

July 13, 1943.

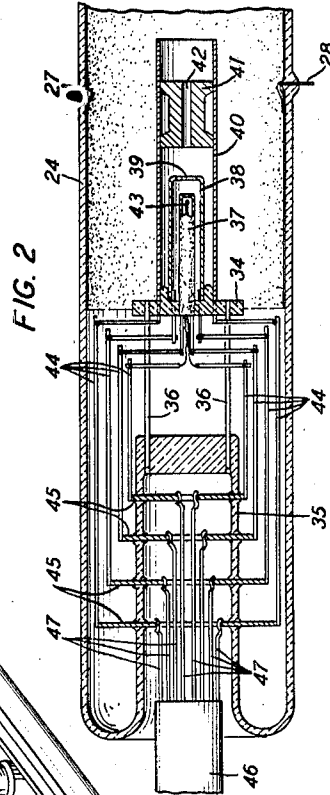
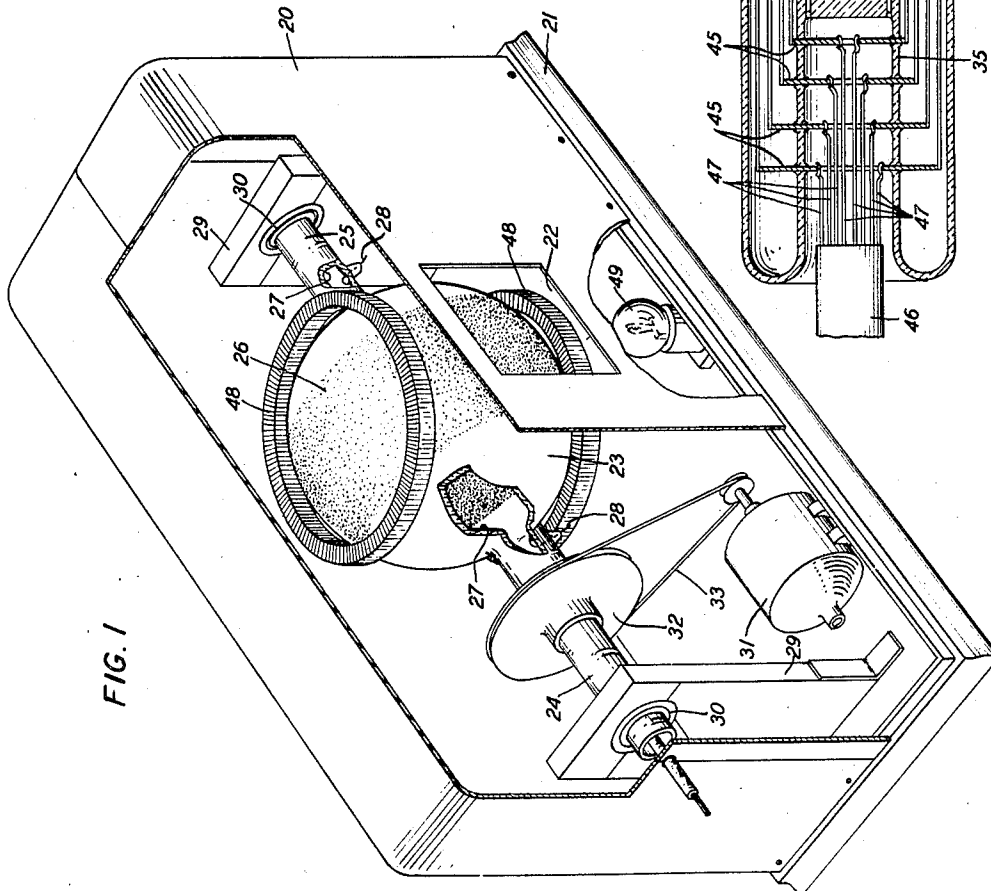
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2,324,089

ELECTRON DISCHARGE APPARATUS

Filed Dec. 9, 1941

3 Sheets-Sheet 1



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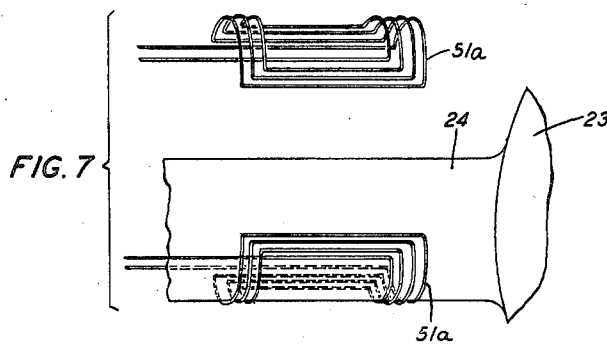
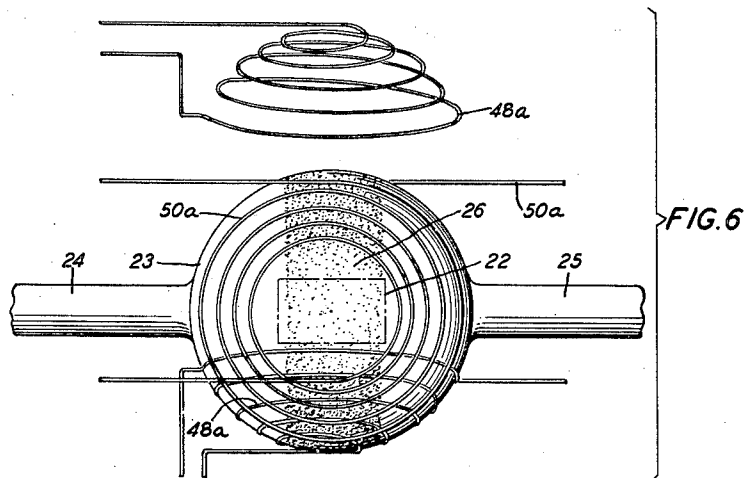
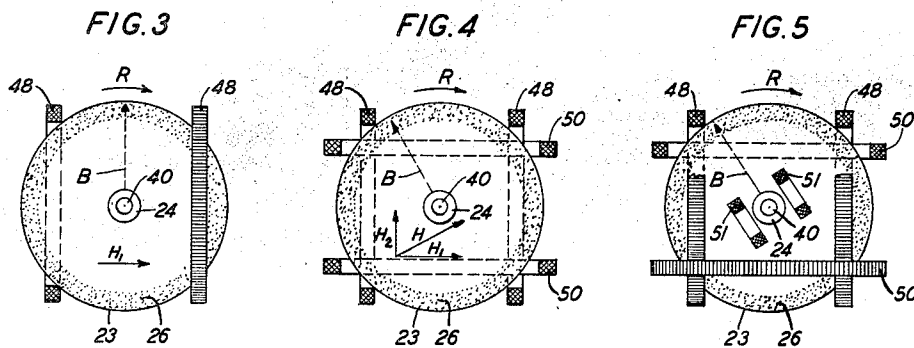
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ELECTRON DISCHARGE APPARATUS

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3 Sheets-Sheet 2



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ELECTRON DISCHARGE APPARATUS

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3 Sheets-Sheet 3

FIG. 8

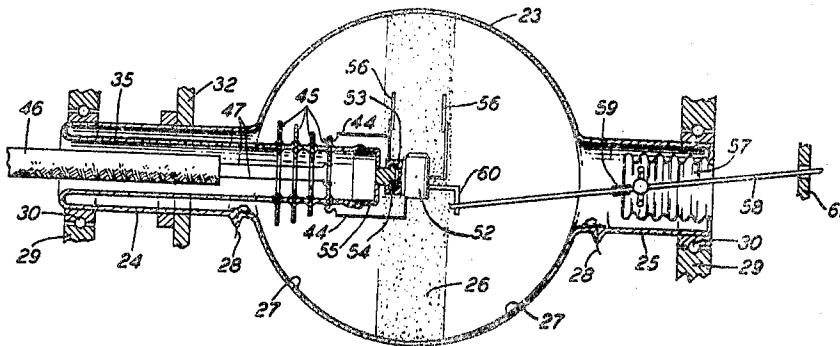


FIG. 9

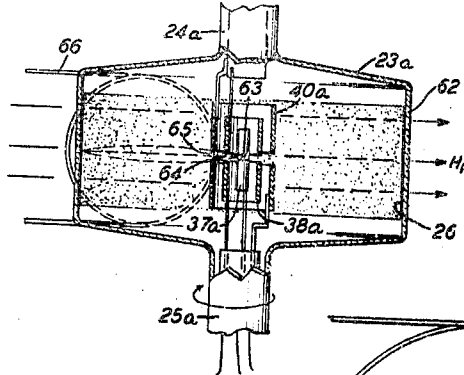


FIG. 10

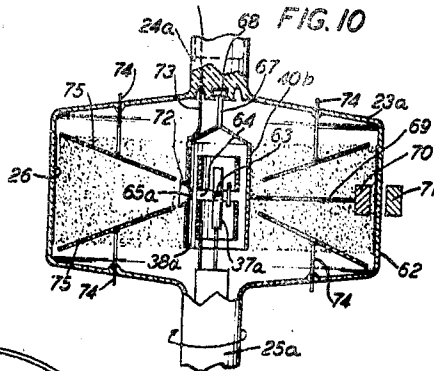


FIG. 11

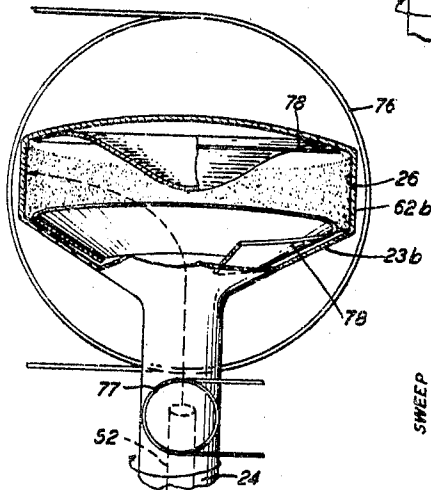
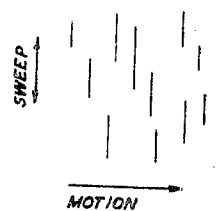


FIG. 12



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2,324,089

ELECTRON DISCHARGE APPARATUS

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Application December 9, 1941, Serial No. 422,192

13 Claims. (Cl. 250—141)

This invention relates to electron discharge apparatus and more particularly to such apparatus including an electron discharge device of the cathode ray type wherein the electron beam is subjected to varying deflecting forces to trace upon a fluorescent screen a pattern indicative of the characteristics of the deflecting forces.

In such electron discharge devices, when the beam is swept across a fluorescent screen in accordance with a varying signal, a visual pattern indicative of the forces acting upon the beam appears upon the fluorescent screen. In the case of a complex continuously varying signal, analysis of the signal by the visual pattern and coordination of the information obtainable is particularly difficult due to, among other things, the complexity of the pattern produced, the rapidity with which the pattern changes and overlapping of traces corresponding to successive transients or variations in the signal.

One general object of this invention is to improve electron discharge devices of the cathode ray type particularly adapted for the visual representation of complex signals. More specifically, one object of this invention is to enable the production of a visual pattern accurately representative of a complex signal and of a form facilitating coordination of the information conveyed thereby as to the characteristics of the complex signal.

In one illustrative embodiment of this invention, a cathode ray discharge device comprises an enclosing vessel having on a wall portion thereof a cylindrical fluorescent screen coaxial with the longitudinal axis of the enclosing vessel, an electron gun for projecting a concentrated electron stream along the longitudinal axis of the vessel, suitable means for directing the stream along a path terminating at the fluorescent screen, and a deflection system, which may be magnetic, electric or both, energizable by the signal and effective to sweep the stream across the fluorescent screen in directions parallel to the longitudinal axis thereof. The enclosing vessel is rotatable about its longitudinal axis, and the stream directing means is effective to hold the beam in a fixed plane passing through this axis, so that during operation of the device the stream sweeps across successive incremental areas of the screen and a pattern composed, for example, of discrete parallel lines or of a continuous trace, and corresponding to the signal, is produced upon the screen. Such a pattern enables coordination of the information conveyed thereby as to the characteristics of the

signal, inasmuch as segregation of the components of or transients in the signal is effected, overlapping of indicia does not occur and, because of the persistence of the fluorescent screen material, a representation of an appreciable time segment of the signal, visual for some time, is produced.

The apparatus may be employed, for example, in systems such as disclosed in the application Serial No. 438,878, filed April 14, 1942, of Ralph K. Potter, to translate sound into a fairly readily comprehensible visual pattern whereby speech may be conveyed to deaf people. It may be employed also in systems such as disclosed in the application Serial No. 438,879, filed April 14, 1942, of Ralph K. Potter, to detect and to analyze signals, for example of radio frequencies of unknown origin, frequency and character. Other applications will occur to those skilled in the art.

The invention and the various features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of electron discharge apparatus illustrative of one embodiment of this invention, a portion of the housing and of the enclosing vessel of the discharge device being broken away to show details of construction more clearly;

Fig. 2 is a view in section of a portion of the electron discharge device included in the apparatus shown in Fig. 1 illustrating the construction of the electron gun and the electrical association of the electrodes thereof with an external cable;

Figs. 3, 4 and 5 are fragmentary views, partly diagrammatic, illustrating various forms of field and deflection coils which may be associated with the electron discharge device in accordance with this invention;

Fig. 6 is an exploded perspective view showing another form of deflection coil structure which may be employed and the association of the several parts thereof with the bulbous portion of the enclosing vessel of the electron discharge device;

Fig. 7 is an exploded perspective view illustrating another deflection coil structure and the association thereof with the end of the enclosing vessel adjacent which the electron gun is mounted.

Fig. 8 is a side view mainly in section of an electron discharge device illustrative of another embodiment of this invention wherein, during

operation of the device, the enclosing vessel is rotated and the electron gun is fixed in position;

Fig. 9 is a side view mainly in section of an electron discharge device illustrative of still another embodiment of this invention wherein the fluorescent screen is concentric with the electron gun structure;

Fig. 10 is a side view mainly in section of a modification of the electron discharge device shown in Fig. 9, wherein a portion of the electron gun structure is rotatable relative to the enclosing vessel of the device and electrostatic deflection of the electron beam is employed;

Fig. 11 is a side view mainly in section of an electron discharge device illustrative of still another embodiment of this invention wherein combined magnetic and electrostatic control of the electron beam is utilized; and

Fig. 12 is a diagram showing an illustrative trace produced on the fluorescent screen in apparatus constructed in accordance with this invention.

Referring now to the drawings, the electron discharge apparatus illustrated in Fig. 1 comprises a housing 20 mounted on a base 21 and having in one wall thereof a viewing aperture or window 22, which may be rectangular as shown. Disposed within the housing 20 and supported in a manner to be described hereinafter is an electron discharge device of the cathode ray type which comprises an evacuated enclosing vessel of vitreous material having an intermediate spherical or bulbous portion 23 and axially aligned tubular end portions 24 and 25. The bulbous portion 23 is provided on its inner surface with a central annular screen or coating 26 of a fluorescent material having a moderate persistence of the order of a few seconds. A suitable material is zinc-cadmium sulphide activated by copper. In a particularly advantageous construction, the inner walls of the tubular end portions 24 and 25 and portions of the internal surface of the bulbous portion 23 are coated with a conductive film, such as colloidal graphite, commercially known under the trademark "Aquadag," indicated at 27, the conductive films terminating immediately adjacent or partly overlapping the fluorescent screen 26. Suitable potentials may be applied to the films 27 through leading-in conductors 28 connected thereto and sealed to the end portions 24 and 25.

Extending upwardly from the base 21 are a pair of supports 29 having bearings 30 for receiving the end portions 24 and 25 of the enclosing vessel and in which these portions are freely rotatable. The enclosing vessel may be rotated about its longitudinal axis by a motor 31 mounted on the base 21 and coupled to a pulley 32 secured to the end portion 24, by a band 33.

Mounted within the end portion 24 of the enclosing vessel and coaxial therewith is an electron gun which may be of the general construction disclosed in Patent 2,141,387, granted December 27, 1933, to Douglas A. S. Hale. As shown in Fig. 2, the electron gun comprises a foundation member or platform 34 of insulating material, rigidly supported from the hollow stem 35 by supports 36 embedded in the stem. Supported in coaxial relation on the platform 34 are a cathode 37, which may be of the equipotential indirectly heated type including a heater filament 43, a control electrode 38 having a central restricted aperture 39 in one end thereof and a cylindrical anode 40 having therein an insert 41 provided with a restricted central aper-

ture 42 in axial alignment with the aperture 39. The heater filament, cathode, control electrode and anode are provided with pairs of leading-in conductors 44, each pair of conductors being secured to a corresponding one of metallic, e. g., copper discs 45 hermetically sealed to and projecting through the stem 35. Associated with the discs 45, to apply the requisite potentials to the electrodes of the electron gun, is a cable 46 the conductors of which terminate in pairs of resilient contacts 47 frictionally engaging the inner edges of the discs 45.

Mounted adjacent the bulbous portion 23 of the enclosing vessel and at opposite ends of an axis parallel to the plane of the viewing aperture 22 are a pair of magnetic field coils 48.

During operation of the device, the electron gun produces a thin concentrated electron stream which is projected axially of the enclosing vessel of the device and into the bulbous portion 23 thereof where it comes under the influence of the magnetic field, normal to the projected direction of the stream, due to coils 48. The magnetic field strength and the accelerating potential effective on the stream are correlated in accordance with known principles so that the stream is deflected in a plane midway between the two coils 48 and directed along a substantially 90 degree arc to impinge upon the fluorescent screen 26 at a point thereof opposite the viewing aperture or window 22. When the tube is stationary and the current through the coils 48 is constant, a spot will appear upon the fluorescent screen 26. If, with the tube stationary, a current corresponding to a signal to be analyzed or recorded is superimposed upon the constant direct current flowing through the coils 48, the electron stream will be deflected in a plane parallel to and between the coils 48 and a line trace will appear on the screen 26 opposite the viewing window 22.

However, when the electron discharge device is rotated slowly so that the rate of travel of the fluorescent screen past the viewing window is of the order of one inch per second and the signal current is superimposed on the direct current in the coils 48, the beam will be swept across the screen, always in the same plane midway between the coils 48 and parallel thereto, and an amplitude and frequency pattern of the signal, of the general form illustrated in Fig. 12, will appear upon the screen 26 opposite the viewing aperture or window 22. Because of the persistence of the fluorescent material, the pattern corresponding to a time portion of several seconds of the signal will be visible at one time upon the screen. For example, if the signal current corresponds to speech, a frequency and amplitude pattern of one or more syllables will be visible upon the screen opposite the viewing window. Thus, the signal will be analyzed and a visual representation thereof obtained. Hence, the apparatus may be utilized to convey speech, in visible form, to deaf people. Illustrative systems for this purpose are disclosed in the aforementioned application Serial No. 438,878.

The intensity of the pattern produced upon the screen 26 will be dependent, of course, upon the current in the electron stream. Hence, if the signal source is associated with the control electrode 38 through appropriate volume control circuits, the intensity of the pattern produced upon the screen can be made to conform to the signal.

In cases where the fluorescent material has such length of persistence that the pattern does

not disappear from the screen completely in one revolution of the device, there may be provided within the housing 20 a source of infra-red light, such as a lamp 49, effective to erase the pattern from the screen after the pattern passes opposite the viewing window 22.

The apparatus may be utilized also to detect and to present a visual picture of radio signals within a particular band of frequencies as described in the aforementioned application Serial No. 438,879.

As indicated in Fig. 3, wherein the direction of rotation of the device is indicated by the arrow R and the direction of the magnetic field due to the coils 48 is indicated by the arrow H_1 , in the construction illustrated in Fig. 1, the beam, indicated by the arrow B, is swept in a plane midway between the coils 48. Consequently, the trace produced on the screen 26 is visible through the window 22 for a period equal to the time required for one half the length of the screen between the two coils to pass by the window. The period throughout which the trace is visible through the window 22 may be increased by employing two sets of coils as illustrated in Figs. 4 and 5.

As shown in Figs. 4 and 5, the second pair of coils 50 is mounted at right angles to the coils 48 to produce a field H_2 at right angles to the field H_1 and of such intensity relative to the field H_1 that the beam B strikes the screen 26 immediately adjacent one of the coils 48. The resultant of the fields H_1 and H_2 is indicated by the arrow H, to which the plane of the beam becomes normal.

The beam may be swept across the screen 26, in a plane normal to the plane of the drawings, in accordance with the signal to be detected or analyzed by superimposing the current corresponding to the signal upon the constant direct current in the coils 48 and 50. Alternatively, the beam may be thus deflected by supplying the signaling current to a pair of coils 51 mounted adjacent the end portions 24 of the enclosing vessel and on opposite sides of and parallel to the plane of deflection of the beam B so that the field thereof is in the relation to the fields H_1 and H_2 indicated by the arrow H in Fig. 4.

A particularly advantageous construction for the field coils is illustrated in Fig. 6, wherein each of the coils 48a and 50a is substantially hemispherical and fitted about the bulbous portion 23 of the enclosing vessel, the several coils being wound to have uniform turn density in the direction of their depth, to produce a uniform field, and being of such depth and so spaced as not to overlap the boundaries of the window 22, indicated in phantom in Fig. 6.

A particularly advantageous construction for the deflecting coils is shown in Fig. 7, wherein each of the coils 51a is substantially semicylindrical and conforms to the portion 24 of the enclosing vessel.

In all of the constructions shown and described hereinabove, it will be understood that the coils are fixedly mounted and so related to the enclosing vessel of the electron discharge device that the device may rotate freely.

In the electron discharge device illustrated in Fig. 8, the movement of the fluorescent screen relative to the electron beam to produce the time axis is effectuated by rotating the screen relative to the electron gun structure and the beam is swept across the screen electrostatically. The electron gun, designated as a whole by the nu-

meral 52, is of the construction shown in Fig. 2 and is positioned centrally within the bulbous portion 23 of the enclosing vessel of the device. The gun as a unit is affixed to a support 53 rotatably fitted on a bearing 54 extending from a cap 55 hermetically sealed to the stem 35. Mounted adjacent the electron egress end of the gun and mechanically integral with the gun are a pair of deflector plates 56. Electrical connection to the deflector plates and to the electrodes of the gun is established through pairs of conductors 44 which frictionally engage the discs or slip rings 45 and resilient conductors 47 which also frictionally engage the discs or slip rings 45. For simplification of the drawing only one pair of conductors 44 has been shown in Fig. 8 although it will be understood that a number of pairs, one for each of the electrodes and deflector plates, are provided in the device.

The end portion 25 of the enclosing vessel has hermetically sealed thereto a flexible metallic closure or bellows 57 through which a lever 58 extends, the lever being sealed hermetically to the bellows as indicated at 59. One end of the lever is fixed to a rigid bracket or finger 60 extending from the electron gun and the other end thereof is fixed in an aperture in a plate 61 rotatable together with the enclosing vessel of the device.

During operation of the device illustrated in Fig. 8, the voltage corresponding to the signal to be analyzed or delineated is impressed between the deflector plates 56 and the enclosing vessel and the plate 61 are rotated, as by a motor coupled to the pulley 32 affixed to the end portion 24 of the enclosing vessel. The electron gun, it will be appreciated, is held in a fixed position so that the screen 23 rotates with respect thereto and a trace, presenting an amplitude and frequency pattern of the signal impressed between the deflector plates, is produced upon the fluorescent screen.

The electron discharge device illustrated in Fig. 9 comprises an enclosing vessel mounted, as in the manner illustrated in Fig. 1, to be freely rotatable about its longitudinal axis and including a central bulbous portion 23a having a cylindrical wall 62 and axially aligned end portions 24 and 25. The inner surface of the cylindrical wall 62 is coated with a fluorescent screen 26. Mounted within the enclosing vessel and coaxial therewith is an electron gun structure comprising a cathode 37a having a restricted emissive surface in the form of an annular band 63, a control electrode 38a having an annular opening 64 in alignment with the emissive band 63 and an anode 40a having an annular opening 65 in alignment with the opening 64. A suitable magnet structure, of either the permanent or electromagnet type, not shown, is provided for producing a magnetic field, indicated by the arrows H_1 , normal to the longitudinal axis of the device, the field serving to focus the electrons emanating from the gun into two diametrically opposite electron beams. A pair of coils 66 are mounted adjacent opposite ends of the bulbous portion 23a to produce a field normal to the field H_1 and to the plane of the drawing and, when energized in accordance with the signal to be analyzed or delineated, produce a magnetic field, indicated by the arrow H_2 , normal to the magnetic field H_1 and effective to deflect one of the electron streams in directions parallel to the longitudinal axis of the device. When the device is rotated and the coils 66 are energized in accordance with

the signal, the electron stream subjected to the deflecting field will produce a trace on the screen 26 visually depicting a frequency and amplitude pattern of the signal.

In the modification of the device shown in Fig. 9, illustrated in Fig. 10, the anode 40b is supported by a rod 67 rotatably pivoted as indicated at 68 and is provided with an arm 69 having a magnetic head 70 adjacent which there is mounted an external magnet 71. The anode is provided with a restricted aperture 65a and with a guiding or focussing lip 72 adjacent the aperture 65a. Electrical connection to the anode is established through a brush 73. Mounted in coaxial relation with the anode, as by supports 74 sealed in the ends of the bulbous portion 23a, two of the supports serving as leading-in conductors as shown, are a pair of annular dished deflector plates 75.

During operation of the device, the signal to be analyzed or delineated is impressed between the deflector plates 75 and the device is rotated as in the constructions described heretofore. Because of the attraction between the external magnet 71 and the magnetic head 70, the anode will be held stationary and there is thus produced a single, concentrated electron stream emanating from the aperture 65 and producing upon the screen 26 a trace representative of the amplitude and frequency pattern of the signal.

In the electron discharge device illustrated in Fig. 11, the enclosing vessel is rotatable as in the devices described hereinabove and comprises a neck portion 24 and an enlarged head portion 23b having a cylindrical wall 62b, the inner surface of which is coated with a fluorescent screen 26. Mounted within the neck portion 24 is an electron gun 52, which may be of the construction illustrated in Fig. 2, for projecting a concentrated electron stream axially of the neck portion 24. Adjacent the enclosing vessel and spaced therefrom to allow rotation of the vessel are magnetic coils 76 and 77. Within the head portion 23b are a pair of circular dished deflector plates 78 having their peripheries adjacent the boundaries of the fluorescent screen 23.

The magnetic coil 76 produces a field effective to bend the electron stream along an arc of substantially 90 degrees, the stream path being indicated by the dotted line in Fig. 11. The current corresponding to the signal to be analyzed or delineated is supplied to the coil 77 whereby there is superimposed upon the field due to the coil 76, a field corresponding to the signal so that the beam is deflected accordingly in directions parallel to the longitudinal axis of the enclosing vessel of the device.

A potential corresponding to the signal may be impressed between the deflector plates 78 to produce an electron field of such direction, i. e., in the plane of the beam deflection due to the magnetic field produced by the coil 77, as to either augment the deflection due to the latter field or to oppose it. In the former case, the electric field due to the deflector plates 78 would be effective to cause the electron stream to strike the fluorescent screen at substantially right angles; in the latter case this electric field would be particularly effective to reduce distortion of the trace due to the large bending of the beam by the magnetic field. In any case, when the device is rotated and the signal impressed upon the coil 77 and the deflector plates 78, a pattern indicative of the amplitude and frequency of the signal is produced on the fluorescent screen.

It will be understood that in all of the embodiments shown in Figs. 8 to 11, inclusive, the pattern produced upon the fluorescent screen may be made to conform also in intensity to the signal by associating suitable volume control circuits with the control electrode, as described in connection with the embodiment of this invention illustrated in Fig. 1.

Reference is made of the application Serial No. 422,194, filed December 9, 1941, of Ralph K. Potter wherein a related invention is disclosed and claimed.

Although several specific embodiments of the invention have been illustrated and described, it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. Electron discharge apparatus comprising a fluorescent screen, means for projecting an electron stream parallel to the face of said screen and in proximity thereto, means for directing said stream along an arcuate path terminating at said face and located in a fixed plane passing through said screen, means mounting said screen with said face thereof in fixed relation to said electron stream projecting means, means for deflecting said stream in said plane to thereby shift the terminus of said stream upon said face, and means for moving said screen to pass successive incremental areas of said face across said plane in the direction at substantially right angles to the direction of deflection of said stream.

2. Electron discharge apparatus comprising a cylindrical fluorescent screen, means for projecting an electron stream along the longitudinal axis of said screen, means mounting said electron stream projecting means and said screen in fixed relation to one another, means for directing said stream along an arcuate path terminating at said screen and lying in a fixed plane parallel to the longitudinal axis of said screen, means for deflecting said stream in said plane to thereby sweep said beam across said screen parallel to said axis, and means for rotating said screen about said axis.

3. Electron discharge apparatus comprising a cylindrical fluorescent screen, means including an electron gun for projecting an electron stream in the direction of the longitudinal axis of said screen, magnetic means maintaining said stream in a fixed plane and directing said stream against said screen, means for deflecting said stream in said plane, and means for rotating said screen and said gun about said longitudinal axis.

4. Electron discharge apparatus comprising a hollow member having a cylindrical fluorescent screen on the inner wall thereof, means for projecting an electron stream within said member including an electron gun coaxial with said screen and opposite one end thereof, means for rotating said screen about its longitudinal axis, means for directing said stream to impinge upon said screen including means producing a magnetic field adjacent said screen and normal to said axis, and means for modulating said field to sweep said stream across said screen.

5. Electron discharge apparatus comprising an enclosing vessel having a bulbous portion, means for rotating said portion about an axis thereof, an annular fluorescent screen on said bulbous portion and concentrically encompassing said axis, means for projecting an electron stream into

said portion along said axis, means for fixing said stream in a plane passing through said axis and directing said stream to impinge upon said screen, and means for deflecting said stream in said plane to sweep across said screen.

6. Electron discharge apparatus comprising an enclosing vessel having a bulbous portion and a cylindrical portion extending outwardly from and along an axis of said bulbous portion, an electron gun within said cylindrical portion for projecting an electron beam along said axis into said bulbous portion, a cylindrical fluorescent screen within said bulbous portion and concentrically encompassing said axis, means for producing a magnetic field within said bulbous portion and at substantially right angles to said axis, means for deflecting said beam in a plane passing through said axis, and means for rotating said vessel about said axis, said screen being rotatable with said vessel.

7. Electron discharge apparatus in accordance with claim 6 wherein said magnetic field producing means comprises two pairs of coils symmetrically mounted about said bulbous portion and the coils of each pair are at substantially right angles to those of the other.

8. Electron discharge apparatus in accordance with claim 6 wherein said stream deflecting means comprises a pair of coils on opposite sides of said cylindrical portion and having their axes substantially normal to said plane.

9. Electron discharge apparatus comprising an enclosing vessel having an axis, a cylindrical fluorescent coating on an inner wall portion of said vessel and encompassing said axis, an electron gun within said vessel for projecting an electron stream at an angle to said axis and toward said screen, said vessel being rotatable with respect to said gun, means for rotating said vessel about said axis, means holding said gun in fixed position

when said vessel is rotated, and means for sweeping said stream across said screen.

10. Electron discharge apparatus comprising an enclosing vessel having a bulbous portion and a stem extending into said bulbous portion along an axis thereof, a fluorescent screen on said bulbous portion and encompassing said axis, an electron gun mounted on said stem in rotatable relation thereto for projecting an electron stream toward said screen, means for sweeping said stream across said screen, means for rotating said vessel about said axis, and means for holding said gun fixed in position when said vessel rotates.

11. Electron discharge apparatus comprising an enclosing vessel having a cylindrical fluorescent coating on an inner wall portion thereof, means for rotating said vessel about the longitudinal axis of said coating, means for projecting an electron stream normal to said axis and toward said coating including an electron gun mounted centrally with respect to said coating, means for producing a magnetic field fixed in the direction of and along the electron path between said gun and said stream, and means for deflecting said stream in directions normal to said path and parallel to said axis.

12. Electron discharge apparatus in accordance with claim 3 wherein said magnetic means comprises two pairs of coils adjacent said screen and related to produce crossed magnetic fields.

13. Electron discharge apparatus in accordance with claim 5 wherein said third means comprises two pairs of coils mounted about said bulbous portion, the coils of each pair being at right angles to those of the other pair, and each pair being mounted to produce a magnetic field at substantially right angles to said axis.

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