July 16, 1946. R. K. POTTER 2,403,996

ELECTRON DISCHARGE APPARATUS

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FIG. 1

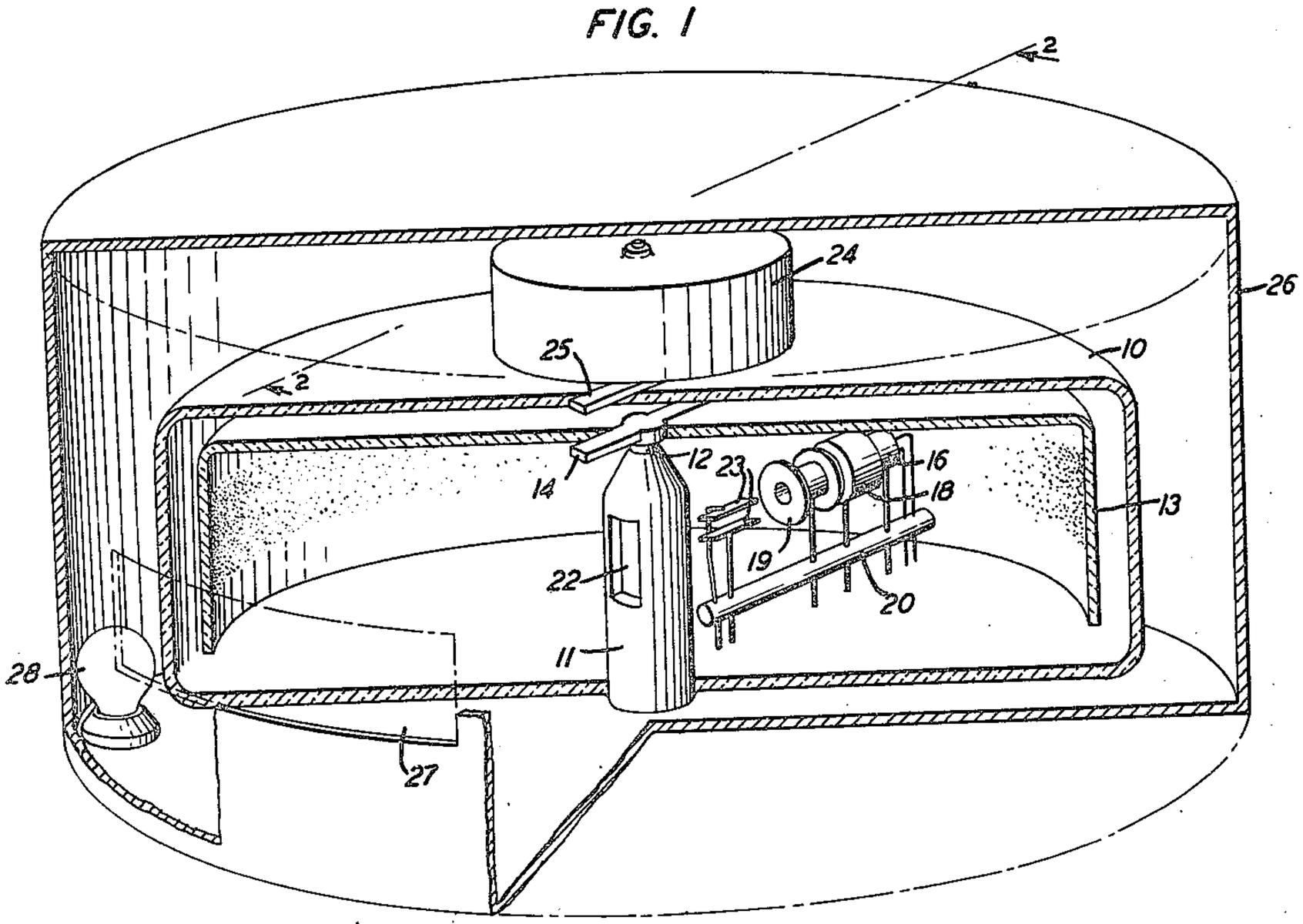

FIG. 2

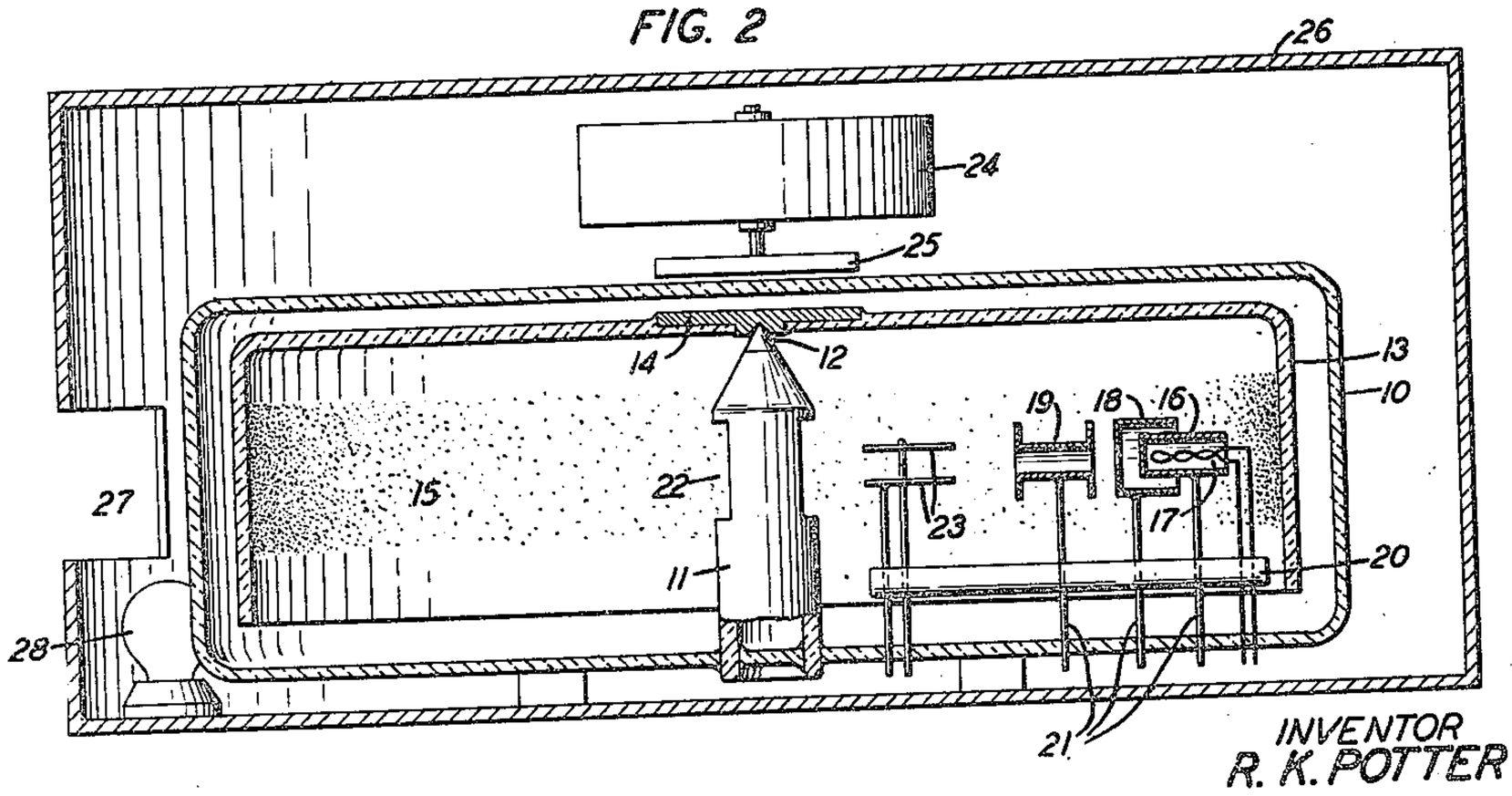

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FIG. 3

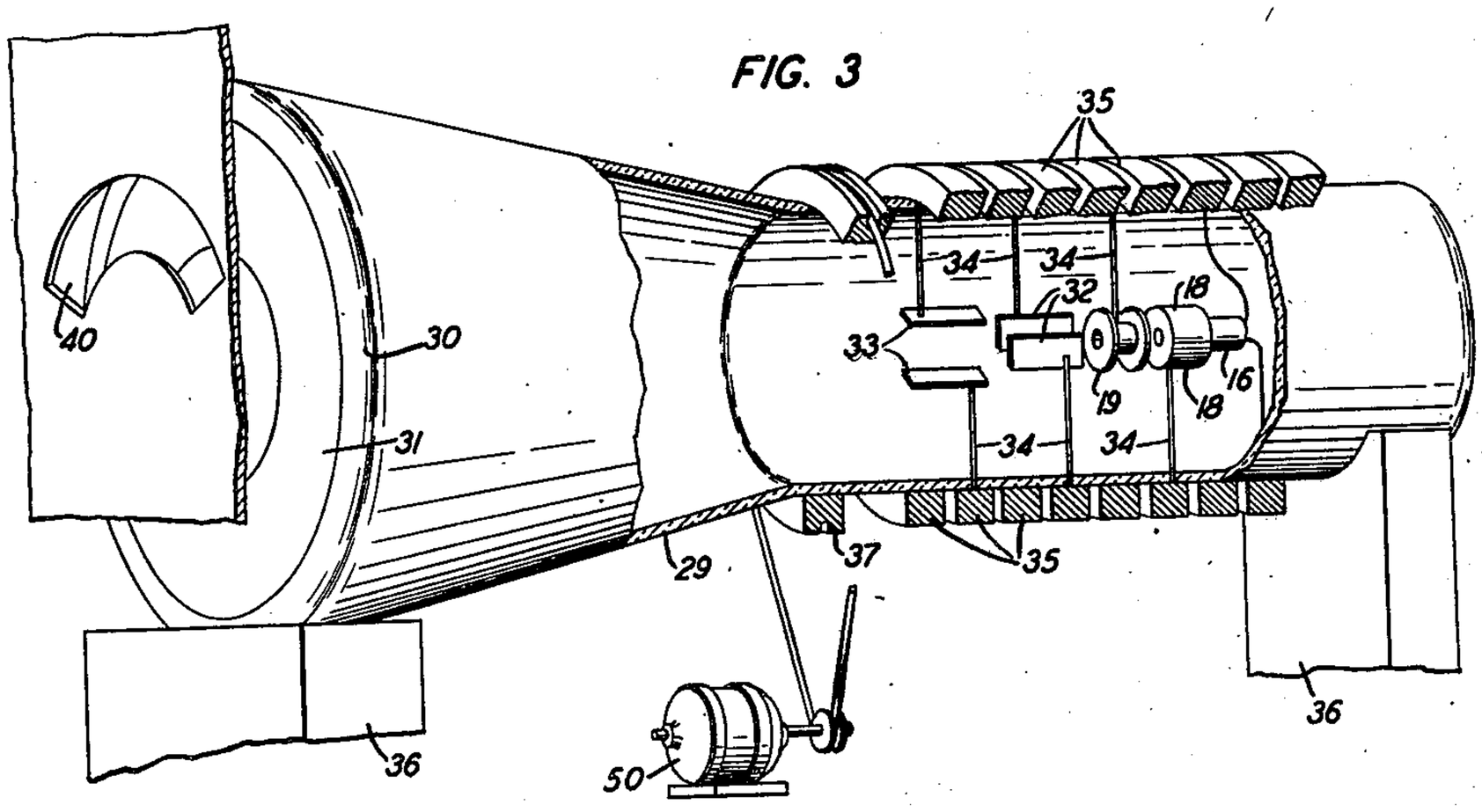
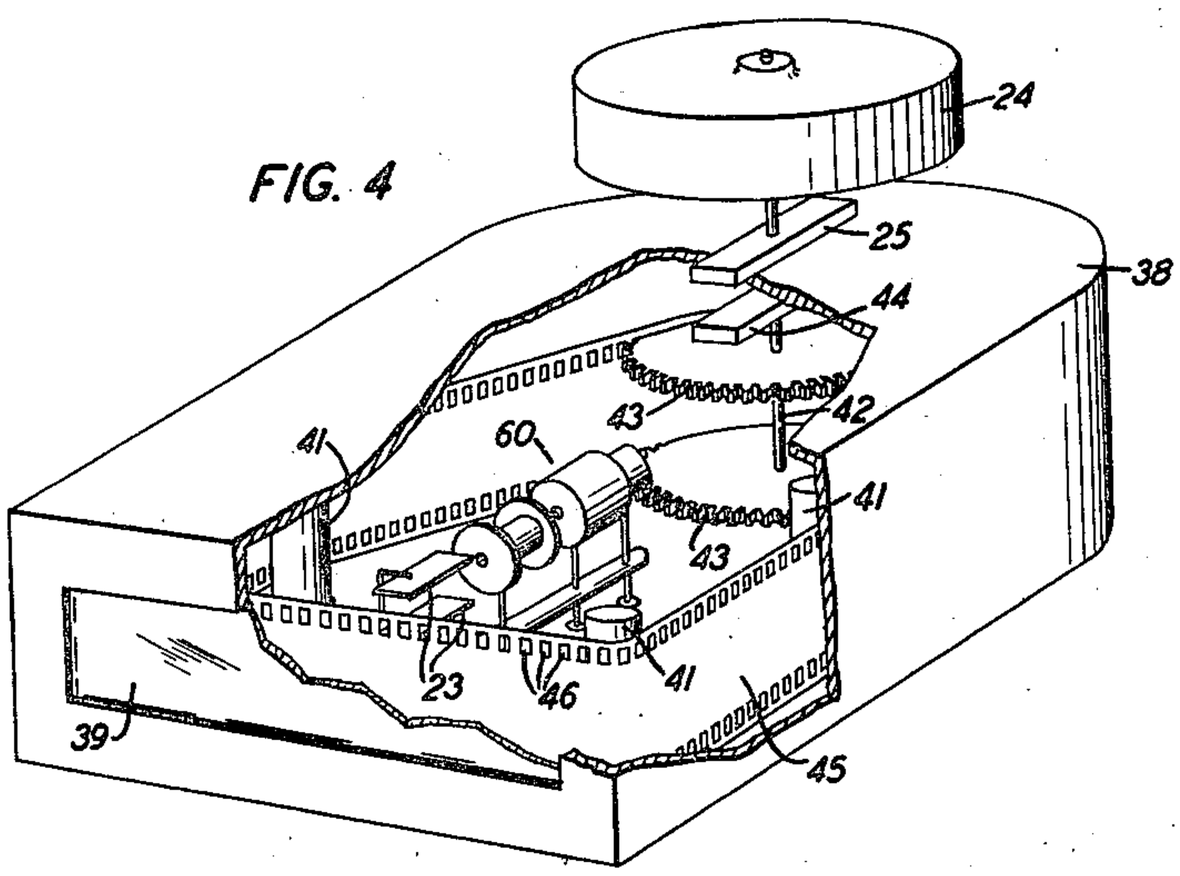


FIG. 4



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Patented July 16, 1946 2,403,996

UNITED STATES PATENT OFFICE

2,403,996

ELECTRON DISCHARGE APPARATUS

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Application December 9, 1941, Serial No. 422,194

9 Claims. (Cl. 250—157)

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This invention relates to electron discharge apparatus and more particularly to electron discharge devices of the type wherein an electron stream is utilized to trace upon a fluorescent screen a pattern representative of the characteristics of a varying current or voltage.

In such devices, when the electron stream is controlled, as in direction or intensity, in accordance with a signal, a visual pattern indicative of the characteristics of the signal appears upon the screen. When the signal is complex or continuously varying, coordination of the information as to the character thereof, depicted upon the screen is, in general, very difficult if not impossible due to, among other factors, the complexity of the pattern produced, the rapidity with which this pattern changes, and the overlapping of or interference between traces corresponding to successive transients or variations in the signal.

One object of this invention is to enable and to facilitate the analysis of complex signals by coordination of the information with respect to such signals presented by a visual pattern on a fluorescent screen. More specifically, one object of this invention is to produce a pattern, corresponding accurately to a varying signal, of substantial duration and in which the visual indicia of transients or variations in or time segments of a complex signal are segregated or delineated and the signal thereby, in effect, is pictorially dissected or translated into a clear visual pattern readily analyzable in terms of the characteristics, such as amplitude and frequency, of the components of the signal.

In one illustrative embodiment of this invention, an electron discharge device comprises an enclosing vessel housing a fluorescent screen, an electron gun for projecting a concentrated electron stream toward the screen, and suitable elements for controlling the direction or intensity or both of the electron stream. For example, there may be provided in cooperative relation with the electron gun a control electrode or grid and deflector plates.

In accordance with one feature of this invention, the deflection of the beam is restricted to a fixed plane and the screen is moved relative to this plane, for example, at right angles to the direction of deflection of the electron stream, whereby incremental areas of the screen are swept or scanned in succession by the beam or, viewed in another way, the screen is moved past a fixed scanning line. If the deflection or other control of the stream is in accordance with a signal, there will be thus produced on the screen a visual pattern indicative of the characteristics of the signal and in which successive incremental traces, corresponding to transients or variations in the signal, are segregated. The screen may be of a material having a moderate persistence so that there is visible upon the screen at any one time a pattern corresponding to an appreciable time segment of the signal.

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The device may be used advantageously in systems, such as disclosed in my application Serial No. 438,878, filed April 14, 1942, for producing word patterns to visualize speech or may be used also in systems, such as disclosed in my application Serial No. 438,879, filed April 14, 1942, for analyzing audio or radio frequency signals of unknown composition and origin. Other applications of such devices will occur to those skilled in the art.

The invention and the above-noted and other 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, portions of the electron discharge device and the housing therefor being broken away to show details of construction more clearly;

Fig. 2 is a sectional view of the electron discharge device, taken along plane 2—2 of Fig. 1;

Fig. 3 is a perspective view of electron discharge apparatus illustrative of another embodiment of this invention wherein the fluorescent screen is on one wall of the enclosing vessel; and

Fig. 4 is a view similar to Fig. 3 illustrating another embodiment of this invention wherein the fluorescent screen is in the form of a flexible movable band mounted within the enclosing vessel.

Referring now to the drawings, the electron discharge device illustrated in Figs. 1 and 2 comprises a cylindrical evacuated enclosing vessel 10, for example, of vitreous material, having mounted on the base wall thereof a rigid stem or support 11, which may be of vitreous material and extend axially of the vessel 10. The support 11 has secured thereto at its inner end a jewel bearing 12. Within the vessel 10 and coaxial therewith is a cup-shaped member 13 of transparent material, such as glass, which is rotatably supported upon the bearing 12 and has affixed thereto a magnetic bar 14, for example of iron. The cylindrical inner wall of the member 13 has thereon a fluorescent screen 15, which may be, for example, a fluorescent coating applied to this surface or a transparent tape coated with fluorescent material and secured to this surface.

Within the cup-shaped member 13 is an electron gun which, as shown more clearly in Fig. 2, comprises a cathode 16, for example, of the indirectly heated type provided with a heater filament 17, a control electrode 18, which, as shown, may be a metallic cylinder encompassing and co-

axial with the cathode 16, and a cylindrical accelerating anode 19 coaxial with the control electrode 18. The several electrodes of the electron gun are mounted in spaced relation by a vitreous bead 20 which is supported from the base wall of the vessel 10 by the leading-in conductors 21 for the electrodes. The electron gun is positioned along a radius of the cup-shaped member 13 and produces a concentrated electron stream which passes through an elongated slot or aperture 22 in the support 11 and impinges upon the fluorescent screen 15.

Supported from the vitreous bead 20 are a pair of deflector plates 23 mounted parallel to each other and at right angles to the longitudinal axis of the cup-shaped member 13.

External to the vessel 10 is a motor 24 on the shaft of which there is mounted a bar magnet 25 positioned in immediate proximity to the magnetic bar 14.

The discharge device and motor may be enclosed within a housing 26 having a restricted viewing aperture 27 in one wall opposite and closely adjacent the enclosing vessel 10.

During operation of the device, the motor is operated so that, by virtue of the magnetic coupling between the bar 14 and the magnet 25, the cup-shaped member 13 is rotated at a uniform rate, whereby successive areas of the screen 15 are moved past the terminus of the electron stream upon the screen. In a particular construction, the cup-shaped member 13 may be of the order of 6 inches in diameter and rotated at a rate of the order of five revolutions per minute. The signal to be analyzed or delineated is impressed between the deflector plates 23 so that the beam is deflected in a plane normal to the longitudinal axis of the screen 15. Thus, in effect, the screen is moved across a reference line and successive incremental areas thereof are scanned by the electron stream. Hence, there is produced upon the screen a visual trace indicative of the characteristics of the signal impressed between the deflector plates and, due to the motion of the screen, indicia of successive transients or time segments of the signal are segregated upon the screen whereby correlation of the information conveyed thereby is enabled. Inasmuch as the deflection of the beam is confined to a plane, it will be appreciated that a complex signal impressed between the deflector plates is, in effect, delineated in the trace appearing upon the fluorescent screen 15.

In a particularly advantageous construction, the screen is of a material having moderate persistence, for example, of zinc-cadmium sulphide activated by copper, so that at any instant there is visible through the receiving aperture 27 a trace corresponding to an appreciable time segment, for example, of several seconds, of the signal being analyzed. To prevent excessive persistence of the trace, there may be mounted within the housing 26 a source of infra-red light, such as a lamp 28, effective to substantially erase from the screen traces thereon which have been viewed through the aperture 27.

In the operation described, the trace appearing on the screen will present a two-coordinate visual indicia of the characteristics of the signal impressed between the deflector plates 23, the movement of the screen 15 providing a time axis or coordinate and the sweep of the stream along the reference line providing an amplitude coordinate. Suitable scales may be provided adjacent the aperture 27 to enable ready analysis of the signal

frequency and amplitude. In some systems, such as those disclosed in my applications referred to hereinabove, the intensity of the trace may be varied in accordance with the signal by suitable association of the signal with the control electrode 18, so that the amplitude of the signal and its components is indicated by the brilliance of the trace.

Although in the specific embodiment of the invention disclosed in Figs. 1 and 2 and described hereinabove the rotatable member 13 is coupled magnetically to the motor 24, it will be understood that other forms of coupling may be employed. In structures wherein magnetic coupling is employed, if the stray magnetic fields from the coupling are of appreciable magnitude, suitable magnetic shielding may be provided advantageously between the magnetic members 14 and 25 and the path traversed by the electron stream to prevent distortion of the electron stream by such stray fields.

In the embodiment of this invention illustrated in Fig. 3, the electron discharge device comprises an evacuated enclosing vessel 29 having a transparent end wall 30 the inner surface of which has thereon a fluorescent screen 31, for example, a coating of zinc-cadmium sulphide activated with copper. Mounted within the vessel adjacent the end thereof remote from the screen 31 is an electron gun, which may be of the same general construction and comprise the same electrodes as the electron gun included in the device shown in Figs. 1 and 2, the gun being axially aligned with the screen 31. Two pairs of deflector plates 32 and 33 are mounted at right angles to each other and adjacent the gun. Electrical connection to the deflector plates and to the electrodes of the electron gun is established through conductors 34 connected to coaxial slip-rings 35 mounted on the enclosing vessel 29.

The electron discharge device is mounted, as upon bearings or supports 36, so as to be rotatable about the longitudinal axis of the enclosing vessel 29, as, for example, by a motor 50 coupled to a pulley 37 secured to the vessel.

The apparatus may be enclosed in a suitable housing, only a fragment of which is shown, having an arcuate receiving aperture 40 opposite the end wall 30 of the enclosing vessel 29.

During operation of the device, the enclosing vessel 29 is rotated about its longitudinal axis at a uniform rate and the deflector plates 32 and 33 are energized in phase quadrature so that the resultant field therebetween rotates at the same rate as the vessel 29 but in the opposite direction. Consequently, the electron stream produced by the electron gun is effectively fixed in a plane passing through the longitudinal axis of the enclosing vessel and, for steady-state conditions, i. e. with a constant amplitude supply to the deflector plates, the stream terminus upon the screen 31 is a point and the trace upon the screen is a circle. Potentials corresponding to the signals may then be superimposed upon the aforementioned energizing potentials for the deflector plates, as a result of which the electron stream is deflected in the plane mentioned to move the spot along a radial line upon the screen 31. Successive deflections of the stream are segregated visually upon the screen and, as in the device illustrated in Figs. 1 and 2, there is visible, at any instant, through the receiving aperture 40 a trace representative of the characteristics of an appreciable time segment, for example, of the order of several seconds, of the

signal. Also, as in the device shown in Figs. 1 and 2, the intensity of the stream may be varied in accordance with the signal, by the control electrode 18 whereby the trace appearing on the screen varies in brilliance in accordance with the signal intensity.

It will be understood that in the apparatus illustrated in Fig. 3, an infra-red lamp may be provided, as in the apparatus shown in Figs. 1 and 2, to prevent undesirably long persistence of the trace upon the screen 31.

In the embodiment of this invention illustrated in Fig. 4, the evacuated enclosing vessel 33 is generally semi-oval in form and may be entirely of vitreous material or mainly of non-magnetic metal and provided with a plane, rectangular transparent window 39, for example, of glass. Mounted within the vessel 38 is an electron gun, designated generally as 60, which may be of the same construction as the gun included in the devices shown in Figs. 1 and 3 and is mounted at right angles to and opposite one end of the window 39. Deflector plates 23 are mounted adjacent the gun 60 and effective, when energized, to deflect the beam in a plane normal to the window 39 and parallel to the shorter sides thereof.

A plurality of parallel spindles or guides 41 are rotatably mounted upon the base of the vessel 38. Also rotatably mounted upon the base of the vessel is a drive member 42 carrying a pair of sprockets 43 and having affixed thereto a magnetic bar 44. External to the vessel is a suitable motor 24 having on the shaft thereof a bar magnet 25 positioned in juxtaposition to the magnetic bar 44.

The spindles or guides 41 and the drive member 42 carry a flexible transparent band or tape 45 which is coated on its inner surface with a fluorescent material and is provided adjacent its edges with perforations 46 in the proper relation to receive the teeth of the sprockets 43.

During operation of the device, the motor 24, by virtue of the coupling between the magnet 25 and the magnetic bar 44, rotates the drive member 42 so that the tape 45 also is rotated and thus drawn past and parallel to the window 39. The deflector plates 23 deflect the beam at right angles to the direction of motion of the tape by the window 39 in accordance with the signal impressed between the plates. There is thus produced upon the tape a trace or pattern indicative of the characteristics of the signal and, as will be apparent, there is visible through the window 39 at any instant a pattern corresponding to an appreciable time segment of the signal.

Although several specific embodiments of this invention have been shown 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 an enclosing vessel having an end wall, a fluorescent screen on said wall, an electron gun within said vessel and substantially coaxial with said screen for projecting an electron stream thereagainst, means adjacent said gun for subjecting said stream to a field rotating about the axis of alignment of said gun and said screen, means for rotating said vessel about said axis and in the direction opposite to the direction of rotation of said field, and means for sweeping said stream linearly across said screen.

2. Electron discharge apparatus in accordance with claim 1 comprising means for controlling the intensity of said stream.

3. Electron discharge apparatus comprising an enclosing vessel having a substantially circular end wall concentric with the longitudinal axis of said vessel, a fluorescent coating on the inner face of said wall, means for projecting an electron stream against said coating comprising an electron gun within said vessel and coaxial with said wall, means for revolving said stream in one direction about said axis comprising two pairs of deflector plates adjacent said gun and mounted in space quadrature about said axis, and means for rotating said vessel in the opposite direction about said axis.

4. Electron discharge apparatus comprising an enclosing vessel, a fluorescent screen upon a wall portion of said vessel, means for projecting an electron beam upon said screen, means for deflecting said beam in a fixed plane intersecting said screen thereby to shift the terminus of said beam upon said screen, and means for rotating said vessel to pass successive incremental areas of said screen across said plane.

5. Electron discharge apparatus in accordance with claim 4 comprising means for controlling the intensity of said electron beam.

6. Electron discharge apparatus comprising an enclosing vessel having a longitudinal axis, a fluorescent screen upon a wall portion of said vessel and coaxial with said axis, means for producing an electron stream and directing said stream to impinge upon said screen, means for deflecting said stream to shift the terminus thereof upon said screen, and means for continuously rotating said vessel about said axis.

7. Electron discharge apparatus comprising an enclosing vessel, a fluorescent screen within said vessel, means for projecting an electron stream upon said screen, means for deflecting said beam to sweep it across said screen, said screen being rotatable with said vessel, and means for continuously rotating said vessel to subject successive incremental areas of said screen to sweeping by said stream.

8. Electron discharge apparatus comprising a fluorescent screen, means for projecting an electron stream upon said screen, means for rotating said screen about an axis, means for subjecting said stream to a rotating field revolving about said axis in the direction opposite to the direction of rotation of said screen, the rates of revolution of said screen and said field being substantially equal, and means for sweeping said stream across said screen.

9. Electron discharge apparatus comprising a fluorescent screen, an electron gun for projecting an electron stream upon said screen at a region thereof spaced from an axis common to said screen and said gun, means mounting said screen and said gun in fixed relation to each other, means for rotating said screen and said gun about said axis, means for maintaining said stream in a fixed plane intersecting said screen, and means for deflecting said stream in said plane.

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