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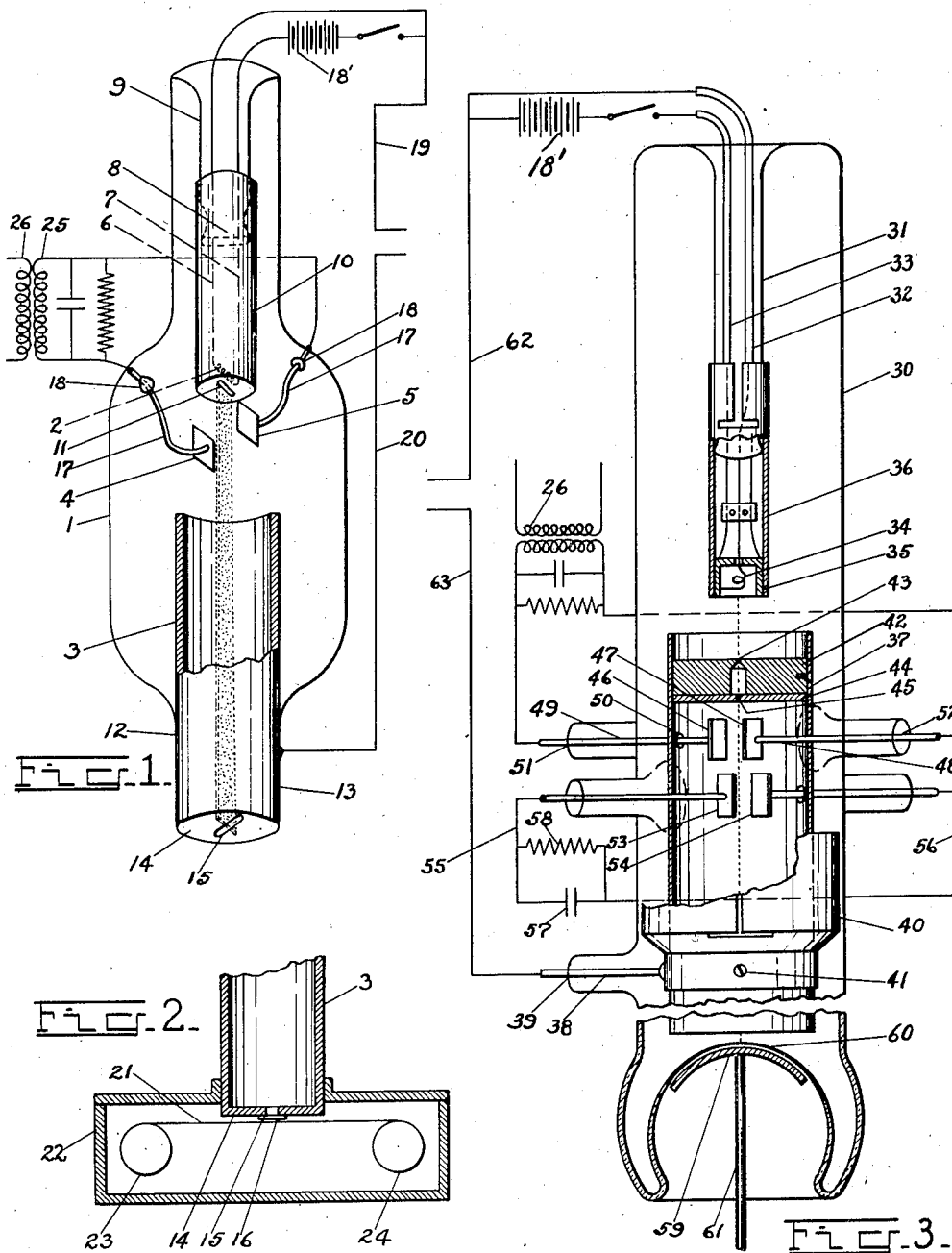
C. T. ULREY

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CATHODE RAY OSCILLOGRAPH

Filed Sept. 11, 1928

2 Sheets-Sheet 1



INVENTOR
C. T. ULREY
BY *M. J. Geze*
ATTORNEY

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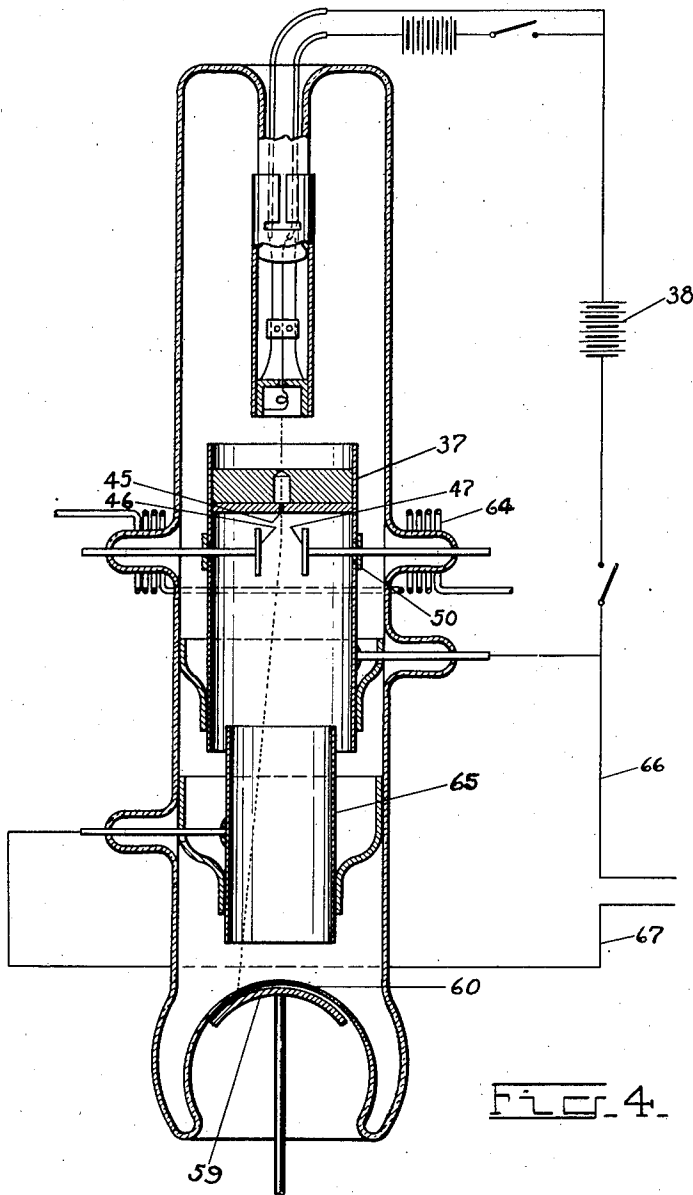


Fig. 4.

INVENTOR
C.T. ULREY
BY *M. F. Reyes*
ATTORNEY

UNITED STATES PATENT OFFICE

CLAYTON TRIDDLE ULREY, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTINGHOUSE LAMP COMPANY, A CORPORATION OF PENNSYLVANIA

CATHODE RAY OSCILLOGRAPH

Application filed September 11, 1928. Serial No. 305,295.

This invention relates to a cathode ray oscillograph and more particularly to such a device with which photographic images of the form of current and voltage variation with time, in an electrical circuit, may be obtained.

Cathode ray oscillographs employed heretofore for the determination of such current or voltage variations have been essentially of two types. In one type, a fluorescent screen is contained inside a sealed glass envelope. This construction limits the use of the oscillograph to the examination of simple wave forms, combinations of which will cause the cathode rays to trace Lissajou figures on the screen, or by the use of auxiliary devices to cause a section of a wave train to be repeated over the same path a large number of times. In another type, the wave trace is recorded on a photographic plate placed inside the apparatus but this requires the operation of the oscillograph while connected to a vacuum pump and the insertion of a plate in the evacuated device for exposure and the removal of the plate therefrom for development. This is troublesome and requires an involved exhaust procedure of the device and restricts the use of such oscillographs very greatly.

Other types of oscillographs depending upon the motion of a coil in connection with a rotating mirror or a moving photographic film to give the wave form of an electric current are not capable of recording high frequency changes in the electric current, due to the inertia of the moving parts.

The cathode ray beam will respond to the highest frequency obtainable in an electric circuit and it is one of the objects of this invention to employ this property of cathode rays to produce an oscillograph in which the cathode ray beam traces its path upon a sensitized photographic material disposed outside of the tube.

Another object is to produce a cathode ray oscillograph in which a single train of waves or other electrical variations of high frequency and of either simple or complicated form may be photographed.

In accordance with my invention I pro-

duce a cathode ray oscillograph employing a heated cathode serving as a source of electrons, and an anode cooperating therewith to produce a stream of high velocity electrons. The electron stream is deflected by an electrostatic field in accordance with the current or voltage variations being studied and a window is provided in the tube, in the path of the electron stream which, while vacuum tight, is pervious to the high velocity electrons. Externally of the tube I arrange a photographic film or other sensitized material positioned close to the window so that the beam of electrons traversing the window will trace the form of the current or voltage variations with time on the sensitized material. The photographic film may be moved to spread the wave form over the film or the oscillating cathode beam may be deflected by an electric or magnetic field to distribute the wave form over the surface of the film.

In order that the invention may be more fully understood, reference will be had to the accompanying drawings in which,

Fig. 1 is a perspective view, partly in section of a cathode ray oscillographic tube embodying my invention and employing a moving film upon which the oscillogram is traced;

Fig. 2 is a sectional view of the anode end of the device of Fig. 1 showing the film carrying container; and,

Fig. 3 is an elevation, partly in section, of an oscillographic tube employing a stationary film.

Fig. 4 is a sectional view of a modified form of oscillographic tube.

The oscillographic tube shown in Fig. 1 comprises an envelope 1 of glass containing an electron emitting cathode 2, and anode 3, and a pair of insulated parallel metal plates 4 and 5. The cathode consists of a coiled filament arranged normal to the axis of the tube and supported within the envelope by supporting wires 6 and 7 sealed in the press 8 of a reentrant glass stem 9 sealed to the bulb. A metallic sleeve 10 disposed about the supporting wires 6 and 7 and the cathode 2 has a linear slit 11 arranged adjacent the

cathode, parallel to and in line therewith so as to produce a line beam of cathode rays. The sleeve 10 is supported by the stem 9 and serves as a shield to protect the press and to prevent sparking and sharp point discharges from the cathode and cathode leads.

The anode 3 consists of a metallic cylinder sealed to the glass envelope as at 12 and having a portion 13 extending exteriorly of the envelope. The end 14 of the anode is closed and has a narrow slit 15 arranged at right angles to the slit 11.

The slit 15 is covered by a window 16 of thin material, which is pervious to cathode rays and is sealed to the anode in a vacuum tight manner.

The plates 4 and 5 are supported on opposite sides of the path of the cathode stream by supports 17 sealed through the envelope at 18.

The cathode 2 may be heated to an electron-emitting temperature by a battery 18'. When direct current of sufficient potential is applied between the cathode and anode, as by wires 19 and 20, the cathode rays originating at the cathode 2 will emerge through the slit 11 in a line beam which, when no voltage is applied to the plates 4 and 5, will be disposed centrally of the slit 15 and at right angles thereto so that a narrow concentrated beam of rays will pass through the foil and emerge into the open air. When a variable potential is applied between the plates the line or band beam will be deflected so as to move along the slit 15 in accordance with the impressed variable potential due to the electrostatic field produced between the plates 4 and 5. This will cause a concentrated beam of cathode rays to emerge from the window 16 and to fluctuate back and forth in line with the window, the amplitude of which fluctuation corresponds to the strength of the variable voltage applied to the plates 4 and 5.

A strip of sensitized photographic material 21 may be mounted in a light proof box 22 upon reels 23 and 24 so that it may be rapidly moved past the slit 15. The direction of travel of the sensitized material is at right angles to the slit 15.

Assuming, by way of example, that it is desired to measure the wave form of the output of the secondary winding 25 of a transformer 26, the ends of the secondary winding may be joined electrically to the plates 4 and 5 so as to charge up the same in accordance with the output of the transformer. If a potential is then applied between the cathode and the anode sufficiently high to produce electrons of a velocity which will penetrate the window 16, the electron stream will be deflected in accordance with the potential changes in the output of the transformer and if the sensitized strip 21 is moved rapidly past the slit 15 a permanent trace of the wave form will

be recorded. The box 22 may then be removed from the end of the oscillographic tube and the sensitized material readily removed.

The voltage between the cathode and anode required to propel the electron stream through the window 16 depends upon the thickness of the window and the density thereof. With an aluminum foil or glass window having a thickness of from .00025 to .0003 inches a potential of the magnitude of about 30,000 volts is required to cause the electron stream to pass through the window. With molybdenum foil of the same thickness much higher voltages are required, due to the much greater density of molybdenum.

The electron stream upon emerging into the atmosphere is dispersed to some extent by collision with the gas molecules in the air and in order to render the oscillogram sharp it is necessary to dispose the film 21 as close as practical to the window as, for instance, about 1 mm. In order to increase the sensitivity of the device the parallel plates 4 and 5 should be spaced close to the slit 11 so as to deflect the electron stream before it has acquired too high a velocity.

In Fig. 3 I have illustrated a form of cathode ray oscillograph which does not employ a moving film. In this modification a fine beam of cathode rays is produced and deflected or caused to oscillate in a plane in accordance with the wave form of the current under consideration and this deflected or oscillating beam is spread out uniformly with time at right angles to the plane of oscillation over the face of the photographic element.

The tube comprises an envelope 30 having a reentrant stem 31 through which the lead wires 32 and 33 for the incandescent cathode 34 are sealed. The cathode 34 is mounted within a focusing cup 35 as is usual in X-ray tube construction. The cathode may be composed of any suitable electron-emitting material but I prefer to employ either tungsten or tantalum wire.

An electrostatic shield 36 surrounds the cathode and protects the seal from puncturing. This shield may take the form of a split metal tube of nickel, Monel metal, chrome iron, etc., held in place on the reentrant stem 31 by friction. Obviously, other convenient methods of support may be devised.

The anode consists of a tube 37, preferably of copper and is provided with a leading-in conductor 38 sealed through the envelope, as at 39. The tubular anode is supported in the envelope by a split collar 40 of chrome-iron or other suitable metal which fits snugly into the glass envelope and is secured to the anode by screws 41. The tubular anode is arranged with its axis aligned with the axis of the electron stream which is directed by the focusing cup 35 centrally of the anode.

A partition 42 is disposed in the end of the anode adjacent the cathode and is provided with a central opening 43 of very small diameter for restricting the cathode streams to a narrow beam. A second partition 44 is also provided with an aligned opening 45. In tubes constructed in accordance with this modification I have employed openings 43 and 45 of .013 inches diameter and .004-.006 inches diameter respectively. The sharpness of the oscillogram is dependent upon the size of the openings.

Within the anode are placed a pair of spaced parallel plates 46 and 47. These plates are supported by stems 48 and 49 passing through insulating bushings 50 in the anode. The stems 48 and 49 are sealed through the envelope at 51 and 52 respectively. The plates 46 and 47 correspond to the plates 4 and 5 of the oscillographic tube shown in Fig. 1 and serve to deflect the cathode beam in accordance with the electrical conditions existing in the circuit under consideration, as the secondary of the transformer 26.

A second pair of parallel plates 53 and 54 are mounted within the anode at right angles to the plates 46 and 47. The plates 53 and 54 when charged oppositely, deflect the oscillating cathode beam toward the more positively charged plate and if the charge is decreased, the oscillating beam will be caused to move at right angles to the plates 53 and 54. Thus, for instance, the plates may be connected by wires 55 and 56 to a condenser 57 charged in any suitable manner not shown, so as to deflect the cathode beam towards one of the plates, as 53.

If the condenser is allowed to discharge slowly, over an interval of time, as through a resistance 58, the cathode beam will be deflected away from the plate 53, so as to trace the wave form with time on a sensitized photographic film 59 disposed externally of the tube closely adjacent the window 60.

The window 60 in this embodiment is of the type disclosed in a copending application of C. M. Slack, Serial No. 272,194, filed April 23, 1928 and entitled "Cathode ray tube". This window consists of a bulbous glass portion sealed to the envelope and of extreme thinness, as for instance, 0.00025 inches. Glass of this thinness when formed of bulbous shape, will withstand atmosphere pressure and maintain vacuum tight conditions within the device while permitting the cathode rays to pass therethrough readily at high voltages.

The photographic film 59 is shaped to correspond to the curvature of the window and is mounted on a rod 61 so that it may be held in contact with or very close to the window 60 and may be readily removed, after the exposure, for development.

The cathode 34 may be heated by battery 18' as in Fig. 1 and the voltage between the

anode and cathode may be supplied from any desired source by conductors 62 and 63.

I have shown in Fig. 4, an oscillographic tube which is more sensitive than that of Fig. 3. In this embodiment the deflecting field is caused to act upon the cathode beam before it has acquired a high velocity and the beam is subsequently accelerated so that it will pass through the window to the exterior of the tube.

In this device, a relatively low voltage is applied to the anode 37 as by means of a battery 38 so that the cathode beam emerging from the orifice 45 is of relatively low velocity and therefore more readily deflected by the parallel plates 46 and 47. In place of the deflecting plates 53 and 54 I have illustrated a deflecting coil 64 disposed externally of the envelope so as to deflect the cathode beam in a direction at right angles to the deflection caused by the plates 46 and 47. When employing such a coil the tubular anode 37 should be composed of a non-magnetic material such as copper.

Such a deflecting coil may be employed in place of either of the sets of deflecting plates shown in Figures 1 and 3.

In addition to the anode 37 I provide a second or supplemental anode, 65 to which a high potential may be applied by conductors 66 and 67 for accelerating the cathode beam to a sufficiently high velocity to penetrate the glass window 60 and trace the oscillogram on the film 59.

The supplemental anode 65 preferably extends into the anode 37 in order to shield the cathode beam from any undesired external fields which might tend to deflect the beam.

With the construction shown in each of the embodiments it is possible to obtain oscillograms of current or voltage variations of high frequency and complicated form, and to record the same on a photographic film placed outside of the tube by the direct action of the cathode rays on the film.

It is obvious, of course, that various changes and modifications may be made in the construction shown and described and I do not desire to be limited to the exact details thereof except in accordance with the appended claims.

What is claimed is:

1. A cathode ray oscillograph comprising an envelope, means therein for producing a beam of electrons of small cross section, a tubular anode, a window in said envelope in line with said beam of electrons and permeable thereto, means for deflecting said beam and means disposed externally of the envelope for directly recording the extent of the deflection of said beam.

2. A cathode ray oscillograph comprising an envelope, means therein for producing a beam of electrons of restricted cross section, an anode, a window in the envelope per-

meable to said beam of electrons and in alignment therewith, means for deflecting said beam and means disposed externally of the envelope sensitive to cathode radiations for producing an image of the path of deflection of said beam of electrons.

3. A cathode ray oscillograph comprising an envelope, means therein for producing a beam of electrons of small cross section and high velocity, an anode having a restricted opening therein in alignment with said beam of electrons, a window in the envelope permeable to said high velocity electrons, electrostatic means for deflecting said beam and means disposed externally of the envelope sensitive to cathode radiations for producing an image of the path of deflection of said beam.

4. A cathode ray oscillograph comprising an envelope, a source of electrons of high velocity therein, a tubular anode, a window in said envelope permeable to said high velocity electrons, means for projecting said electrons through said window, means within the envelope for deflecting said electrons from their normal path in accordance with electrical conditions in an external circuit and means disposed externally of said envelope sensitive to cathode radiations for recording the deflection of said electrons.

5. A cathode ray oscillograph comprising an envelope, a source of electrons of high velocity within said envelope, a tubular anode having a restricted opening therein in the path of said high velocity electrons for producing a restricted beam of cathode rays, a window in said envelope permeable to said cathode beam and in line therewith, means for deflecting said cathode beam and means externally of said envelope adjacent said window for directly recording the path of deflection of said cathode beam upon a photographic film.

6. A cathode ray oscillograph comprising an envelope, an incandescent cathode therein, a tubular anode, means for directing electrons from said incandescent cathode through said tubular anode, a window permeable to electrons, means for deflecting said electrons and means externally of said tube sensitive to cathode radiations for recording the deflection of said electrons.

7. A cathode ray oscillograph comprising an envelope, a source of electrons therein of high velocity, a tubular anode, a partition in said anode having a pair of aligned openings of small size, means for directing said electrons through said openings, a window in line with said electron stream permeable thereto, means for deflecting said electron stream and means externally of the envelope to intercept said deflected radiations and to record the extent of said deflection.

8. A cathode ray oscillograph comprising an envelope, an incandescent electron-emitting cathode therein, a tubular anode, a window permeable to cathode rays, means for directing a narrow beam of cathode rays through said window, means for deflecting said beam and means externally of said envelope adjacent said window adapted to be bombarded by said cathode rays to trace the path of deflection thereof.

9. A cathode ray oscillograph comprising an envelope, an electron emitting cathode therein, a tubular anode, a window permeable to said electrons, means for producing a restricted beam of cathode rays, means for deflecting said beam, and means disposed externally of said envelope in position to be bombarded by said beam for recording the path of deflection thereof.

10. A cathode ray oscillograph comprising an envelope, a source of electrons therein, means including a tubular anode for producing a restricted beam of cathode rays, a window in said envelope permeable to said beam in line therewith, means for deflecting said beam in accordance with conditions in an external electric circuit and means external of said window to photographically record the path of deflection of said beam.

11. A cathode ray oscillograph comprising an envelope, a source of electrons therein, an anode, means for producing a restricted beam of electrons, means for deflecting said beam, means for accelerating said beam of electrons to a high velocity, a window in line with said beam permeable thereto and means positioned adjacent said window sensitive to said cathode rays to record the path of deflection of said beam.

In testimony whereof, I have hereunto subscribed my name this 6th day of September 1928.

CLAYTON TRIDLE ULREY.