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M. VON ARDENNE

2,111,231

RECORDING DEVICE

Filed June 14, 1935

Fig. 1

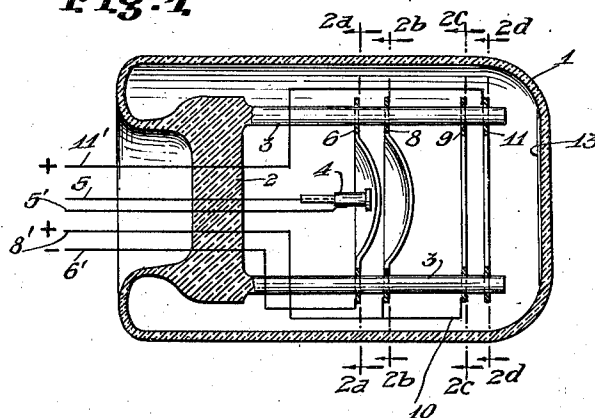


Fig. 2^a

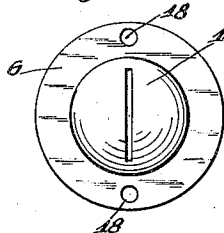


Fig. 2^b

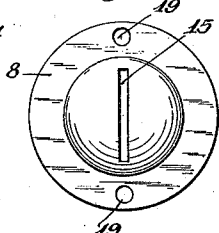


Fig. 2^c

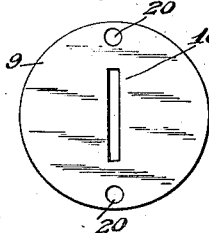


Fig. 2^d

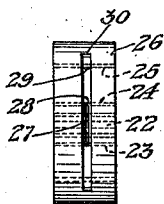
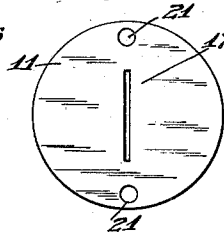


Fig. 4

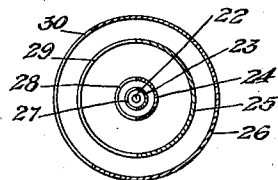


Fig. 3

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2,111,231

RECORDING DEVICE

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13 Claims. (Cl. 250—27.5)

This invention relates to recording devices, more particularly devices for photographic recording of sound and the like, and a method of operating such devices.

5 The sound recording device as described by the invention is constructed and operated according to the cathode ray oscillograph principle, such as embodied in the well known Braun cathode ray tubes as known in the art.

10 A great number of special constructions of Braun tubes have become known specially designed for sound recording purposes. In most of these devices a fluorescent line is produced upon the luminous screen of the cathode ray tube, the
15 intensity of which is varied in accordance with the vibrations such as sound vibrations to be recorded. In one construction of a recording tube of this type, the luminous line is secured by means of a filamentary cathode in connection
20 with a cylindrical lens which may be either an optical lens or a lens of the electronic type. According to another construction of recording tubes of the Braun oscillograph type, the luminous line is produced by a deflection of the cath-
25 ode ray in one direction by a high frequency sweep potential causing a luminous line upon the fluorescent screen as is well known. Other constructions of recording tubes employ diaphragms with a slit-like aperture and strong
30 magnetic fields in the vicinity of the fluorescent screen for securing a sharply defined luminous recording line.

The above and further constructions known in the art possess various disadvantages especially
35 when designed for recording sound such as for use in the talking moving picture and similar arts. These disadvantages consist primarily in a poor quality of the sound record, low light intensity, the necessity of high controlling poten-
40 tials, short life of the tube, lack of constancy of operating characteristics and difficulties in adjustment and attendance. Thus for instance, when employing deflection of the cathode ray in one direction at high frequency as mentioned
45 above, the end portions of the recording line have a higher intensity due to the longer stay of the fluorescent spot at the reversing points of the high frequency sweep potential. This disadvantage may be eliminated by screening off the
50 end portions of the recording line, with the result of a substantial loss of light or, if no screen is used, of a decrease of the possible effective control range. Moreover, tubes containing a gas filling have the disadvantage that a displacement
55 of the fluorescent line occurs simultaneously with

the intensity variations. Such displacement causes frequency variations in the case of sound recording, resulting in undesirable distortions of the sound vibrations, such as speech or musical sounds to be recorded.

On the other hand, devices employing a linear source of electron emission associated with an electron lens system to produce an image of the linear electron source upon the fluorescent screen, possess similar disadvantages of a displacement
10 of the recording line together with and dependent on the variations of the light intensity. Moreover, devices of this type have the further drawback of an uneven luminosity of the lumi-
15 nous line caused by unavoidable irregularities of the electron emission from different points of the cathode surface. Extensive experiments carried out by the inventor have proven that great difficulties are encountered in securing a uniformly illuminated line of extended and constant
20 length by means of a punctiform or linearly shaped cathode and an associated cylindrical electronic lens system. There are two substantial defects inherent in devices of this type. In the first place, the range of equal luminosity es-
25 pecially during the control in the direction to "dark" value amounts to a few millimeters only, resulting in a too narrow sound track when using the customary optical reduction. In the second
30 place, the length of the fluorescent line varies dependent on the intensity within wide limits. Thus for instance, the length of equal luminos-
ity during the control to "bright" values amounts to about five to ten times the above mentioned
35 length during the control to "dark" values. This amplitude modulation is highly undesirable as it leads to uncontrollable conditions and distortions in sound recording.

The above mentioned variations of the length of the luminous line dependent on the controlling signal intensity are primarily due to the fact that in the usual construction of the tubes the diverging angle of the electrons emitted from the cathode varies dependent on the potential applied to the control electrode. The control is usually
40 effected by means of a control electrode disposed close to the cathode and having a potential varying about a mean value, in most cases a negative potential, in a manner similar to the grid electrode in known vacuum tube amplifiers used in
45 radio and allied arts. The divergent angle of the electrons emitted from the cathode decreases with increasing negative potential of the control electrode, and vice versa the divergent angle increases
50 with decreasing negative potential of the control-
55

ling electrode. This undesired variation of the divergent angle of the electrons leaving the cathode in tubes employing a cylindrical electron lens system can be eliminated by providing a suitably constructed control electrode arranged and oriented in such a manner that divergence occurs only in a direction at right angle to the light slit in the control electrode and is substantially prevented in a direction parallel to the light slit in the control electrode. This effect can be obtained practically by using a filamentary cathode and by constructing the control element in the form of plate electrodes disposed at both sides of the cathode filament. By a proper design of the shape or marginal curves of these plates and also by using cathodes curved in a direction towards the electron lens system, it is possible to diminish the variations of the divergent angle to a substantial degree.

An object of the present invention is to provide a simple construction of a recording tube of the Braun oscillograph type for producing a fluorescent line of extended length and substantially uniform intensity. Other objects and aspects of the invention will be apparent hereafter from the detailed description thereof in connection with the accompanying drawing in which I have shown one embodiment of a recording tube constructed in accordance with the principles of the invention.

Fig. 1 of the drawing shows the recording tube in cross-section.

Figs. 2a to 2d represent side views of the separate electrodes taken on line *a-a* to *d-d*.

Figs. 3 and 4 are front and side elevational fractional views showing a modified electrode construction for a tube according to Fig. 1.

Similar reference numerals identify similar parts.

Referring to the drawing, I have shown at 1 an evacuated vessel or container such as a glass bulb of suitable size and shape having a re-entrant stem 2 and a pair of mounting rods 3 for supporting the separate electrodes within the tube. The electrons emitted from a suitable source such as the cathode 4 which may be an indirectly heated cathode of known construction, are passed through the small slit 14 of a control electrode shown at 6 disposed in close vicinity to the cathode and being of a curved or arcuate shape and having its concave side directed towards the cathode as shown. This electrode is connected to an outside terminal 6' through a suitable lead wire passed through the stem 2 of the tube and in operation is suitably biased by a negative potential and connected to the source of controlling current variations, such as the output circuit of a microphone or similar device producing electric current or potential variations to be optically recorded. The cathode may be heated by any suitable source in a known manner connected to the terminal leads shown at 5 and 5'. Opposite the control electrode 6 a further electrode 8 is arranged also provided with a narrow slot 15 substantially parallel to the slot 14 of the control electrode 6 and being also of curved or arcuate shape as shown with its concave side directed towards the cathode. The electrode 8 which serves as a first acceleration electrode is connected to another outside lead shown at 8' similar to the control electrode 6 and in operation is connected to a source of positive potential of several hundred volts in such a manner as to secure a sharply defined line upon the luminous screen 13 at the opposite end of the

tube by the conjoint action of the cylindrical electron lens system to be described presently. The special shape of the first pre-acceleration electrode 8 as described has the effect that the lines of the electric field which the electrons have to follow after leaving the cathode assume strongly divergent directions. This divergence of the field lines is independent of the potential applied to the control electrode and in the case of a tube of the approximate dimensions as shown is sufficient to cause the opening of the cylindrical electron lens formed by the electrodes 9 and 11 to be evenly and uniformly irradiated by the electron pencil. Experiments have proven this fact and shown that the diverging angle is substantially independent of the varying intensity of the electron pencil.

According to a further feature of the invention, the cathode is preferably provided with a uniformly heated flat emitting surface evenly covered with a suitable oxide or other electronically active material as indicated in the drawing. At the edges the distance of the negatively biased control electrode from the emission surface is less than in the middle due to the curvature of the control electrode, resulting in a greater effect of the accelerating field and increased electron emission at these regions. In this manner the end regions of the light line which otherwise would have a lesser luminosity will have substantial equal light intensity as the remaining portions of the line. The small distance of the control electrode from the cathode insures a high mutual conductance of the characteristic control curve thus making it possible to operate a tube of this type with very low controlling potentials of a few volts only.

The part of the electrode system described heretofore serves to produce an electron pencil of linear cross-section and of equal and uniform intensity impinged upon the electron lens system independently of the intensity variations in accordance with the controlling signal variations.

The cylindrical electron lens system in the example shown is comprised of the two further substantially disc shaped electrodes 9 and 11 arranged parallel to the electrodes 6 and 8. The electrode 9 mounted at the side of the electron source is provided with a slit 16 of a larger width than the slit 17 of the final acceleration electrode 11 mounted at the side of the fluorescent screen 13. In order to simplify the construction of the tube, the acceleration electrode 8 and the electrode 9 are conductively connected, as shown. However, it is understood that these electrodes may be provided with separate leads and separately and differently biased to suit any special requirements. The high tension anode voltage which in the case of present day sound recording devices of this type amounts to about 1500-2000 volts is applied to the final acceleration electrode 11 which is shown connected to an outside terminal lead 11'. The cylindrical electron lens system shown is constructed in accordance with an electrostatic acceleration lens. It is understood, however, that any other electron lens system or combinations of electronic lenses may be provided for practicing this invention. The image formed on the fluorescent screen corresponds to the slit of the first acceleration electrode 8.

I have shown in Figs. 3 and 4 a modified practical form of an electrode construction for a tube as described in Fig. 1 comprising a set of concentric cylindrical electrodes in place of the flat electrodes shown by Fig. 1. Item 22 repre-

sents a cylindrical cathode of known construction concentrically surrounded by a cylindrical control electrode having a horizontal slot 27 and serving a similar purpose as the electrode 6 according to Fig. 1. The remaining cylindrical electrodes 24, 25 and 26 provided with horizontal slots 28, 29 and 30, respectively, in register with the slot 27 correspond to the electrodes 8, 9 and 11 as shown by Fig. 1 and it is understood that the same effect of a radially divergent electric field is obtained with an electrode construction of this type for the object and purpose in accordance with the novel principle of this invention.

Practical experiments made with a recording tube of the type described have proven its high sensitivity and substantial independence of the length of the luminous line on the controlling light intensity as well as a complete elimination of the displacement of the luminous line which may have an extremely narrow width (in the case of dimensions corresponding to those shown in the drawing about $\frac{1}{4}$ of a millimeter). As a result of this, the luminosity is increased to such values that despite the losses in the associated lens systems arranged outside the tube less sensitive photographic emulsions may be successfully used for sound recording than was heretofore possible in the art.

While I have described my invention in its preferred embodiment, I desire it to be understood that modifications and variations may be made and that no limitations upon the invention are intended than are imposed by the scope of the appended claims.

I claim:

1. A recording device comprising an evacuated vessel, a cathode therein, a control electrode having a slit therein disposed opposite said cathode for producing an electron pencil of linear cross-section, a fluorescent screen impinged by said electron pencil, an acceleration electrode disposed close to said first electrode having a curved shape with its concave side directed toward said cathode, said acceleration electrode having a slit parallel to said first slit for passing said electron pencil.

2. A recording device comprising an evacuated vessel, a cathode therein having a flat electron emitting surface, a control electrode of curved shape and having a slit disposed close to said cathode with its concave side directed toward said cathode for producing an electron pencil of linear cross-section, a fluorescent screen impinged by said electron pencil, and means for accelerating said pencil towards said screen in uniformly diverging directions from said cathode.

3. A recording device comprising an evacuated vessel, a cathode therein having a flat electron emitting surface, a control electrode of curved shape having a slit disposed close to said cathode with its concave side directed towards said cathode, a fluorescent screen opposite said cathode, a first acceleration electrode disposed close to said control electrode having curved shape and arranged substantially parallel to said control electrode, said acceleration electrode being provided with a slit in line with said first slit, final acceleration means close to said screen.

4. In a cathode ray device, the combination of a source of electrons, an accelerating electrode disposed close to that source and having a curved shape with its concave side directed towards that source, said electrode having a slit to produce a

fan shaped electron pencil, and a luminescent screen impinged by said electron pencil.

5. In a cathode ray device, the combination of a source of electrons, an accelerating electrode disposed close to and in line with said source and having an arcuate shape with its concave side directed towards said source, said electrode having a slit to produce a fan shaped electron pencil and a luminescent screen impinged by said electron pencil.

6. A recording device comprising an evacuated vessel, a cathode therein having a flat electron emitting surface, a control electrode of curved shape having a slit and disposed opposite said cathode with its concave side directed towards said cathode, a fluorescent screen, a first acceleration electrode having a curved shape and disposed opposite and parallel to said control electrode, said acceleration electrode having a slit in line with said first slit, and an electron lens and final acceleration means between said first acceleration electrode and said screen.

7. A recording device comprising an evacuated vessel, a cathode therein having a flat electron emitting surface, a control electrode of curved shape having a slit and disposed close to said cathode with its concave side directed towards said cathode, a fluorescent screen opposite said cathode, a first acceleration electrode having a curved shape and disposed opposite and parallel to said control electrode, said acceleration electrode having a slit in line with said first slit, and an electron lens and final acceleration means comprising a pair of plates disposed between said first acceleration electrode and said screen, each of said plates having a slit in line with said first slits.

8. A recording device comprising an evacuated vessel, a cathode therein having a flat electron emitting surface, a control electrode of curved shape having a slit and disposed opposite to said cathode with its concave side directed towards said cathode, a fluorescent screen, an initial acceleration electrode of curved shape disposed opposite and parallel to said control electrode, said acceleration electrode having a slit in line with said first slit, and an electron lens and final acceleration means comprising a pair of acceleration electrodes disposed between said initial acceleration electrode and said screen, said final acceleration electrodes being provided with slits in line with said first mentioned slits, the slit in the final acceleration electrode close to said screen having a smaller width than the slit in the final acceleration electrode close to said initial acceleration electrode, and a conductive connection between said initial acceleration electrode and the final acceleration electrode adjacent to it.

9. In a device of the character described, an evacuated vessel, a source of electrons therein, means for initially concentrating the electrons emitted from said source into a flat fan shaped pencil of substantially uniform density diverging from said source, a fluorescent screen impinged by said electron pencil and electron-optical focusing arrangement comprising a pair of final acceleration electrodes disposed between said initial concentrating means and said screen and having slits in line with each other for passing said electron pencil, the slit of the acceleration electrode at the side of said screen having a lesser width than the slit of the acceleration electrode at the side of said initial concentrating means, thereby to define a luminous line of predetermined narrow width upon said screen.

10. In a device of the character described, an evacuated vessel, a source of electrons therein, an arcuate initial acceleration electrode adapted to produce a divergent field for initially accelerating and forming electrons emitted from said source into a flat fan shaped pencil of substantially uniform density, a luminescent screen arranged for impingement by the electron pencil, and an electron-optical focusing arrangement comprising a pair of final acceleration electrodes arranged between said initial acceleration electrode and said screen and having slits arranged to pass said electron pencil, the slit in the final acceleration electrode at the side of said screen having a lesser width than the slit in the final acceleration electrode at the side of said initial acceleration electrode, thereby to define a luminous line of predetermined narrow width upon said screen.

20 11. In a cathode ray device, an evacuated vessel, a cathode stream source therein, an initial electrode adapted to produce an acceleration field uniformly spreading the cathode stream from said source in divergent directions, means for segregating a flat fan shaped electron pencil from the electron stream accelerated by said field, a luminescent screen arranged for impingement by said electron pencil, and an electron-optical focusing arrangement disposed between said segregated means and said screen comprising a pair of final acceleration electrodes having slits arranged to pass said electron pencil, the slit in the final acceleration electrode at the side of said screen being of lesser width than the slit in the final acceleration electrode at the side of the cathode, thereby to define a luminous line of predetermined narrow width upon said luminescent screen.

12. In a cathode ray device, the combination of a source of electrons, means for initially forming electrons emitted from said source into a flat pencil of substantially uniform density, a luminescent screen impinged by said electron pencil, and an electron-optical focusing arrangement comprising a first acceleration electrode having a slit arranged for passing said electron pencil and at least one further acceleration electrode disposed behind said first acceleration electrode in the direction of the electron pencil, said further acceleration electrode having a slit in line with the slit of said first acceleration electrode and having a lesser width than the slit of said first acceleration electrode, thereby to define a luminous line of predetermined narrow width upon said screen.

13. In a cathode ray device, the combination of a source of electrons, means for initially concentrating the electrons emitted from said source into a flat pencil of substantially uniform density, a luminous screen impinged by said pencil and an electron-optical focusing arrangement disposed between said initial concentrating means and said screen and comprising a diaphragmatic pre-acceleration electrode having a slit arranged to pass said electron pencil and a second diaphragmatic final acceleration electrode disposed behind said pre-acceleration electrode in the direction of the electron beam, said final acceleration electrode having a slit in line with said first slit and of lesser width than said first slit, thereby to define a luminous line of predetermined narrow width upon said luminescent screen.

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