

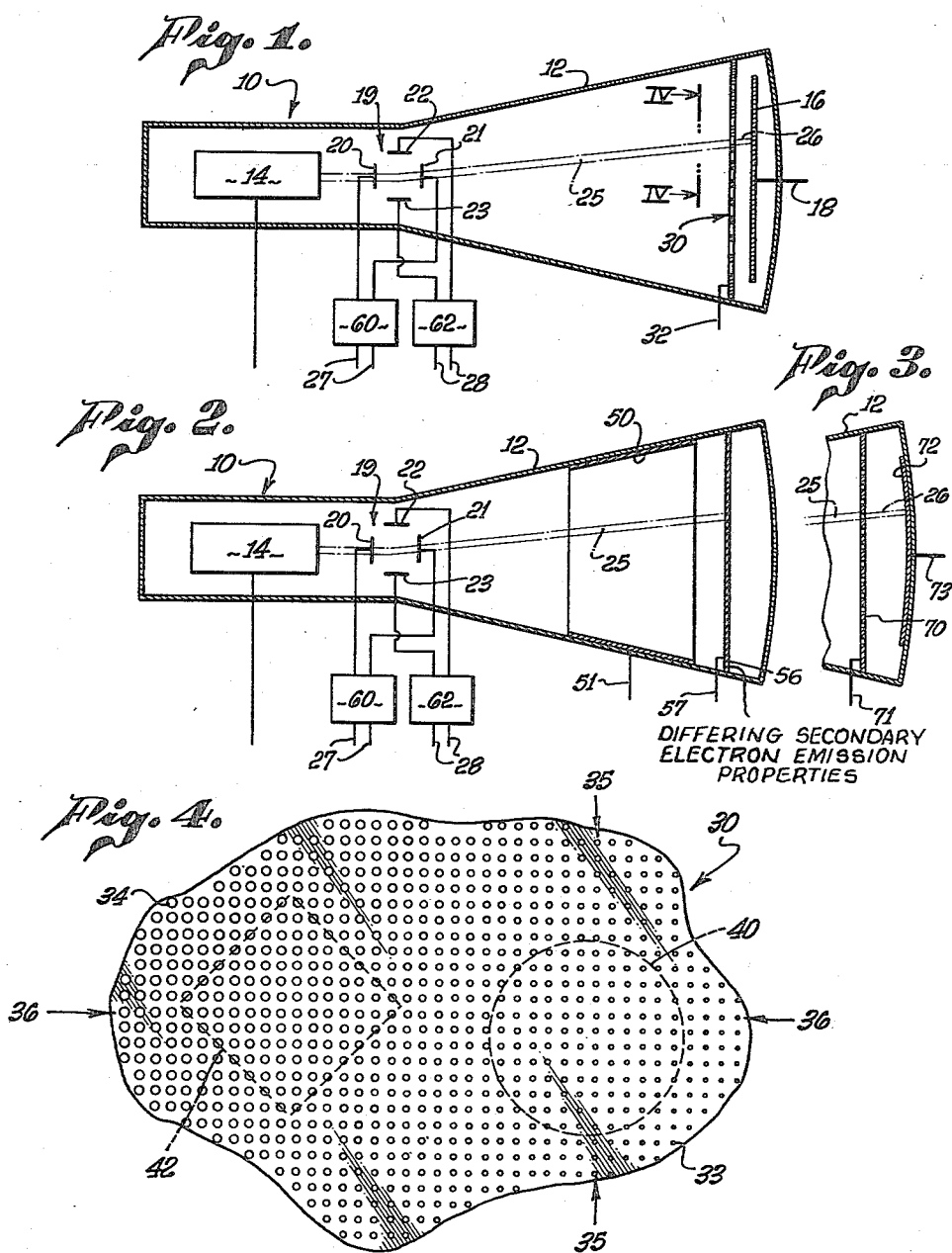
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CATHODE-RAY TUBE

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CATHODE-RAY TUBE

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1

This invention relates generally to electron tubes and is particularly directed to an improved form of cathode ray tube having an output current which is a function of the values of one, two or more independent input currents. The present invention is a continuation-in-part of my copending application, "Apparatus and Methods for Use in Color Reproduction," Serial No. 702,173, filed October 9, 1946, now Patent No. 2,560,567, issued July 17, 1951.

In electronic circuits and apparatus it is often desirable to generate a current whose relationship to an input current is complex. Such relationship may, for example, be empirically determined for a given application or for a given set of data. To illustrate, it is well known in the art that equipment exists by which an output current may be derived having a logarithmic relationship to an input current or voltage. Similarly an output current may be anti-logarithmic with respect to an input electrical phenomenon. The problem under discussion, however, assumes the desirability of obtaining an output electric current which bears a more complex relationship to an input electrical phenomenon than can be accomplished by presently available conventional equipment.

Moreover, it is often desirable to produce an output current whose value is a function of not one but two or more independent input electrical values, and such relationship may itself be complex and perhaps discontinuous with respect to one or more of the input values. A particular instance of the problem is found in electric circuits used for color correction in preparing color separation plates or negatives in the printing art, all discussed more fully in my aforesaid copending application.

By the present invention I propose to modify the construction of a conventional cathode ray tube by omitting the fluorescent target screen and substituting therefor a collector electrode. An additional electrode, which may be referred to herein as the "pattern electrode," is provided between the deflecting means of the cathode ray tube and the collector electrode so that the additional electrode is in the path of the electron beam. This latter electrode, in one form of my invention, may be perforated with a very large number of apertures of varying sizes with the result that the number of electrons which succeed in reaching the collector electrode in the end of the tube is a function of the position of the electron beam within the tube. Input signals impressed upon the deflecting means of the

2

tube control the position of the electron beam and thereby govern the number of electrons reaching the collector electrode.

In a different form of the present invention the collector electrode may be disposed around the inner surface of the cathode ray tube and the additional pattern electrode previously referred to may be positioned near the end of the tube. In this structure the pattern is formed not by perforations but rather by two materials having differing secondary emissions characteristics. Electrons dislodged from the pattern electrode by secondary emission are collected by the collector electrode. In common with the form of the invention first referred to, this device will provide an output current carried by the collector electrode which is a function of the position of the electron beam in the tube.

In yet another embodiment of the present invention I may combine the features above described by providing a perforated pattern electrode made of a material having a high secondary emission characteristics. In this structure I provide two collector electrodes so positioned and maintained at such positive potentials that the current flow in one collector electrode is caused by secondary emission electrons from the pattern electrode, while the current flow in the other collector electrode is caused by electrons which have passed through the apertures of the pattern electrode. Thus two output currents may be obtained, one from each of the collector electrodes, and the values of each of such currents may be made to assume desired values dependent upon the position of the electron beam as controlled by input signals applied to the deflecting means of the tube.

In each form of the invention the collector electrode or electrodes are maintained at high positive potentials by any suitable means in customary manner. For reasons appearing hereinafter the voltage need not be so high as in usual cathode ray tube practice when using the instrument as a measuring or indicating device. The pattern electrode is maintained at a positive potential somewhat lower than that of the collector electrode or electrodes.

From this general description, it will be readily apparent that any desired pattern may be reproduced on the pattern electrode in order to produce any desired value of output current for any given position of the electron beam. Therefore, if input electrical phenomena are caused to shift the beam as by electrostatic deflection or electromagnetic deflection, the resultant output current

in the collector electrode or electrodes will be whatever function of the two input electrical phenomena is dictated by the arrangement of electron-affecting areas of the pattern electrode.

An object of my invention is, therefore, to disclose an improved cathode ray tube.

Another object of the invention is to provide in a cathode ray tube a collector electrode and a pattern electrode for supplying an output signal having a value dependent upon the bi-directional deflected position of the electron beam.

A further object is to provide means for supplying two output electric signals having desired complex relationships to one or more input electric signals.

A further object of the invention is to provide such a device using a pattern electrode capable of secondary emission.

Still another object of the invention is to disclose a modified cathode ray tube wherein a high frequency electric value may be superimposed upon a signal impressed on a deflecting means of the tube.

These and other objects and purposes of the invention will become apparent from a careful study of the following description of typical embodiments thereof. In the drawing I have illustrated exemplary forms by which the invention may be practiced, and in said drawing:

Fig. 1 is a side elevational view, in section, of a cathode ray tube including a perforated pattern electrode in accordance with my invention.

Fig. 2 is a side elevational view in section of a modified form of my invention wherein one surface of the pattern electrode is made up of two materials having different secondary emission characteristics.

Fig. 3 is a fragmentary view in side elevation of the target end of a cathode ray tube showing a further modification of my invention.

Fig. 4 is a fragmentary view on a greatly enlarged scale and taken on line IV—IV of Fig. 1 showing a portion of the perforated pattern electrode and two typical outlines of the electron beam impinging thereon.

As previously indicated, my invention contemplates a cathode ray tube which is modified in two major respects from the conventional tube. First, there is no fluorescent screen but instead there is provided a collector electrode maintained at a predetermined positive potential relative to the cathode. Secondly, a pattern electrode is introduced into the tube in the path of electrons traveling from the electron gun. The pattern electrode presents a surface to the electron beam which is non-uniform in an electrical characteristic whereby the number of electrons eventually reaching the collector electrode (and hence the output current of the cathode ray tube) is a function of the particular portion of the pattern electrode to which the electron beam is directed. One or more input signals control the deflecting means.

For example, the pattern electrode may be so arranged that when the electron beam strikes it in its upper portion, a large number of electrons reach the collector electrode. The current carried by the collector electrode is therefore high. On the other hand, if the electron beam strikes the pattern electrode in its lower portion, the characteristic of the pattern electrode at that point may be such that a relatively small number of electrons eventually reach the collector electrode. Similarly, a non-uniformity in the horizontal direction, from right to left, may be in-

corporated in the pattern electrode with the result that the output current of the tube will be dependent upon not only the vertical position of the deflected electron beam but also its horizontal position. If now two independent input signals are caused to actuate the horizontal and vertical deflecting means, an output current will be obtained from the tube whose value is affected by each of the two input currents. It is to be especially noted that the pattern electrode may be calibrated by any desired means so that the output current of the tube can be made to bear any desired relationship—linear, logarithmic, exponential, complex of discontinuous—with respect to either of the two input currents.

Referring now in detail to the drawing and particularly to Fig. 1 thereof, I have there shown a conventional cathode ray tube indicated generally at 10 and having a conventional envelope 12 of glass or the like. An electron gun 14 may be of conventional design although, as pointed out in greater detail hereinafter, it may be so arranged as to achieve a greater efficiency than the electron gun usually used in cathode ray tubes. A collector electrode 16 is maintained at a positive potential by a suitable D. C. source (not shown) connected to lead 18.

Tube 10 includes conventional deflecting means which may take the form, as indicated generally at 19, of horizontal deflecting plates 20 and 21 and vertical deflecting plates 22 and 23. It will be understood that other deflecting means may also be employed including conventional electromagnetic means having coils disposed on angularly related axes to move the electron beam in well-known manner. Electron beam 25 may thus be caused to travel any desired angular path within the cathode ray tube. An input signal is impressed upon the horizontal plates through leads 27, and a second and independent signal may be impressed on vertical plates 22 and 23 through leads 28.

A pattern electrode indicated generally at 30 is disposed transversely to the axis of tube 10 and is positioned intermediate deflecting means 19 and collector electrode 16, and preferably relatively close to collector electrode 16 as shown. Pattern electrode 30 is maintained at a positive potential somewhat lower than that of collector electrode 16 by a suitable source of D. C. (not shown) connected to lead 32.

In the particular embodiment of the invention shown in Fig. 1, pattern electrode 30 may take the form of a perforated sheet of metal, and the perforations vary in cross sectional area over the extent of the electrode 30. As appears in Fig. 4, wherein a portion of the pattern electrode is shown on a greater enlarged scale, pattern electrode 30 includes a very large number of relatively small apertures. In this example the size of the apertures varies from perforation 33, which is the smallest shown, up to aperture 34, which is the largest shown. Furthermore, the variation in size of apertures is two-dimensional. It will be noted that the perforations in the column indicated at 35 become larger from the bottom to the top of the electrode 30. Similarly, apertures in row 36 become larger as one goes from right to left on the pattern electrode.

Two typical electron beams are shown in outline in Fig. 4 as they impinge pattern electrode 30. The cross section of the electron beam may be circular, as shown at 40, or may be polygonal as shown at 42. In either case, it is important that the electron beam, of whatever outline, be

caused to cover a large number of the perforations in pattern electrode 30. This is necessary in order that a small shift in the position of the electron beam 25, as it assumes a position dictated by deflecting means 19, may not cause any sharp or discontinuous change in the total apertured area of pattern electrode 30 impinged by the electron beam.

Of all the electrons constituting electron beam 25, a portion 26 will arrive at an aperture in pattern electrode 30, will pass therethrough and be drawn to collector electrode 16 by reason of the high positive potential thereon. In contrast, the electrons which impinge the solid portion of pattern electrode 30 will go no further in the tube but will appear as a flow of current in lead 32. Thus the output current appearing in lead 18 will be a measure of the number of electrons which have succeeded in passing through an aperture of pattern electrode 30. It will be evident that the value of such output current will depend upon the proportion of apertured area of the pattern electrode impinged by the electron beam.

In place of the perforated pattern electrode 30, I may provide a cathode ray tube whose pattern electrode includes a surface made up of two materials having differing secondary emission characteristics. Such a tube is shown in Fig. 2 wherein the glass envelope 12, the electron gun 14 and the deflecting means 19 are identical to those already described in connection with Fig. 1. I provide an annular collector electrode 50 disposed on the inner tapering surface of envelope 12 and maintained at a high positive potential by a D. C. source (not shown) through lead 51. A pattern electrode 56 extends completely across tube 10 adjacent the target end thereof, and is maintained at a positive potential somewhat lower than that of collector electrode 50 by means of a D. C. source (not shown) through lead 57. On the surface of pattern electrode 56 facing electron gun 14 a pattern is provided in materials having different secondary emission characteristics. I may, for instance, make pattern electrode 56 out of a thin sheet of nickel (which has a relatively high secondary emission characteristic). Superimposed upon said nickel, I may provide a patterned coating of carbon or other similar material having a low secondary emission characteristic. The similarity to the perforated pattern electrode 30, previously described, may be seen if the coating of carbon is understood to correspond to the solid portion of pattern electrode 30, and the exposed nickel surface of pattern electrode 56 is understood to correspond to the apertures of pattern electrode 30.

It will now be understood that when an electron beam impinges pattern electrode 56, the number of secondary electrons resulting from such impingement will depend upon an integration, over the area of the impinging electron beam, of the secondary emission characteristics of the impinging surface. Electrons dislodged by secondary emission from pattern electrode 56 will be drawn to collector electrode 50 because of the higher D. C. potential at which this electrode is maintained relative to the potential of pattern electrode 56. In this manner the number of electrons reaching collector electrode 50 will be a function of the bi-directional deflected position of the electron beam 25 as it impinges pattern electrode 56.

In either of the embodiments of the invention thus far described, the electron beam 25 may assume either of the two outlines illustrated in

Fig. 4, the requirement being only that a large number of apertures or areas of high secondary emission be included within the beam. The circular cross-section of electron beam 25, shown at 40, may be attained merely by less exact focusing of the beam than is customary for cathode ray practice generally. Another method of obtaining an electron beam of large cross-section may be by a redesign of the electron gun whereby a larger proportion of electrons emitted by the cathode is utilized than in conventional design.

Alternatively, electron beam 25 may assume a polygonal cross-section as shown at 42 in Fig. 4. In order to attain this configuration I may provide oscillators 60 and 62 in the input deflecting circuits of the tube. Such oscillators may be adapted to produce either a saw tooth or a triangular wave having an amplitude small relative to that of the input signal. The frequencies of the waves produced by such generators should be separated by a factor of, for example, twenty to one. By this means the electron beam 25 is caused to scan a small area surrounding what would be the much smaller area of impact of electron beam 25 if it were unmodulated by oscillators 60 and 62. In this manner no sharp discontinuity of current flow to the collector electrode occurs when the point of impact of electron beam 25 is moved slightly on the pattern electrode.

A further modification of the invention is shown in Fig. 3, illustrating a modified arrangement of circuit elements in the target end of the tube of Fig. 2. Pattern electrode 70 is made of a material having a high secondary emission characteristic, and it is perforated in the same manner as described in connection with pattern electrode 30 of Fig. 1. It is maintained at a positive potential lower than that of collector electrode 50 by a D. C. source (not shown) through lead 71. An auxiliary collector electrode 72 is provided behind pattern electrode 70, adjacent the target wall of envelope 12, and is maintained at a high positive potential, substantially equal to that of collector electrode 50, by a D. C. source (not shown) through lead 73. It will be seen that an electron in beam 25 will, if it passes through an aperture of pattern electrode 70 reach auxiliary collector electrode 72. On the other hand, if an electron impinges the solid surface of pattern electrode 70, it will dislodge a number of electrons by secondary emission, which will be drawn to collector electrode 50. Thus two output signals are available having different relationships to the input signals impressed on deflecting means 19. One output signal flows through lead 51 and another through lead 73. In addition, it will be evident that a third output signal may be obtained from lead 71, connected to pattern electrode 70, since current flowing in that lead will bear a complex relationship to input signals impressed on deflecting means 19. In this connection, attention may also be called to the fact that in the forms of the invention shown in Figs. 1 and 2, output signals may be taken from leads 32 and 57, connected respectively to pattern electrodes 30 and 56.

The apertures of pattern electrode 30 are preferably on center lines spaced approximately 80 to 100 per inch, and the electron beam should have an area such as will cover 100 or more apertures in order to minimize the abruptness of changes in output signal responsive to shifts in the position of the electron beam. It is especially to be noted that the pattern of the pattern electrode (whether produced by apertures as in Fig. 1

or by materials of dissimilar secondary emission as in Fig. 2) may incorporate any desired relationship between input signals and desired output signals. Obviously the pattern need not change in substantially uniform gradations as would be the case when using the particular configuration of apertures shown in Fig. 4. Similarly the incremental changes in output signal from top to bottom or from right to left of the pattern electrode need not be in the same sense; a particular application may require that, as an input signal increases in value at a uniform rate, an output signal rise rapidly to a maximum, then fall slowly a desired amount, then rise again at a different rate. Such a complex or discontinuous output signal may be produced with facility by the use of the invention herein described. A second input signal, applied to a deflecting means affecting the electron beam in a different plane from that of the first input signal, may simultaneously affect the output signal according to a different relationship so that the value of the output signal is a resultant of two input signals.

Although I have shown conventional deflecting means operable only in horizontal and vertical planes, the deflecting means may provide for deflection in more than two angularly related planes. For example there may be three pairs of deflecting plates (or deflecting coils if electromagnetic deflecting is employed) effective to shift the electron beam in three planes passing through the axis of the tube and angularly spaced 60° apart. Similarly four, five or more pairs of deflecting plates may be provided to shift the beam in as many different planes. It will be understood that the electron beam will in each case be positioned in accordance with the vectorial resultant of the effects of each of the pairs of deflecting plates.

The positive voltage at which the collector electrodes are maintained may be very much lower than the accelerating voltages used in conventional cathode ray tubes, since no light output is involved in the apparatus of the present invention. However, voltages in the range of 400 to 500 volts are desirable in the forms of the invention utilizing secondary emission for the reason that such voltages are necessary to achieve maximum secondary emission for common materials. It is to be noted that secondary emission is a phenomenon greatly affected by the temperature of the impinged surface, and a warm-up period is hence necessary before uniform results may be obtained. I therefore consider the first form of my invention as preferable for most purposes.

Although the collector electrodes 16 and 72 have been shown relatively large, it is understood that this showing is schematic only. I may provide much smaller electrodes in order to minimize the capacitance effect of such electrodes in accordance with well known principles.

It will be observed that in all the forms of the invention the pattern electrode is characterized by having a large number of elemental portions which may be referred to as "sub-areas," and the sub-areas have different electron-modifying abilities with respect to individual electrons directed thereto. Furthermore, the sub-areas are small relative to the cross-sectional area of the electron beam in order that a slight variation in the position of the deflected electron beam will not cause an abrupt change in the number of electrons reaching a collector electrode. To achieve a smoothly changing collector electrode current, the

beam should cover at least twenty sub-areas, although as previously stated I prefer that the beam cover approximately one hundred. These areas may be defined in terms of their electron-absorbing ability or electron-affecting ability, and it will be seen that a sub-area having a large aperture, or a large proportion of high secondary emitting material, will cause a large electron flow to the collector electrodes, and conversely in the case of a sub-area of opposite characteristics.

Modifications and changes in addition to those mentioned herein will occur to those skilled in the art. All such modifications and changes within the spirit of the invention are intended to be embraced within the scope of the following claims.

I claim:

1. In a cathode ray tube including an electron gun for generating an electron beam and means for controllably deflecting said beam in accordance with an input signal, the provision of means for producing an output signal having a predetermined relationship to an input signal, comprising: a pattern electrode disposed in the path of the electron beam and a collector electrode positioned to receive electrons as modified by the pattern electrode, said pattern electrode bearing a multiplicity of sub-areas differing in electron-affecting ability, said sub-areas being arranged in accordance with a predetermined pattern, the beam, as seen in cross-section at the pattern electrode, being large relative to a sub-area in mutually perpendicular directions whereby a plurality of sub-areas lie in the path of the beam and a small change in the deflected position of the beam produces a smooth change of output current in said collector electrode.

2. A cathode ray tube as stated in claim 1 wherein the cross-sectional area of the electron beam exceeds the area of not less than 20 sub-areas of the pattern electrode.

3. A cathode ray tube as stated in claim 1 wherein the sub-areas of the pattern electrode have different secondary emission characteristics.

4. A cathode ray tube as stated in claim 1 wherein the sub-areas of the pattern electrode differ in electron-absorbing characteristics.

5. A cathode ray tube as stated in claim 1 wherein the pattern electrode is provided with a multiplicity of minute apertures differing in size and arranged in accordance with said predetermined pattern.

6. A cathode ray tube as stated in claim 1 wherein said collector electrode is maintained at a positive potential relative to said pattern electrode.

7. A cathode ray device for producing an output signal having a predetermined relationship to an input signal, comprising an electron gun adapted to generate an electron beam; means responsive to an input signal for deflecting said beam; means for superimposing on said input signal electrical oscillations of magnitude small relative to that of the input signal; a pattern electrode disposed in the path of the deflected electron beam; an output collector electrode receiving electrons from the pattern electrode, said pattern electrode having a multiplicity of sub-areas small relative to the cross-sectional area swept by the electron beam as deflected by said electrical oscillations, said sub-areas differing in electron modifying ability and disposed in accordance with a predetermined pattern.

8. A device as stated in claim 7 wherein said sub-areas are of differing secondary emission characteristics.

9. A device as stated in claim 7 wherein said sub-areas include apertures in said pattern electrode.

10. In a cathode ray tube having an electron gun adapted to generate an electron beam, deflecting means responsive to an input signal impressed thereon for deflecting said beam, and a collector electrode, the provision of a pattern electrode maintained at a lower potential than the said collector electrode and disposed in the path of the electron beam, said pattern electrode provided with a multiplicity of sub-areas having an electrical effect upon the electrons in said beam differing in accordance with a predetermined pattern whereby the number of electrons reaching said collector electrode depends upon the deflected position of the electron beam at said pattern electrode, the area of the beam, as seen in cross-section at the pattern electrode, being large relative to a sub-area in mutually perpendicular directions.

11. A cathode ray tube comprising: an electron gun adapted to generate an electron beam; means for deflecting said beam in angularly related planes; means for impressing an input signal on one of said deflecting means including means for superimposing on said input signal electrical oscillations of magnitude small relative to that of the input signal; a pattern electrode disposed in the path of said beam; and a collector electrode maintained at a higher potential than the pattern electrode, said pattern electrode being provided with a multiplicity of sub-areas differing in electron-affecting ability and disposed in accordance with a predetermined pattern, the area swept by said beam as deflected by said oscillations being large relative to a sub-area.

12. A cathode ray tube comprising: an electron gun adapted to generate an electron beam; first

and second deflecting means adapted to deflect said beam in angularly related directions; means for impressing on said first deflecting means an input signal; means for superimposing on said input signal electrical oscillations of magnitude small relative to said input signal; means for impressing on said second deflecting means electrical oscillations of frequency different from the frequency of the first named oscillations; a pattern electrode disposed in the path of said beam; and a collector electrode maintained at a higher potential than the pattern electrode, said pattern electrode being provided with a multiplicity of sub-areas differing in electron-affecting ability and disposed in accordance with a predetermined pattern, the area swept by said beam as deflected by said oscillations being large relative to a sub-area.

13. A cathode ray tube as stated in claim 12 including means for impressing a second input signal on said second deflecting means of magnitude large relative to the electrical oscillations impressed thereon.

14. A cathode ray tube as stated in claim 13 wherein the frequencies of said oscillations differ by a ratio of at least approximately three to one.

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