanning beam 6 impacts the area of the target at an angle approximating 120 degrees spaced from that direction of impact along which the scanning beam 5 is directed toward the target. The angle here mentioned is purely illustrative in value.

Consequently, with the arrangement of Fig. 22 serving as an exemplification of the manner in which the second of the three assumed component color images is developed, the corresponding beam will seemingly be in a position more or less from the back of the tetrahedra as compared with the direction of impact of the beam 5. According to such a pattern trace, for instance, as the general arrangement of the impacted target area 15, it will be seen that the horizontal direction of scanning of the green responsive areas takes place also in the direction marked "H" in Fig. 22, or along the path indicated by the arrow 225; and the vertical direction of scanning in connection with the green responsive areas occurs in the direction marked with the arrow "V" and the designation 227. Accordingly, to this end, the horizontal deflection of the cathode ray beam, or scanning beam 6, which issues from the electron gun 32, is provided by means of the deflecting coils 229 and 230 through the fields of which the cathode ray beam 6 is projected.

A suitable current or voltage input source for energizing the deflection coils 229 and 230, which are connected as indicated, is connected at terminals 231 and 232 and, where necessary, the horizontal deflection energy has a vertical component added thereto or subtracted therefrom, as the case may be, in accordance with the teachings hereinabove set forth.

Similarly, vertical deflection is provided by way of a pair of vertical deflecting coils 235 (of which only one is shown) which have energy of suitable wave form, such as those forms hereinabove described, applied to terminal points 236 and 237 so that a vertical deflecting field is developed in a plane normal to that of a horizontal deflection.

In this way, depending upon the position of the electron gun (such as the electron gun 31 for instance), will be determined the type and character of distortion which must be corrected to return the traced pattern to rectangular formation, as indicated by area 35 of Fig. 5; and accordingly, in either or both the horizontal or the vertical deflection direction, suitable correction components may be added or subtracted in the manner heretofore explained.

According to the two showings of Figs. 21 and 22, it will be seen that the relationship between the scanning beams and deflecting coils is some-

what different, both as to the position of the vertical and horizontal deflection systems, and as to the angles and the axes of the deflection systems for horizontal and vertical deflections relative to the scanning beam 6 as compared with the arrangement and relationship of the horizontal and vertical deflection systems relative to scanning beam 5 in Fig. 21.

Obviously, from the showing of Figs. 21 and 22, the scanning beam for scanning blue responsive areas or faces of the pyramids or tetrahedra on the impacted target 15 would be somewhat similar to that shown by Fig. 21. Except as will be evident from what is shown by Fig. 3, such a scanning beam would be arranged so that it would proceed obliquely downward to the target area (looking at the sheet of the drawing) instead of obliquely upward.

If reference is now made to Fig. 23, it will be seen that provisions have been made for eliminating deviations from registration between the component color images, representing the red, the green, and the blue images, for instance, from which the ultimate additive color representations result.

To this end, the multicolor image reproducing tube 30 (see Fig. 3) has a screen or target area 15 which is understood, for purposes of illustration, to comprise a formation substantially analogous to that represented in any of Figs. 4, 21 or 22; or where desired areas are represented by the formations exemplified by Figs. 6 and 7, a suitable anode connection for an anode element 250 within the tube is provided at point 251 from a suitable voltage supply source, conventionally represented at 252, which has its high voltage output transmitted, for instance, by way of conductor 253 to the tube anode 250.

As was shown in connection with Fig. 3, the electron gun 31 contained within the neck 25 of the tube is assumed to provide for the development of an electron scanning beam 5, from which the red component color image is developed. The scanning beam 6 for producing the green component color image is developed from an electron gun 32 contained within the neck portion 27 of the same tube envelope, and the electron beam 7 emanates from the gun 33 contained in the tube neck 28.

These portions have been shown also by Fig. 3 without reference to the complete combination of circuit connections.

It will be understood, in connection with the disclosure of the various electron guns for developing cathode scanning ray beams, that these comprise in usual manner the electron-emitting cathode element provided with direct or indirect heater current and one or more anode elements and one or more grid elements which may be of the controlling or screening variety. Since electron gun structures for producing cathode rays are per se well known in the art, further reference need not be made thereto.

However, in order that the variation in anode voltage, which may arise in such a system, may have a minimum effect upon the operation and, as nearly as possible, an equal effect upon the electron guns for producing all of the scanning beams 5, 6, and 7, from which the several component color images are developed these guns are all supplied with energy from the same anode supply source 52 by way of conductor elements 255 and 256 and, accordingly, with the second anode element 250 serving as a common second anode for all of the electron guns within the

tube, and the anode elements of the guns 21, 33 and 32 all being maintained at the same voltage (or approximately so) relative to the respective cathodes, it can be seen and appreciated that the various cathode ray beams will each focus to approximately the same size at substantially equal distances from the electron guns (assuming uniform tube geometry), so that uniformity in the scanning traces shall at all times be had.

It was already explained, in connection with Figs. 15 and 17, how provision for development of the deflection waves in both vertical and horizontal directions may be had whether singly or doubly oblique scanning is utilized, and it was also explained how these various deflection waves may be developed by suitable modulation or admixture, or both, of the normal horizontal and vertical deflection waves in suitable proportions in either positive or negative sense in each instance.

In the usual operation the vertical deflection energy source 101 and the horizontal deflection energy source 100 will be seen to serve as a common source for all of the deflections in both the vertical and horizontal directions for all of the electron beams 5, 6 and 7, as can be appreciated from the arrangements of Figs. 15 and 17.

In this connection it will be understood, of course, that the deflecting electron members shown adjacent to the tube neck portions are merely and purely of schematic character, and, accordingly, it will be appreciated that in an actual operation the electron elements represented may be either electrostatic deflecting plates arranged within or without the tube neck, or they may be constituted in the form of deflecting coils which are usually arranged externally of the tube neck, or still further, deflecting coils may be provided for one direction and deflecting plates for the other direction of deflection.

In connection with systems of the type herein disclosed, where there is an oblique scanning of an image or other area, and in a system where keystone or other types of distortion is later to be corrected, it will become apparent that it is essentially desirable to provide for systematic variations in the deflection voltages or currents during each scanning to cause corresponding changes in the angular velocity of the scanning spot across the target area. A control of this nature provides ways and means by which uneven spacing or crowding or separation of the successive scanning traces or lines or parts due to keystone or distortion may be avoided. Alternatively, such systems provide ways and means to avoid a foreshortening such as a compression or an expansion of one of the other sides of the image area. To this end, various compensating systems of the type hereinabove described have been set forth.

It is obvious that similar corrective means must be applied in the multicolor system so that if the field is scanned obliquely by a scanning beam emanating from a source below the center of the image area and in a plane passing vertically through the center of the image area, the scanning area will be keystone with the wider edge at the top before correction. Accordingly, the vertical scanning velocity should be higher at the bottom of the image and lower at the top of the image so as to avoid the mentioned effect. If the scanning beam emanates from a scanning gun in the same plane as mentioned in the first assumed condition, above

stated, but above the center of the image area, the keystone will be reversed. The result of this is that the vertical velocity should be higher at the top and lower at the bottom to avoid line crowding or separation.

Following what has been above explained, if the electron beam which scans the target is developed from a gun placed to the left of the center of the picture or the image area, but in a plane passing through the center horizontally and perpendicularly to the image area, there will also be keystone with the right side of the image higher or longer than the left side. To provide compensation for such distortion, it will be apparent that there should be a higher horizontal deflection velocity at the left side of the image and a lower horizontal deflection velocity at the right side of the image in order to prevent compression foreshortening of the image at the left side and expansion of the image at the right side. Likewise, if the scanning beam emanates from a gun in the same plane as that above mentioned, but to the right side of the image area, the keystone will again be reversed.

It thus shows that where there is doubly oblique scanning, the criteria hereinabove set forth for the four assumed methods of compensation must be combined, and if it be assumed, for instance, that the image area is scanned by means of an electron beam emanating from an electron gun situated broadly to the upper left of the image and in a plane perpendicular to the image passing, for example, through the upper left hand corner and the lower right hand corner, the traced image area would be a trapezoidal area before any correction was made, and it will be apparent that the pattern corrections may be accomplished through the combination of one or more of the above outlined procedure of steps as above suggested.

In carrying the invention into practice it may, in some instances, be desirable to make correction for de-focusing of the beam occasioned, for instance, by a variance in the length of traveled electron beam path from the gun termination to the target. It is, of course, apparent that different forms of compensation for de-focusing should be applied in connection with each of the electron beams, in that the areas normally traced or traversed on the target area from the different electron guns would tend to be areas such as those indicated at 36, 37 and 38 in Fig. 5. However, for the purpose of this disclosure, the various methods by which this compensation may be effected will not be discussed in that they are not, per se, necessary to a full and complete understanding of the invention.

In the light of what has been hereinabove disclosed, it will be apparent that the system set forth provides for electrically scanning an image area in three or more colors, with or without key color scanning, so that the scanings which take place either simultaneously or sequentially and so that the scanned areas shall be caused to match accurately in all respects in such fashion as to provide for unit matching and registration of all scanned areas.

It has been above suggested that the television system more particularly referred to herein by the receiver instrumentality, is capable of reproducing images in substantially natural colors as a result of controlled signal impulses. Various ways and means for generating and producing the control signals may be provided. Among such systems would be, for instance, a plurality of

separate camera tube instrumentalities upon which related optical images were cast in order to provide for the proper registration of the reproduced images. The separate camera tubes which would develop signals representative of each of the selected component colors should have provisions made for correcting each of the separate optical images for all parallax distortion. Alternatively, a single positive lens system may produce substantially identical and non-parallax images on the screens of each of the camera tubes using a conventional and well known light beam splitting system for the purpose. Such a system may use half-silvered reflectors which also transmit light, all as shown, for example, by my pending U. S. patent application Serial No. 455,556, filed August 21, 1942 (D-19565), issued U. S. Patent No. 2,423,769, July 8, 1947. Accordingly, from what has been stated above, systems of the types referred to might control the image signals effective to modulate each of the electron beams designated as 5, 6, and 7, respectively, for the red, the green, and the blue image reproductions, assuming, of course, that a tri-color additive system is being used.

However, it is also within the scope of this invention to provide suitable means for generating and producing the signal energy representative of the several image signals by means of a single camera tube having a mosaic area or target upon which the optical image is projected. A tube of this character is so constituted as to be capable of resolving the image into a desired number of selected color components. To this end, the television camera tube may have its mosaic electrode formed in a manner somewhat similar to that hereinabove described for the formation of the luminescent target area described particularly in connection with Fig. 6.

In any television tube of this character, however, it will be appreciated that for color uses it is both desirable and necessary that the color filter elements by which the component colors are selected be placed beneath the photo-electrically selective surface or mosaic for electrical reasons and yet, it is equally as desirable and necessary that these filter elements, by which the several component colors may be selected, should be interposed in the optical path of the image forming light rays which are directed upon the mosaic electrode itself. Accordingly, as the mosaic electrode structure is considered in the light of what has been taught in the art with references to the tubes known as the "Iconoscopes," for instance, and as a tube of this character is considered in its arrangement of elements from that surface which faces toward the electron scanning beam which is to release the signal energy to the external circuit, it can be seen that the mosaic electrode is a surface suitably divided into elements as required for the scanning, and that the support for such a surface should be transparent in nature.

Next, the elements of the signal plate, by which the signals are released to the external circuit, should be in capacitive relationship with and also in registration with the corresponding component color elements of the mosaic, these elements, of course, also being transparent. At the same time, the elements of the signal plate should all be electrically connected in such a manner as to provide a common terminal which will give the electrical output at each instant which corresponds to the scanned component color elements of a selected group, and, further, in con-

sidering a mosaic of this general type, it will be appreciated that the color filter elements will be in direct registration with the corresponding component color elements of the signal plate, and that the light path of the image forming rays directed upon the mosaic from some suitable sort of lens system which forms the image passes through such color filters.

Reference now may be made to Fig. 24 of the drawings in which will be found a schematic representation of one suitable form of arrangement by which the various color responsive elements of the signal plate may be connected, it being understood, of course, that the transparent and thin layers of insulating material, across which electrostatic charges are to be developed, are to be included, and that such insulating areas or sheets may be mica, very thin sheet glass, or the like, which will be understood as lying between the mosaic of the photoelectric elements 547 and the signal plate elements. So considered, the conductive or semi-conductive coatings which form the signal plate for the different colors may be formed by sputtered or plated thin metallic coatings which will exhibit a minimum amount of light absorption and yet which will have reasonably high electrical conductivity.

The various elements of such a mosaic electrode 547 herein shown are formed, it will be seen, somewhat similar to the structure of Fig. 4, but, in the form represented, the areas 525 may be considered, by way of example, as indicating green responsive areas; the areas 527 may be considered as the red responsive areas, and the areas 529 considered as indicating the blue responsive areas. These areas, of different color response characteristics, for the purpose of illustrating the manner in which the several forms of signals may be developed, are formed on the back of the mosaic support which, of course, is itself transparent, and are in accurate registration, so that when the complete mosaic structure is mounted or positioned within the tube envelope, such as 30 for instance, these strips or areas will also be accurately registered.

In order that the various red, green and blue responsive areas may be interconnected, connecting strips 531 have been schematically illustrated as connecting the various green responsive areas to the external circuit (not shown). These strips are suitably secured to the conductive or semi-conductive coatings at points such as those indicated at 533 for instance, whereby all of the various green areas may be suitably attached and connected to the external points. Likewise, strips equivalent to those shown at 531 for connecting the green responsive areas may be provided for connecting the blue and the red responsive areas, with provisions made for insulating the different color strips one from the other at points where they would normally tend to overlap.

Various ways and means for accomplishing the separation or insulation of such elements may readily be provided so that dissimilar component color elements 527, 529, or 531 cannot affect the output of different portions of the system. At some times it will be necessary to vary the thickness of the strips 531 where they intersect, or to overlap strips carrying signals representing other component colors, or the strips carrying different signals which have intersecting points will be bent and the different conducting strips separated by layers or strips of insulation having minimal gas releasing characteristics, which insulating

strips thus provide the separation and prevent physical contact between the various strips.

It is, of course, apparent that many and various ways of forming such structures may be relied upon, and the illustration hereinabove given is intended merely as one of several possible ways. All of the receiver instrumentalities hereinabove explained are intended for operation and use where the signals are developed according to various methods. Where the receiver control is obtained from signals developed by completely separate camera tubes, it is, of course, evident that adequate provisions must be made in the camera tubes for correcting for both the scanning distortion and parallax, if these exist, which would tend to prevent accurate picture point registration.

Accordingly, a tube of the type herein exemplified by Fig. 24 may be utilized to provide the separate component color image signals when the mosaic area of the type described is scanned by a number of scanning beams equal to the number of selected component image colors, so that the individual signals may be derived from the individually connected mosaic sections. In this way, the optical image may be focused upon the mosaic area as a single image and, of course, parallax effects disappear. Accurate registration of the re-created image points may be provided readily through control of the scanning beams in the manner hereinabove explained for the receiver type tubes. With synchronous operation of the electron scanning beams of the transmitter or camera tube and also of the receiver tube, proper registration of the resulting patterns thus traced may readily be obtained.

In the consideration of the scanning operation according to this disclosure it will be appreciated that each scanning beam impacts related surface areas of the different pyramids along paths which are not greatly different from orthogonality. Thus, for descriptive purposes a scanning beam direction may be regarded as approximating orthogonality. It will be appreciated that in any television system and particularly for a tri-colored system the scanning beam should preferably impact the central-most areas of the target orthogonally because in practice, the scanning tends to become more oblique at the corner areas of the scanning raster and minimized compensation is required for the other areas where the central-most areas is accurate. For purposes of general reference it will be understood that a scanning path is defined as being such that the scanning electron beam strikes the target area in directions approximating orthogonally. It will be understood to permit a variance from an orthogonal direction up to ranges including, for instance, a 20° to 30° variance.

In the foregoing discussion, considerable mention has been made of the fact that the several electron beams are directed toward the target areas so as to strike upon the target along angular paths. In order that difficulties of operation shall not result because of these varying impact angles, care should be taken in the operation of the system to see that the tube geometry and design are such that the angle of all of the electron beams relative to the target area is substantially alike, or, in the alternative, where the tube geometry is such that several electron beams impinge at different angles, then precaution should be taken to establish and maintain proper or suitable operating voltages whereby the impacting velocity of the electrons forming the

several beams shall be of appropriate value relative to each other to maintain substantially like secondary emission from the target surface for all beams. Where the secondary emission varies to any substantial degree over different areas of target, because of the fact that a plurality of electron beams are used, it will be appreciated that picture or color distortion may result in the absence of compensation of the character above noted, for instance.

While the aforementioned conditions may become important in the operation of systems and tubes of the types herein set forth, it should be mentioned more particularly that the possible difficulties, due to secondary emission, are largely difficulties connected with transmitting or camera tubes in contrast to the image reproducing or viewing tubes of the types hereinabove mentioned. In fact, it has been found that from the standpoint of a viewing tube, in many instances, it becomes almost immaterial that secondary emission may vary with variations in angle of beam impact or even beam velocity. Accordingly, it is to be understood that the invention is in no way limited either to like beam velocities or like angles of beam impact, especially insofar as the receiver or viewing tube is concerned.

Various modifications may be made in the system herein disclosed and therefore it is to be understood that the arrangement represented is merely presented as illustrative of the system and method herein set forth.

Having now described the invention, what is claimed and desired to be secured by Letters Patent is the following:

1. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the number selected of component colors in a color system and wherein each electron beam is directed toward the target along a separate angular path, the method of correcting distortion and lack of image registry due to the differently angularly located scanning beams impacting the target which comprises independently and simultaneously deflecting each of the separate electron beams along bidirectional paths relative to the target to trace a predetermined raster, and expanding and contracting the amplitude of the trace in at least one direction of scanning in the path traced by the plurality of independent electron beams relative to the target by adding amplitude components varying linearly with time so that the effect of orthogonality of scanning by all beams is established and related elements in each scanned raster are in registry and homologically positioned.

2. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the number selected of component colors in a color system and wherein each electron beam is directed toward the target along a separate angular path, the method of correcting distortion and lack of image registry due to the differently angularly located scanning beams impacting the target which comprises independently and simultaneously deflecting each of the separate electron beams along bidirectional paths relative to the target to trace a predetermined raster, and expanding and contracting the amplitude of the trace of at least one of the scanning beams in at least one direction of scanning in the path traced by the plurality of independent electron beams relative to the target by adding to the

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deflection energy amplitude components varying linearly with time so that the effect of orthogonal scanning by all beams is established and related elements in each scanned raster are in registry and homologously positioned.

3. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the number selected of component colors in a color system and wherein each electron beam is directed toward the target along a separate angular path, the method of correcting distortion and lack of image registry due to the differently angularly located scanning beams impacting the target which comprises independently and simultaneously deflecting each of the separate electron beams along bidirectional paths relative to the target to trace a predetermined raster, and expanding and contracting the amplitude of the trace in at least one direction of scanning in the path traced by the plurality of independent electron beams relative to the target by adding components linearly varying in amplitude with time so that the effect of orthogonality of scanning by all beams is established and related elements in each scanned raster are in registry and homologously positioned.

4. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the number selected of component colors in a color system and wherein each electron beam is directed toward the target along a separate angular path, the method of correcting distortion and inaccuracy of image registry due to the differently angularly located scanning beams impacting the target which comprises independently and simultaneously deflecting each of the separate electron beams along horizontal and vertical paths relative to the target to trace a predetermined raster, and expanding and contracting the amplitude of the trace in at least one direction of scanning in the path traced by the plurality of independent electron beams relative to the target by deriving energy from the other direction of scanning in controlled amounts varying linearly in amplitude with regard to time to combine with the normal deflection in the first direction so that the effect of orthogonal scanning by all beams is established and related elements in each scanned raster are in registry and homologously positioned.

5. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the number of selected component colors in a color system and wherein such electron beam is directed toward the target along a separate angular path tending to produce elongated and foreshortened traces with variances in position of impact, the method of causing the paths traced by the independent electron beams relative to the target to have related elements homologously positioned and in substantial registry and the scanned rasters to be substantially alike whereby color fringes and distortions are substantially compensated which includes independently and simultaneously deflecting each of the separate electron beams along bidirectional paths relative to the target to trace a raster normally different for each beam due to different angular location relative to the target, and then expanding and contracting, by the addition of linear quantities in at least one direction of scanning under the control of the deflection in the other direction.

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6. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the number of selected component colors in a color system and wherein each electron beam is directed toward the target along an individual angular path tending to produce elongated and foreshortened traces with variances in position of impact, means for independently and simultaneously deflecting each of the separate electron beams along bidirectional paths relative to the target to trace a raster normally different for each beam due to different angular locations of the beams relative to the target, and means for expanding and contracting, by the addition of linearly varying quantities in at least one direction of scanning, the paths traced by the independent electron beams relative to the target so that the combined rasters have related elements homologously positioned and in substantial registry, whereby color fringes and distortions are substantially compensated.

7. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the number of selected component colors in a color system and wherein each electron beam is directed toward the target along an individual angular path tending to produce elongated and foreshortened traces with variances in position of impact, means for independently and simultaneously deflecting each of the separate electron beams along bidirectional paths relative to the target to trace a raster normally different for each beam due to different angular locations of the beams relative to the target, and means for supplying deflecting energy in controlled amounts from the deflection control in one of the two directions to the other in either direction for expanding and contracting, by the addition of linearly varying quantities in at least one direction of scanning, the paths traced by the independent electron beams relative to the target so that the combined rasters have related elements homologously positioned and in substantial registry, whereby color fringes and distortions are substantially compensated.

8. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the number of selected component colors in a color system and wherein each electron beam is directed toward the target along an angular path tending to produce elongated and foreshortened traces with variances in position of impact, means for independently and simultaneously deflecting each of the separate electron beams along vertical and horizontal scanning paths of different but related deflection rates relative to the target to trace a raster normally different for each beam due to different angular locations of the beams relative to the target, and means for feeding deflecting energy in controlled amounts and directions between the horizontal and vertical deflection controls for expanding and contracting, by the addition of linearly varying quantities in at least one direction of scanning, the paths traced by the independent electron beams relative to the target so that the combined rasters have related elements homologously positioned and in substantial registry, whereby color fringes and distortions are substantially compensated.

9. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the

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number of selected component colors in a color system and wherein each electron beam is directed toward the target along a separate angular path tending to produce elongated and foreshortened traces with variances in position of impact, electron beam means for independently and simultaneously deflecting each of the separate electron beams relatively rapidly relative to the target area in one direction and relatively slowly relative to the target in a mutually perpendicular direction so as to scan the target to trace a raster normally different for each beam due to different angular locations of the beams relative to the target, and circuits connecting the deflection controls in each of the two directions for each electron beam deflection to supply energy in one direction between the two deflections in linearly varying amounts for expanding and contracting, by the addition of linearly varying quantities in at least one direction of scanning, the paths traced by the independent electron beams relative to the target so that the combined rasters have related elements homologously positioned and in substantial registry whereby color fringes and distortions are substantially compensated.

10. In a tricolor television system wherein there is utilized an electron tube having a target based upon a quasi-focal plane which is adapted to be impacted by electron beams substantially focused thereat and wherein a group of multiplicities of substantially contiguously located rudimentary surfaces are supported upon and systematically spaced relative to the quasi-focal plane of the tube with each of the multiplicities of elements being sensitized as groups to radiate light, when activated, in one of a plurality of selected component colors for producing tricolor images and wherein three separate electron scanning beams are developed and directed upon the rudimentary surfaces of the target area, the combination comprising means for applying bidirectionally acting deflecting fields to each of the developed beams to trace predetermined scanned rasters across the surfaces supported upon the target by each of the separately produced electron scanning beams, and means for applying correcting energy to each produced field to cause the deflection trace to deviate from orthogonality by amounts varying linearly in time so that the raster traced by each beam is contracted and expanded to match with the traced area of each other beam and image point registry is attained for homologously located points in each scanned raster.

11. The system claimed in claim 10 comprising, in addition, means to apply modulating signals to each of the beams to modulate the individual beams by signaling energy representative of one of the component colors of the tricolor system.

12. In combination with a color television system comprising an electron tube having a target based upon a quasi-focal plane adapted to be impacted by an electron beam substantially focused thereat and a group of multiplicities of substantially elementary size surfaces systematically located relative to the quasi-focal plane of the tube with each of the multiplicities of elements being light emissive as a group to radiate light, when activated, in one of a plurality of selected component colors for producing additive color images, means for developing a plurality of electron scanning beams and for directing and focusing the resultant electron beams upon the target areas, means for scanning the target areas by the separately produced electron scanning beams, means

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for restricting the scanning of the target by the separate electron scanning beams each to one only of the group of multiplicities of the elementary surfaces and means for controlling the scanning of the target areas by each of the independent electron beams to correct the totally scanned groups of areas for non-rectangularity and boundary distortion of the scanned areas so that the resultant light pattern appears substantially rectangular and is maintained substantially in registry for homologously positioned component elements of the separately produced color images.

13. In a color television system, the combination of an electron tube having a target based upon a quasi-focal plane adapted to be impacted by an electron beam substantially focused thereat, said target comprising a group of multiplicities of substantially contiguously positioned triangularly faced rudimentary surfaces systematically located relative to the quasi-focal plane of the tube with each face of the multiplicity of triangularly faced elements being color discriminative as a group, when activated, to be operative in relationship to one of the plurality of selected component colors of an additive color process, means for developing three separate electron scanning beams and for directing and focusing the said electron beams toward and upon the target, means for scanning each triangular face of each target element by a separate electron scanning beam, means for restricting the scanning of the target by each of the separate electron scanning beams so that like colors only of each of the group of rudimentary surfaces is scanned by the same scanning beam, and means for controlling the scanning of the target areas by each of the independent electron beams to correct the totally scanned groups of areas for non-rectangularity and boundary distortion of the scanned pattern so as to maintain substantial registry and homologously positioned component elements of the separately produced color discriminative images.

14. A system for establishing registry of multi-electron beam scanings of a target area in simultaneous multi-color television which comprises means for independently and simultaneously deflecting each of the separate electron beams along bidirectional paths relative to the target to trace the beams thereacross to provide a predetermined scanned raster, and means for introducing linear deviations in the deflections for expanding and contracting in at least one direction of scanning the paths traced by the independent electron beams relative to the target so that related elements in each scanned raster in each beam are homologously positioned in registry.

15. In a system of color television wherein a color responsive target area is scanned by a plurality of electron beams equal in number to the number of selected component colors in a color system and wherein each electron beam is directed toward the target along a separate angular path, means for independently and simultaneously deflecting each of the separate electron beams along bidirectional paths relative to the target to trace a predetermined raster, and means for expanding and contracting in at least one direction of scanning the paths traced by the independent electron beams relative to the target so that related elements in each scanned raster in each beam are in registry and homologously positioned relative to each other.

16. In a color television system wherein there

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is provided an electron tube having a target element forming a quasi-focal plane adapted to be impacted by an electron beam substantially focused thereat, and upon which is supported a group of multiplicities of substantially contiguously positioned rudimentary surfaces systematically located relative to the target area and each of the multiplicities of elements being light and color discriminative as a group, when activated by radiant energy, to be operative in relationship to one only of the plurality of selected component colors of an additive color process, the combination of means for developing a plurality of electron scanning beams and for directing the resultant electron beams toward the rudimentary surfaces upon the target, means for scanning the rudimentary surfaces by the separately produced electron scanning beams, means for so restricting the scanning traces by each of the separate electron scanning beams that each beam scans one group only of the multiplicities of light and color responsive rudimentary surfaces, and means for controlling the scanning raster traced by each of the independent electron beams by expanding and contracting the normal scanning path in at least one direction to correct the totally scanned raster and impacted rudimentary surfaces for non-rectangularity and boundary distortion of the scanned pattern so as to maintain substantial registry and homologously positioned component elements of the separately produced color discriminative images.

17. A color television system comprising an electron tube having a target element, said target being based upon a quasi-focal plane adapted to be impacted by an electron scanning beam substantially focused thereat, said target comprising a group of multiplicities of substantially contiguously positioned rudimentary surfaces systematically located relative to the quasi-focal plane of the tube with each of the multiplicities of elements being light responsive and color discriminative as a group, when activated, to be operative in relationship to one only of the plurality of selected component colors of an additive color process, means for developing a plurality of electron scanning beams and for directing the resultant electron beams toward and upon the target, means for scanning the target by the separately produced electron scanning beams, means for so restricting the scanning of the target by each of the separate electron scanning beams that each beam scans one group only of the multiplicities of light and color responsive rudimentary surfaces, and means to develop output signal energy by each scanning operation at time periods of target illumination.

18. A color television system comprising an electron tube having a target upon which a light image is to be projected, said target being based upon a quasi-focal plane adapted to be impacted by an electron scanning beam substantially focused thereat, said target comprising a group of multiplicities of substantially contiguously positioned rudimentary surfaces systematically located relative to the quasi-focal plane of the tube with each of the multiplicities of elements being light responsive and color discriminative as a group, when activated, to be operative in relationship to one only of the plurality of selected component colors of an additive color process, means to restrict impinging light upon the individual groups of rudimentary surfaces upon the target to one only of the plurality of

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selected component colors, means for developing a plurality of electron scanning beams and for directing the resultant electron beams toward and upon the target, means for scanning the target by the separately produced electron scanning beams, means for so restricting the scanning of the target by each of the separate electron scanning beams that each beam scans one group only of the multiplicities of light and color responsive rudimentary surfaces, means to develop output signal energy by each scanning operation at time periods of target illumination, and means for controlling the scanning of the target areas by each of the independent electron beams to correct the totally scanned groups of areas for non-rectangularity and boundary distortion of the scanned pattern so as to maintain substantial registry and homologously positioned component elements of the separately produced color discriminative images.

19. A color television system comprising an electron tube having a target upon which a light image is to be projected, said target being based upon a quasi-focal plane adapted to be impacted by an electron scanning beam substantially focused thereat, said target comprising a group of multiplicities of substantially contiguously positioned rudimentary surfaces systematically located relative to the quasi-focal plane of the tube with each of the multiplicities of elements being light responsive and color discriminative as a group, when activated, to be operative in relationship to one only of the plurality of selected component colors of an additive color process, means to restrict impinging light upon the individual groups of rudimentary surfaces upon the target to one only of the plurality of selected component colors, means for developing a plurality of electron scanning beams and for directing the resultant electron beams toward and upon the target, means for scanning the target by the separately produced electron scanning beams, means for so restricting the scanning of the target by each of the separate electron scanning beams that each beam scans one group only of the multiplicities of light and color responsive rudimentary surfaces, and means to develop output signal energy by each scanning operation at time periods of target illumination.

20. A color television system comprising an electron tube having a target upon which a light image is to be projected, said target being based upon a quasi-focal plane adapted to be impacted by an electron scanning beam substantially focused thereat, said target comprising a group of multiplicities of substantially contiguously positioned rudimentary surfaces systematically located relative to the quasi-focal plane of the tube with each of the multiplicities of elements being light responsive and color discriminative as a group, when activated, to be operative in relationship to one only of the plurality of selected component colors of an additive color process, means to restrict impinging light upon the individual groups of rudimentary surfaces upon the target to one only of the plurality of selected component colors, means for developing a plurality of electron scanning beams and for directing the resultant electron beams toward and upon the target, means for scanning the target by the separately produced electron scanning beams, means for so restricting the scanning of the target by each of the separate electron scanning beams that each beam scans one group only of the multiplicities of light and color responsive

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rudimentary surfaces, means for controlling the scanning of the target areas by each of the independent electron beams to correct the totally scanned groups of areas for non-rectangularity and boundary distortion of the scanned pattern so as to maintain substantial registry and homologically positioned component elements of the separately produced color discriminative images.

21. In a system for scanning a target area by a plurality of electron beams each directed toward the target from different angular inclinations, means for independently and simultaneously deflecting each of the separate electron beams along bidirectional paths relative to the target to trace a predetermined raster, and means for expanding and contracting in at least one direction of scanning the paths traced by the independent electron beams relative to the target so that related elements in the raster traced by each scanning beam are in registry.

22. A color television system comprising an electron tube having a target based upon a quasi-focal plane adapted to be impacted by at least one electron beam substantially focused thereat, a group of multiplicities of substantially elemental size light responsive elements systematically located in predetermined positions relative to the quasi-focal plane of the tube with each of the multiplicities of elements being color discriminative as a group, when activated, to be operative only in relationship to one of the plurality of selected component colors of an additive color process, means for developing a plurality of electron scanning beams and for directing the resultant electron beams upon the elemental area elements, means for scanning the elemental area elements by the electron scanning beams, means for restricting the scanning by each of the individual electron scanning beams to one only of the groups of multiplicities of the elemental size elements, and means for developing signaling energy outputs representative of the values of light and shadow in each of the selected colors with the separate outputs being equal in number to the number of the scanning beams developed.

23. A color television system comprising an electron tube having a target based upon a quasi-focal plane adapted to be impacted by an electron beam substantially focused thereat, a group of multiplicities of substantially elementary size surfaces systematically located relative to the quasi-focal plane of the tube with each of the multiplicities of elements being light emissive as a group to radiate light, when activated, in one of a plurality of selected component colors for producing additive color images, means for developing a plurality of electron scanning beams and for directing the resultant electron beams upon the target area, means for scanning the target areas by the separately produced electron scanning beams, means for restricting the scanning of the target by the separate electron scanning beams each to one only of the group of multiplicities of the elementary surfaces and means for controlling the scanning of the target areas by each of the independent electron beams to correct the totally scanned groups of areas for non-rectangularity and boundary distortion of the scanned areas so that the resultant light pattern appears substantially rectangular and is maintained substantially in registry for homologically positioned component elements of the separately produced color images.

24. Electronic tube apparatus for use in a color

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television system comprising an envelope having included therein a multiplicity of pyramidal elements and a target area for supporting said elements with the target surface forming a quasi-focal plane adapted to be impacted by an electron beam focused substantially thereat, a coating of luminescent materials on each of three of the faces of the pyramidal elements with each face being adapted to luminesce with electron beam excitation to radiate light in a different one of a plurality of selected component colors for producing additive color images, means for developing a plurality of electron scanning beams equal in number to the selected component colors and for directing the resultant electron beams upon the pyramidal faces to produce light, means for scanning the pyramidal elements supported on the target by the separately produced electron scanning beams, means for restricting the scanning of like color responsive pyramidal faces by the separate electron scanning beams each to one only of the plurality of electron beams whereby collectively a color image is developed on the target, a coating of white light producing luminescent material coating the fourth face of each pyramidal element, and means to develop a separate electron beam simultaneously to scan the last named material so that a black-and-white key image is developed simultaneously and in registry with the multi-color image.

25. A color television system comprising an electron tube having a mosaic target based upon a quasi-focal plane adapted to be impacted by an electron beam substantially focused thereat, said target comprising a group of multiplicities of substantially contiguously positioned rudimentary surfaces systematically located relative to the quasi-focal plane of the tube with each of the multiplicities of elements being color discriminative as a group when activated by impinging light so as to separate the light responses into groups representing a plurality of selected component colors of an additive color process, photoelectrically responsive elements insulatingly supported from each other and from the color discriminative means to develop, when light activated, electrostatic charges representative of the impinging light, means for developing a plurality of electron scanning beams and for directing the resultant electron beams toward and upon the target, means for scanning the target by the separately produced electron scanning beams to release the charges and produce signal outputs thereby, means for restricting the scanning of the target by each of the separate electron scanning beams to one only of the group of multiplicities of light responsive rudimentary surfaces.

26. The combination claimed in claim 25 comprising, in addition, means for controlling the scanning of the target areas by each of the independent electron beams to correct the totally scanned groups of areas for non-rectangularity and boundary distortion of the scanned pattern so as to maintain substantial registry and homologically positioned component elements of the separately produced color discriminative images.

27. In a tricolor television system wherein there is utilized an electron tube having a mosaic target based upon a quasi-focal plane which is adapted to be impacted by electron beams substantially focused thereat and wherein a group of multiplicities of substantially contiguously located rudimentary surfaces systematically are supported upon and spaced relative to the quasi-focal plane of the tube with each of the multi-

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plicities of elements being photoelectrically sensitized as groups to respond to impinging light of one of a plurality of selected component colors for developing electrostatic charges proportional to impinging light activation and wherein three separate electron scanning beams are developed and directed upon the rudimentary surfaces of the target area to scan the area to release the said charges, the combination comprising means for applying bidirectionally acting deflecting fields to each of the developed beams to trace predetermined scanned rasters across the surfaces supported upon the target by each of the separately produced electron scanning beams, and means for applying correcting energy to each produced field to cause the deflection trace to deviate from orthogonality by amounts varying linearly in time so that the raster traced by each beam is contracted and expanded to match with the traced area of each other beam and image point registry is attained for homologously located points in each scanned raster.

28. The system claimed in claim 27 comprising, in addition, means to apply the signals resulting from each scanning operation to individual load circuits.

29. In a system of additive color television, an electron beam receiving target element formed as a plurality of pyramidal elements, said elements each having the surface areas thereof which extend above the supporting base responsive in individual predetermined component colors of a multicolor television system, means for developing a plurality of electron beams each angularly disposed relative to the target and to each other, means for directing each of the issuing electron beams toward correspondingly co-functioning surfaces of each pyramidal element, separate deflecting means for causing each developed

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electron beam to traverse the impacted areas of the target elements in bidimensional patterns so that the chromatic response from the target is controlled by the direction of electron beam impact upon the target, means for modifying the deflection of each electron beam in accordance with the instantaneous spacial position thereof so that each electron beam traces substantially an identical area, and means for modulating each separate electron beam to provide an intensity control thereof so that the intensity of the color response of the said several co-functioning surfaces in the several component colors is modified in accordance with the intensity of the electron beam impacting thereon.

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