March 12, 1963 D. M. GOODMAN 3,081,414

WIDE BAND CATHODE RAY TUBES AND THE LIKE

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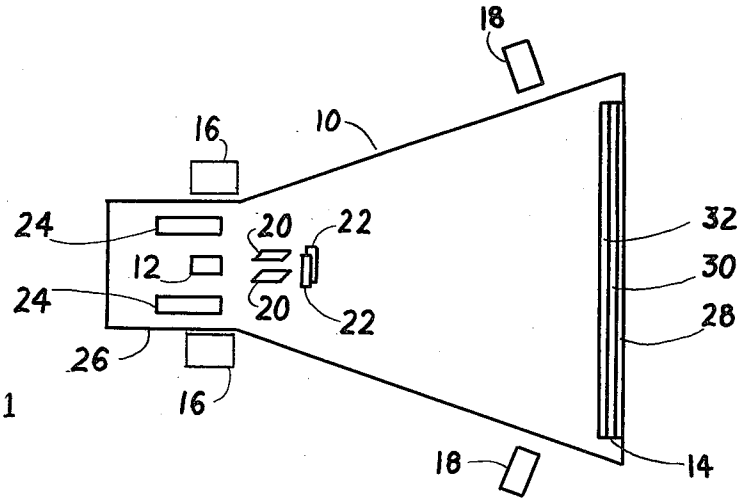


FIG. 1

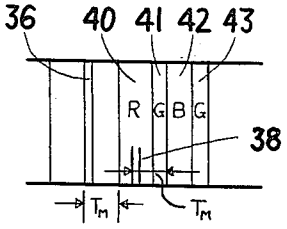


FIG. 2

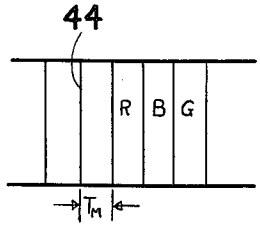


FIG. 3

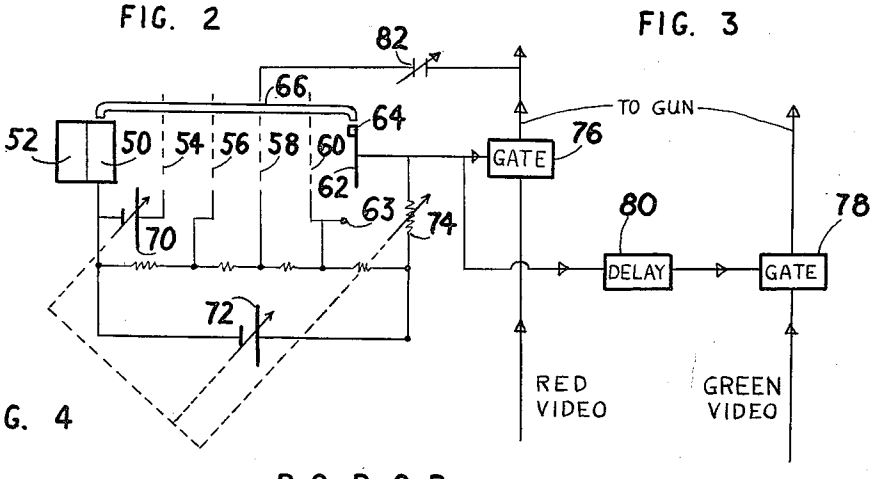


FIG. 4

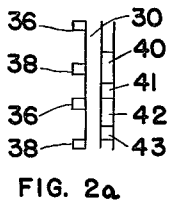


FIG. 2a

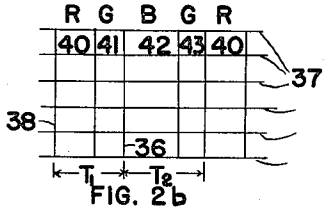


FIG. 2b

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WIDE BAND CATHODE RAY TUBES AND THE LIKE

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FIG. 5

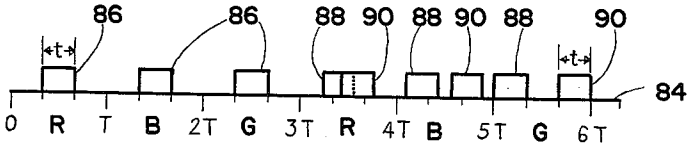


FIG. 6

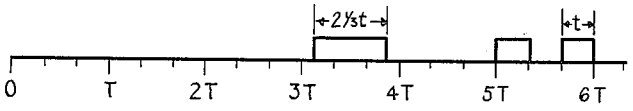


FIG. 7

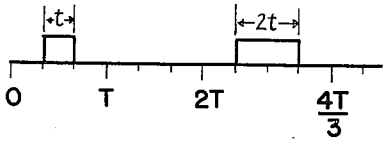


FIG. 8

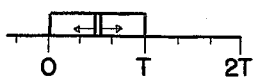


FIG. 9

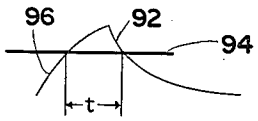


FIG. 10

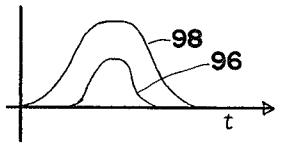


FIG. 11

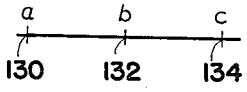


FIG. 12

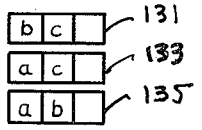


FIG. 13

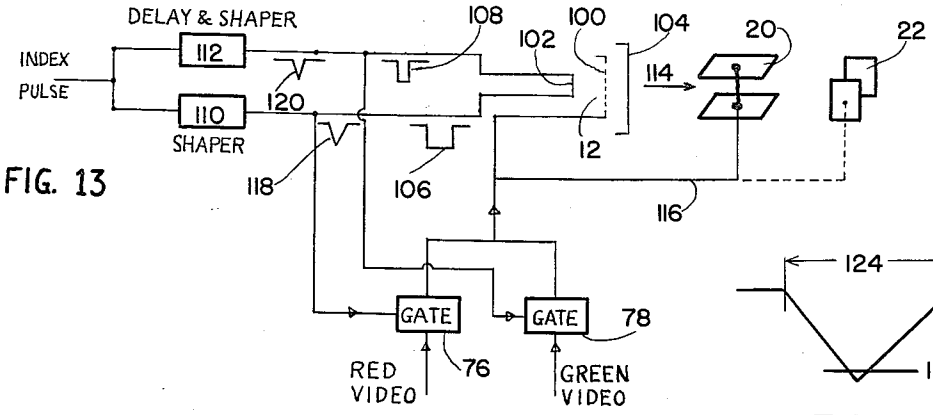


FIG. 13a

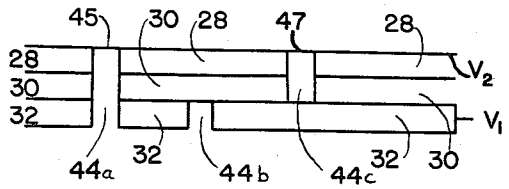


FIG. 3a

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March 12, 1963 D. M. GOODMAN 3,081,414

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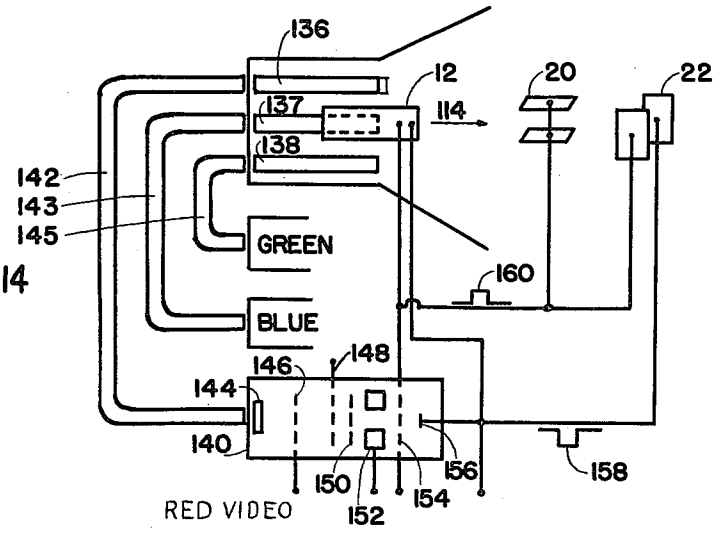


FIG. 14

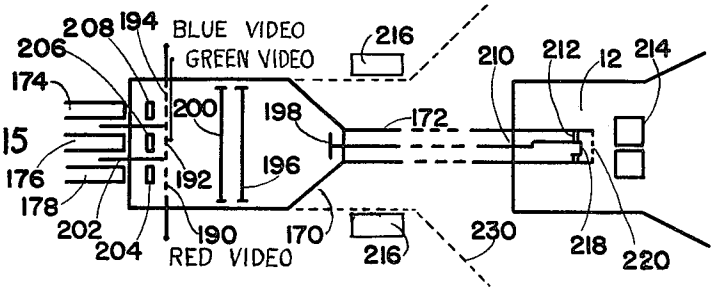


FIG. 15

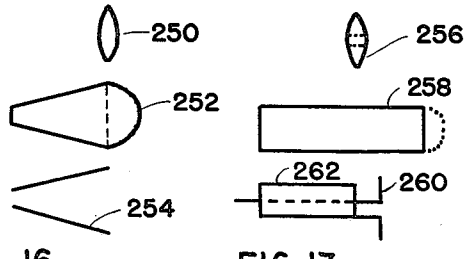


FIG. 16

FIG. 17

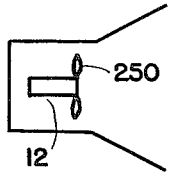


FIG. 18

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WIDE BAND CATHODE RAY TUBES AND THE LIKE

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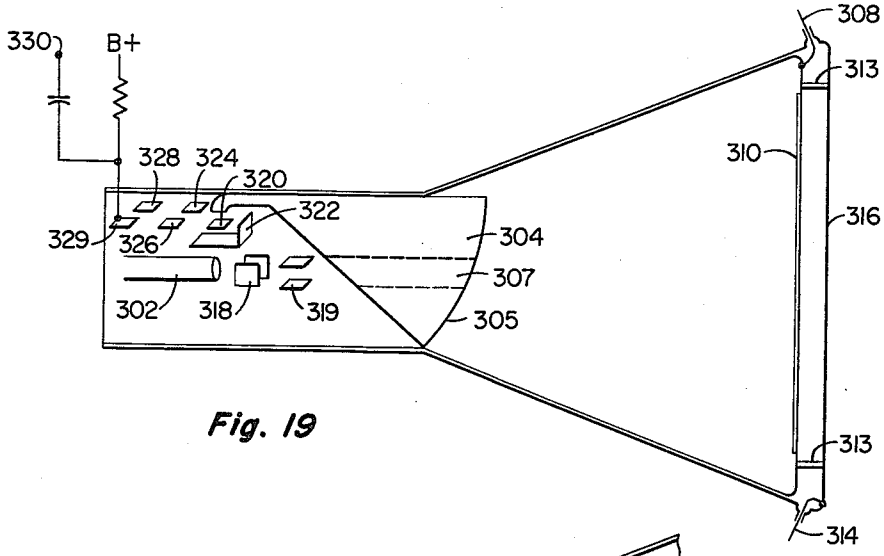


Fig. 19

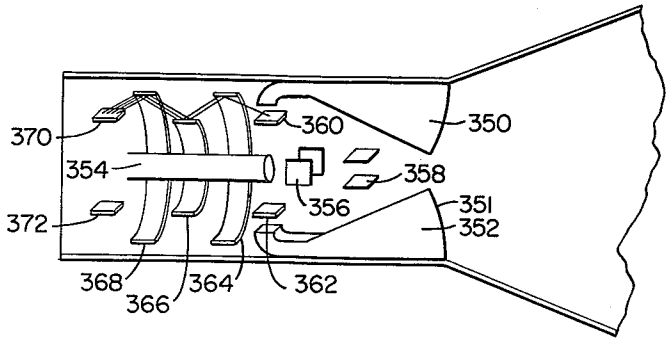


Fig. 20

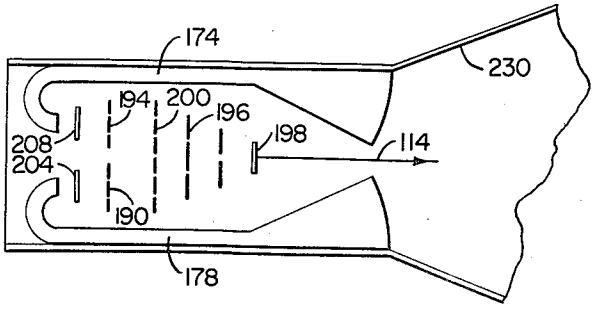


Fig. 21

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United States Patent Office 3,081,414
Patented Mar. 12, 1963

3,081,414
WIDE BAND CATHODE RAY TUBES AND THE LIKE

David M. Goodman, 3843 Debra Court, Seaford, N.Y.
Filed Mar. 20, 1959, Ser. No. 800,854
23 Claims. (Cl. 315—10)

This invention relates to directed ray tubes and systems that utilize electro-magnetic index signals to indicate the position or intensity of the directed rays in such tubes. More specifically, this invention relates to cathode ray tubes and systems that may be used in color television.

This invention is a continuation-in-part of my application entitled "Directed Ray Tube and the Like," filed July 18, 1955, Serial Number 522,609, now U.S. Patent 2,897,388. It is also a continuation-in-part of three other of my pending applications. A brief description of these other applications follow: (1) In the application entitled "System for Selected Transmission, Storage, Display, Coding or Decoding of Information," filed August 5, 1954, Serial Number 448,039, now U.S. Patent 2,897,398, there is disclosed the feature of controlling the time duration of a pulsed electron beam in a cathode ray tube in such manner that considerable non-linearity in the horizontal sweep of a color television receiver system can be tolerated. (2) In the application entitled "Cathode and Directed Ray Tubes," filed June 13, 1955, Serial Number 514,973, now U.S. Patent 2,885,591, there are disclosed methods and means for controlling the efficiency and geometrical configuration of phosphor depositions in order to yield a wide range of electro-magnetic signals from a variety of screen structures that may be used in cathode ray or directed ray tubes. (3) In the application entitled "Radiation Generating and Transmitting Device," filed January 14, 1957, Serial Number 634,019, now U.S. Patent 2,915,659, there is disclosed a method of controlling the color display by varying the effective widths of the color producing strips in a prescribed fashion; and there is disclosed special means for collecting electro-magnetic index signals generated within a cathode ray tube and transmitting them to a photo-multiplier for detection and utilization.

It is also known that controlling the electron beam shape and size, and its horizontal sweep, is often times advantageous. It has been attempted thereby to achieve color registration and purity.

One of the primary objects of this invention is to present additional novel methods and techniques, especially for use in color television, that provides a degree of control of the electron beam not heretofore attainable. This invention achieves this control by shaping and suitably delaying the electron beam as a function of the modulation imparted on the beam. The electro-magnetic index signals, generated as a consequence of bombardment of a target screen by the controlled beam, then are manipulated to provide numerous improvements in circuit operation.

Another object is to provide new modulation techniques for use with cathode ray tubes.

Another object is to provide a cathode ray tube with special features that increases the maximum modulation rates which may be applied to the tube.

Further advantages and objectives will become clear from the specification and the drawing wherein:

FIGURE 1 represents a cathode ray tube with a target screen, beam indexing means, and a plurality of radiation detectors. The tube also contains special beam shaping electrodes which are shown schematically.

FIGURE 2 represents a target screen configuration that may be used in the tube of FIGURE 1.

FIGURE 2*a* illustrates a cross sectional view of the target screen of FIGURE 2.

FIGURE 2*b* illustrates a mesh-like structure that may be used as a target screen.

FIGURE 3 represents another target screen configuration that may be used in the tube of FIGURE 1.

FIGURE 3*a* illustrates a cross sectional view of the target screen of FIGURE 3 with three different arrangements for generating index signals.

FIGURE 4 represents one channel of a system embodying a pulse generator responsive to an indexing radiation from the target screen of a tube which is used to control the modulation of the electron beam generated in the tube.

FIGURE 5 represents an idealized excitation of the target screen of FIGURE 3 when the electron beam is scanned linearly from 0 to 3T and non-linearly from 3T to 6T.

FIGURE 6 represents another idealized excitation of the target screen of FIGURE 3 by the electron beam wherein pulses of different size or duration are used.

FIGURE 7 represents still another idealized excitation of a target screen, with the last strip being of increased dimension and the pulses being of different size or duration.

FIGURE 8 represents the idealized excitation of one strip of a target screen wherein the period of excitation is modulated in time as a function of amplitude of the signal to be displayed.

FIGURE 9 represents an electrical pulse signal with exponential-like rise and decay.

FIGURE 10 illustrates bell-shaped curves representative of the effects an electron beam has upon an indexing strip.

FIGURE 11 represents an indexing feature of a target screen akin to that of FIGURE 3.

FIGURE 12 represents a filter-detector combinations suitably responsive to indexing radiation from the screen of FIGURE 11.

FIGURE 13 illustrates a method of controlling the scanning velocity, shape, and amplitude of an electron beam as a function of video modulation.

FIGURE 13*a* illustrates a waveform that may be used in the arrangement of FIGURE 13 to control the period of excitation of the electron beam as a function of video modulation.

FIGURE 14 illustrates a minimum time delay system embodying three grid-controlled photo-multiplier tubes driving a three color, single gun cathode ray tube.

FIGURE 15 illustrates a special photo-multiplier tube, with three inputs, three control grids, and a single coaxial line output which feeds the gun of a special cathode ray tube.

FIGURE 16 illustrates a plurality of electro-magnetic radiation gatherers and transmitters.

FIGURE 17 illustrates further electro-magnetic radiation gatherers and transmitters.

FIGURE 18 represents the neck section of a cathode ray tube with a plurality of lenses affixed to the electron gun structure.

FIGURE 19 represents a cathode ray tube with a target screen for generating X-radiation and with detection means for converting the X-radiation into electrical signals.

FIGURE 20 represents a cathode ray tube with two detectors responsive to two different electro-magnetic radiations.

FIGURE 21 represents a cathode ray tube in which the electron beam is furnished by the last stage of a secondary emission electron multiplier.

This invention provides novel cathode ray tubes, target

screens, beam indexing means comprised of electro-magnetic radiation generators and detectors, pulse generators, and video modulators, interconnected with circuit means in various arrangements that provide color television receiver systems. The manner in which these systems operate will be understood from the following specification taken in conjunction with the drawing.

In FIGURE 1, there is shown a cathode ray tube envelope **10** containing an electron beam forming member **12**. Target screen assembly **14** is scanned by the electron beam furnished by member **12**. Coils **16** conventionally provide the vertical and horizontal scanning action. Two radiation detectors **18** are shown located external of the tube. They are X-ray responsive and are disposed substantially parallel to and near the plane of the target screen assembly **14**. Vernier vertical deflection plates **20**, and Vernier horizontal deflection plates **22** are disposed to control the electron beam as hereinafter set forth. Two radiation detectors **24** are shown disposed within the neck portion **26** of the cathode ray tube. Detectors **24** may be used with detectors **18**, depending upon the total number of indexing signals being generated as will become clear. The target screen assembly **14** consists of members **28**, **30**, and **32**. Member **28** in one embodiment, is comprised of phosphors or other visible radiation emitting materials arranged in narrow strips which are positioned length-wise in the vertical direction. The horizontal scanning of these strips takes place substantially perpendicular to the thus designated vertical direction. Member **30** is an electron-transparent light-reflecting aluminum layer. Member **32** consists of strips that provide electro-magnetic index radiation when bombarded by the scanning beam of electrons. Depending upon the materials that these strips are made of, the electro-magnetic index radiation may extend from waves of infra-red to X-rays. When this indexing radiation is in the X-ray region, members **30** and **32** may be interchanged, as will be explained infra. In FIGURE 3*a* a target assembly is shown which is capable of generating index signals in the Hertzian range.

FIGURE 2 shows, on an enlarged scale a front view of one possible arrangement of layer **28** of target screen assembly **14**. Red, green, and blue color producing phosphors are arranged in the sequence red-green, blue-green and are designated **40—41**, **42—43**. The dimensions of the phosphor strips that are selected for this purpose are such that when the horizontal scanning beam, which proceeds linearly from left to right across FIGURE 2, is constant in intensity, a substantial white image is presented to the observer. This is achieved by having the widths of the strips in the path of scan inversely proportional to the luminous efficiencies of the color producing phosphors. Phosphors are presently available which are more efficient in the green than in the blue, which is more efficient than the red. Therefore the red strip is widest, the blue strip is narrower, and the sum of the two green strips is narrowest. The efficiencies stated are those which apply when a human being is the observer. The green strip is divided as shown since the visual acuity of the eye is greatest in the green region of the spectrum. For detectors other than the eye similar considerations prevail. Strips **36** and **38** of which layer **32** is comprised, are deposited, or placed on the aluminum layer **30**, or on the phosphor layer **28**. These strips provide the electro-magnetic index signals. The signal from strip **36** is used to excite, via suitably circuitry, the red-green phosphor combination; the index signal from **38** is used to excite, via suitable circuitry, the blue-green phosphor combination. The indexing strip is "in front of" the color producing strips with which it is associated so that the scanning time required for the beam to proceed from strip **36** to strip **40** is substantially equal to the overall delay that is encountered between the generation of the index signal at **36** and the time that its effect is felt at strip **40**. This time delay is shown in FIGURE 2 as T_m. An equal delay T_m is shown to exist between the indexing strip **38** and color producing strip **42**. For optimum performance the period T_m should be reduced to a minimum. This may be accomplished by using an electro-magnetic radiation index signal and by using a minimum number of wide band circuits.

In FIGURE 2*a* there is a cross sectional view of one configuration of the screen of FIGURE 2. The color producing phosphor strips **40**, **41**, **42**, **43** are illustrated. The layer **30** of electron-transparent aluminum is also shown. Indexing strips **36** and **38** are on the side of the screen intended to face the gun of the tube, corresponding to layer **32** of FIGURE 1. Strips **36** may consist of suitably prepared Hex ZnO, or Ba_2SiO_4 activated by lead, or by triclinic $CaMgSiO_4$ activated by cerium. When bombarded by the scanning beam the strip **36** will produce electro-magnetic radiation in the neighborhood of 3700 A. This radiation has the further characteristic of decaying very rapidly upon cessation of energization. Strip **38** may consist of a tungsten wire, or molybdenum, or other material with high atomic number that generates X-rays upon excitation by the scanning beam. X-ray production is normally encountered when the scanning beam strikes layer **30**, and the phosphor strips. It is made to increase substantially when the beam strikes **38** due to the fact that the efficiency of X-ray production is proportional to the atomic number of the metal of which the target is constructed. The governing equation essentially is: $\text{Efficiency}=1.4\times10^{-9}ZV$ where Z is the atomic number of the target, and V is the electron accelerating voltage. For tungsten, $Z=74$, and at 20 kv. the efficiency is approximately 0.2%. This X-radiation also decays very rapidly after cessation of energization; more so than the phosphors of which strip **36** may consist. Hence the screen of FIGURE 2*a* may be used to generate two electro-magnetic index signals which are distinguishable from each other, from the visible display, and from spurious radiations.

In the event that strip **36** also is preferred to be an X-ray emitter then it is desirable to make use of the characteristic radiation of the X-ray producing strips. Molybdenum for example, operated at 20 kilovolts will yield characteristic radiation at 0.71 and 0.63 Angstrom. By suitable filtering, in the detector or in the screen, it is possible to distinguish the continuous distribution of X-rays produced by the tungsten strip **36**, from the characteristic radiation of molybdenum strip **38**. If it is desired to use a plurality of strips that emit characteristic radiation it is necessary to make a selection governed by Moseley's law $f^{1/2}=K(Z-6)$ which states that the frequency of the characteristic radiation is proportional to the atomic number of the emitter. For example, copper has a K-radiation at 1.53 A. when excited by 8 kv. electrons. At 15 kv. this radiation increases much more rapidly than the background, or continuous radiation. The method of generating these characteristic spectra, and of filtering the separate radiations, is well known to those skilled in the use of X-rays. I refer to "X-Rays and Electrons" by Arthur H. Compton, 1926, published by D. Van Nostrand Company, and to "X-Rays in Practise" by Wayne T. Sproull, published by McGraw Hill, 1946, Tables III, IV, and V, for further particulars. Three points will be mentioned here for simplifying the understanding of this facet of the invention. First, the characteristic radiation shows up as a sharp peak in the plot of intensity versus wavelength for a particular target. Second, an excitation energy which exceeds a certain minimum is required to excite these peaks. Third, a material that is the same as the target material used in generating characteristic spectra does not have a strong affinity for absorbing such characteristic radiation.

In view of the importance of generating these signals alternate means are illustrated in FIGURE 2*b*, and in FIGURE 3*a*. In FIGURE 2*b* a mesh-like structure is formed of horizontal members **37**, and vertical members

36 and 38. The interstices of this structure are filled, strip-wise, with phosphors to provide the color producing strips 40, 41, 42, and 43. Member 36 may consist of a copper wire; member 38 may consist of a molybdenum wire; many other choices exist as was just explained. The members 37 may or may not be conductive but should be substantially different from 36 or 38 insofar as X-ray producing qualities are concerned. The conductive assembly is operated at high voltage. It is clear that as the electron beam scans from left to right indexing signals will be generated. The overall time delay in the circuitry using these signals should be adjusted to T_1 and T_2, which represent periods of time akin to T_m of FIGURE 2.

In FIGURE 3, a single indexing strip 44 is shown. The signals derived from 44 will provide gating pulses for energization of the red, blue, and green phosphors. The overall time delay, between generating the index signal at 44 and energizing the first phosphor strip, is shown to be T_M. As was stated with respect to FIGURE 2, it is desirable to reduce the overall time delay to a minimum.

In FIGURE 3*a* a cross section of a target screen configuration is shown which will provide three different electro-magnetic index signals. Phosphor layer 28 comprises strips of color emitting phosphors; layer 30 is electron-transparent and light-reflecting; layer 32, also electron-transparent, provides continuous X-radiation, and may also provide characteristic X-radiation. A constant voltage V_2, is maintained at the side of the target screen opposite layer 32. A suitable voltage V_1 is maintained across layer 32. When the scanning beam of electrons traverses the layer 32, electro-magnetic index signals are generated at 44*a*, 44*b*, and 44*c*. The voltage V_2 may be applied by means of a transparent electrical coating. This coating may be applied to member 28 or to the faceplate of the tube to which it is to be positioned, or adhered. The voltage V_1, may be applied via member 32.

The signal at 44*a* occurs in the following manner. Layer 32 is maintained at 20 kv. and consists of a thin layer of copper for example. When 32 is scanned by 20 kv. electrons a continuous spectrum, and 1.53 Angstrom characteristic radiation, are emitted. Either, or both, of these signals may be detected. The region 45 is maintained at V_2 a voltage substantially different from V_1. This may be accomplished by the transparent coating or by placing a wire grid at 45. The faceplate of tube envelope 10 may also be used to provide the grid; or construction as illustrated in FIGURE 19 may be used.

The signal at 44*b* occurs due to the removal of a strip of layer 32. When the electron beam scans this region clearly a change in the X-radiation will be produced which is detectable.

The signal at 44*c* also occurs due to acceleration or deceleration of the electrons. However, the layer 32 is not altered as at 44*a* and 44*b*. This may be desirable for production purposes. When X-radiation is augmented at 47 for indexing purposes in one of the manners previously set forth, it will be found that the thin, electron transparent layer 32, which is at 44*c*, will not materially attenuate these X-rays.

Another mode of operation of the target screen at 44*c*, and at 44*a*, consists of regulating the velocity change of the electrons, and the rate of the velocity change, to produce electro-magnetic signals in the Hertzian and microwave range. The frequency of these signals is controlled by V_1, V_2, and the physical distance between them. FIGURE 17 shows an antenna arrangement which may pick up these signals for further utilization.

Referring back to FIGURE 1, means 18 are shown positioned outside the cathode ray tube and means 24 are shown within the tube to detect the electro-magnetic index signals. Means 18 may be comprised of suitably responsive photo-multipliers such as the RCA 931A; means 24 may be comprised of the elements of which the 931A consists. Alternatively, the arrangements of FIGURE 19 may be used when one detector is required, and that of FIGURE 20 may be used when a plurality of detectors are required.

In FIGURE 19 the target screen 310 is maintained at the voltage introduced through lead 308. The inside of the face plate 316 is maintained at the voltage introduced through 314. Insulators 313 separate the target screen from the face plate. When the electrons from gun 302 pass through screen 310, they will be accelerated or decelerated, thereby producing electro-magnetic radiation index signals. When these signals are in the X-ray region, the interruption or change in X-radiation may be detected by coating light collecting and transmitting means 304 with a material such as zinc oxide at 305 which will radiate near or in the visible spectrum when excited by X-rays. Means 304 serves as a light pipe to transmit the radiation thus generated at 305 to photo-muliplier elements 320, 324, 326, which operate in a well known manner to yield an electrical signal at 330. Means 304 may have a channel therethrough as at 307 to permit passage of the electrons from gun 302 to the target screen. Element 320 converts the radiation which is transmitted to it via 304 into electrons for subsequent multiplication by the secondary emission process. Alternatively, means 304 and the wave-changer 305, may be eliminated by having element 320 comprised of a material such as bismuth which will convert the X-radiation which impinges upon it directly into electrons.

The arrangement in FIGURE 20 provides for two internal detectors of electro-magnetic index radiation. Light pipes 350 and 352 are akin to 304 of FIGURE 19; detectors 360 and 362 are akin to 320; dynodes 364, 366, 368, are akin to 324, 326, and 328; collector plates 370 and 72 are akin to 329. Gun 354 is akin to 302. One electrical index signal is obtained from 370, the other from 372, in order to control the electron beam furnished by gun 354. This arrangement may be used with the target screen of FIGURE 2*a*. The target screen generates an ultra-violet index signal and an X-ray index signal as previously described. Accordingly, element 350 may comprise nickel-oxide glass to transmit the ultra-violet signal and element 352 may comprise fuse silica coated at 351 with zinc oxide to convert the X-radiation to a longer wave-length which is capable of being transmitted through 352. Elements 350 and 352 are positioned as shown to pick up an amount of radiation from the target screen which is substantially independent of the position on the screen of the radiating area.

An arrangement is shown in FIGURE 4 which makes use of the indexing signals generated by the target screen structure of FIGURE 2. Element 50 is photon-sensitive and emits electrons in response to bombardment or energization by the electro-magnetic indexing signals. Element 52 is a filter that transmits the radiation from index strip 36, and that attenuates or stops the radiation from index strip 38, and the spurious radiations. By way of example, if strip 36 is Hex ZnO radiating at 3700 Angstroms, and strip 38 is copper radiating a 1.53 Angstroms, then 52 suitably may consist of a thick layer of nickel oxide glass. This material will pass the 3700 Angstroms signal, attenuate the 1.53 Angstroms signal and attenuate the spurious X-radiations and the spurious visible radiations. Dynodes 54, 56, 58 and 60 operate to increase the signal represented by the electron flow from element 50 by a process of secondary emission amplification. Anode 62 collects the output signal from where it is fed to gate 76. After a short time delay, furnished by element 80, the output signal is fed to gate 78. Thus the pulse-like signal generated by strip 36 will be detected by element 50, amplified, and used to operate gate 76 for the purpose of allowing the red video information to modulate the intensity of the electron beam. The cumulative time delay in excitation and transmission of the electro-magnetic index signal; in transmission of the electron signal

through the dynodes, gate, and to the gun of the cathode ray tube; and in the passage of the intensity modulated electron beam from the gun to the target screen, is substantially equal to the period T_M designated in FIGURE 2. Element **80** delays the output signal obtained at **62** for a time equal to that which the scanning beam takes in traversing the red strip **40**. This delayed signal operates gate **78** for the purpose of allowing the green information to modulate the intensity of the electron beam. It is clear that in this manner proper color synchronization is obtained. A second photon-sensitive secondary-emission detector-amplifier and gate arrangement are required but not illustrated to operate the blue-green phosphor combination. Likewise, the method and means for deriving the video information are not illustrated as being unnecessary for understanding of the present invention. Element **52** in the second detector-amplifier combination may suitably consist of a relatively thick layer of copper. This layer **52** clearly will pass the 1.53 Angstroms characteristic copper radiation; will attenuate the 3700 Angstroms signal emitted by index strip **36**; and will attenuate spurious visible radiation.

It is of interest now to control the delay and the shape of the pulses that operate the gates. This may be achieved conventionally by delay lines, multi-vibrators, blocking oscillators, biased amplifiers, biased gates, etc. The arrangement of FIGURE 4 is novel for the purposes herein intended. A fast decay phosphor deposit **64** is excited by the leading edge of the detected and amplified index signal. Light pipe **66** provides feedback to element **50** to produce a positive feedback signal. Very rapidly a saturated output signal is obtained at anode **62**. A negative going signal is obtained from the output of gate **76**, or from a delay line akin to **80**, which is coupled to dynode **58** via capacitor **82**. This negative going signal interrupts the positive feedback path, terminates the output pulse, and the detector-amplifier is ready to receive a new trigger signal. Element **64** may consist of Hex Z_nO. Element **66** may consist of fused silica. The time constants are adjusted in consequence of the pulse width desired. The first dynode **54** may be a grid structure akin to that used in vacuum tube triodes and by means of voltage source **70** may be adjusted to control the threshold of operation so that the incident electro-magnetic index signal must exceed a minimum value before the triggering signal is effective. Variable voltage source **72** may be used to control the overall delay through the dynodes. Variable resistor **74** may be used to control the amplitude of the output signal. Since these controls are inter-dependent, they may be ganged together mechanically after initial adjustment to provide for convenient system readjustment by the operator or technician. Thus, there is provided a fast rise-time pulse generator which responds to the leading edge of the index signal, which responds to a definite index signal level, and which yields an output pulse of fixed width and amplitude. Additionally, if it is desired, the sweep or scanning voltages may be applied to the control elements of this pulse generator to compensate for fixed distortions in the electron beam deflection system.

In FIGURE 5 a base line **84** may be considered to represent distance along the target screen of FIGURE 3 in the direction of the horizontal scan. Pulses **86**, **88**, and **90** represent in an ideal fashion the excitation of the scanning beam on the target screen. The pulses may be derived from arrangements such as just described using the target screen index strip **44** and two pulse delay circuits. The intervals from 0 to 6T represent equal time periods. The intervals also represent the widths of the color phosphor strips as shown. When the scanning beam traverses the screen with constant velocity from 0 to 3T the pulses **86** are equally spaced and preferably centered in each interval of space. When the scanning velocity is not constant, or when the pulse delays introduce errro, as shown from 3T to 6T, the pulses **86** are advanced to the positions shown by pulse **90**, or retarded to the position shown by pulse **88**. The pulse width is shown equal to "*t*" which in this case is approximately $T/3$. The non-linearity illustrated is $T/3$ for each time period 3T. The errors resulting from non-linearity of scan are cumulative for the time between successive indexing pulses. Therefore the pulse first derived from the indexing pulse is shown to have a small shift between 3T and 4T, the second derived pulse is shown to have a larger shift between 4T and 5T, and the last derived pulse is shown with the largest shift between 5T and 6T.

The illustration in FIGURE 6 teaches how the pulse first derived from the indexing pulse may be made of greater duration than the pulse last derived while still maintaining color purity. This is due to the fact that the accumulated errors of scan position are much less for the first derived pulse. For the example cited the excitation period may be increased from t to $2\frac{1}{3}t$. Since the red phosphor is least efficient it is clear that doubling the excitation period of this strip is of considerable consequence; and this is achieved without increasing the width of the red strip.

The illustration in FIGURE 7 teaches still another method of improved utilization of variable pulse and phosphor widths and spacings. Here it is clearly shown that by increasing the width by 33% of the strip which is excitated by the pulse last derived from the index pulse it is possible to increase the period of excitation of that strip by 100% and still preserve color purity.

The illustration in FIGURE 8 shows that the duration of the target excitation pulse may be modulated within the interval 0 to T, making it possible to use a constant intensity scanning beam. Each color video signal modulates the duration of the beam within each respective color strip so that the duration of excitation is proportional to the magnitude of the information to be presented. The use of a constant intensity scanning beam is of considerable value in maintaining uniform focus and spot size of the beam. Clearly a combination of intensity modulation and duration modulation of the beam may also be used to advantage.

The pulse shapes illustrated in FIGURES 5, 6, 7, and 8 are rectangular. These pulses represent the idealized excitation of the target screen. In practice two sources of distortion of the idealized excitation are to be expected. First, the passage of a rectangular pulse through delay lines, gates, transmission lines, etc. can be expected to distort the original pulse. This distortion, which is correctable, is a function of the original pulse width and shape, and of the bandwidth of the circuits through which the pulse travels. It is also a function of the design of the electron gun. In FIGURE 9 a distorted wave shape is illustrated that might result from passing a rectangular pulse through circuits with inadequate bandwidth. By use of shaping circuits, Schmidt Triggers, etc. it is possible to reshape or restore the distorted waveform so that its effect is lessened. The leading edge of the distorted pulse is shown at **96**, the trailing edge at **92**. By biasing at **94** it is possible to re-create a rectangular pulse with a duration "*t*."

The second source of distortion of the idealized excitation results from the shape of the scanning beam. An electron beam that is circular in cross section will have a variation in density of electrons measured across a diameter that may be represented by curve **96** in FIGURE 10. Were a scanning beam of this shape to scan and energize a strip that emits indexing radiation it is clear that something less than a rectangular pulse of indexing radiation would be obtained. The extent to which this distortion is detrimental depends upon many factors and may or may not be serious. In my application Serial No. 448,039 I disclose the use of an index radiation generating strip that has an output whose magnitude saturates upon excitation; I also disclose that the output of the pulse generator may saturate in amplitude. Both

of these modes of operation will reduce the distortion caused by the scanning process. Referring back to FIGURE 4, and the explanation thereof, it is seen that the distortion may be still further reduced by using the leading edge of the index radiation pulse to trigger a pulse generator. The stability of this leading edge is of prime importance in this mode of operation. When the scanning beam is intensity modulated the effect of an increase in intensity upon the beam dimensions, or upon its effect, is illustrated at 98 in FIGURE 10. When this situation prevails the effect is the same as advancing, in time, the leading edge of the index radiation pulse. This will result in jitter of the index pulses that is a function of the amplitude modulation of the scanning beam. One method of reducing this jitter is to provide an index strip that is scanned by a beam whose characteristics are held constant during scanning of the index strip. Another method is illustrated in FIGURE 13.

To explain FIGURE 13, reference should first be made to the FIGURE 19 and FIGURE 20. Deflection plates 318 and 319 of FIGURE 19 and 356, 358 of FIGURE 20 akin to 22 and 20 of FIGURE 1 may be incorporated and utilized when it is desired to vary the shape and position of the electron beam in the cathode ray tube. For example, the horizontal scanning velocity in a color television system using substantially vertical strips of phosporescent materials may be regulated so that the effective time during which the electron beam impinges on a particular strip or strips is considerably longer than would be permissible with a uniform, horizontal scanning velocity. The set of plates orthogonal, or nearly so, to those imparting the variations in horizontal velocity may be incorporated and utilized when it is desired to elongate the electron beam in a direction substantially parallel to the aforementioned strips. For equal horizontal and vertical resolution in a color kinescope, of the type considered, it is possible to increase the length of the electron beam transversely of its horizontal travel, or parallel to the "vertical" phosphor strips, by a factor of the order of 3:1 without adversely affecting the ultimate resolution. Further due to the anticipated correlation in the picture bright areas it is possible to increase this ratio still further without suffering an undue loss of resolution. These last set of deflecting plates may be utilized so that the spot stretch is controlled by the picture content at the point, or area, in question.

The arrangement of FIGURE 13 is responsive to an index pulse. The index pulse may be derived for example from the detector-amplifier of FIGURE 4, and may be used to control the excitation of the target screen of FIGURE 2. Pulse 106 is provided by means 110; pulse 108 is provided by means 112. Pulse 106 is first derived from the index pulse and is made to have a greater duration than pulse 108 which is later derived. Pulse 106 operates gate 76 which releases the red video signal. This gated signal in turn furnishes a positive going pulse of voltage to the grid 100 of gun 12. The greater the red video signal the more positive becomes grid 100 so that the red phosphor strip 40 of FIGURE 2 will be energized in an amount proportional to the magnitude of the red video signal. Simultaneously the index pulse is delayed and shaped in means 112 to provide a pulse 108 to operate the green gate 78 which in turn releases the green video signal to intensity modulate the electron beam furnished by gun 12. The pulses 106 and 108 which are negative, fixed in amplitude, and rectangular in shape, may also be fed to the cathode 102 of gun 12. The amplitude of this pulse is adjusted to overcome the bias which has been set between the cathode and grid of the gun so that a small beam current is obtained. Now the gated video signals will drive the grid 100 more positive to intensity modulate the beam 114. To reduce the spread of the beam 114 when its intensity is increased, plates 20 are made positive via connection 116 by the gated video signals. These plates 20 may be in the path of the beam as shown or may be part of anode 104. In the latter event anode 104 would be built in segmented fashion. The positive pulses on plates 20 will stretch beam 114 in the direction perpendicular to the horizontal scan; this direction is parallel to the phosphor strip long dimension. This stretching will reduce the spread of beam 114 in the horizontal direction. Should this horizontal spread still be excessive, plates 22 are utilized. These plates are also in the vicinity of gun 12 and are connected to retard the velocity of scan in the horizontal direction when horizontal beam spread occurs. The retardation signal is equal to or proportional to the amplitude of the gated video signals, and thus will cancel the effects of horizontal beam spread insofar as the timing of the leading edge is concerned. This will reduce leading edge jitter and provide a more stable electro-magnetic index signal.

For the arrangement of FIGURE 13 to provide a modulation similar to the type illustrated in FIGURE 8, the means 110 and 112 are selected to provide triangular pulses 118 and 120, or additional pulse shaping elements are added. Then not only will the intensity of beam 114 be increased when the gated video signals increase, but the time duration of the beam will increase from a minimum of 122 to a maximum of 124 as illustrated in FIGURE 13*a*. The voltages that operate the gates preferably remain rectangular in shape. The advantage gained here is that of reducing the intensity variations and therefore the focus variation in the beam 114 from that required with constant duty-cycle energization of the phosphor strips. Other circuits for converting variable amplitude information into variable pulse-width information are well known and not further described. When using this type of modulation it may be desirable to provide an index strip which is energized by a constant intensity scanning beam. This fixed beam may be obtained by known means.

The overall time delay, and distortion, in the feedback loop comprising the gun, the target screen, the electro-magnetic radiation, the detector, the amplifier, the gate, and back to the gun, is reduced in the arrangement of FIGURE 14 from that achievable in FIGURE 4 or 13. Also the gate is eliminated. The gun 12 provides an electron beam 114. Vernier deflection plates 20 and 22 may be used for the purposes just described. The target screen provides a plurality of indexing radiations; one for each color strip to be excited and controlled. A three color producing screen is selected for illustrative purposes. The three index radiation generators are symbolized in FIGURE 11 at 130, 132, and 134. Three index radiation gatherers are shown at 136, 137, and 138. These elements transmit the proper index radiation to means which detect the radiation to provide an electrical signal, which is amplified, and modulated to furnish output signals for modulating the beam 114 in accordance with the video information that is to be viewed on the target screen. Three index radiation filters are symbolized in FIGURE 12. Filter 131 attenuates or reflects the radiation from generators *b* and *c*, but passes that from generator *a*. Filter 133 attenuates the radiation from generators *a* and *c*, but passes that from generator *b*. Filter 135 attenuates the radiation from generators *a* and *b*, but passes that from generator *c*. These filters are used in conjunction with the index radiation gathering, transmitting, or detection means to properly synchronize the overall operation. For example, element 136 picks up the index radiation that is to be associated with the energization of the red phosphor strip. This radiation is transmitted through 142 to means 140. Photon-sensitive means 144 provides a group of electrons in response to excitation by the index radiation. Elements 144, 146, and 148 are arranged to operate as a heaterless vacuum triode. The emission from 144, the spacing of 146, and 148, and the voltages impressed thereon

are selected to provide a space charge in the region between **144** and **146**. Design details familiar to vacuum tube designers can be applied here for construction purposes. The red video signals are applied to grid **146** to control the passage of electrons from **144** to **148**. Plate or anode **148** collects the thus controlled electron flow. Plate **148** is unlike an ordinary triode however, in that it also behaves as a dynode and emits secondary electrons. Further stages of secondary emission amplification follow such as at **150**. The output signal is collected at **156** to furnish a negative going pulse signal, **158**, to the cathode of the gun **12**. The time delays are arranged so this pulse signal controls the energizaof the red phosphor strip. Voltage **158** may also be fed to plates **22** to retard the leading edge of the index radiation pulse for reasons described previously. To control incrementally the horizontal scan rate it is desirable to use also the positive output **160** from element **154** so that the signal on plates **22** will be push-pull. The output from **154** may also be used for spot stretch as described previously. Means similar to **140** are symbolized in FIGURE 14 for exciting the blue and green color producing phosphor strips.

Instead of introducing the red control voltage as a video signal at **146** it is possible to use deflection plates **152** to obtain synchronous demodulation of the carrier signal but this goes beyond the teachings of the instant invention and will not be discussed further.

In FIGURE 15 the three electro-magetic index signals cause low velocity electrons to be emitted from the surfaces upon which they impinge. During the process of controlling and amplifying the electrical signal, other low velocity electrons are emitted from dynodes of which **200**, **196**, and **198** are part. The successive dynodes may may be reduced in physical size, as depicted, to reduce associated capacitances, to increase the potential frequency response of the output signals, and to help match element **198** to its transmission line. Thus in FIGURE 15 the output of means **170** conveniently feeds into a coaxial cable **172**. Means **170** combines the three detector-amplifier-modulators of FIGURE 14 into a single device. Elements **174**, **176**, and **178** are akin to elements **143**, **145**, and **142** respectively. Element **204** is akin to **144**. Control grid **190** is akin to control grid **146**. Dynodes **200** and **196** are akin to **148** and **150** respectively. Output plate **198** is akin to **156**. Elements **206** and **208** furnish electron groups in response to the excitation by radiation of the green and blue index strips respectively. Member **202** provides optical and electrical shielding. Member **192** is a control grid that is connected to the green video signals. This grid **192** regulates the passage of electrons from **206** to plate **200**. Likewise **194** is a control grid that is connected to the blue video signals. This grid **194** regulates the passage of electrons from **208** to plate **200**. The operation of **170** follows from the description of operation of FIGURE 14. Three electro-magnetic index signals are generated, collected, filtered, and brought to impinge upon three different photon-sensitive electron-emitting surfaces. Each index signal and electron-emitting surface is associated with a different color producing phosphor. Each electron-emitting surface furnishes a copious supply of electrons which are space charge limited. A control grid is provided for each supply of electrons. Each grid is connected to its associated color video signal to control the passage of these electrons. The electrons are passed in individual groups, sequentially, and are amplified by a series of dynodes. The amplified and controlled electron groups are combined in the dynode stages to provide a series of signals as the output. The output plate is shaped to feed into a transmission line. The transmission line carries these signals to the cathode ray tube for modulation of the scanning beam contained therein. The scanning beam excites the target screen. Electro-magnetic index signals are generated, and the process continues. The advantages gained in simplicity of construction and in performance are numerous. Most important, the time delays and distortions may be reduced still further from the arrangement of FIGURE 14. Still additional significant advantages occur by constructing the gun **12**, in FIGURE 15, of the cathode ray tube in planar fashion, with coaxial input connections at **210**, and with a resistor at **212** which effectively matches the impedance of coaxial transmission line **172**. Thereby a reflection-less termination for the output of means **170** may be provided. This arrangement clearly provides for improved transmission and utilization of very short pulses. Resistor **212** may be cylindrical or annular. Alternatively, the internal impedance between the grid cathode may terminate the transmission line. Elements **214** are illustrated to indicate that means similar to plates **20** and **22** may also be used.

The construction of FIGURE 15 also draws attention to the fact that the conventionally heated cathode of gun **12** of the cathode ray tube may be eliminated. Plate **198** may be fabricated to be secondary emissive. With this arrangement the plate **198** may yield the electrons normally furnished by cathode **218**. Grid **20** of gun **12** may also be dispensed with, since the output at **198** is properly modulated; i.e. its amplitude is proportional to the intensity of the image to be displayed. The dotted outline of a tube envelope **230**, and deflection coils **216**, are shown to symbolize this mode of operation. Although not shown, it is clear that the pulse generator of FIGURE 4 may be incorporated into the embodiment of FIGURE 15 to provide pulses of saturated space charged clouds of electrons which are then grid controlled by the video signals.

The arrangement of FIGURE 15 that yields the heaterless cathode is illustrated more clearly in FIGURE 21. Two of the index signal paths are shown. The numeration of elements in FIGURE 21 akin to those in FIGURE 15 remain the same.

In FIGURE 16 a lens **250**, a cone shaped member **252**, and a hollow cone **254** are illustrated. These devices may be used to pick up and transmit electro-magnetic index radiation in the range from infra-red to ultra-violet. Flat fresnel type lenses may also be used. In FIGURE 17 a lens **256** with a hole therethrough, and a rod **258**, are devices that may be used for the same purpose. Rod **258** may be solid; if hollow it may be made of metal. Antenna **260** is connected to a coaxial transmission line **262** and may be used to extend the range of index radiations, that are picked up and transmitted to microwaves and to Hertzian waves. To extend the range of signals that may be picked up into the X-ray region members **250**, **252**, **254**, **256**, or **256** may be coated with a material, such as Hex Z_nO, as described heretofore.

In FIGURE 18 electro-magnetic radiation gatherers **250** are shown affixed to the electron source **12** of the cathode ray tube. Any of the pick-up elements may be so affixed. That this is advantageous is clear from my co-pending application Serial No. 634,019.

Thus, a plurality of electro-magnetic index signals may be generated that indicate the position of a scanning beam on a directed ray tube. A plurality of means are disclosed for synchronizing the energization of the scanning beam with the target screen upon which it impinges. A plurality of means are disclosed for modulating the scanning beam; this modulation being directed towards presenting information on the target screen, and being directed towards insuring proper synchronization. In combination with these features are additional means that reduce the time delay in system synchronization and means that increase the band width handling capabilities of cathode ray tubes.

It is to be repeated that although this invention is described in a color television display system it is not limited thereto. The use of the word color encompasses other than visible radiations in a proper interpretation of this

invention. Many electro-magnetic radiations may be used, it being clear that each radiation may serve as a separate communication or control channel. In the case of radiation in the visible range optical techniques for filtering the radiations are well known; in the microwave, or Hertzian, range electrical filtering techniques are also well known; in the X-ray region techniques for producing and filtering monochromatic radiation are likewise well known. In addition to the Compton and Sproull references already cited, I also refer to Applied X-Rays, by Clark, McGraw Hill, 1955. The wide range of signals that may be utilized constitutes one advantage of this invention. It is also to be noted that these teachings can be applied to storage-type devices, to signal generators, to quantizers, etc. In applications utilizing the scanning of a beam relative to a target where high speeds, high definition, wide band widths, and minimum distortions are required, this invention provides its greatest advantages.

Having thus described my invention, I claim:

1. A system for use in displaying colored images comprising: a cathode ray tube containing an electron gun and an electron sensitive screen, means for scanning said screen with an electron beam furnished by said gun, said screen comprising a first plurality of color emitting strips and a second plurality of electro-magnetic index signal emitting strips, said first and second plurality of strips being arranged in repeating groups and emitting their electro-magnetic radiation upon excitation by the scanning of said electron beam, said second plurality of strips adapted to provide thereby at least two electromagnetic index signals which are in different regions of the spectrum, and separate means for receiving and detecting each of the different electromagnetic index signals.

2. In combination: a cathode ray tube for use in presenting a display in a plurality of colors comprising an electron gun for producing an electron beam, and an electron sensitive screen, said screen comprising means for emitting X-rays upon excitation by the electron beam, means for changing the characteristics of the emitted X-rays as a function of position of the beam on said screen; and means for detecting the X-rays to provide signals that are utilized in controlling the display.

3. A system embodying the cathode ray tube of claim 2, wherein said means for detecting the X-rays are disposed approximately at right angles to the path of travel of said electron beam when impinging upon said screen.

4. A system in accordance with claim 2, wherein the means for detecting the X-rays comprise means to convert said X-rays to another electro-magnetic signal at a lower frequency.

5. A system in accordance with claim 2 wherein the means for detecting the X-rays comprises a member that emits electrons when impinged upon by said X-rays, and a plurality of dynodes for secondary emission multiplication of said electrons.

6. A structure comprising: a housing containing a member which emits electro-magnetic radiation comprising a component in the X-ray region upon excitation by a scanning beam of energy, said member comprising discrete elements extending over a substantial area which provides said radiation, and means within said housing which are impinged upon by the X-rays and which convert said X-rays to a longer wavelength signal in the range from infra-red to ultra-violet, and means within said housing for collecting and transmitting only said longer wavelength signal.

7. A structure in accordance with claim 6 wherein said last mentioned means comprises an elongated member.

8. A cathode ray tube comprising: an electron gun, first means responsive to excitation by electrons from said gun, said first means emitting electro-magnetic radiation in the range extending from infra-red to waves of X-radiation as a result of said excitation, and second means within the tube which converts to a lower frequency electro-magnetic radiation the emitted radiation which impinges upon it, and which picks up and transmits at least a portion of said lower frequency radiation, said second means being affixed to said electron gun.

9. A cathode ray tube comprising: an envelope, an electron gun, means responsive to excitation by electrons from said gun, said means emitting electro-magnetic radiation in the range extending from infra-red to waves of X-radiation as a result of said excitation, means which convert to a lower frequency electro-magnetic radiation the emitted radiation which impinges upon it, and which transmits at least a portion of said lower frequency electro-magnatic radiation to a situs outside the tube, said last means comprising an elongated member one end of which is affixed to said envelope in the vicinity of the gun.

10. A cathode ray tube comprising: an envelope, an electron gun, and a target screen, wherein said screen is adapted to be scanned by an electron beam from said gun to generate a plurality of colors and an electro-magnetic index signal indicative of the position of the beam on the screen, said screen being characterized by the feature that the said index signal is in the X-ray region of the spectrum.

11. A cathode ray tube comprising an envelope and a target screen, said screen being capable of emitting a plurality of electro-magnetic radiations designated x_1, x_2, . . . upon excitation by a scanning beam of electrons, in combination with means excited via each of said radiations to furnish electrons in different spatial regions designated y_1, y_2, . . ., and means for simultaneously amplifying and combining the thus-furnished electrons.

12. A cathode ray tube comprising an envelope and an electron gun adapted to emit a beam of electrons, said beam being capable of scanning electron-sensitive means that emit electro-magnetic radiation in the X-ray region upon excitation by said electrons, and means comprising a lens within the cathode ray tube separated from the envelope thereof and positioned to face said electron-sensitive means, said lens being coated with a material which emits radiation when impinged upon by the X-rays which is in the range from infra-red to that of ultra-violet.

13. A multi-color cathode ray tube comprising: an electron gun that furnishes an electron beam, a target screen structure comprising discrete definite color emissive areas and index signal generating means that provide electro-magnetic radiation indicative of the position of the beam on the target screen, the index signal radiation being in the X-ray region of the spectrum, and means within the tube that convert a portion of said index signal radiation to a lower frequency radiation.

14. A color television cathode ray tube defined by claim 13 including means for transmitting at least a portion of said lower frequency radiation to a situs outside the tube.

15. A cathode ray tube comprising an envelope and an electron gun adapted to emit a beam of electrons, said beam being capable of scanning electron-sensitive means that emit electro-magnetic radiation in the X-ray region of the spectrum upon excitation by said electrons, converting means within the cathode ray tube that are impinged upon by at least a portion of the X-radiation, said converting means generating thereby a lower frequency electro-magnetic signal, and means that bundles a portion of said lower frequency electro-magnetic radiation into a concentration thereof.

16. A cathode ray tube comprising an envelope and an electron gun adapted to emit a beam of electrons, said beam being capable of scanning electron-sensitive means that emit electro-magnetic radiation in the X-ray region of the spectrum upon excitation by said electrons, converting means within the cathode ray tube that are impinged upon by at least a portion of the X-radiation, said converting means generating thereby a lower frequency electro-magnetic signal, and means that bundles a portion of said lower frequency electro-magnetic radiation

into a concentration thereof, and second converting means inside the tube that converts at least a portion of the concentrated radiation into electrical signals.

17. A color cathode ray tube comprising: an electron sensitive target, and only one electron gun adapted to furnish a single cathode ray beam for scanning the target, said target containing first portions which generate the different colors, and second portions which generate a series of electro-magnetic index signals having frequencies f_1, f_2, . . . for indicating the position of the beam on the target, each of said frequencies being in a different region of the spectrum and being different from the colors to be displayed.

18. A device for displaying information in a plurality of colors comprising: an envelope, a target structure, an electron gun adapted to provide an electron beam for scanning said target, means for emitting the various colors to be displayed, and means which produce electromagnetic index signals for indicating the position of said electron beam on the target, said last means comprising a first series of index strips which generate a first series of index signals and a second series of index strips which generate a second series of index signals, said first and second series of index signals being in different regions of the spectrum and being different from the various colors emitted, and where at least one of the index signals is in the X-ray region of the spectrum.

19. A cathode ray tube for displaying information in a plurality of colors comprising: an electron sensitive target, and an electron gun adapted to furnish a cathode ray beam for scanning the target, said target containing portion s_1, s_2, . . . which generate in response to excitation by said beam electro-magnetic index signals having frequencies f_1, f_2, . . . , said frequencies each being in a different region of the spectrum and being different from the colors to be displayed, and means l_1, l_2, . . . responsive to frequencies f_1, f_2, . . . , respectively, for picking up said electro-magnetic index signals, said means l_1, l_2, . . . being symmetrically positioned with respect to said target screen.

20. A color cathode ray tube comprising: an electron gun adapted to provide an electron beam, and a target screen adapted to be scanned by the beam from said gun, said screen containing color producing electron sensitive areas and index signal producing electron sensitive areas, whereby first and second electro-magnetic index signals are generated in response to excitation by the electron beam, said index signals being in regions of the spectrum different from each other and different from the colors produced, first pick-up means responsive to the first index signal and second pick-up means responsive to the second index signal, both said pick-up means facing the target screen and being positioned near the electron gun.

21. A cathode ray tube comprising: an electron sensitive target, and an electron gun adapted to furnish an electron beam for scanning the target, said target generating in response to excitation by the electron beam a plurality of electro-magnetic signals having frequencies f_1, f_2, . . . , and a plurality of light pipe means l_1, l_2, . . . positioned symmetrically about said electron gun, there being one light pipe for picking up each of the different electromagnetic signals and for transmitting signals representative of those picked up.

22. A color cathode ray tube comprising: an electron gun adapted to provide an electron beam, and a target screen adapted to be scanned by the beams from said gun, said screen containing color producing electron sensitive areas and index signal producing electron sensitive areas, whereby index signals are generated in response to excitation by the electron beam which are in the X-ray region of the spectrum, means disposed near the electron gun for picking up the index signals and for transmitting signals representative of same to a situs external of the tube.

23. A color cathode ray tube comprising: an electron sensitive target, and spaced therefrom an electron gun adapted to furnish a cathode ray beam for scanning the target, said target containing first portions which generate the different colors and second portions which generate electro-magnetic index signals in response to excitation by said beam, and means positioned between said gun and said target for picking up said electro-magnetic index signals, said means having an opening therethrough for passage of the cathode ray beam from said gun to said target.

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