



## UNITED STATES PATENT OFFICE

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## CATHODE RAY DEVICE

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This invention relates to cathode ray devices and more specifically to cathode ray devices used for electrostatic recording and reproducing.

It is an object of this invention to provide a novel cathode ray device.

It is another object of this invention to provide a novel method of and means for the electrostatic recording and reproducing of signals.

It is a further object of this invention to provide a cathode ray device to record varying signals and a predetermined time thereafter to reproduce said signals.

In Patent No. 2,200,741 issued May 14, 1940, to Frank Gray, there is disclosed a method of electrostatically recording and reproducing signals and various apparatus for producing this result. The present invention provides a compact and simple apparatus for electrostatically recording and reproducing varying signals which is an improvement on that described in the Gray patent. A feature of the present invention is that electron beams are used to both record and reproduce the signals.

In the single embodiment of this invention, which is herein described by way of example, the cathode ray device comprises a gas tight enclosure divided into two compartments which are separated by a common target. In one compartment, a beam of electrons which is modulated by the signals to be recorded is caused to move in a curved path in succession over one end of each of a plurality of metallic elements mounted in said target to thereby cause the formation of charges thereon which are respectively proportional to the varying signal currents to be recorded. In the compartment or chamber on the opposite side of the target, a second electron beam is caused to move in a curved path over the opposite ends of the metallic elements in order to remove the charges produced a predetermined period of time before by the recording beam. The target preferably comprises a circular plate of insulating material which is pierced by the metallic elements arranged in a circle near the periphery of the plate. Between the periphery of the plate and the inside wall of the enclosure is placed a ring of metallic material which is preferably connected through a source of direct potential to the last accelerating anode of the gun structure for producing the electron beam used for the recording, and through a resistance and a source of direct potential to an electrode in the reproducing compartment which is used for collecting secondary electrons emitted from the metallic elements

when the reproducing beam moves over each of them in turn. This resistance is also connected in the input circuit of an amplifying device in the reproducing circuit. Sweep circuits are provided to cause the beam to move in circular paths over the metallic elements and a phase shifting arrangement is provided to keep the beams in synchronism but out-of-phase with respect to each other. As a modification, the metallic elements may be arranged in an ellipse and the beams caused to trace elliptical paths.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawing forming a part thereof in which:

Fig. 1 is a diagrammatic showing of a cathode ray device used for the electrostatic recording and reproducing of signals; and

Fig. 2 is a front view of the target of the device shown in Fig. 1.

Referring more particularly to the drawing, Fig. 1 shows a cathode ray device 10 comprising in general a recording tube or compartment 11 and a reproducing tube or compartment 12 separated by a target 13 which is common to both. The target 13 comprises a plate of insulating material in which is inserted therethrough a circle of metal plugs 46. An input circuit is provided for the recording tube 11, an output circuit is provided for the reproducing tube 12, and circuits are provided to cause the beam in each tube or compartment to move in a circle over the target 13 with a suitable phase displacement between the movements of the two beams.

The recording tube 11 includes an electron gun comprising a cathode 14, an anode cylinder 15, an anode plate 16, and a conducting coating 17 for forming and accelerating a beam of electrons and for focussing it into a fine spot upon the composite target 13. The cathode 14 is heated by a filament 18 which is supplied with current from a source of potential 19. The anode 15 is positively biased with respect to the cathode 14 by means of a source of direct potential 20, while the anode plate 16 and the screen 17 are positively biased with respect to the anode 15 by means of a source of direct potential 21. A source of direct potential 22 may be included in circuit between the coating 17 and a metallic ring 45 the purpose of which will be more fully described below. The intensity of the beam is modulated by means of incoming signals applied, through the coupling condenser 23, between a modulating element 24 and the cathode 14. A high resistance 25 and bias-

ing source of direct potential 26 are also included in this input circuit in the usual manner.

The reproducing tube 12 includes an electron gun comprising a cathode 30, a cylindrical anode 31, a plate anode 32, and a conducting coating 33 for forming and accelerating a beam of electrons and for focussing it into a fine spot upon the surface of the target or screen 13 remote from the recording tube 11. The cathode 30 is heated by a filament 34, which is supplied with current from a source of potential 35. The cylindrical anode 31 is positively biased with respect to the cathode 30 by means of a source of direct potential 36, while the apertured plate 32 and the conducting coating 33 are placed at a positive potential with respect to the anode 31 by means of the source of potential 37. Between the metal ring 45 which surrounds the target 13 and a secondary electron collecting electrode 60 is connected an output resistance 38 and a source of direct potential 39. The resistance 38 is coupled by means of a transformer 49 to the circuit between the grid 40 and the cathode 41 of an amplifying device 42. A biasing source of potential 43 is also included in this input circuit.

The electron beams in the tubes 11 and 12 are preferably caused to trace circular paths over the metallic plugs 46 in the composite target 13, one beam acting to form charges on one side of the target and the other beam acting a predetermined time thereafter to remove these charges. While it should be understood that separate sources for the deflecting voltages may be provided to control the movement of the cathode ray beams in the respective tubes 11 and 12, it is preferred to supply the deflecting voltages from a single source of oscillations in order to interlock the movements of the two beams. The oscillator 50 preferably supplies waves of sinusoidal form which are applied to the pairs of deflecting plates 51 and 52 of the tube or compartment 12 through a resistance 53 and a condenser 54 connected in series with the oscillator 50. These impedance elements serve as a phase splitter for obtaining quadrature voltage components of the output of the oscillator 50 which components are applied to the respective pairs of deflector plates 51 and 52.

Also connected in series with the oscillator 50 is a phase shifter 55 which may be any one of a variety of well-known forms and is preferably so constructed that the amount of the phase shift may be adjusted. The output of the phase shifter is applied across a resistance 56 and a capacity 57 connected in series. These latter impedance elements serve as a phase splitter for obtaining quadrature voltage components which are applied to the respective pairs of deflector plates 58 and 59. The value of the voltage delivered by the oscillator and the values of the resistance and capacity elements 53, 54, 56 and 57 are preferably so adjusted that the beam in the tube 11 traverses a circular path over one end of each of the metallic elements 46 and the beam in the tube 12 traverses a similar circular path over the opposite end of each of these metallic elements but a predetermined time thereafter, this time interval being determined by the amount of the phase shift produced by the phase shifter 55 and the frequency of oscillations generated by the oscillator 50.

The operation of the device shown in Fig. 1 will now be described. A cathode ray beam in the tube 11 is formed and accelerated by the

cathode 14 and the anodes 15, 16 and 17 and is focussed into a fine spot on the target 13 by means of the electron lens action of the anodes. This beam is modulated in intensity by incoming signals which are applied between the modulating element 24 and the cathode 14. The modulated beam is caused to move in a circular path successively over one end of each of the metallic elements 46 to cause the formation of charges thereon which vary in accordance with the variations in the incoming signals. If the incoming signals are voice currents, the charges formed successively on the metallic elements 46 vary in accordance with the variations in the voice of the speaker but if the incoming signals are currents from a picture transmitting or television transmitting station, the charges upon the successive elemental metallic elements 46 vary in accordance with the light-tone values of the successively scanned elemental areas of the object at the transmitting station. The charges will be held on the metallic elements 46 because of the condenser action between the elements 46 and the metallic ring 45 which ring is separated by a narrow ring of insulating material 47 from the elements 46 (see Fig. 2). If desired, the ends of the metallic elements 46 in the tube 11 may be coated with a suitable substance such as, for example, carbon to prevent or decrease secondary emission. The electrons in the beam which are not laid down on the metallic elements 46 are collected by the conducting coating 17. In the cathode ray tube or compartment 12 an electron beam is formed and accelerated by the cathode 30 and the anodes 31, 32 and 33, and is focussed into a fine spot on the target 13 by the electron lens action of the anodes. This beam is also caused to move in a circle over the ends of the metallic elements 46 remote from the tube 11 by the quadrature voltage components applied to the deflecting plates 51 and 52. Due to the action of the phase shifter 55, the beam in the tube 12 which lag behind the beam in the tube 11 by a predetermined phase angle, depending upon the amount of the phase shift produced in the device 55. In order to obtain the maximum time delay, this phase shift may amount to almost 360 degrees. The amount of time delay between the signals applied to the input circuit of tube 11 and the reproduced signals in the output circuit of tube 12 depends upon the period of time taken for one complete revolution of the beam and upon the angular amount of the phase shift produced by the device 55.

By the present theory of operation of this device, the negative charges applied to the metallic elements 46 by the beam in the tube 11 are removed by the electron beam in the tube 12 by secondary emission action. The voltages applied to the anode members in the tube 12 and the material of the metallic elements 46 are chosen so that more secondary electrons are emitted than there are primary electrons in the beam. The elements 46, for example, may be made of nickel, or they may be made of any good conducting metal and coated with a suitable alkaline earth oxide layer to enhance the emission of secondary electrons. The secondary electrons are collected by the electrode member 60, thus removing the charges from each metallic member in turn. As the charges are removed from the metallic elements 46 which are successively contacted by the beam in the tube 12, a succession of surges is set up in the resistance

38 which is representative of the incoming signals in the input circuit of the tube 11 displaced in time by a predetermined amount. The reproduced signals are amplified by the device 42 which may be, if desired, multistage, and then applied to a suitable translating device, such as a telephone receiver or a television receiving apparatus. The source of potential 39 which is connected in series with the resistance 38 between the ring 45 and the collecting electrode 60 is preferably so poled that the collecting electrode 60 is at a positive potential with respect to that of the metallic elements 46 in order to encourage secondary emission from these elements to the electrode 60. The potential of this source and of the potentials applied to the accelerating anodes are so chosen that the desired amount of secondary electrons is removed. For proper operation only those charges which are placed on the elements 46 by the electron beam in the tube 11 are removed by secondary emission in the tube 12. After the charges have been removed from the metallic elements 46 these elements remain uncharged at this original or equilibrium potential until the beam of the tube 11 passes over them again to charge them up to their new values depending upon the new signal.

It is apparent that there has been described a compact mechanism for introducing a time delay between recorded and reproduced signals in which no moving parts are used. The device is easily adjustable as the output signals may be delayed from the input signals by a time interval that can be made any fraction of the time of one revolution of the electron beam. It is suitable for frequencies much above the upper frequency limit of the telegraphphone which limit is generally of the order of 5000 cycles although the time delay of signals of higher frequency ranges will be limited by the number of metallic elements 46.

It is to be understood that this invention is not limited to the arrangement where the metallic elements are arranged in a circular path as they may be arranged in other paths, such as that of an ellipse. The sweep circuits can be adjusted to cause the beams to sweep in paths of this nature by varying the values of the resistances 53 and 56 and the capacities 54 and 57 with respect to each other to produce the required elliptical paths.

As a further modification the metallic elements may be arranged in rows and the cathode ray beam caused to scan each of these rows in turn as in the well-known television transmitting and receiving systems employing cathode ray devices. This last modification makes possible the use of a great deal more metallic elements 46 without having larger tubes. In this arrangement, the metal ring 45 is replaced by a mesh grid electrode imbedded in the insulating material of the target 13, the elements 46 being inserted between the interstices of the mesh.

Other modifications may be made in the arrangement as above described without departing from the spirit or principles of the invention as herein expressed, the scope of which is defined by the appended claims.

What is claimed is:

1. In combination, a target comprising a plate of insulating material, and a plurality of conducting portions in said insulating material, said conducting portions being arranged in a curved path, and means for generating and moving two

electron beams over said conducting portions in the same order.

2. In combination, a screen comprising an insulating plate containing a plurality of conducting portions, said conducting portions being arranged in a circular path, and means for generating and moving two electron beams over said conducting portions in the same order.

3. The combination with a conductive element having one portion thereof a poorer emitter of secondary electrons when bombarded by electrons than a second portion thereof, said element piercing an insulating member, of means for bombarding said portions alternately with electrons, and means for utilizing the secondary electrons emitted from said second portion to set up an electric current.

4. The method of varying the potential of an insulated conductive element which comprises bombarding it with electrons to impart a negative charge thereto, non-concurrently therewith bombarding it with electrons so as to set up secondary electron emission therefrom and preventing released secondary electrons from returning to said element by the application of an electric field.

5. In combination with a cathode ray device having means for generating and deflecting two electron beams, a source of oscillations, means for applying current from said source of oscillations through a resistance and capacity in series, means for applying the impedance drop across said resistance and capacity to respective pairs of deflecting plates associated with one electron beam, a phase shifting arrangement the input of which is in series with said resistance and capacity, a second resistance and capacity in the output circuit of said phase shifter, and means for applying the impedance drop of said second resistance and capacity across respective pairs of deflecting plates associated with said second electron beam.

6. A composite target comprising a layer of insulating material, a row of metallic elements arranged in a circle near the periphery of said insulating material, a carbon coating for one end of each of said metallic elements, and a metallic ring located around the periphery of said insulating material.

7. A cathode ray device for electrostatic recording and reproducing comprising two gas-tight envelopes separated by a target common to both, said target comprising a plate of insulating material pierced with a plurality of conducting elements located in a circular path near the periphery thereof, and a ring of metallic material around the periphery of said insulating plate, one of said envelopes enclosing means for generating a beam of electrons, means for modulating said beam in accordance with incoming signals, and means for deflecting said beam in a circular path over said metallic elements one by one in succession, and said second envelope enclosing means for generating a beam of electrons, and means for deflecting said beam in a circular path over the ends of the metallic element remote from said first envelope.

8. A composite target for a beam of electrons comprising a layer of insulating material, a row of metallic elements arranged in a curved path near the periphery of said insulating material, and a metallic ring located around the periphery of said insulating material.

9. A composite target for a beam of electrons comprising a layer of insulating material, a row

of metallic elements arranged in a curved path near the periphery of said insulating material, a carbon coating for one end of each of said metallic elements, a coating of a material that emits secondary electrons freely when impinged upon by primary electrons for the other end of each of said metallic elements, and a metallic ring located around the periphery of said insulating material.

10. A composite target for a beam of electrons comprising a layer of insulating material, a row of metallic elements arranged in a curved path near the periphery of said insulating material, said metallic elements being of material which is a good emitter of secondary electrons, and a metallic ring located around the periphery of the entire layer of said insulating material.

11. In combination with a cathode ray device having means for generating and deflecting two

electron beams, a source of oscillations, means for deriving from said source of oscillations deflecting voltages to apply to the means for deflecting one of said beams to cause said beams to move in a closed path, means for deriving from said source potentials to apply to the means for deflecting said second electron beam to cause said second means to be deflected in a closed path, and means for adjusting the phase of the movement of said electron beams with respect to each other.

12. In combination, a screen comprising an insulating plate containing a plurality of conducting portions, said conducting portions being arranged in an elliptical path, and means for generating and moving two electron beams over said conducting portions in the same order.

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