April 27, 1937. L. E. SWEDLUND 2,078,644

ELECTRIC DISCHARGE APPARATUS

Filed Aug. 24, 1935

Fig. 1.

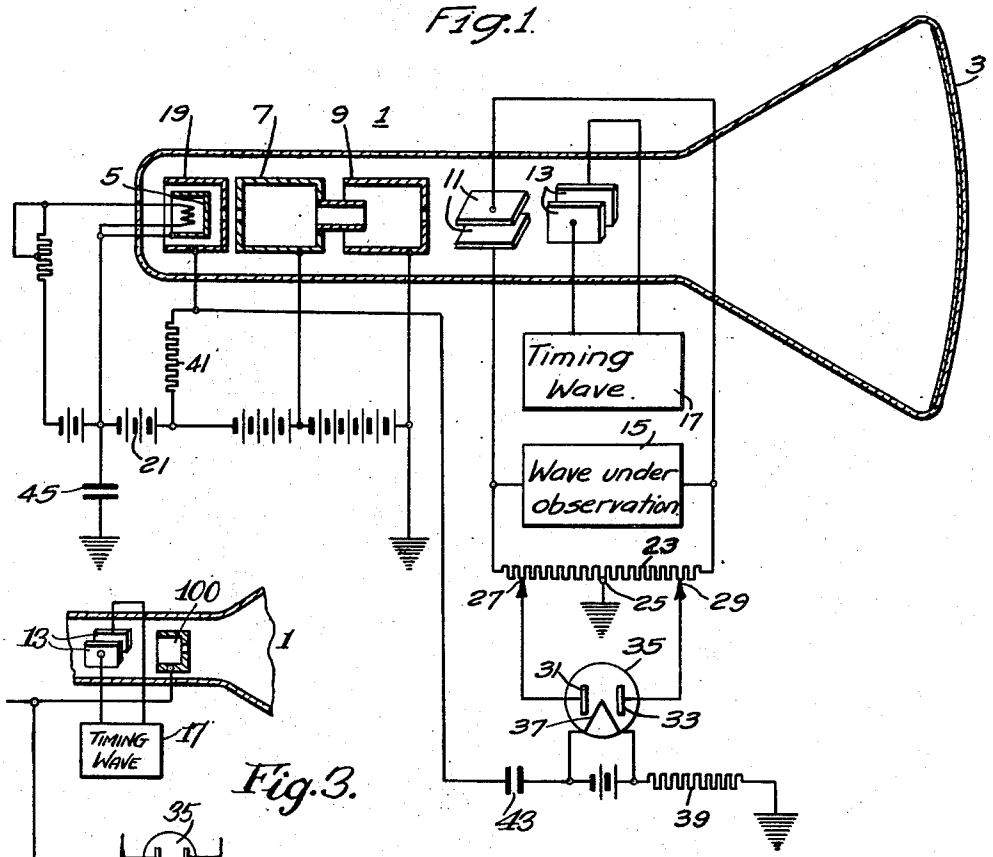
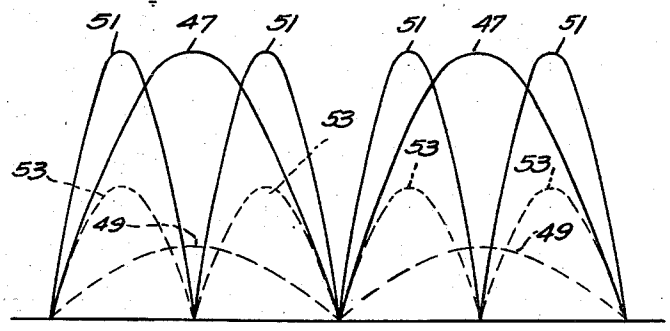


Fig. 3.

Fig. 2.



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ELECTRIC DISCHARGE APPARATUS

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16 Claims. (Cl. 171—95)

My invention relates to a display apparatus and it has particular relation to apparatus in which a display corresponding to a signal is produced by a stream of cathode rays impinging on a sensitive screen.

In apparatus of the type to which my invention relates, the signal may be any general physical disturbance as for example, a sound disturbance or a mechanical movement. Whatever the character of the disturbance is, it is converted into an electrical disturbance and the electrical disturbance is so coupled to the stream of electrons that the terminal of the stream which impinges on the screen is shifted in accordance with the magnitude of the disturbance. The stream impinging on the screen produces a fluorescent spot at the point where it impinges. As the stream shifts the spot shifts and the shift is customarily so rapid that by reason of persistance of vision the illusion of a pattern is produced. When the moving spot is photographed the same effect is produced on the film.

While, as a general rule, the spot produced is visible to the eye, this need not necessarily be the case. The screen utilized may be of a type such that the spot produced emits ultra-violet or infrared radiations. Under such circumstances, the spot is not visible to the eye, but for example, may be photographed or the radiations emitted thereby may be projected onto a light-sensitive cell of a particular type. The cathode ray beam may also be projected directly on a photographic emulsion rather than a screen which is excited by cathode rays to emit radiant energy.

In the following discussion I shall refer to luminosity as the intensity of radiant energy emitted by a radiating body. Where the cathode rays are projected directly on an emulsion the luminosity may be taken to be a function of the visibility or distinctness of the lines photographed. For the sake of brevity I shall in the following discussion refer largely to the phenomena produced with sensitive screens. However, the discussion is to be taken to be equally as well applicable to photographic plates directly energized by a cathode ray beam. The word "screen" is to be taken as having a broad meaning covering photographic emulsions as well as fluorescent plates.

The luminosity of the radiations emitted by a fluorescent screen energized by a cathode ray stream is a function of the velocity and current density of the electrons in the stream. This property of the stream in turn depends on the potential whereby the electrons in the cathode ray stream are accelerated and on the number of electrons in the stream. On the other hand the elements of the pattern which are produced by the cathode ray stream have a luminosity as far as the eye or the photographic camera is concerned, which depends on the rapidity of the swing of the cathode ray beam over the screen. If the cathode ray beam persists in any one position for an appreciable length of time a brighter region of the pattern is produced than in spots where the cathode ray beam moves rapidly over the screen. By reason of this property of the apparatus a pattern which is non-uniform in luminosity and which, in spots, is difficult to discern is often produced.

It is accordingly an object of my invention to provide display apparatus, whereby a display, corresponding to a signal, is produced by a cathode ray beam impinging on a sensitive screen by the operation of which the display pattern produced shall have substantially uniform luminosity.

Another object of my invention is to provide display apparatus in which the luminosity of the portions of the pattern normally having a low luminosity shall be so increased that the pattern shall appear to be of uniform luminosity.

A further object of my invention is to provide a system whereby the luminosity of the portions of a cathode ray pattern shall be so varied that the total pattern shall have uniform luminosity.

More concisely stated, it is an object of my invention to provide a circuit for controlling a cathode ray beam in such manner that the pattern which is produced when the beam impinges on a screen shall be uniformly luminous throughout.

According to the preferred practice of my invention, the condition of the electrons in the cathode ray stream is varied in accordance with the signal in such manner that the current density of the cathode rays is increased in proportion to the rate of change of the spacial shift of the cathode ray beam. The variation in the density of the electrons is attained by coupling an electrical potential corresponding to the rate of change of the signal under observation to a control electrode which is so disposed as to influence the density of the beam in the cathode ray beam. The cross section of the beam remains constant so that the spot which it produces on the screen remains approximately unchanged.

According to a modification of my invention the velocity or voltage of the electrons is varied in accordance with the signal to compensate for the variations in the velocity of shift. However, since the deflection of the cathode ray beam

is a function of the velocity of the electrons, the compensating variations in velocity must be introduced after the beam has passed through the deflecting regions. The necessary accelerating velocity is therefore impressed in the beam by potentials impressed on suitable accelerating electrodes at or near the screen.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawing, in which

Figure 1 is a diagrammatic view showing a preferred embodiment of my invention,

Fig. 2 is a graph illustrating the operation of the apparatus shown in Fig. 1, and

Fig. 3 is a diagrammatic view showing a modification of my invention.

The apparatus shown in Fig. 1 comprises a cathode ray oscillograph tube 1 of the usual type. The tube is provided with a fluorescent screen 3 onto which a stream of electrons or cathode rays are projected from a suitably heated electron source 5. In the path of the electron stream the usual anodes 7 and 9 are provided. In addition there are a plurality of sets of electrostatic deflecting plates 11 and 13.

When an electrostatic potential is impressed between the plates the cathode ray beam is spacially deflected in the direction of the field. The plates are so disposed that the deflection by one set 11 is at right angles to deflection by the other set 13. While the deflection is shown as produced electrostatically in the preferred practice of my invention, it may be produced in other ways, as for example, magnetically. The electrostatic deflecting plates are shown merely for the purpose of illustration and I do not intend to be in any way limited by the illustration, either as far as the method of deflection utilized or the geometric arrangement of the plates is concerned.

Between one pair 11 of the plates, the signal or wave under observation is impressed as an electrical potential from a suitable source 15. Between the other pair 13 a timing wave in the form of an electrical potential is impressed from a second source 17. The wave under observation may be compared by reference to the timing wave.

In the path of the cathode ray beam there is also a control element 19 which is analogous, in that it controls the magnitude of electron current, to a grid in the ordinary thermionic tube. The control element is disposed adjacent to the source 5 of electrons and control potentials are impressed thereon to vary the number of electrons as they are projected towards the screen. In addition a negative biasing potential is customarily impressed from a battery 21 between the control element 19 and the cathode 5 through a suitable resistor.

In accordance with my invention, a voltage divider 23 is connected across the source of potential 15 provided by the signal under observation. The voltage divider is grounded at an intermediate point 25 and a plurality of movable taps 27 and 29 connected thereto at intermediate points spaced from the grounded point are, in turn, connected to the anodes 31 and 33 of a full wave rectifier 35. The cathode 37 of the rectifier 35 is connected to ground through a suitable resistor 39. It is also connected to the junction point of the control electrode 19 and a resistor 41 in the control electrode-cathode circuit through a suitable capacitor 43. The latter resistor 41 is connected to ground through the biasing battery 21 and a blocking capacitor 45. The capacitor 43 is of comparatively low magnitude. The biasing battery 21 is of such negative magnitude that appreciable current flow between the control electrode 19 and the cathode 5 is prevented and the capacitor 43 connected to the cathode 37 of the rectifier 35 does not become charged with a blocking potential.

The pulsations transmitted by the rectifier 35 are of positive polarity. They are not filtered and are transmitted through the capacitor 43 to an extent dependent on the impedance of the capacitor. The impedance of the latter, on the other hand, decreases as the frequency of the pulsations increases, or more generally as the rate of change of the shifting voltages increases. Accordingly it happens that when the rate of change is high, comparatively large positive potential is impressed between the control electrode 19 and the cathode 5 and when the rate of change is small, a considerably smaller positive potential is impressed. The electrons emitted by the cathode 5 are, therefore, accelerated in proportion to the rate of change of the potential transmitted through the capacitor 43 and, therefore, in accordance with the rate of change of potential under observation. When the potential under observation is of such character that the spacial shift of the cathode ray beam is rapid, the component frequencies of the potential are comparatively high, and, therefore, the density of electrons in the cathode ray as determined by the control electrode 19 is comparatively great. When the rate of spacial shift is low, the density of the cathode ray is correspondingly less. It thus happens that the luminous intensity of regions of the cathode ray display which would appear dim by reason of the rapid shift of the beam is so increased as to equalize the visibility of the pattern.

The transmissibility of pulsations through the capacitor is illustrated graphically in Fig. 2. In this view the signal, assumed to be a sine wave, is shown as rectified as two full-line half waves 47. The corresponding potential transmitted through the capacitor 43 is shown as two broken-line half waves 49 of the same frequency as the full-line half waves. A corresponding potential of double the frequency is illustrated by four full-line half waves 51. The corresponding potential transmitted by the capacitor is correspondingly illustrated by broken lines 53. It will be noted that while the amplitudes of the original waves are equal, the amplitude of the double frequency wave transmitted is greater than the amplitude of the single frequency wave transmitted.

My invention has been shown herein as embodied in a particular system. A number of changes may be made in the system without deviating from the essence of my invention. For example, in the embodiment described, the equalization is attained by impressing on the control electrode only positive potentials of greater or less magnitude depending on the instantaneous magnitude of the signal transmitted. This has certain important advantages. Under certain circumstances, however, it may be desirable

to decrease the brightness of certain regions of the pattern in equalizing the luminosity of the pattern or to both increase and decrease the electron density. In such a case, in lieu of the positive potentials impressed on the control electrode from the signal source, positive and negative potentials are impressed. This change may be made in the operation by removing the rectifier from the apparatus and superimposing the alternating potentials derived from the signal on a suitable direct current potential in such manner that the increase and decrease of luminosity takes place in the desired manner.

It is also possible to impress the controlling waves on the control electrode through other elements than a capacitor such as the capacitor **43**. The essential requirement is that the potential transmitted to the control electrode should be substantially proportional to the frequency of the signal. The object may be accomplished by utilizing a transformer, the coupling of which varies in proportion to the frequency of the signal transmitted. If a transformer is utilized, the primary thereof is connected between the cathode of the rectifier and ground while its secondary is connected in place of the resistor in the control circuit of the cathode ray tube.

In the apparatus shown in Fig. 3, the compensation is obtained by impressing the equalizing potential in such manner that it varies the velocity of the electrons. This is accomplished by connecting capacitor **43** to electrode **100** which is located between the screen **3** and the last set of deflecting plates **13**.

Although I have shown and described a certain specific embodiment of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. The method of producing an image of uniform intensity which corresponds to a given signal with apparatus incorporating a screen, means for projecting a stream of electrons on said screen and means for shifting the end of said stream of electrons which impinges on said screen in a manner corresponding to said signal; which comprises the step of varying the density of the electrons in said stream in accordance with the velocity of shift of the end of said stream over said screen.

2. The method according to claim 1 characterized by that the speed rather than the density of the electrons is varied to compensate for variations in the velocity of shift.

3. The method of producing an image of uniform intensity which corresponds to a given signal with apparatus incorporating a screen, means for projecting a stream of electrons on said screen and means for shifting the end of said stream of electrons that impinges on said screen in a manner corresponding to said signal; which comprises equalizing the loss of intensity in the regions of the image produced by rapid shift of the end of the stream by an increase in the density of the electrons producing such regions of the image.

4. Display apparatus comprising a screen on which a display corresponding to a signal is to be produced, means for projecting a stream of electrons on said screen, means for shifting the end of said stream that impinges on said screen in accordance with said signal and means for varying the effectiveness of said stream in producing a manifestation of radiant energy substantially in direct proportion with the rapidity of the shift of the end of the stream.

5. Display apparatus comprising a screen on which a display of radiant energy corresponding to a signal is to be produced, means for projecting a stream of electrons on said screen, means for shifting the end of said stream that impinges on said screen in accordance with said signal and means for varying that property of the stream, which determines the intensity of the manifestation of radiant energy on the screen produced thereby, substantially in direct proportion to the rapidity of the shift of the end of the stream.

6. Apparatus according to claim 4 characterized by that the last mentioned means includes a conductor in the path of said stream, the potential between the conductor and the source of the stream being varied in accordance with the rapidity of the shift of the end of the stream that impinges on the screen.

7. Apparatus according to claim 4 characterized by that the last mentioned means includes a conductor in the path of said stream, the potential of the conductor relative to the source being increased in a positive sense in accordance with the rapidity of the shift of the end of the stream that impinges on the screen.

8. Display apparatus comprising a screen on which a display of radiant energy corresponding to a given signal is to be produced, means for converting said signal into an electrical disturbance, means for projecting a stream of electrons on said screen, means for coupling said electrical disturbance to said stream in such manner that the stream is shifted in space in accordance with said disturbance and additional means for coupling said disturbance to said stream in such manner that the intensity of the radiant energy display produced at any instant depends directly on the speed of the special shift of said stream at that instant.

9. Apparatus according to claim 8 characterized by that the last-mentioned means includes means for rectifying the electrical disturbance.

10. Apparatus according to claim 8 characterized by that the last-mentioned means includes a conductor in a position to electrically influence the stream, means for converting the electrical disturbance into an electrical potential and means for coupling said electrical potential between said conductor and the source of the stream.

11. Apparatus according to claim 8 characterized by that the last-mentioned means includes a conductor in a position to electrically influence the stream, means for converting the electrical disturbance into an electrical potential and means for coupling said electrical potential between said conductor and the source of the stream, said coupling means being of such character that the magnitude of the electrical potential impressed between said conductor and the source of said stream increases as the velocity of spacial shift of the stream increases.

12. Apparatus according to claim 8 characterized by that the last-mentioned means includes a conductor in a position to electrically influence the stream, means for converting the electrical disturbance into an electrical potential and a capacitor for coupling said electrical potential between said conductor and the source of the stream.

13. Apparatus according to claim 8 characterized by that the last-mentioned means includes a conductor in a position to electrically influence the stream, means for converting the electrical disturbance into a direct-current electrical potential and means for coupling said electrical potential between said conductor and the source of the stream.

14. Apparatus according to claim 8 characterized by that the last-mentioned means includes a conductor in a position to electrically influence the stream, means for converting the electrical disturbance into an electrical potential and an impedance for coupling said electrical potential between said conductor and the source of the stream, the magnitude of said impedance being directly proportional to frequency.

15. Apparatus according to claim 8 characterized by that the last-mentioned means includes a conductor in a position to electrically influence the stream, means for converting the electrical disturbance into a pulsating direct current electrical potential and a capacitor for coupling said electrical potential between said conductor and the source of the stream.

16. The method of producing an image of uniform intensity which corresponds to a given signal with apparatus incorporating a screen, means for projecting a stream of electrons on said screen and means for shifting the end of said stream of electrons that impinges on said screen in a manner corresponding to said signal; which comprises the step of varying a property of the electrons in said stream which affects the luminosity of the spot produced on the screen in accordance with the velocity of shift of the end of said stream over said screen.

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