July 27, 1937. L. E. SWEDLUND 2,088,495

ELECTRIC DISCHARGE APPARATUS

Filed Aug. 24, 1935

Fig. 1.

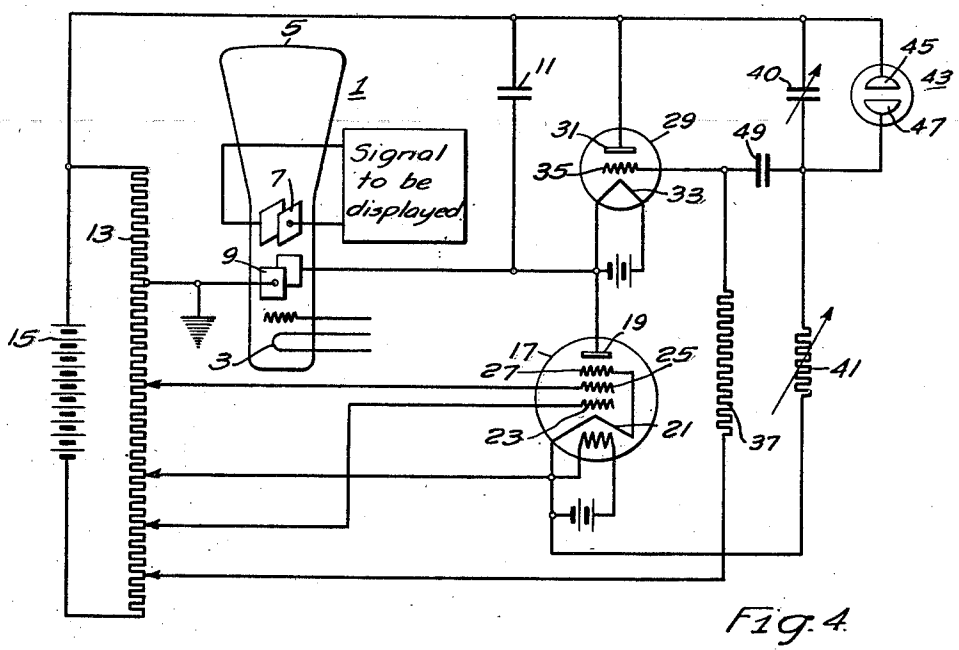


Fig. 2.

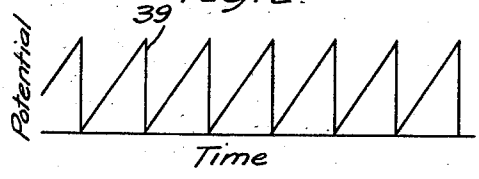


Fig. 3.

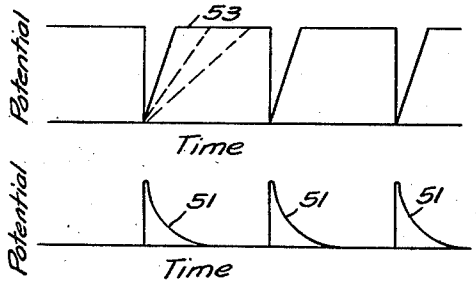


Fig. 4.



Fig. 5.

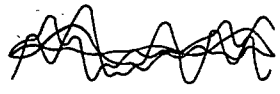


Fig. 6.



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ELECTRIC DISCHARGE APPARATUS

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My invention relates to electric discharge apparatus, and it has particular relation to apparatus in which a cathode ray stream impinging on a sensitive screen produces a radiant-energy display of a signal.

In apparatus of the type to which my invention relates, the signal may be a sound or a mechanical disturbance. It is converted into electrical energy and its properties are manifested as radiant energy variation by the deflecting effect which it produces on the cathode ray stream. So that the display corresponding to the signal may be properly observed, a timing deflection is provided for the cathode ray stream and the signal deflection is referred to the timing deflection. For proper observation, the timing deflection is, as a general rule, applied at right angles to the signal deflection. It is moreover, generally applied in such manner that the cathode ray beam is deflected by the timing impulse at a constant rate. The signal deflection is then built up along the apparent line produced by the timing impulses, and appears as an ordinary wave.

It happens at times that the signal under observation is a comparatively complicated non-recurring wave of relatively high frequency. Such a situation may exist, for example, if a non-repeating audio wave is being analyzed or observed. If, when such a signal is applied, the timing impulses shift the cathode ray at a comparatively low rate, the waves of the signal under observation will be crowded very near to each other and a confusing visual effect will be produced. The information available from such a display is too limited for complete analysis or satisfactory observation of the waves.

On the other hand, the audio wave may be spread out over the screen by providing timing impulses which shift the cathode ray stream at a comparatively high rate. In accordance with the teachings of the prior art of which I am aware, where such rapid timing impulses are provided, they succeed each other without any interval of time between impulses. Under such circumstances, by reason of persistance of vision, more than one timing wave and its superimposed signalling wave is seen by the observer and the display is more confusing even than that which results when a slow timing wave is utilized.

Somewhat the same situation occurs when the display is photographed. If the timing wave is comparatively slow, the elements of the wave under observation are confusingly close to each other; if the timing sweep is comparatively fast, the elements of the signal wave are confusingly superposed on each other.

It is, accordingly, an object of my invention to provide apparatus for analyzing a wave of comparatively high frequency that shall produce a radiant-energy display corresponding to the wave which shall show the character of the wave clearly.

Another object of my invention is to provide, in apparatus of the type incorporating a screen and a cathode ray beam to be projected onto the screen to produce a display corresponding to a signal, a timing impulse device for the cathode ray stream which shall make possible the display of a comparatively high frequency signal with such clarity as to permit analysis or observation with facility.

More concisely stated, it is an object of my invention to provide timing impulses for a cathode ray stream utilized in producing a radiant energy display of a signal on a screen, which shall so shift the cathode ray stream that a signal of even a comparatively high frequency shall appear clearly outlined on the screen.

According to my invention, the timing impulses are of such character that in the timing direction the cathode ray stream is shifted at a rate comparable to the frequency under observation. The waves of the signal under observation are, therefore, well spread out along the line produced by the timing impulses. On the other hand, confusion by super-position of the impulses is avoided by interrupting the application of the timing impulses, after a single timing impulse is applied, for an interval of time long enough to suppress the difficulties arising by reason of persistence of vision, or the characteristics of the response of a camera when the display is photographed. I have found that for practical purposes, it is not necessary that every element of a signal under observation be analyzed. It is sufficient if portions of the wave, say at intervals of $\frac{1}{10}$ second, are selected for analyzing purposes. Of course, if the whole wave is to be analyzed, a plurality of screens, each of which takes up the display of the signal in the proper timed relationship, or a cathode ray tube with a large screen, may, according to my invention, be provided.

It is conceivable that the interruption of the application of the timing impulse may be accomplished by hand; for example, by opening the timing circuit after each application of a timing impulse. However, preferably apparatus is provided to automatically accomplish this object. Such apparatus may, for example, stop the tim-

ing sweep of the cathode ray stream for, say, 1/10 second after the cathode ray beam has swept across the screen. The apparatus may be so adjusted, moreover, that the pause takes place before the stream sweeps across the screen. Alternately, the sweep circuit may be an oscillator which operates continuously but the effect of which on the cathode ray stream is cut off by a biasing potential on the control grid of a discharge device which is rendered conductive when the effect is to be cut off.

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 certain of the elements of Fig. 1;

Fig. 3 is a graph illustrating the operation of certain other elements of Fig. 1;

Fig. 4 is a copy of a photograph of an audio signal as it appears when referring to a comparatively slow timing sweep;

Fig. 5 is a copy of a photograph of the same audio signal as it appears when steep timing waves succeeding each other without intervals between waves are utilized and

Fig. 6 is a copy of a photograph of a portion of the wave shown in Fig. 4 and produced in accordance with my invention.

The apparatus shown in Fig. 1 comprises a cathode ray tube 1 of the usual type. A cathode ray stream emitted by a suitable cathode 3 and properly accelerated is projected onto a sensitive screen 5 and produces a spot of radiant energy on the screen. Preferably, the wave-length of the radiant energy is of such character that the spot is visible. However, this need not necessarily be the case. Useful results are produced even if the spot emits only ultra-violet or infra-red rays.

To produce a pattern, the cathode ray beam is deflected. For this purpose, electrostatic deflecting plates 7 and 9 are provided. Between one set of plates 7, the signal to be displayed, having been converted into electrical energy, is impressed as an electrostatic potential. Between the other set of plates 9, a timing signal is impressed also as an electrostatic potential. The plates 7 and 9 are so adjusted that the potentials are impressed at right angles to each other and cause the beam to be displaced in right angle directions. The timing potential is of such character that when subjected to it alone, the cathode ray beam moves at a uniform rate across the screen 5 in one direction. The rate of movement is, of course, such that by reason of persistence of vision, a line is seen on the screen. The deflection arising from the signal being impressed on the screen at right angles, causes lines at right angles to the timing line to be displayed on the screen. The net appearance of the phenomenon is that of an ordinary wave corresponding in frequency and amplitude to the signal.

While, as herein illustrated and described, electrostatic deflecting plates are utilized, this feature of the cathode ray tube is not an essential necessity of my invention, and the deflection may take place by magnetic means, or in any other manner.

To produce the timing potential, a capacitor 11 is connected across the timing plates 9 through a portion of the windings of a voltage divider 13. The voltage divider 13 is supplied from a direct-current source 15. The capacitor 11 is charged through a discharge device 17 of the type having an anode 19, a cathode 21, a control grid 23, a screen grid 25 and a suppressor grid 27. Potentials are impressed between the electrodes of the discharge device 17 which are of such magnitude that over a considerable range of plate potential, the current transmitted between its anode 19 and its cathode 21 is substantially independent of the plate potential. As the potential impressed between the principal electrodes 19 and 21 of the discharge device 17 varies, the current transmitted between the principal electrodes remains constant. The discharge device 17 which I preferably utilize is a Westinghouse pentode sold under the designation RJ—571.

When power is applied to the apparatus current is transmitted through the discharge device 17 to charge the capacitor 11. Since the current transmitted by the discharge device 17 remains unchanged as the potential impressed between its principal electrodes 19 and 21 varies, the difference of potential between the plates of the capacitor 11 increases at a constant rate and the impulse applied to the cathode ray stream is the so-called linear impulse.

To discharge the capacitor, an electric discharge device 29, preferably of the gas-filled type, is provided. The discharge device has an anode 31, a cathode 33 and a control electrode 35. Since it is of the gas-filled type, its characteristic is abrupt. For certain potentials impressed between the electrodes of the discharge device, it is in deenergized condition. When these potentials are changed, it becomes abruptly energized and passes considerable current until its anode-cathode potential is properly reduced. In the following discussion I shall refer to the potential impressed between the anode 31 and the cathode 33 of the gas-filled discharge device 29 as the principal potential. The potential impressed between the control electrode 35 and the cathode 33 of the discharge device 29 I shall designate as the control potential.

While a gas-filled discharge device utilized for discharging the capacitor 11 has certain advantages, it is important to note that a high vacuum discharge device may be utilized in the same relationship and my invention is in no way to be limited by the fact that I prefer to utilize a gas-filled discharge device.

Principal and control potentials are impressed on the gas-filled discharge device 29 from the voltage divider 13. On the principal potential impressed from the voltage divider the potential impressed on the capacitor 11 is superimposed. The control potential is impressed through a suitable resistor 37 which is connected to the control electrode 35 at one terminal and to the voltage divider 13 at the other. In accordance with the teachings of the prior art of which I am aware, the principal and control potentials impressed from the voltage divider 13 are so adjusted relative to the principal potential superimposed on the capacitor 11 that the discharge device 29 is abruptly energized immediately after the capacitor is charged to near its maximum difference of potential. The capacitor is then abruptly discharged and the charging and discharging process repeated. Under such circumstances, a sawtooth type wave illustrated by curve 39 in Fig. 2 is produced. As has already been explained,

such a timing wave is not suitable for detailed study of a complicated wave form of comparatively high frequency. If the timing wave 39 shown in Fig. 2 is of comparatively low frequency, the signal wave is contracted into a comparatively small space. In such a case, the wave assumes the form illustrated in Fig. 4 and detailed study thereof is substantially impossible. If, on the other hand, the timing intervals are comparatively small, the waves produced during successive intervals are superimposed on each other and the net result is similar to the confusing photograph reproduced in Fig. 5.

In accordance with my invention, the control and principal potentials impressed on the gas-filled discharge device 29 are of such magnitudes that when the capacitor 11 is charged to its maximum difference of potential, the discharge device remains deenergized. The control potential, however, is such that the discharge device is preferably on the verge of becoming energized, and only a small positive impulse of control potential is necessary to cause the discharge device to become energized. This impulse is supplied to the gas-filled discharge device 29 after a predetermined interval of time, which is appreciably longer than the time of persistence of vision.

To apply the impulse a second oscillating circuit is provided. The circuit comprises a variable capacitor 40 which is connected to a point on the voltage divider 13 through a variable resistor 41. Across the capacitor 40 a glow tube 43 is connected.

The glow tube 43 comprises a plurality of electrodes 45 and 47 immersed in a gaseous medium at a pressure of from 50 microns to several centimeters of mercury. The variable capacitor 40 is connected directly to the anode 31 of the gas-filled discharge device 29 on the one hand, and to the control electrode 35 of the discharge device through another capacitor 49, on the other hand. The glow tube 43 is normally deenergized. When the capacitor 40 is charged to a high enough difference of potential, the glow tube 43 becomes energized and the potential drop across the capacitor and the glow tube abruptly becomes small. The control electrode 35 of the gas-filled discharge device 29 is thus abruptly raised to a positive potential approaching the potential of its anode 31.

The positive impulses thus impressed between the control electrode 35 and the principal electrodes 31 and 33 of the gas-filled discharge device 29 are represented by the peak curves 51 shown in the lower graph of Fig. 3.

The timing of the positive impulses may be adjusted by varying the capacitor 40 or the resistor 41, or both. These elements are so adjusted that the positive impulses are applied a predetermined interval of time after the capacitor 11, connected across the discharge device 29, is charged to its maximum value. When these impulses are applied, the control potential of the gas-filled discharge device 29 is raised to such a value that the gas-filled discharge device becomes energized, and the capacitor connected between its anode and cathode is abruptly discharged. The resulting timing wave applied is illustrated by the curve 53 in the upper graph of Fig. 3. It is to be noted that the falling and rising portions of curve 53 occur at the same time as the potenial peaks 51.

The auxiliary oscillator is so timed that the interval between discharges of the capacitor is longer than the time of persistence of vision, and by reason thereof, a single unconfusing display is produced even for the most complicated signal. The character of the pattern which is produced is illustrated in Fig. 6. This pattern represents a portion of the complex signal shown in Figs. 4 and 5.

To illustrate my invention, I have shown and described herein a single embodiment thereof. It is apparent that many changes may be made in the apparatus without effecting the essential features of my invention. For example, the oscillators utilized may be changed materially. The principal saw-tooth oscillator, for example, may be replaced by one of the many oscillators of other types which are available. Thus, it may be replaced by a Dynatron type oscillator, or under certain circumstances, by one of the well-known feed-back oscillators. In the same manner, the auxiliary oscillator may be replaced by a Dynatron oscillator, or a feed-back oscillator of the ordinary type.

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. Apparatus for producing a radiant energy display of a signal comprising a screen, means for projecting a stream of electrons on said screen, means for shifting said stream spacially in accordance with a predetermined timing signal, and means for shifting said stream spacially in accordance with said first-mentioned signal, said timing signal producing only intermittent timing shifts of said stream, the time of shift of said stream being of the order of the frequency of the signal to be displayed and the periods between timing shifts being so long that the display produced by one timing shift leaves an impression on the eye of the observer which is independent of the display produced by a subsequent timing shift.

2. The method of producing a radiant energy display of a signal with apparatus incorporating a screen, means for projecting a cathode ray beam on said screen and means for spacially shifting said cathode ray beam in accordance with said signal, which comprises shifting said cathode ray beam with reference to a timing signal which is applied intermittently, an appreciable interval of time elapsing between successive timing signals.

3. The method of producing a radiant energy display of a signal with apparatus incorporating a screen, means for projecting a cathode ray beam on said screen and means for spacially shifting said cathode ray beam in accordance with said signal, which comprises shifting said cathode ray beam with reference to a timing signal which is applied intermittently, and the frequency of which is of the same order as the frequency of the signal to be displayed, an appreciable interval of time elapsing between successive timing signals.

4. The method of producing a radiant energy display of a signal with apparatus incorporating a screen, means for projecting a cathode ray beam on said screen and means for spacially shifting said cathode ray beam in accordance with said signal, which comprises shifting said cathode ray beam with reference to a timing

signal which is applied intermittently, an interval of time greater than the time during which an instantaneous visual image persists in the mind of the observer between successive timing signals.

5. The method of producing a radiant energy display of a signal with apparatus incorporating a screen, means for projecting a cathode ray beam on said screen and means for spacially shifting said cathode ray beam in accordance with said signal; which comprises shifting said cathode ray beam with reference to a timing signal which is applied intermittently, and the frequency of which is of the same order as the frequency of the signal to be displayed, an interval of time greater than the time during which an instantaneous visual image persists in the mind of the observer elapses between applications of the timing signal.

6. The method of producing a radiant energy display of a signal with apparatus incorporating a screen, means for projecting a cathode ray beam on said screen and means for spacially shifting said cathode ray beam in accordance with said signal; which comprises shifting said cathode ray beam with reference to a timing signal which is applied intermittently, and the frequency of which is of the same order as the frequency of the signal to be displayed, an interval of time of the order of $\frac{1}{10}$ second elapsing between applications of said timing signal.

7. In combination, means for producing a stream of electrons and means for deflecting said stream of electrons, the last said means including means for producing periodic electrical impulses of one frequency and means for producing periodic electrical impulses of a second and smaller frequency cooperating with said means for producing the impulses of the first said frequency to cause the impulses of the first said frequency to be applied effectively to said stream with the periodicity of the second frequency.

8. Apparatus according to claim 7 characterized by that the means for producing the impulses of the first frequency includes an electric discharge device having a control electrode and a plurality of principal electrodes, said discharge device being of the type having only an energized and a deenergized condition and being capable only of abrupt transition from one condition to the other, means for applying potentials to said device which vary in accordance with the first frequency, said device being on the verge of passing from one condition to the other after each operation of the last said means and the means for producing the second frequency including means for applying control potentials to said discharge device with the periodicity of the second frequency to cause said discharge device to pass from one condition to the other.

9. In combination, a plurality of terminals, a capacitor connected between said terminals, an electric discharge device having a plurality of principal electrodes and a control electrode, and means for impressing potentials between the electrodes of said discharge device normally to maintain it non-conductive, means for connecting the principal electrodes of said discharge device across said capacitor, means for gradually charging said capacitor to a difference of potential such that said discharge device is on the verge of becoming conductive, means maintaining said discharge device on the verge of becoming conductive for a predetermined interval of time, and means for supplying potentials between the control electrode and the principal electrodes of said discharge device after said predetermined interval of time to abruptly discharge said capacitor.

10. Apparatus according to claim 9, characterized by that the discharge device is of the type having an energized condition and a deenergized condition and being capable only of abrupt transition from one condition to the other.

11. The method of producing a radiant energy display of a signal with apparatus incorporating a screen, means for projecting a cathode ray beam on said screen and means for spacially shifting said cathode ray beam in accordance with said signal; which comprises shifting said cathode ray beam with reference to a timing signal which is applied intermittently, the time of shift of the cathode ray beam across the screen being of the same order as the period of the signal to be displayed, an interval of time of the order of $\frac{1}{10}$ second elapsing between applications of said timing signal.

12. In combination, a plurality of terminals, a capacitor connected between said terminals, means for gradually charging said capacitor, means for maintaining said capacitor charged for a predetermined interval of time, a discharge device having principal electrodes connected across the capacitor, means in circuit with said discharge device for maintaining said discharge device non-conductive when said capacitor is uncharged, and non-conductive but on the verge of conductivity when said capacitor is charged, and means for applying an impulse of potential to render said discharge device conductive after the interval of time during which the capacitor is to be maintained charged.

13. In combination, a plurality of terminals, a capacitor connected between said terminals, means for gradually charging said capacitor, means for maintaining said capacitor fully charged for a predetermined interval of time, means for abruptly discharging said capacitor after said interval of time together with means for producing a stream of electrons and means, to be actuated by electrical energy, for deflecting said beam, the electrical energy being supplied to said last mentioned means through the terminals across which the capacitor is connected.

14. In combination, a plurality of terminals, a capacitor connected between said terminals, means including said capacitor for producing periodic electrical impulses of one frequency at said terminals, means withholding the application of said impulses to said terminals for a predetermined time while said capacitor is fully charged and means for producing periodic electrical impulses of a second and smaller frequency cooperating with said first mentioned means for producing the impulses of the first said frequency to cause the impulses of the first said frequency to be applied to said terminals with the periodicity of the second frequency.

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