May 23, 1933. E. H. NORINDER 1,910,560

CATHODE RAY OSCILLOGRAPH

Filed Aug. 1, 1928 2 Sheets-Sheet 1

Fig. 1.

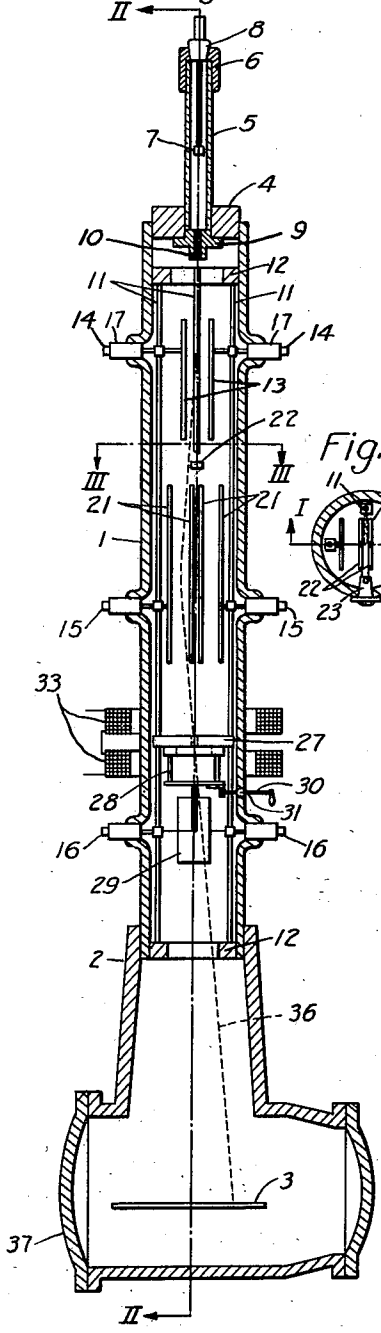
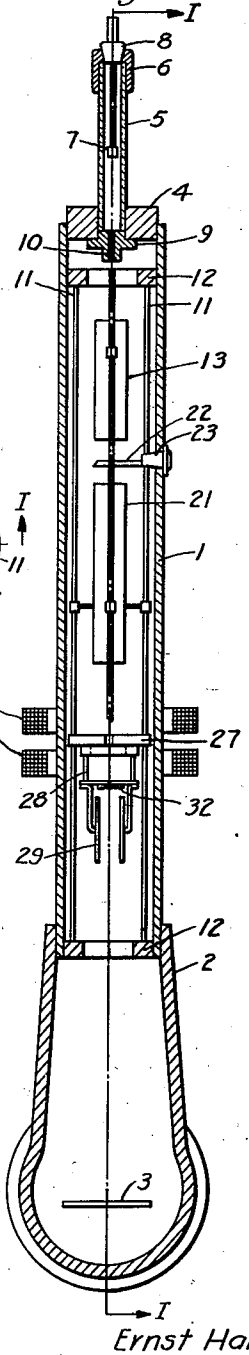


Fig. 3.

Fig. 2.



INVENTOR

Ernst Harald Norinder

BY

ATTORNEY

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Fig. 4.

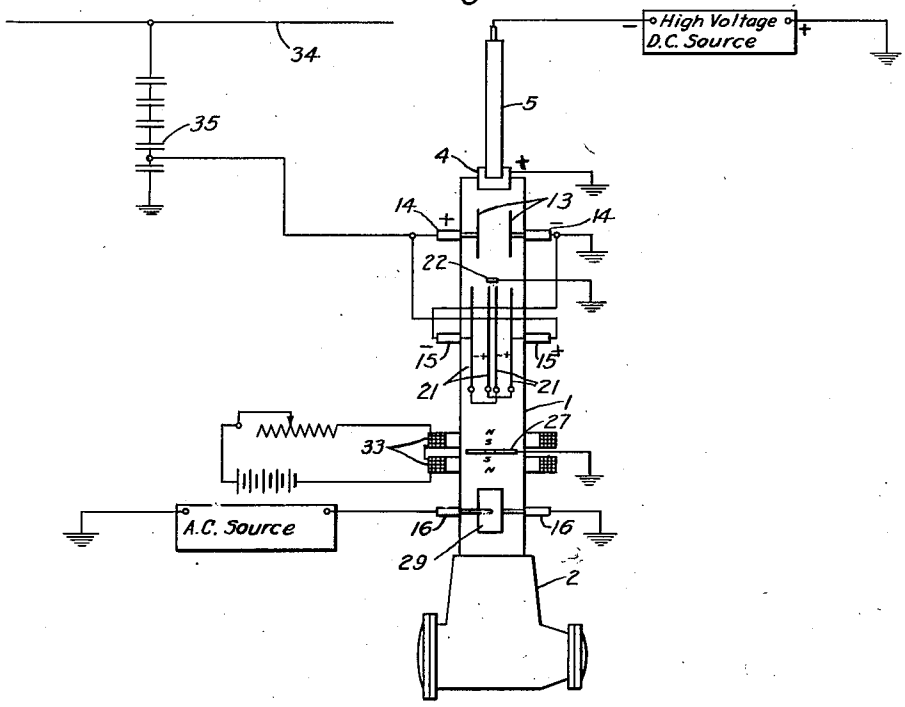


Fig. 5.

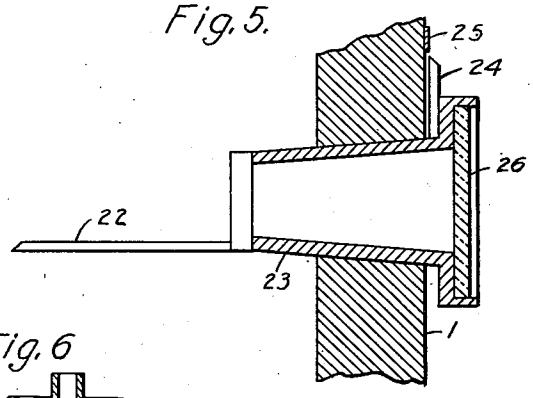
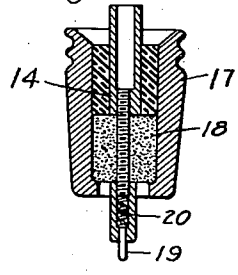


Fig. 6



INVENTOR

Ernst Harald Norinder

BY

ATTORNEY

Patented May 23, 1933 1,910,560

UNITED STATES PATENT OFFICE

ERNST HARALD NORINDER, OF UPPSALA, SWEDEN

CATHODE RAY OSCILLOGRAPH

Application filed August 1, 1928, Serial No. 296,844, and in Sweden August 9, 1927.

My invention relates to oscillographs of the type wherein the deviation of an electron jet or beam in an evacuated vessel is used for measurements of electrostatic and magnetic field variations with regard to time and amplitude.

An object of my invention is the provision of an oscillograph of the above mentioned type which shall operate automatically, in response to the occurrence of a transient condition on an electric circuit, with which it is associated, to record the magnitude of said transient condition.

A further object of my invention is to provide means for automatically operating an oscillograph of the above mentioned type in response to, and simultaneously with, the occurrence of a transient condition to be recorded.

A further object of my invention is the provision of means for preventing the electron stream from coming in contact with the recording device except upon the occurrence of a transient condition, the magnitude of which it is desired to record.

A further object of my invention is the provision of means for preventing stray electrons and secondary radiations from coming into contact with the recording device.

A further object of my invention is the provision, in an oscillographic device of the above mentioned type, of means for focusing or concentrating the electron beam with respect to the recording device.

A further object of my invention is the improvement of the deflecting system in an electron-beam oscillograph, resulting in an improved oscillograph structure which is more compact than structure heretofore employed.

In practicing my invention, I provide an elongated casing having means at one end thereof for generating an electronic beam and for projecting said beam longitudinally of the casing, and a sensitized recording surface at the other end of the casing for intercepting said beam.

A target, or shield, in disposed intermediate the ends of said casing to normally prevent the beam from coming into contact with the recording surface.

I provide further, means operative upon the occurrence of, and in accordance with the magnitude of, a transient to be recorded for deflecting said beam around said target to permit the recording of the deflection thereof. In order to facilitate the reading of the record thus obtained, the beam may also be so deflected, in a lateral direction with respect to the first deflection, that a record of the magnitude of the transient with respect to time is afforded.

In order to avoid the diffused blackening of the sensitized surface, which may occur outside the shadow region of the target, a shield, having an aperture covered by the shadow of said target, may preferably be placed below the deflecting plates, the cathode jet passing through said aperture and being then deflected by the timing means.

Other features and advantages of my invention will appear from the following description, taken in connection with the accompanying drawings, in which

Figure 1 is a view, in longitudinal section, taken on line I—I of Fig. 2, of an oscillograph, constructed in accordance with my invention,

Fig. 2 is a view, in longitudinal section, taken on the line II—II of Fig. 1.

Fig. 3 is a view, in lateral section, taken on the line III—III of Fig. 1.

Fig. 4 is a diagram of the electrical connections of an oscillograph embodying the present invention.

Fig. 5 is a detail view of the target, and

Fig. 6 is a detail view of a terminal.

Referring to Fig. 1, the apparatus comprises a metal envelope or tube 1 at the lower end of which is supported a metal casing 2 in which a suitable photographic plate or film 3 may be placed.

The upper end of the envelope 1 is closed by means of a plug 4 having a tube 5 of insulating material, such as glass, secured thereto and projecting axially from said envelope. The upper end of the tube 5 is provided with a cap 6 centrally apertured to permit the passage therethrough of the ter-

minal of a cathode 7. The cathode terminal is enlarged, as at 8, to completely close the aperture in the cap 6.

The ends of tube 5 are planished at right angles to the central axis thereof, and a suitable sealing compound may be employed to secure the several elements together. The planishing of the ends of the tube 5 facilitates the adjustment of the face of the cathode 7 at right angles to the central axis of the tube so that the electrons will move along the axis of the tube. Preferably, a cold cathode is employed, but obviously, a hot cathode may be employed, if desired.

An annode 9 is supported at the lower end of the glass tube and is provided with an axial aperture 10 so that the beam of electrons from the cathode to the anode will pass therethrough. The anode is provided, if necessary, with suitable water-cooling means.

A frame, supported inside the metal tube 1, consists of four rods 11 supported at their respective ends by rings 12. The rods 11 are preferably of metal in order to make a strong frame but may be of insulating material. Metal deflecting plates 13 are secured to the rods 11 near the upper end of the frame. The plates 13 are insulated from the rods and are connected to terminals 14 that lead to the outside of the metal tube.

Referring to Fig. 6, the terminal 14 extends through a hollow metal conical plug 17 and is supported therein and insulated therefrom by suitable insulating material 18. Electrical connection is made between the terminal and the deflecting plate by a pin 19 and a spring 20. Terminals 15 and 16 are supported in the same manner as terminal 14.

Near the middle of the frame, and, suitably secured thereto and insulated therefrom, other deflecting plates 21 are supported. The four laterally juxtaposed plates are electrically connected, in alternation, to terminals 15, so that adjacent plates of the group may be maintained at opposite values of potential. Although four plates are shown, it is possible to omit the two middle plates and have the apparatus function properly, but if this is done, the lengths of the outside plates must be considerably increased. The two middle plates are employed in order to get a more intense electrostatic field, through which the electron beam will pass, than could be obtained by the same voltage with only the two outside plates. As a result, shorter plates may be employed to get the required deflection of the electrons with the four-plate arrangement than with the two-plate arrangement. The outside plate is connected to the middle plate on the opposite side of the axis of the tube, as is shown, more particularly, in Fig. 4. The lengths of the lower deflecting plates may be approximately twice the lengths of the upper deflecting plates, but this is not a critical proportion.

A target, or shield, 22 is disposed between the two sets of deflecting plates. It will be noted that, because of the position of the target, it is necessary to bend one of the rods 11 around it. The target is shown in detail in Fig. 5 as comprising a strip of metal 22 attached to a conical metal plug 23. The plug 23 carries a pointer 24 which cooperates with a scale 25 on the outside of the envelope 1.

In order to so adjust the apparatus that the target shall be directly in the path of the undeflected electron beam, a target having fluorescent material on one face thereof is inserted into approximate position, and, since the target is eccentric, with respect to the axis of the supporting plug 23, by rotating the plug, the target may be moved across the path of the beam. When the target is properly positioned, as evidenced by a luminous spot in the center thereof, as viewed through the window 26 in the plug, the scale reading is noted, and the plug and target are removed. Another target, substantially the same as that removed, but having no fluorescent material thereon, is then substituted and rotated to the desired position, as indicated by the scale reading. This substitution may not be necessary in all cases, but is believed desirable, since the action of the electron on the fluorescent material may result in the generation of undesirable gases.

Below the second set of deflecting plates 21 is a screen or diaphragm 27 mounted on the frame. This screen is preferably of metal and need not be insulated from the supporting rods. A rotatable frame 28 depends from the lower side of the screen, and supports a pair of deflecting or timing plates 29. The plates 29 are insulated from the frame 28 and rods 11 and are electrically connected to terminals 16 projecting through the envelope 1.

Magnetic deflecting coils may be substituted for the deflecting plates shown, as is well understood.

A rod 30 carrying a pinion, is supported in the side of the metal tube by means of a conical metal plug 31. The pinion meshes with a gear-wheel 32 on the rotatable frame, so that, by turning the rod 30, the timing plates 29 may be rotated with respect to the axis of the envelope 1.

The screen 27 is provided with a central opening, the diameter of which is approximately the same as the width of the target 22. The two middle plates of the deflecting plates 21 are spaced apart such distance that their outer edges are separated by approximately the width of the target.

Two concentration, or focusing, coils 33 are preferably placed outside the metal envelope and surround the screen in order to keep the electron beam from spreading out too much to give a sharp line on the photographic plate. The coils 33 are so connected that their fields are in opposition. Preferably, the coils are connected either in series or in parallel but they may be connected to separate sources of current. Each of the coils 33 may consist of 1500 turns of wire, approximately .031 inches in diameter. However, the number of turns and size of the wire may be varied as desired. The action of a single concentration coil is fully described in the Journal of the Institute of Electrical Engineers for November, 1925, pages 1083 and 1084. If desired, both concentration coils may be placed either above or below screen 27. The concentration coils merely improve the operation of the apparatus and may be omitted entirely if desired.

The use of a single concentration coil is objectionable because it not only concentrates the beam of electrons, but also twists their plane of deflection. With a single concentration coil, therefore, it would be necessary to rotate the timing plates 29 through a rather large angle so that the curve would be shown on the plate in the manner desired, that is, with the time axis at right angles to the voltage axis.

By using a second coil having its field in opposition to the field of the first coil, a concentration action is obtained by the second coil as well as by the first coil, and, at the same time, the plane of deflection of the beam of electrons is given a twist in a direction opposite to the twist given by the first coil. Even if two coils are employed a slight adjustment of the timing plates may be necessary but the varying twist resulting from a change in cathode potential or concentration coil current is avoided.

Referring to Fig. 4, the cathode is connected to the negative terminal of a high-potential direct-current source. A potential of 45 kilo-volts is satisfactory when using a cold cathode but the potential may vary within wide limits, as is well understood. The anode is grounded. The upper deflecting plates 13 are electrically connected to the lower deflecting plates 21 and are oppositely connected with respect to them. One of the deflecting plates of each set and the target are preferably grounded.

The concentration coils are connected to a source of direct current, such as a 110 volt D. C. line. The timing plates 29 are connected to a source of alternating current, such as a tube oscillator. The oppositely connected deflecting plates 13 and 21 are connected to the source of potential to be measured and, in the drawings, they are shown as connected to a power line 34 by means of suitable high-potential condensers 35.

The operation of the circuit will now be described. A negative voltage is impressed upon the cathode which results in an electron beam shooting through the anode to be intercepted by the target. The alternating potential is next impressed on the timing plates and current is sent through the concentration coils. The voltage to be measured is then impressed upon the deflecting plates 13 and 21. The upper set of deflecting plates 13 will so deflect the beam that it will pass to one side of the target. This beam will then pass between deflecting plates 21 of the second set and be deflected by them in a direction opposite to the first deflection, as indicated by the dotted line 36 in Fig. 1. The deflected beam will then pass through the hole in the shield 27 and between the timing plates 29, and be intercepted by the photographic plate 3. The angle which the deflected beam makes with respect to the longitudinal axis of the tube depends upon the value of the voltage impressed upon the deflecting plates. Therefore, the amount which the beam is deflected, as recorded on the photographic plate, is a measure of the voltage impressed upon the deflecting plates. If a stationary plate is employed, it is necessary to employ the timing plates illustrated, as is well understood in the art.

If voltages of comparatively low frequencies are to be measured, rather than transient phenomena, it may be desirable to utilize a rotating film rather than the stationary photographic plate and the timing plates. It may also be desirable to replace condensers 35 by a transformer.

It is evident, from an inspection of either Fig. 1 or Fig. 4, that the electron beam cannot reach the photographic plate until it has been deflected around the target. It is also evident that the shield 27 will prevent stray electrons, and secondary radiations having their source at the anode opening, at the target, or at any other point in the tube, from reaching the photographic plate. For these reasons, the oscillograph may be connected to a power line in the fully operative condition, that is, with all sources of potential connected to the oscillograph terminals, ready to record any electrical disturbance that may arise. A surge, due to lightning, is an example of a disturbance it may be desired to record. Without the special shielding arrangement shown, such operation would be impossible, since the electron beam would strike the middle of the photographic plate, and, instead of merely making a line in the middle of the plate, it would cause the entire plate to become fogged in a very short time.

With the target arrangement shown, the electron beam will never reach the middle of

the plate, and no curve will be recorded on that portion. This, however, is but a small portion of the plate and corresponds to the part that would be used in a cathode ray oscillograph of the ordinary type to show the normal transmission-line voltage.

A portion of the normal line voltage, in the arrangement shown in Fig. 4, is always impressed on the deflecting plates, but its value is not great enough to cause the cathode beam to be deflected to one side of the target. The deflecting plates 13 and 21, the target 22 and the screen 27 are so adjusted with respect to each other that, for every angle of deflection sufficient to pass the beam around the target, the beam will pass through the hole in the screen.

Since the cover 37 of the casing 2 must be removed to get the photographic plate out of the apparatus, the engaging surfaces of parts 37 and 2 must be carefully ground and may be additionally treated by coating them to make the joints gas tight.

Plug 4, like the other plugs fitting into tube 1 is of conical shape to aid in making the casing gas tight.

Any of several well known pumps may be connected to the casing to keep the gas pressure at the proper value.

When using a cold cathode a gas pressure of 7 microns is satisfactory, but the pressure may vary within wide limits, as is well understood in the art.

Various modifications may be made in my invention without departing from the spirit and scope thereof, and I desire, therefore, that only such limitations shall be placed thereon as are shown by the prior art and set forth in the appended claims.

I claim as my invention:—

1. In an electrical system, a transmission line, an instrument connected to said line embodying means for generating a beam of charged particles, and means in said instrument responsive to a surge on said line to impress said beam upon a recording means.

2. In an electrical system, a transmission line, an instrument connected to said line embodying means for generating a beam of charged particles, and means operative in response to a surge on said line for impressing said beam on a recording means in accordance with the magnitude of said surge to record said magnitude.

3. In combination with a transmission line, an instrument connected to said line to automatically record a surge of energy on said line, said instrument comprising a recording means, means for generating a beam of charged particles, and means for preventing said beam from reaching said recording means until the voltage on said line reaches a predetermined value.

4. In combination with a transmission line, an instrument connected to said line to automatically record a surge of energy on said line, said instrument comprising a recording means, means for generating a beam of charged particles directed toward said recording means, means for preventing said beam from reaching said recording means until the voltage on said line reaches a predetermined value, and means for deflecting said beam into contact with said recording means in accordance with the magnitude of said voltage to record said magnitude.

5. An electrical instrument comprising means for generating a beam of charged particles, means for concentrating said beam comprising two magnetic coils, the fields of said coils being in opposition.

6. An electrical instrument comprising means for generating a beam of charger particles, two magnetic coils so mounted on the instrument that said beam passes therethrough, and means for so energizing said coils that the fields thereof are in opposition.

7. An electrical instrument comprising means for generating a beam of charged particles, means for deflecting said beam, means for concentrating said beam and for twisting the plane of said deflection, and means for further concentrating said beam and for twisting the plane of said deflection in a direction opposite to the first twist.

8. An electrical apparatus comprising a record-receiving surface and means for generating a beam of charged particles, means for preventing charged particles other than those in said beam from reaching said receiving surface, said second named means comprising a shield having an aperture therein and a target between, and in line with, said aperture and said first-named means, and a concentration coil on each side of said shield, the field of the coil on one side of said shield being opposed to the field of the coil on the other side of said shield.

9. In an electrical apparatus comprising a receiving surface and means for generating a beam of charged particles, means for preventing charged particles, other than those in said beam, from reaching said receiving surface, said second named means comprising a shield having an aperture therein and a target between and in line with said aperture and said first named means, and two concentration coils located near said shield, the field of one coil being opposed to the field of the other coil.

10. An electrical apparatus comprising means for generating a beam of charged particles, means for deflecting said beam comprising four plates in laterally juxtaposed relation with respect to the longitudinal axis of said apparatus, and means electrically connecting alternate plates.

11. An electrical apparatus comprising

means for generating a beam of charged particles which normally travel along the longitudinal axis of the apparatus, a target for intercepting said beam, means for deflecting said beam comprising a pair of plates parallel with said axis and on opposite sides thereof, a second pair of plates disposed on opposite sides of the first mentioned pair, and means electrically connecting alternate plates.

12. An electrical apparatus comprising means for generating a beam of charged particles which normally travel along the longitudinal axis of the apparatus, a target for intercepting said beam, means for deflecting said beam comprising a pair of plates parallel with said axis and on opposite sides thereof, a second pair of plates disposed on opposite sides of the first mentioned pair, means electrically connecting alternate plates, and a screen having an aperture therethrough, said parallel plates being located between said target and said screen.

13. An electrical apparatus comprising means for generating a beam of charged particles, means for deflecting said beam comprising four plates in laterally juxtaposed relation with respect to the longitudinal axis of said apparatus, said plates being electrically connected in such manner that adjacent plates are of opposite potential.

14. An electrical apparatus comprising a record receiving surface and means for generating a beam of charged particles for cooperation therewith, means for preventing charged particles other than those in said beam from reaching said receiving surface, said second named means comprising a shield having an aperture therein and a target between and in line with said aperture and said first named means, and means for adjustably mounting said target with respect to said aperture and said first named means.

15. An electrical apparatus comprising a receiving surface and means for generating a beam of charged particles, means for preventing charged particles other than those in said beam from reaching said receiving surface, said second named means comprising a shield having an aperture therein and a target between and in line with said aperture and said first named means, and means for adjustably mounting said target with respect to said aperture and said first named means, said target mounting including means permitting the viewing of said target from outside said apparatus.

16. An electrical apparatus comprising a record-receiving surface and means for generating a beam of charged particles, means for preventing charged particles, other than those in said beam, from reaching said receiving surface, said second named means comprising a shield having an aperture therein and a target between and in line with said aperture and said first named means, and means for adjustably mounting said target with respect to said aperture and said first named means, said target mounting including means permitting the viewing of said target from outside said apparatus, said target being coated with a fluorescent material.

17. A cathode-ray oscillograph comprising means for generating a beam of charged particles, means for deflecting said beam in accordance with a quantity to be measured, means for deflecting said beam in a direction transverse to said first deflection, and means for adjusting the angle said last-named means makes with said second named means.

18. A cathode-ray oscillograph comprising means for generating a beam of charged particles, means comprising pairs of electrostatically charged plates, for deflecting said beam in accordance with a quantity to be measured, means comprising an additional pair of plates, for deflecting said beam in a direction transverse to the direction of said first deflection, and means for adjusting the angular relation between said pairs of plates.

19. The combination with an electric circuit, of means operative upon the occurrence of a transient condition in said circuit for recording the magnitude thereof, said means comprising means for generating a beam of charged particles, a sensitized recording surface, a target disposed between said means and said surface in the path of said beam, and means energized in accordance with the magnitude of said transient for deflecting said beam around said target and into contact with said surface.

20. In a recording device comprising means for constantly generating a beam of electrons, a sensitized record surface in the path of said beam, means normally preventing said beam from coming into contact with said surface, and means responsive to a condition to be recorded for rendering said last-named means ineffective.

21. Electrical recording apparatus comprising means for generating a beam of energy, an obstruction in the path normally taken by said beam, a photographic surface, and means responsive to a quantity to be recorded for deflecting said beam to one side of said obstruction and against said surface.

22. A cathode-ray oscillograph for recording the instantaneous values of a disturbance in an electrical circuit comprising means for generating a beam of electrons, means for intercepting said beam so long as it is undeflected, a photographic surface, means for bending said beam around said intercepting means to permit the passage of said electrons to said photographic sur-

face, said bending means comprising two pairs of deflecting plates oppositely connected to said circuit for deflecting said beam at said photographic surface in proportion to the magnitude of said instantaneous values.

In testimony whereof, I have hereunto subscribed my name this eighteenth day of July 1928.

ERNST HARALD NORINDER.