

Nov. 8, 1949

G. R. KILGORE

2,487,656

ELECTRON DISCHARGE DEVICE OF THE BEAM DEFLECTION TYPE

Filed Nov. 22, 1943

2 Sheets-Sheet 1

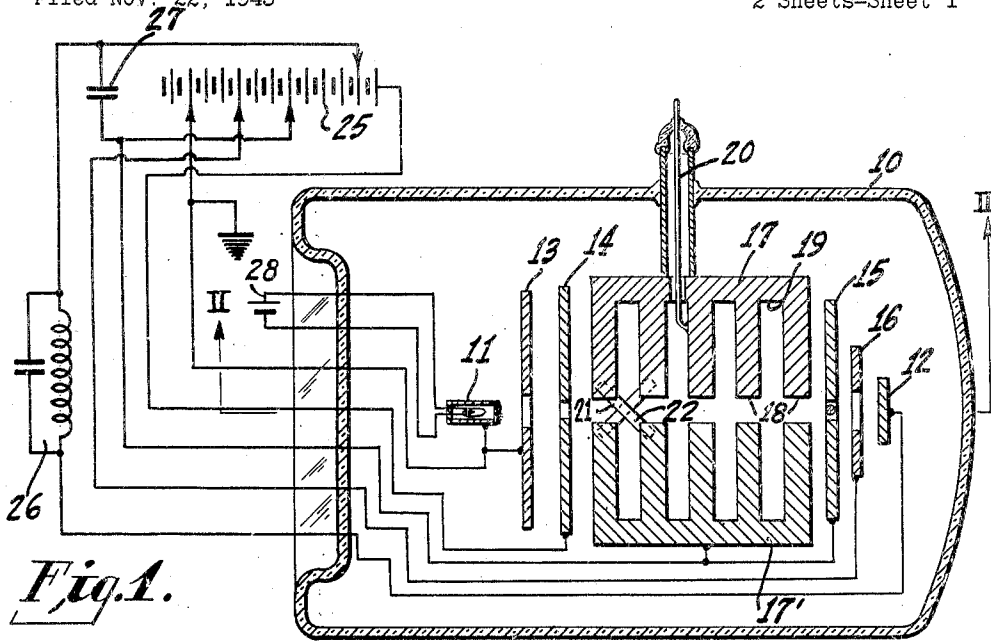


Fig. 1.

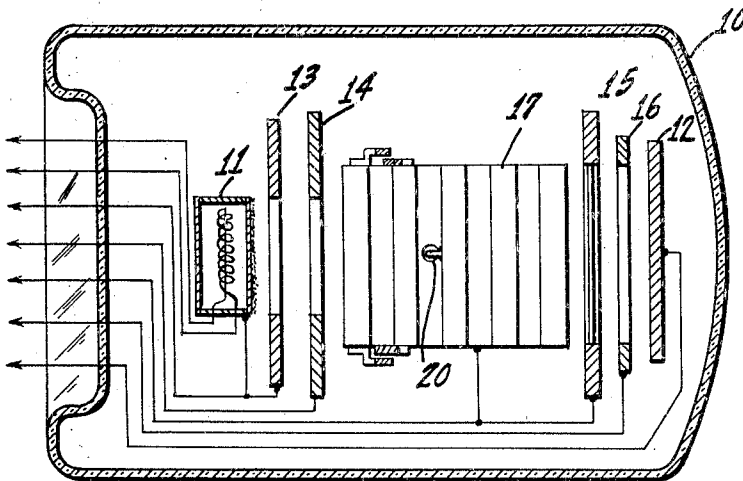


Fig. 2.

INVENTOR
GEORGE R. KILGORE
BY
Charles M. Clair
ATTORNEY

Nov. 8, 1949

G. R. KILGORE

2,487,656

ELECTRON DISCHARGE DEVICE OF THE BEAM DEFLECTION TYPE

Filed Nov. 22, 1943

2 Sheets-Sheet 2

Fig. 3.

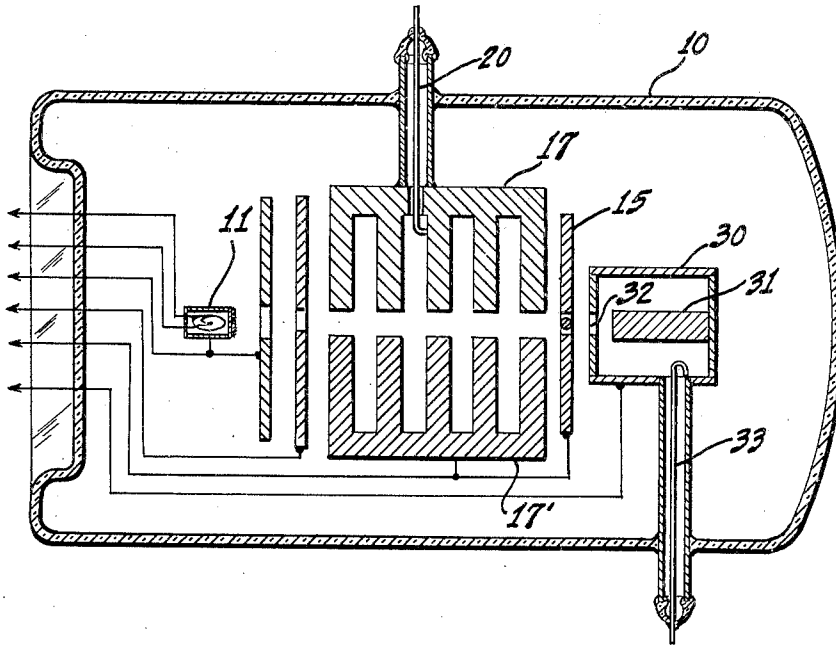
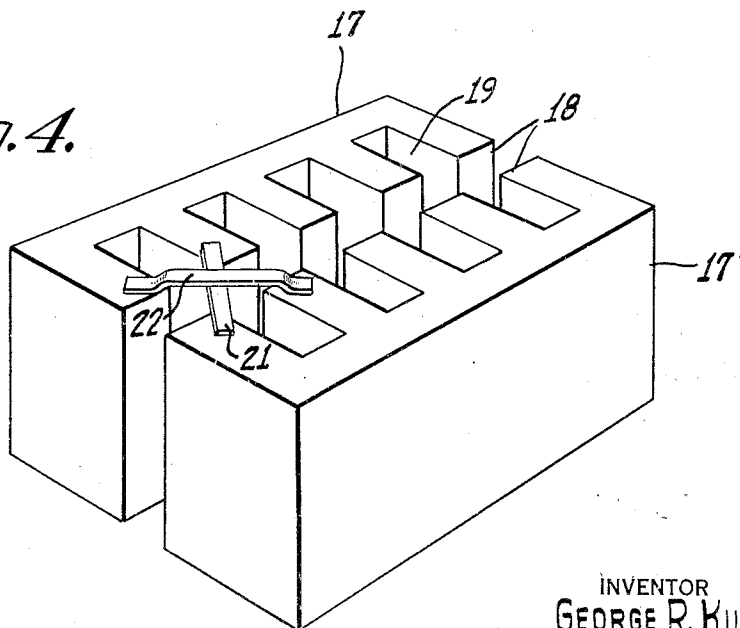


Fig. 4.



INVENTOR
GEORGE R. KILGORE
BY
Charles M. Blair
ATTORNEY

UNITED STATES PATENT OFFICE

2,487,656

ELECTRON DISCHARGE DEVICE OF THE
BEAM DEFLECTION TYPEGeorge Ross Kilgore, Princeton, N. J., assignor to
Radio Corporation of America, a corporation
of Delaware

Application November 22, 1943, Serial No. 511,208

12 Claims. (Cl. 315—6)

1

My invention relates to electron discharge devices utilizing periodic electron beam deflection and particularly useful at ultra high frequencies.

In conventional electron discharge devices of the type under consideration, a beam of electrons is directed between a pair of deflecting electrodes toward an apertured electrode, behind which is usually placed a collector. Alternating high frequency voltages are applied to the deflecting electrodes to cause the electron beam to be periodically deflected across the aperture to thus control the instantaneous flow of electron current to the collector, which may be used as an output electrode. In such conventional types of tubes the deflection sensitivity drops off as the frequency at which the tube is operated is increased due to electron transit time effects. Efforts have been made to increase the deflection sensitivity or the transconductance of the tube but such efforts have not met with a great deal of success. Conventional tubes of this kind are also subject to the limitation that when operated at ultra high frequencies the input circuit tends to be of low resonant impedance resulting in an excessive amount of power being required to drive the tube. This decreases the effective power gain of the tube when operated as an amplifier. Fundamental causes of low resonant impedance include, among other things, radiation and resistance losses due to high circulating current in electrodes and leads. Electron loading also results from the interaction of the electron stream and the circuits connected to the tube and electrodes and may cause undesired degenerative and regenerative effects caused by lead impedances common to more than one circuit.

It is an object of my invention to provide an electron discharge device of the beam deflection type, which is particularly suitable for use at ultra high frequencies and which has a comparatively high transconductance.

It is another object of my invention to provide such a device utilizing an input circuit having a high resonant impedance, thus making more effective the use of the driving power.

A further object of my invention is to provide such a device in which undesired coupling due to common leads and ineffective shielding between circuits is reduced to a minimum.

Another specific object of my invention is to provide an electron discharge device of the beam deflection type, utilizing multiple additive deflection for providing a tube having high transconductance.

Another object of the present invention is to

2

provide an electron discharge device of the type described, which will operate at very high frequencies, for example, up to 10,000 megacycles or higher.

A further specific object of my invention is to provide such a device utilizing a plurality of successively positioned resonant circuits operable at ultra high frequencies.

Another object of my invention is to provide an electron discharge device which can act as a frequency multiplier.

A still further object of my invention is to provide such a device useful at ultra high frequencies, but which nevertheless has elements of substantial size so that the device can be assembled without difficulty.

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 drawing in which Figure 1 is a schematic longitudinal section of an electron discharge device made according to my invention with its voltage sources and circuit connected thereto, Figure 2 is a section taken along the line 2—2 of Figure 1, Figure 3 is a schematic longitudinal section of a modification of the device shown in Figure 1, and Figure 4 is a perspective of the deflecting electrode assembly utilized in Figures 1, 2 and 3.

In accordance with my invention I provide an electron discharge device having an evacuated envelope 10 and having at one end thereof an indirectly heated cathode 11, which may be of rectangular transverse section and at the other end of the mount assembly I provide an electron collector or anode 12. A beam forming element 13 at cathode potential is placed adjacent the cathode. Acceleration and additional focusing of the electron accomplished by means of a high potential apertured electrode 14. The beam may be deflected across a double aperture electrode 15 before being collected by the electrode 12, secondary electrons being suppressed by an apertured electrode 16 at a low potential with respect to the collector 12.

In accordance with my invention I position between the accelerative electrode 14 and the apertured electrode 15 a deflecting electrode assembly system comprising a pair of oppositely disposed members 17, 17', which include a plurality of oppositely disposed deflecting electrode elements 18 separated by deep slots 19. In effect,

3

the slots 19 provide quarterwave closed cavity resonator circuits connected between adjacent deflecting electrode elements 18. The deflecting electrode members may be made by slotting solid blocks of metal.

When one cavity is driven at the resonant frequency, by coupling a signal into one of the cavity resonator slots as by means of a coaxial input line and loop 20, the other cavities are excited producing potentials across the opposed deflecting electrode elements varying in phase by 180°. Hence, the electric field near the axis will be mainly transverse to the beam path thus giving rise to deflection. The field near the axis in the direction of the beam is substantially zero so that velocity modulation will be small. Successive elements on the same side of the beam path differ by 180° in phase.

The spacing between cavities is proportioned with respect to electron velocity and the frequency so that the transit time between successive deflecting electrode elements 18—18 is a half period. In this manner an electron deflected by one set of electrodes will reach the next set in proper time to be deflected again in the same direction.

The deflected beam crossing the aperture of electrode 15 gives rise to a modulated output current at the electrode 12. In order to insure that the electrodes are properly phased during operation, I employ cross connecting elements or straps 21 and 22 as shown. These straps could be continued down the length of the deflecting electrode system to positively lock all cavities for 180° difference of operation. When used as a converter the input signal and local oscillator signal may be coupled into the cavity resonators by means of the coaxial input line and loop 20. The I. F. output is taken from the output circuit 26, condenser 27 being used to by-pass radio frequency currents around the voltage source 25 which provides the various voltages necessary. A cathode heater may be supplied by voltage sources 28.

In a typical output circuit when the device is used as an amplifier the operating voltages for low voltage tubes might have a voltage of 500 volts applied to the electrode 14, 300 volts on the cavity resonator, 300 volts on the apertured electrode 15, and 300 volts or more on the collecting electrode 12, the electrode 16 being maintained at ground or near-ground potential. If it is desired to use electrode 12 as a secondary emitter and electrode 16 as a collector, electrode 12 may be operated at 250 volts and the electrode 16 at some higher potential.

In a modification instead of employing a collector such as 12, I may utilize a coaxial line cavity resonator such as shown in Figure 3 including an inner conductor 31 and an outer casing 30 provided with aperture 32 into which the electron beam may be directed. The resonator may also be used to provide frequency multiplication. The output may be taken by means of the coaxial line 33.

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.

4

What I claim as new is:

1. An electron discharge device for operation at a predetermined frequency, said device having a cathode for providing a beam of electrons, means for receiving said electrons, and beam deflecting electrode system positioned between the cathode and the receiving means for periodically deflecting the beam of electrons and including a plurality of electrode elements spaced along the path of the beam and on opposite sides of the beam path, the elements on opposite sides being oppositely disposed with respect to each other, adjacent elements on the same side of the beam path being connected by a cavity resonator tuned to said frequency.

2. An electron discharge device for operation at a predetermined frequency having a cathode for producing a beam of electrons, means for receiving said electrons, and a beam deflecting electrode system positioned between the cathode and the receiving means for periodically deflecting the beam of electrons and including a plurality of electrode elements spaced along the path of the beam and on opposite sides of the beam path, the elements on opposite sides being oppositely disposed with respect to each other, adjacent elements on the same side of the beam path being connected by a cavity resonator circuit, said adjacent elements being spaced a distance equal to the distance travelled by an electron during a half period of said operating frequency.

3. An electron discharge device for operation at a predetermined frequency, said device having a cathode for providing a beam of electrons, means for receiving said electrons, a beam deflecting electrode system positioned between said cathode and said receiving means for periodically deflecting said beam of electrons, said beam deflecting electrode system comprising a pair of oppositely disposed members having registering slots therein, the opposed edges of the side walls of said slots adjacent the path of the electrons providing deflecting electrode elements spaced along the path of the beam and the walls of said slots defining resonators tuned to said frequency, and means coupled to one of said cavity resonators to establish an electric field of said frequency therein.

4. An electron discharge device for operation at a predetermined frequency having a cathode for providing a beam of electrons, means for receiving said electrons, and a beam deflecting electrode system positioned between said cathode and said receiving means for periodically deflecting said beam of electrons, said beam deflecting electrode system comprising a pair of oppositely disposed members having registering slots therein, the opposed edges of the side walls of said slots providing deflecting electrode elements spaced along the path of the beam and the walls of said slots providing cavity resonators, adjacent deflecting electrode elements on the same side of the beam path being spaced a distance equal to the distance travelled by an electron during a half period of said operating frequency.

5. An electron discharge device for operation at a predetermined frequency having a cathode for providing a beam of electrons, means for receiving said electrons, and a beam deflecting electrode system positioned between said cathode and said receiving means for periodically deflecting said beam of electrons, said beam deflecting electrode system comprising a pair of oppositely disposed members having registering

5

slots therein, whereby the opposed edges of the side walls of said slots adjacent the path of the beam of electrons providing deflecting electrode elements spaced along the path of the beam and the walls of said slots providing cavity resonators, said slots having a depth substantially equal to a quarterwave length of said operating frequency.

6. An electron discharge device having a cathode for providing a beam of electrons and means for receiving said electrons, and a beam deflecting electrode system positioned between said cathode and said receiving means for periodically and successively deflecting said beam of electrons, said beam deflecting electron system including a pair of oppositely disposed members having a pair of registering slots therein, the opposed edges of the side walls of said slots adjacent the path of the beam of electrons providing deflecting electrode elements spaced along the path of the beam and the walls of said slots providing cavity resonators, and crossed strapping conductors connecting alternate diagonally opposite electrode elements on opposite sides of the beam path.

7. An electron discharge device for operation at a predetermined frequency, said device having a cathode for providing a beam of electrons, means for receiving said electrons, a beam deflecting electrode system positioned between said cathode and said receiving means for periodically deflecting said beam of electrons, said beam deflecting electrode system comprising a pair of oppositely disposed members having registering slots therein, the opposed edges of the side walls of said slots providing deflecting electrode elements spaced along the path of the beam and the walls of said slots providing cavity resonators tuned to said frequency, an apertured electrode between said cathode and said beam deflecting electrode system, and a second apertured electrode between said beam deflecting electrode system and said means for receiving electrons.

8. An electron discharge device for operation at a predetermined frequency, said device having a cathode for providing a beam of electrons, means for receiving said electrons, and a beam deflecting electrode system positioned between said cathode and said receiving means for periodically and successively deflecting said beam of electrons, said beam deflecting electrode system including a pair of oppositely disposed members each having a plurality of slots therein spaced along the path of the beam and registering with the slots in the other member, the opposed edges of the side walls of said slots

6

providing deflecting electrode elements spaced along the path of the beam, and the walls of said slots forming cavity resonators tuned to said frequency.

9. An electron discharge device for operation at a predetermined frequency, said device having a cathode for providing a beam of electrons, an electrode for receiving said electrons, and means positioned along the path of said electrons for deflecting said electrons and including a plurality of cavity resonators successively positioned along the path of said beam, said resonators being open adjacent the beam path and closed at their other ends and tuned to said frequency, the open end walls providing deflecting electrode elements, said adjacent elements being spaced a distance equal to the distance travelled by an electron during a half period of said operating frequency.

10. An electron discharge device according to claim 4, wherein said oppositely disposed members are provided with a plurality of pairs of said registering slots.

11. An electron discharge device according to claim 5, wherein said oppositely disposed members are provided with a plurality of pairs of said registering slots.

12. An electron discharge device according to claim 6, wherein said oppositely disposed members are provided with a plurality of pairs of said registering slots, and the electrode elements of at least one pair of said slots are connected by said cross strapping conductors.

GEORGE ROSS KILGORE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,195,455	Hollmann	Apr. 2, 1940
2,272,165	Varian et al.	Feb. 3, 1942
2,289,952	Zworykin	July 14, 1942
2,308,391	Roberts	Jan. 12, 1943
2,320,860	Fremlin	June 1, 1943
2,403,795	Hahn	July 9, 1946
2,404,078	Malter	July 16, 1946
2,407,163	Kilgore et al.	Sept. 3, 1946
2,407,708	Kilgore et al.	Sept. 17, 1946
2,417,789	Spencer	Mar. 18, 1947

FOREIGN PATENTS

Number	Country	Date
541,623	Great Britain	Dec. 4, 1941