

Sept. 16, 1941.

H. M. WAGNER

2,256,301

ELECTRON BEAM TUBE

Filed Nov. 24, 1939

2 Sheets-Sheet 1

Fig. 1

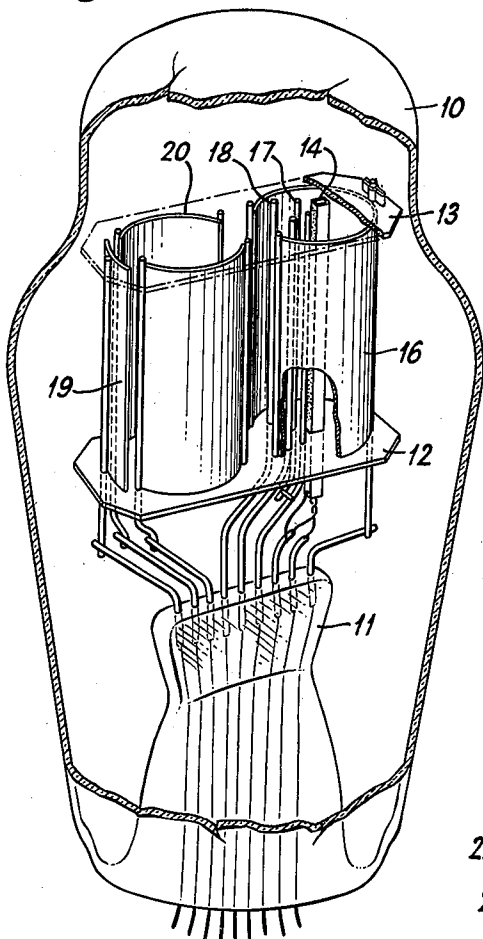


Fig. 2

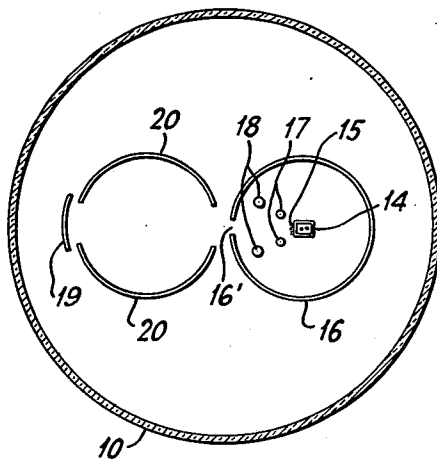


Fig. 3

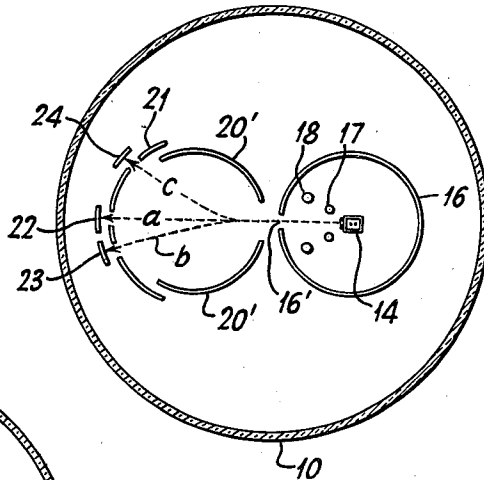
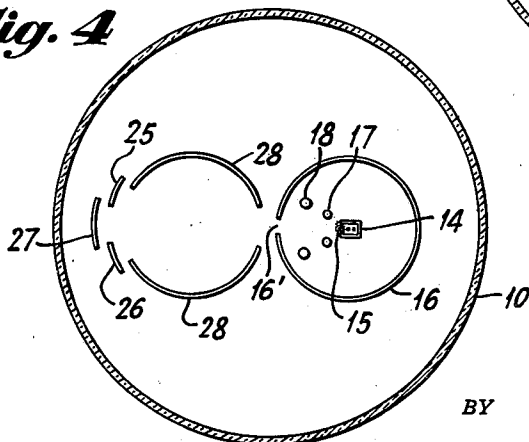


Fig. 4



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Fig. 5

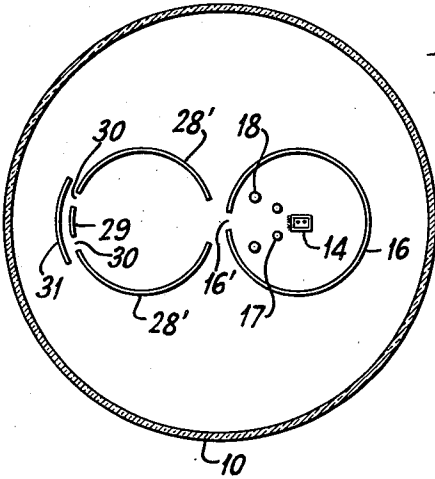


Fig. 6

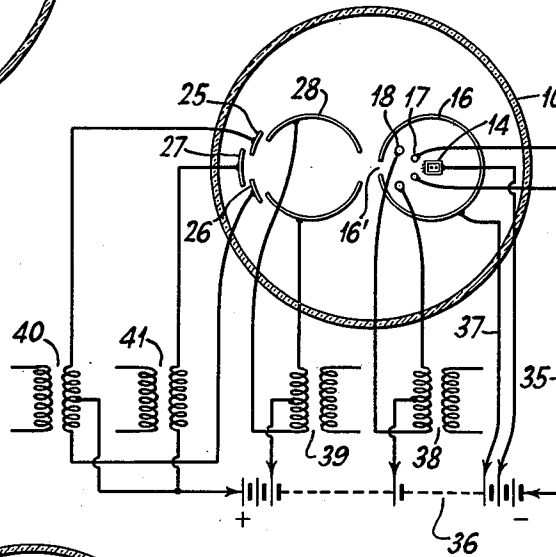
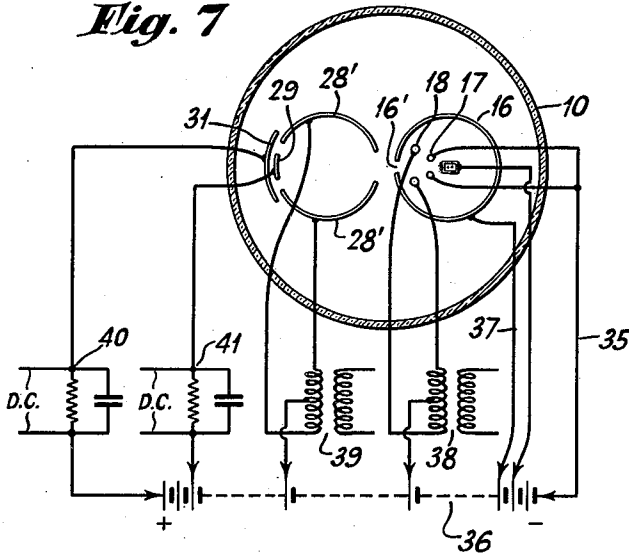


Fig. 7



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ELECTRON BEAM TUBE

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Application November 24, 1939, Serial No. 305,847

6 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices, more particularly to so-called beam tubes in which an electron beam can be deflected by one or more sets of deflecting electrodes for providing various novel results.

It is the principal object of my invention to provide an electron discharge device of the beam type, particularly suitable for measuring quantities including the phase angular displacement between electric oscillations and voltage power and for other purposes. Another object of my invention is to provide such a tube which the output current can be used to maintain a specific condition or conditions governed by phase angular displacement. Another object of my invention is to provide such a tube which can be used for frequency multiplication and for controlling one or more circuits depending upon the phase angular displacement between two different electric oscillations in the form of voltage or current.

In a simple form of the preferred embodiment of my invention a straight thermionic cathode is enclosed by and placed at the axis of a cylindrical electrode provided with a narrow longitudinal slot parallel to the cathode. Positioned between the slot and the cathode are beam forming elements and beam deflecting elements. The beam is directed to an output electrode or electrodes and passes between a pair of arcuate shaped deflecting electrodes positioned on opposite sides of the beam and shielding the beam between the output electrode or electrodes and the slotted cylindrical electrode surrounding the cathode.

Each pair of deflecting electrodes, when the electron discharge device is used in a work circuit, is connected to a different source of voltage whereby the in-phase operation and phase angle difference operation of the applied voltages to the deflecting electrodes produces different results in the output of the tube. The pair of deflecting electrodes between the slotted electrode and the output electrode can affect the beam only while it passes through the aperture in the slotted cylindrical electrode and if voltages applied to both sets of deflecting electrodes are in phase the beam will strike an output electrode at a point directly opposite the aperture. If the voltage applied to the second pair of deflecting electrodes is out of phase the degree to which the beam is deflected by the second pair of deflecting electrodes may be used to shift the output current from one output electrode to another or may be made to shift the beam from

the output electrode to points to the right or left of a midpoint on the output electrode. If a plurality of output electrodes are used each may be connected to the same or different circuits for producing frequency multiplication or for controlling the operation of separate circuits which in turn may be used to control the input circuits and thus control the deflection of the beam.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawings in which Figure 1 is a perspective view partially in section to show details of construction of an electron discharge device made according to my invention, Figure 2 is a longitudinal cross section of the tube showing the position of the various electrodes of the mount of the tube shown in Figure 1; Figures 3, 4 and 5 are transverse cross sections of modifications of electron discharge devices made according to my invention and Figures 6 and 7 are schematic diagrams showing the application of tubes made according to my invention in associated circuits useable with such tubes.

Referring to Figures 1 and 2 an electron discharge device made according to my invention comprises the evacuated envelope 10 provided with a reentrant stem and press 11 upon which the mount is supported between the insulating spacers 12 and 13, which may be, for example, of mica.

The indirectly heated cathode 14 which may be of rectangular cross section is provided along one face with an emitting coating 15. Surrounding and coaxial with the cathode is the cylindrical electrode 16 provided with the narrow slot 16' through which the beam of electrons from the cathode 14 may be directed, the beam being formed by beam forming rods 17 and deflected by control rods 18. The beam is normally directed to an output electrode 19 on opposite sides of which beam are arcuate shaped deflection electrodes 20 which serve not only the purpose of deflecting the beam after its passage through the slot 16' but also shields the beam from external influences.

An alternating voltage is applied to the control electrodes 18 to deflect the beam across the aperture or slot 16' so that the beam passes to the output electrode 19 only during a small portion of the cycle of the applied voltage. A sec-

ond alternating voltage is normally applied to the deflecting electrodes 20. The second pair of deflecting electrodes can affect the beam of electrons only between the apertured electrode 16 and the output electrode 19, the amount of the deflection of the beam depending upon the difference in phase of the voltage applied to the control rods 18 and the arcuate shaped beam deflecting electrodes 20.

In operation the narrow beam of electrons from the cathode 14 receives a double deflection, first back and forth across the slot 18' in the electrode 16 and a second deflection after it emerges from the aperture to the region beyond. The first deflection may be caused by a voltage $V_1 \sin \omega t$ and impressed between the rods 18, and the second deflection may be caused by a voltage $V_2 \sin (\omega t - \theta)$ between the deflecting members 20, the second voltage between the two plates differing in phase from the first voltage between the two rods by the angle θ . Electrodes 20 are active in deflecting the beam only part of the time, that is when the electrons pass through the aperture in the region containing the deflecting electrodes 20. This instant of time occurs when $V_1 \sin \omega t$ is equal to zero or for a short angle plus or minus and is of a short duration depending upon the width of the aperture in the electrode 16 and the narrowness of the beam. At this instant a voltage $\pm V_2 \sin \theta$ is effective in deflecting the beam in the region beyond slotted electrode 16 so that the beam will arrive at the electrode 19 in either of two positions to the right or left of the center point, except when θ equals zero, that is when there is zero phase angle between the voltages V_1 and V_2 . The beam is then in the center. Thus the point of contact of the electron beam and hence the amount of deflection of the beam is a function of $V_2 \sin \theta$ and serves as a measure of this quantity. The electrode 19 may be of a translucent or transparent base coated with fluorescent material so that it can be used for indicating purposes or can be so constructed that output can be used for different operations of electrical devices in accordance with the amount of the deflection of the beam. Obviously, if the angle θ is great no current will flow to the electrode 19.

Another form of my invention which permits the use of the device in controlling a plurality of circuits depending upon the phase angular displacement of the beam is shown in Figure 3. This device may also be used to provide frequency multiplication under certain conditions.

Here again the beam is formed by the cathode 14 and electrodes 17, the first deflection being applied by electrodes 18. However, instead of providing only one output electrode, three electrodes are shown registering with the apertures in the shield or electrode 21 positioned at different angular positions with respect to the slot in electrode 16. These output electrodes 22, 23 and 24 are in back of and register with the slots in the electrode 21. Thus when the voltages applied to control electrodes 18 and deflecting electrodes 20' are in phase the beam will pass through the center aperture to the output electrode 22. After the phase angular displacement reaches a predetermined value, such as indicated by dotted line b, then the output current is deflected to the output electrode 23. If a still further phase displacement takes place as indicated by dotted line c, then the output current may be directed to the output electrode 24. Thus electrodes 23 and 24 may be connected to different circuits to be con-

trolled under different phase angular differences in the applied voltages. Also by connecting electrodes 22 and 23 to the same side of the output circuit it is possible to obtain other effects if in a single swing between the midpoint indicated by the dotted line a and a deflection to either side of this midpoint as far as that indicated by the deflection b, each of the electrodes 22 and 23 receives current during a single cycle of the applied voltages to the two sets of deflecting electrodes. The action above described is controlled and can be varied by varying the slot width and biases of the control or deflecting electrodes.

A simpler form of Figure 3 is shown in Figure 4. Here the output electrodes comprise the elements 25, 26 and 27, forming in effect successively positioned electrodes. In-phase voltages will cause current to flow only to electrode 27. If a phase angle is sufficiently different current will shift to electrodes 25 and 26, which may be connected to different circuits or may be connected to the same circuit for frequency multiplication or for push-pull operation.

In Figure 5 a still further modification of the output electrodes is disclosed. In this modification one of the output electrodes 29 lies in the surface of a cylinder which would be generated in continuing the arcuate shaped elements 28', thus providing a pair of slots 30 between output electrodes 29 and deflecting electrodes 28'. A further output electrode 31 may be positioned in back of the output electrode 29.

The application of the tube in Figure 4 to a circuit is shown in Figure 6. The beam forming electrodes 17 are connected by means of a conductor 25 to a supply voltage 36 negative to the cathode, while the electrode 16 provided with slot 16' is at a positive potential with respect to the cathode. Input circuits 38 and 39 are connected to deflecting electrodes 18 and 20 respectively. Under in-phase conditions only circuit 41 connected to output electrode 27 is energized whereas under other conditions of phase angular difference the push-pull circuit 40 is energized. While this is shown as a push-pull circuit, if both of the electrodes 25 and 26 were connected to the same side of the primary transformer double the frequency would result since the circuit would receive two shocks in the same direction for each cycle of the applied voltage.

In Figure 7 is shown the application of the tube shown in Figure 5 to a different kind of circuit. Here electrode 29 is connected to one output circuit 41 for applying a D. C. voltage which can be used for control purposes. This electrode receives current when voltages applied to the input 38 and 39 are in-phase. If the applied voltages are sufficiently out of phase, then electrode 31 draws current which can be applied as a D. C. voltage if desired to the output circuit 40. If in circuits 40 and 41 the resistors are replaced by transformers, steep voltage forms can be obtained from the transformers.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my

invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device having an envelope containing a thermionic cathode, a cylindrical electrode surrounding and coaxial with said cathode and provided with a longitudinal slot parallel to said cathode, means for forming the electrons from said cathode into a beam passing through the slot in said cylindrical electrode and means between said slot and said cathode for deflecting the beam of electrons across said slot, an output electrode for receiving the beam of electrons and a pair of deflecting electrodes positioned on opposite sides of the beam for deflecting the beam after it emerges through the slot in said cylindrical electrode and shielding the beam between the output electrode and said slot.

2. An electron discharge device having an envelope containing a thermionic cathode, a cylindrical electrode surrounding and coaxial with said cathode and provided with a longitudinal slot parallel to said cathode, means for forming the electrons from said cathode into a beam passing through the slot in said cylindrical electrode and means between said slot and said cathode for deflecting the beam of electrons across said slot, a pair of deflecting electrodes positioned on opposite sides of the beam for deflecting the beam after it emerges through the slot in said cylindrical electrode, an electrode in the path of said beam and provided with a plurality of apertures at different angular positions with respect to the slot in said cylindrical electrode and output electrodes positioned in registry with said apertures on the opposite side of said apertured electrode from said cylindrical electrode, said deflecting electrodes being of arcuate shape and extending from said slotted cylindrical electrode to said electrode having a plurality of apertures for shielding said beam.

3. An electron discharge device having an envelope containing a thermionic cathode, a cylindrical electrode surrounding and coaxial with said cathode and provided with a longitudinal slot parallel to said cathode, means for forming the electrons from said cathode into a beam passing through the slot in said cylindrical electrode and means between said slot and said cathode for deflecting the beam of electrons across said slot, successive output electrodes positioned in the path of said beam and each having a surface exposed to the beam at a different angular position with respect to the slot in the cylindrical electrode, a pair of deflecting electrodes positioned on opposite sides of the beam and extending between the cylindrical electrode and said output electrodes for deflecting the beam after it emerges through the slot in said cylindrical electrode and serving to shield the beam between the output electrodes and said slot.

4. An electron discharge device having an envelope containing a thermionic cathode, a cylindrical electrode surrounding and coaxial with said cathode and provided with a longitudinal slot parallel to said cathode, means for forming the electrons from said cathode into a beam passing through the slot in said cylindrical electrode and means between said slot and said cathode for deflecting the beam of electrons across said slot, a pair of deflecting electrodes of arcuate shape positioned on opposite sides of the beam for deflecting the beam after it emerges through the slot in said cylindrical electrode, an output electrode lying in the same cylindrical surface which would be generated by the continuation of said arcuate shaped deflecting electrodes, whereby a pair of parallel longitudinal slots is provided between the arcuate shaped electrodes and said output electrode and a second electrode positioned outside of said cylindrical surface and overlapping the slots between said output electrode and arcuate shaped deflecting electrodes.

5. An electron discharge device having a cathode for supplying electrons and means for forming said electrons into a beam, an electrode surrounding said cathode and provided with a slot registering with said beam and deflecting means for deflecting said beam across said slot, and an electrode element in the path of the beam and provided with a plurality of apertures at different angular positions with respect to the slot in the slotted electrode and a separate output electrode in registry with each of the apertures and on the other side of said apertured electrode element from said cathode, and deflecting electrodes positioned between said slotted electrode and said apertured electrode, said pairs of deflecting electrodes and said deflecting means for deflecting the beam in the same plane, said electron discharge device having no other deflecting electrodes positioned between said apertured electrode and said slotted electrode.

6. An electron discharge device having a cathode for emitting electrons, means for forming said electrons into a beam, output electrodes lying in the surface of a cylinder for receiving said electrons, an electrode positioned between the cathode and the output electrodes and provided with a slot through which the beam from said cathode passes, and deflecting electrodes on each side of the slotted electrode for deflecting the beam of electrons in the same plane and a second arcuate shaped electrode having apertures registering with said output electrodes and positioned between said output electrodes and said cathode, said pairs of deflecting electrodes being the only deflecting electrodes between the cathode and the output electrodes.

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