Feb. 10, 1942. H. M. WAGNER 2,272,232

ELECTRON BEAM TUBE

Filed July 31, 1940 2 Sheets-Sheet 1

Fig. 1

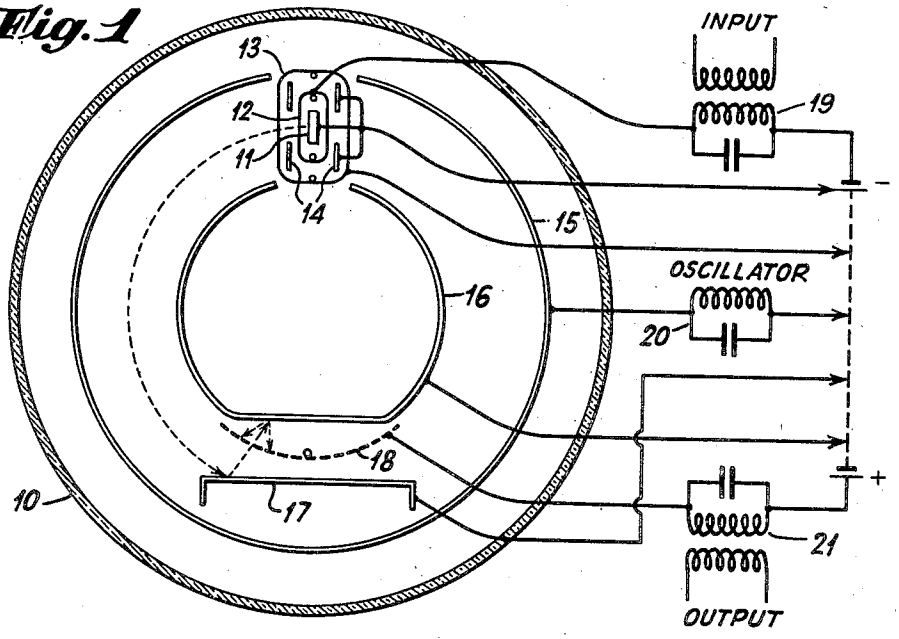
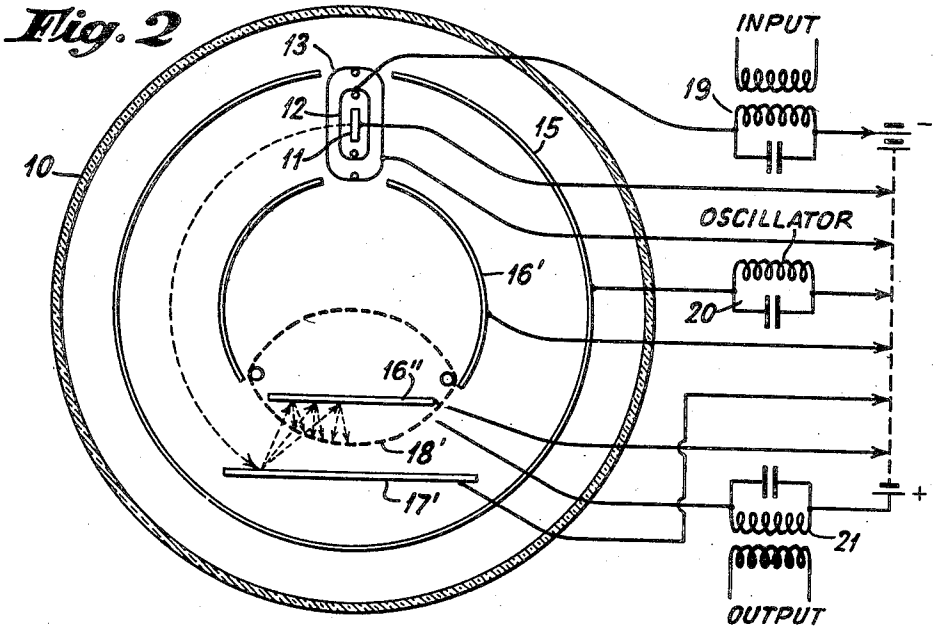


Fig. 2



INVENTOR
HERBERT M. WAGNER

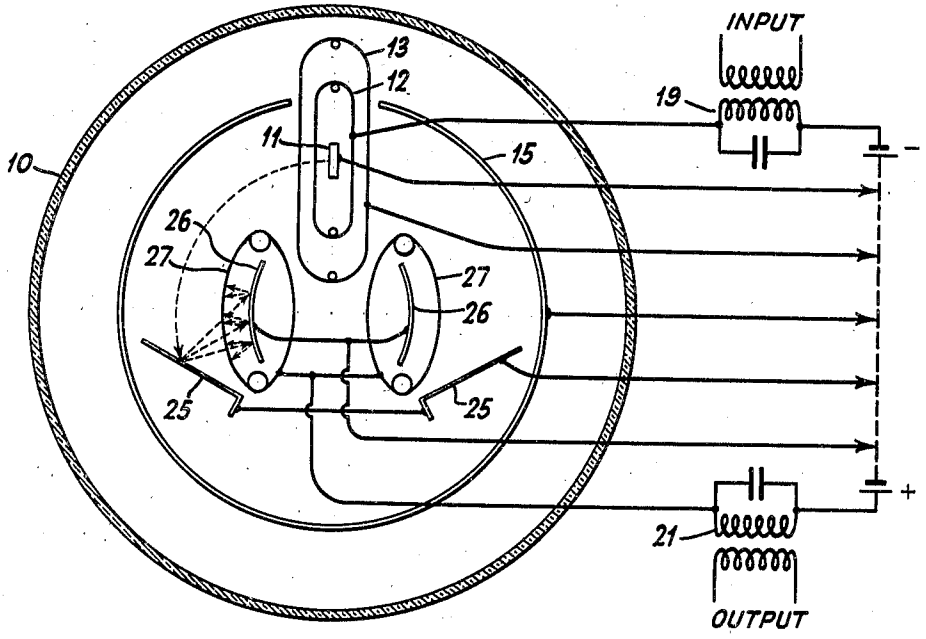
BY Charles McClair
ATTORNEY

Feb. 10, 1942. H. M. WAGNER 2,272,232

ELECTRON BEAM TUBE

Filed July 31, 1940 2 Sheets-Sheet 2

Fig. 3



INVENTOR
HERBERT M. WAGNER

BY Charles McClair
ATTORNEY

Patented Feb. 10, 1942

2,272,232

UNITED STATES PATENT OFFICE

2,272,232

ELECTRON BEAM TUBE

Herbert M. Wagner, Newark, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application July 31, 1940, Serial No. 348,711

12 Claims. (Cl. 250—175)

My invention relates to electron discharge devices, more particularly to beam tubes utilizing an orbital beam and secondary emission amplification, and useful in many different applications.

Certain multipliers do not use beams and are limited in performance. However, straight beams and secondary emitting surfaces have been utilized for increasing the transconductance of conventional and beam type tubes, but where the straight beam is used and where the secondary emitting surfaces are exposed directly to the cathode, material evaporated from the thermionic cathode may deposit on the secondary emitting surfaces and cause reduction of emission from the secondary emitting surfaces. Further, where straight beams are used comparatively long beam paths are necessary to provide desirable sensitivity where deflection is useful, and in some tubes of this type the beam focus is affected when the beam is deflected by the deflecting electrodes, especially when a single deflection electrode is used for control instead of a push-pull arrangement of electrodes. In order to accommodate the electrode system of straight beam tubes the tube envelopes must be of some length and sometimes of an odd shape.

Again where the output electrode is screened from the secondary emitting surfaces in the conventional multiplier type of tubes the electrons must first pass through a screen before initially reaching the secondary emitting surfaces, resulting in the reduction of the number of primary electrons striking the secondary emitting surfaces.

It is, therefore, one of the objects of my invention to provide an electron discharge device employing a beam and secondary emission amplification and having improved characteristics.

More specifically an object of my invention is to provide such a tube in which the secondary emitting surfaces are protected from depositions of evaporated material from the cathode which would reduce the secondary emitting qualities of the secondary emitting surface.

Another object of my invention is to provide a multiplier tube in which the output electrode is carefully screened from the secondary emitting surfaces, but yet in which the primary electrons need not pass through the screen electrode but which nevertheless permit the screen grid to be placed close to the secondary emitter which permits efficient collection of the secondary electrons.

It is another object of my invention to provide increased sensitivity over conventional beam tubes using straight beams and of comparative overall tube dimensions.

It is another object of my invention to provide a beam tube in which, while the deflection sensitivity is increased, no ill effects of the focusing of the beam are experienced when the deflecting electrodes go into operation.

It is a still further object of my invention to provide such a device in which transit time effects of such tubes when utilized at high frequencies are substantially eliminated.

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 transverse section of an electron discharge device made according to my invention and its associated circuit when utilized as a mixer tube, Figures 2 and 3 are transverse sections of modifications of the electron discharge device shown in Figure 1 and an associated circuit which may be utilized with these modifications.

As shown in Figure 1 the electron discharge device made according to my invention comprises the envelope 10 which encloses the electrodes comprising the cathode 11, control grid 12 and screen grid 13, beam forming electrode 14 electrically connected to the cathode as shown and positioned between the control grid and screen grid. These electrodes are positioned with respect to two concentric coaxial tubular electrodes 15 and 16 so as to direct a pair of oppositely disposed beams between the opposed surfaces of these electrodes (only one beam path being shown by the dotted curved path). As shown by the electron beam path, electrons will strike the surface of the secondary emitting electrode 17 as indicated. The secondary electrons then travel through the collector or output eletcrode 18 of mesh material to the coated surface of the electrode 16, which releases further secondary electrons. The combined voltages of the electrodes 18 and 16 cause a majority of the secondary electrons released at the surface 17 to pass through the mesh electrode 18 to the coated surface of the electrode 16, producing other secondary electrons or tertiary electrons The tertiary electrons go to 18, thus resulting in a two-stage amplification.

In operation a first control voltage may be applied to control grid 12 to modulate electron beam in a conventional manner. A second con-

trol voltage may be applied to either electrode 15 or 16 to vary the point at which the electron beam will strike the surface of the electrode 17. It is also possible to vary the output of the tube by shifting the beam so as to strike electrode 16 or 15 so that the secondary emitting surfaces are not struck to release secondary electrons, thus affecting the output of the tube. The tube may be utilized as a mixer tube for superheterodyne circuits, the oscillator voltage being applied to the outer tubular electrode 15 by the circuit 20. The output is transmitted to the output circuit 21 electrically connected to the electrode 18.

In Figure 2 is shown a modification of the electron discharge device shown in Figure 1. The envelope 10 again encloses the cathode 11 and control grid 12 as well as the screen grid 13. The beam forming electrodes 14 of Figure 1, however, are not utilized. The grid side rods of grids 12 are sufficient for this purpose. The oppositely directed beams are directed between the electrodes 15 and 16', the inner electrode 16' being in the form of a pair of arcuate shaped electrodes used as a second control electrode. The beam is directed to the surface of the electrode 17' which again may be coated with secondary emitting material, the second secondary emitting electrode 16'' being surrounded by the lenticularly shaped collector output electrode 18'. The input circuit 19 is again connected to the electrode 12, the oscillator circuit 20 to the electrode 15 and the output circuit 21 to the output electrode or collector 18'.

The modification shown in Figure 3 is shown used as an amplifier. It comprises envelope 10 containing cathode 11, control grid 12 and screen grid 13. In this case the tubular electrode 15 is positioned to direct the electrons from the cathode 11 in a curved path along the inner surface of the electrode 15. The electrodes 25 positioned in the path of the beam may be coated on their surfaces facing the beam to release secondary emitting electrons which are directed to the surfaces of the electrodes 26 to release further secondary electrons which travel to and are collected by mesh output electrodes 27, electrodes 25, 26 and 27 being electrically in pairs, although they may be electrically independent of each other within the tube envelope. The side rods of the collector electrodes 27 shield the secondary emitting surfaces of electrodes 25 from any stray particles of emitting material from the cathode 11. The input circuit 19 is electrically connected to control grid 12. The output circuit 21 is connected to the output electrodes 27. Electrodes 25 may be coated over only part of their surface so that the beam may be shifted from the coated to the uncoated surface to vary the number of secondary electrons released. It is of course obvious that various electrodes above could be connected internally to provide single stage amplification or for other purposes.

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 including an envelope containing a cathode surrounded by a control grid and means for forming electrons from the cathode into a beam, means including a control electrode adjacent the beam of electrons for causing said beam to travel along a curved path, an electrode positioned in the path of said beam and coated with emitting material for emitting electrons when struck by said beam and an electrode adjacent the secondary electron emitting electrode for receiving secondary electrons emitted by the secondary electron emitting electrode and coated with a secondary electron emitting material, and a foraminous electrode positioned between the coated surfaces of the secondary emitting electrodes for receiving secondary emitted electrons.

2. An electron discharge device having an envelope containing a cathode, a first control grid surrounding said cathode, means adjacent said first control grid and said cathode for providing a beam of electrons, means in the path of said beam of electrons for causing said beam to travel a curved path and including a second control electrode, an electrode for intercepting the beam and coated with secondary emitting material for releasing secondary electrons, and an electrode oppositely disposed to the intercepting electrode and coated with secondary emitting material for emitting secondary electrons and a foraminous electrode of arcuate shape positioned between the secondary emitting surfaces for receiving secondary electrons.

3. An electron discharge device having an envelope enclosing a cathode, a control grid and screen grid surrounding said cathode for controlling and focusing electrons from said cathode into a beam and a pair of adjacent electrodes including a control electrode toward which said beam is directed for causing said beam to travel a curved path, the distance between the cathode and control grid electrode being short in comparison with the length of the curved path between the cathode and the pair of adjacent electrodes, an electrode in the path of the beam of electrons and coated with electron emitting material for emitting secondary electrons when struck by said beam, and a second electrode positioned adjacent the coated electrode in the path of the beam and coated with emitting material on the surface oppositely disposed to the first coated surface, and a foraminous electrode positioned between said surfaces for receiving secondary electrons.

4. An electron discharge device having an envelope including a cathode surrounded by a control grid and screen electrode, a pair of concentric tubular electrodes mounted adjacent the screen electrode and positioned so that the beam of electrons passes between the opposed surfaces of the tubular electrodes for causing said beam to travel a curved path, an electrode positioned in the path of the beam and having a surface to be bombarded by said beam for releasing secondary electrons, one of said tubular electrodes being coated with secondary electron emitting material on the surface oppositely disposed to the coated surface of the electrode positioned in the path of the beam, and an arcuate shaped foraminous electrode positioned between the coated surfaces of the electrodes for receiving secondary electrons emitted by said secondary emitting surfaces.

5. An electron discharge device having an en-

velope including a cathode surrounded by a control grid and screen electrode, a pair of concentric tubular electrodes mounted adjacent the screen electrode and positioned so that the beam of electrons passes between the opposed surfaces of the tubular electrodes for causing said beam to travel a curved path, an electrode positioned in the path of the beam and having a surface to be bombarded by said beam for releasing secondary electrons, one of said tubular electrodes being coated with secondary electron emitting material on the surface oppositely disposed to the coated surface of the electrode positioned in the path of the beam, and an arcuate shaped foraminous electrode positioned between the coated surfaces of the electrodes for receiving secondary electrons emitted by said secondary emitting surfaces, said arcuate shaped foraminous electrode being positioned with its concave surface opposite the coated surface of the tubular electrode.

6. An electron discharge device including a cathode surrounded by the control grid and means for forming electrons from the cathode into a beam, a pair of arcuate shaped members positioned adjacent the cathode and control electrode for receiving the beam between their opposed surfaces and directing said beam along a curved path, an electrode having a surface coated with secondary electron emitting material positioned in the path of said beam for releasing secondary electrons when struck by said beam, and a second electrode oppositely disposed to the coated electrode and having its opposed surface coated with secondary electron emitting material and a foraminous electrode surrounding said second coated electrode for receiving secondary electrons emitted by said coated surfaces.

7. An electron discharge device including a cathode surrounded by the control grid and means for forming electrons from the cathode into a beam, a pair of arcuate shaped members positioned adjacent the cathode and control electrode for receiving the beam between their opposed surfaces and directing said beam along a curved path, an electrode having a flat surface coated with secondary electron emitting material positioned in the path of said beam for releasing secondary electrons when struck by said beam, and a second electrode having a flat surface parallel to and oppositely disposed to the flat coated surface of the first coated electrode and having its opposed surface coated with secondary electron emitting material and a foraminous electrode surrounding said second coated electrode for receiving secondary electrons emitted by said coated surfaces.

8. An electron discharge device having a cathode surrounded by a control grid and means for forming the electrons from the cathode into a pair of oppositely disposed beams, a tubular electrode within which said cathode is positioned adjacent the inner surface of said tubular electrode, a pair of arcuate shaped electrodes positioned within and coaxial with said tubular electrode and positioned to receive the beams of electrons between the opposed surfaces of the tubular electrode and the arcuate shaped electrodes, said tubular electrode and arcuate shaped electrodes causing said oppositely disposed beams to travel in opposite curved paths, a pair of parallel electrodes positioned between the tubular electrode and said arcuate shaped electrodes and substantially 180° removed from said cathode and coated with secondary electron emitting material on their opposed surfaces and a foraminous electrode surrounding one of said parallel coated electrodes.

9. An electron discharge device having a cathode surrounded by a control grid and means for forming the electrons from the cathode into a pair of oppositely disposed beams, a tubular electrode within which said cathode is positioned adjacent the inner surface of said tubular electrode, a pair of arcuate shaped electrodes positioned within and coaxial with said tubular electrode and positioned to receive the beams of electrons between the opposed surfaces of the tubular electrode and the arcuate shaped electrodes, said tubular electrode and arcuate shaped electrodes causing said oppositely disposed beams to travel in opposite curved paths, a pair of parallel electrodes positioned between the tubular electrode and said arcuate shaped electrodes and substantially 180° removed from said cathode and having flat opposed surfaces coated with secondary electron emitting material, the surface of one of said electrodes being positioned to intercept said beam and a lenticular foraminous electrode surrounding one of the parallel coated electrodes.

10. An electron discharge device having a cathode for emitting electrons, a control grid surrounding said cathode and means including a screen grid for forming electrons from said cathode into a beam, a tubular electrode within which said cathode is positioned for directing a beam of electrons along the inner surface of said tubular electrode, a plane electrode in the path of the beam and coated with electron emitting material to be bombarded by said beam to release secondary electrons, an oppositely disposed electrode positioned adjacent the coated electrode but out of the path of said beam, and a screen electrode surrounding said last electrode, said last electrode being coated with electron emitting material on its surface oppositely disposed to the coated surface of the first coated electrode, said screen electrode being provided with side rods of substantial cross section for shielding the coated surface of said coated electrode.

11. An electron discharge device including a tubular electrode provided with a longitudinal aperture, a cathode positioned adjacent said aperture and surrounded by a control grid and screen grid, the electrons from the cathode being formed into a pair of oppositely disposed beams directed along the inner surface of said tubular electrode, a pair of plane electrodes positioned in the path of said beams and coated on the surface positioned in the path of said beam with electron emitting material for releasing secondary electrons when bombarded by said beam, a second electrode positioned adjacent each of the first coated electrodes and of arcuate shape, and coated with secondary electron emitting material, and a lenticular foraminous electrode surrounding each of said arcuate shaped electrodes for collecting secondary electrons released from the secondary electron emitting surfaces of said electrode.

12. An electron discharge device including a tubular electrode provided with a longitudinal aperture, a cathode positioned adjacent said aperture and surrounded by a control grid and screen grid, the electrons from the cathode being formed into a pair of oppositely disposed beams directed along the inner surface of said tubular electrode, a pair of plane electrodes positioned in the path of said beams and coated on the surface positioned in the path of said

beam with electron emitting material for releasing secondary electrons when bombarded by said beam, a second electrode positioned adjacent each of the first coated electrodes and of arcuate shape and coated with secondary electron emitting material, and a lenticular foraminous electrode surrounding each of said arcuate shaped secondary emitting electrodes for collecting secondary electrons released from the secondary electron emitting surfaces of said electrode, said arcuate shaped electrodes and the lenticular shaped grids lying parallel to the cathode and control grid.

HERBERT M. WAGNER.