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L. MALTER

2,404,078

ELECTRON DISCHARGE DEVICE

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Fig. 1.

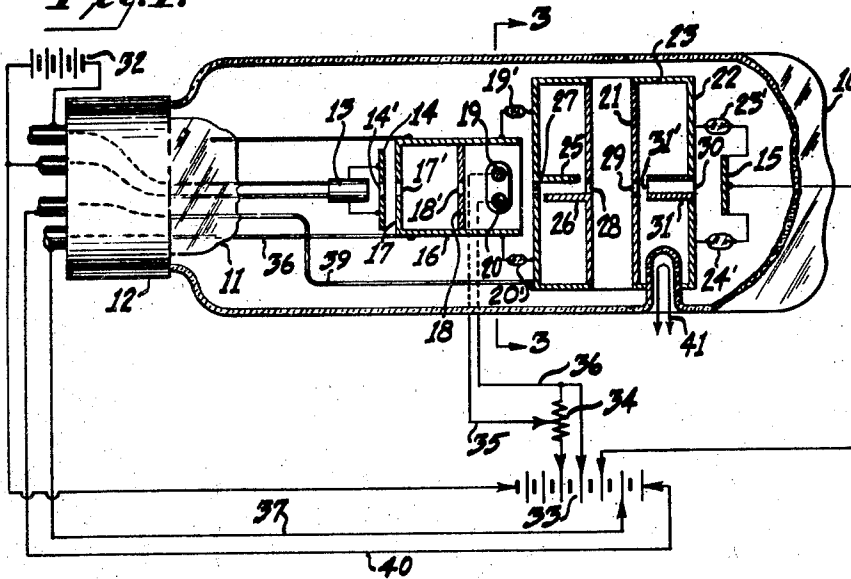


Fig. 2.

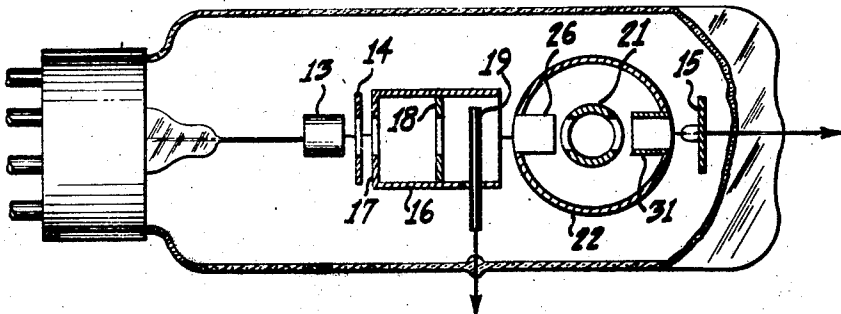
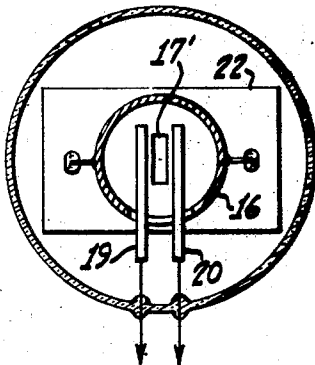


Fig. 3.



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ELECTRON DISCHARGE DEVICE

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10 Claims. (Cl. 250—27.5)

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My invention relates to electron discharge devices useful at ultra high frequencies, particularly such devices utilizing a beam of electrons directed through resonant cavity circuits or resonators.

Electron discharge devices operated as ultra high frequency oscillators and utilizing resonant cavity circuits or resonators have the disadvantage of normally requiring two separate resonant cavity circuits or resonators, the two resonators requiring tuning to the same frequency and adjustment of a coupling link between the two circuits to insure proper phase of the feedback voltage from the output resonator to the modulating resonator. This construction requires unusual methods of tuning to obtain the exact frequency required in the two resonators and usually requires adjustable coupling lines to insure proper phase relationship.

An object of my invention is to provide an improved electron discharge device particularly useful at ultra high frequencies as an oscillator and which utilizes a beam of electrons directed through resonant cavity circuits or resonators.

Another object of my invention is to provide an improved electron discharge device of the type described in which the effect of two resonators and a coupling loop is obtained by the use of a single resonator.

A still further object of my invention is to provide such an electron discharge device in which a single resonator can be used for periodically deflecting a beam of electrons across an output aperture and which also extracts energy from the deflected 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 drawing in which Figure 1 is a longitudinal section of an electron discharge device made according to my invention and its associated circuit diagrammatically shown, Figure 2 is a longitudinal section rotated 90° with respect to Figure 1, and Figure 3 is a section taken along line 3—3 of Figure 1.

In accordance with my invention I provide an electron discharge device with an envelope 10 having the usual press 11 and base 12. A cathode 13, preferably indirectly heated, has mounted adjacent thereto a shield and beam forming electrode 14 having aperture 14' for providing a directed beam of electrons. Electrons which pass through the electrode system to be described are

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collected by a collector 15. Mounted adjacent the cathode and shield is a beam lens and accelerating electrode assembly comprising the tubular member 16 having the apertured partitions 17, 18 and provided with aligned apertures 17' and 18' aligned with aperture 14' for directing a beam of electrons between the beam directing electrodes 19 and 20.

Mounted between this beam lens and accelerating electrode assembly 16 and collector 15 is the circuit and electrode assembly for deflecting the beam and for causing the device to act as an oscillator by providing automatic feedback of energy in the proper phase. It includes a resonant cavity comprising a pair of coaxial tubular members 21 and 22, preferably cylindrical and coextensive with each other and closed by the top and bottom element 23 and 24 of annular shape. Thus the space enclosed within the resonator is annular-shaped, the transverse section being rectangular. The walls of the resonator are provided with a plurality of aligned apertures 27, 28, 29 and 30, which are aligned with apertures 17' and 18'. Mounted on opposite walls within the resonator and adjacent the apertures 27 and 28 are the beam deflecting electrode elements 25 and 26 which deflect the beam across the aperture 29 during operation of the device. Mounted between the apertures 29 and 30 and on one wall of the interior of the resonator is member 31 extending toward aperture 29 to provide a gap 31' across which the beam is directed to the collector 15.

The cathode is heated by means of the voltage source 32 and the various potentials for the other electrodes are provided by the voltage source 33, across which the voltage divider 34 is mounted and connected to the beam directing electrodes 19 and 20 by means of the conductors 35 and 36. By varying the relative potentials on the electrodes 19 and 20, the beam may be properly directed on the aperture 29. The lens assembly 16 which acts to focus the beam of electrons on aperture 29 is provided with a lead-in 36 connected by conductor 37 to voltage source 33 to maintain it at a positive potential with respect to the cathode. The resonator is likewise connected to voltage source 33 by lead 39 and conductor 40. The output coupling loop 41 extends within the resonator for extracting energy for the load.

In operation electrons emitted by the cathode 13 are formed into a beam by electrode 14 and accelerated by the field between the cathode and accelerating lens cylinder 16. A portion of the

current passes through aligned apertures 17' and 18' and is then directed through the aperture 27 of the resonator by means of the lens accelerating assembly and by means of the beam directing rods 19 and 20.

The beam then passes between the deflecting electrodes 25 and 26 and is deflected across output aperture 29. The current passes through the aperture, delivering energy to the resonator as it passes across the gap 31' and through element 31 to the collector 15. If the resonator is excited so that a field maximum exists at the midpoint at the position of the deflecting electrodes, a field will exist in the region between the deflecting electrodes. This will serve to deflect the beam back and forth across output aperture 29, resulting in passing of a varying current through the aperture and further excitation of the resonator.

The resonator is probably first shocked into excitation due to random electrical fluctuations in the resonator. This will cause the beam moving between the deflecting electrodes to be deflected. This in turn will result in variation of current passing by the output gap 31' so that a signal will be induced in the circuit. If this induced signal is set to increase the original random fluctuation, sustained oscillations will result. If the induced signal is not quite of the right phase, a change in beam velocity will correct the situation. This can be accomplished by varying the potentials on the various electrodes. Energy is extracted from the resonator in the usual manner by means of the coupling loop 41.

In operation the beam should be focused as sharply as possible in the plane of the output aperture 29 and so that the ratio variation of current transmitted through the aperture with respect to the field between the deflecting electrodes is a maximum. This ratio corresponds to the transconductance in the ordinary tube and should thus be made as large as possible, such as in the ordinary lower frequency oscillators. This is done by focusing the beam about half on and half off the aperture 29.

The beam which passes by the output aperture will on the average lose some of the D.-C. energy, the loss being that portion which is transformed into R.-F. energy in the circuit. The beam then falls on the collector whose only purpose is to collect spent current. By reducing the D.-C. potential of the collector electrode to the point where it still collects all the current, the D.-C. power is reduced to a minimum and the efficiency of the device is correspondingly increased. For this reason the collector 15 is maintained at a lower potential than that of the resonator.

While I have shown my invention used as an oscillator, it is obvious that it could also be used, for example, as a mixer for superheterodyne operation by applying a signal voltage to the rods 19 and 20 or by coupling into the resonator by means of a signal input loop.

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 means

including a cathode for supplying a beam of electrons and a collector toward which the path of said beam of electrons is directed, an annular hollow resonator positioned between said cathode means and collector in the path of said beam, said resonator having a transverse section of the form of an annulus in a plane parallel to the beam path and confining an annular space and provided with registering apertures in the walls thereof, said registering apertures lying along a transverse axis of said resonator and through which the path of the beam of electrons is directed, oppositely disposed deflecting electrodes positioned within the annular space confined by said resonator adjacent one pair of adjacent registering apertures for deflecting the beam of electrons across another of said registering apertures.

2. An electron discharge device having means including a cathode for supplying a beam of electrons and a collector toward which the path of said beam of electrons is directed, and an annular hollow resonator positioned between said cathode means and collector in the path of said beam, said resonator having a transverse section of the form of an annulus in a plane parallel to the beam path and confining an annular space and provided with registering apertures in the walls thereof, said registering apertures lying along a transverse axis of said resonator and through which the path of the beam of electrons is directed, oppositely disposed deflecting electrodes positioned within the annulus space confined by said resonator between an adjacent pair of registering apertures, one of said deflecting electrodes being connected to one wall and the other of said deflecting electrodes being connected to the opposite wall for deflecting the beam of electrons across another of said registering apertures.

3. An electron discharge device having means including a cathode for supplying a beam of electrons and a collector toward which the path of said beam of electrons is directed, an annular hollow resonator positioned between said cathode means and collector in the path of said beam, said resonator having a transverse section of the form of an annulus in a plane parallel to the beam path and confining an annular space and provided with registering apertures in the walls thereof, said registering apertures lying along a transverse axis of said resonator and through which the path of the beam of electrons is directed, oppositely disposed deflecting electrodes positioned within the annular space confined by said resonator adjacent one pair of adjacent registering apertures for deflecting the beam of electrons across another of said registering apertures, and a tubular member within said annular space and positioned between another pair of apertures and surrounding the beam path and having one end connected to one wall and surrounding an aperture and having its other end spaced from the opposite wall to provide a gap.

4. An electron discharge device having means including a cathode for supplying a beam of electrons and a collector toward which the path of said beam of electrons is directed, an elongated annular hollow resonator positioned between said cathode means and collector and in the path of said beam, said resonator having a section of the form of an annulus in a plane transverse to the longitudinal axis of said resonator and parallel to said beam path and confining an annular space, the walls of said resonator being provided

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with a plurality of aligned apertures positioned along an axis transverse to the longitudinal axis of said resonator and through which the path of said beam of electrons is directed, oppositely disposed deflecting electrodes positioned between a pair of adjacent registering apertures and within the annular space confined by said resonator, one of said electrodes being connected to one wall adjacent one aperture and the other of said electrodes being connected to an opposite wall adjacent the other aperture of said pair, said pair of apertures being on the side of said resonator closest to said cathode means.

5. An electron discharge device having means including a cathode for supplying a beam of electrons and a collector toward which the path of said beam of electrons is directed, an elongated hollow annular resonator positioned between said cathode means and collector and in the path of said beam, said resonator having a section of the form of an annulus in a plane transverse to the longitudinal axis of said resonator and parallel to said beam path and confining an annular space, the walls of said resonator being provided with a plurality of aligned apertures positioned along an axis transverse to the longitudinal axis of said resonator and through which the path of said beam of electrons is directed, oppositely disposed deflecting electrodes positioned within the annular space confined by said resonator and between a first pair of adjacent aligned apertures through which the beam path is directed, one of said electrodes being connected to one wall adjacent one aperture and the other of said electrodes being connected to an opposite wall adjacent the other aperture of said pair, and a tubular member positioned within said annular space between a second pair of adjacent aligned apertures through which the beam path is directed and having one end connected to one wall and surrounding an aperture and having its other end spaced from the opposite wall to provide a gap across which the beam of electrons passes.

6. An electron discharge device having means including a cathode for supplying a beam of electrons and a collector toward which the path of said beam of electrons is directed, a resonator positioned in the path of said beam of electrons and including a pair of coaxial coextensive tubular members, the ends of which are closed and connected together, the longitudinal axis of said tubular members being perpendicular to the beam path, said tubular members having aligned apertures in the walls thereof lying along an axis perpendicular to the longitudinal axis of said resonator, the path of said beam of electrons passing through said aligned apertures, oppositely disposed deflecting electrodes within the resonator and positioned between the tubular members, each electrode being supported on a different opposite wall adjacent an aperture.

7. An electron discharge device having means including a cathode for supplying a beam of electrons and a collector toward which the path of said beam of electrons is directed, a resonator positioned in the path of said beam of electrons and including a pair of coaxial coextensive tubular members, the longitudinal axis of which is perpendicular to the path of the electron beam and the ends of which are closed and connected together, said tubular members having aligned apertures in the walls thereof lying along an axis perpendicular to the longitudinal axis of said resonator, the path of said beam of electrons

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passing through said aligned apertures, oppositely disposed deflecting electrodes within the resonator and positioned between the tubular members, each electrode being supported on a different opposite wall adjacent an aperture, and a tubular element positioned between the other apertures on the opposite side of said resonator from said deflecting electrodes, said last tubular member being connected to one of the coaxial tubular members and extending toward the other of the coaxial tubular members but spaced therefrom to provide a gap.

8. An electron discharge device having means including a cathode for supplying a beam of electrons and a collector toward which the path of said beam of electrons is directed, a resonator positioned in the path of said beam of electrons and including a pair of coaxial coextensive tubular members, the longitudinal axis of which is perpendicular to the path of said beam and the ends of which are closed and connected together, said tubular members having aligned apertures in the walls thereof lying along an axis perpendicular to the longitudinal axis of said resonator, the path of said beam of electrons passing through said aligned apertures, oppositely disposed deflecting electrodes within the resonator and positioned between the tubular members, each electrode being positioned on a different opposite wall adjacent an aperture, and a tubular element positioned between the other apertures on the other side of said resonator from said deflecting electrodes, said last tubular member being connected to one of the coaxial tubular members and extending toward the other of the coaxial tubular members but spaced therefrom to provide a gap, and means positioned between the cathode means and said coaxial tubular members for focusing said electron beam through the apertures in said tubular members.

9. An electron discharge device having means including a cathode for supplying a beam of electrons and a collector toward which the path of said beam of electrons is directed, a resonator positioned in the path of said beam of electrons and including a pair of coaxial coextensive tubular members, the longitudinal axis of which is perpendicular to the path of said beam and the ends of which are closed and connected together, said tubular members having aligned apertures in the walls thereof lying along an axis perpendicular to the longitudinal axis of said resonator, the path of said beam of electrons passing through said aligned apertures, oppositely disposed deflecting electrodes within the resonator and positioned between the tubular members, each electrode being positioned on a different opposite wall adjacent an aperture, and a tubular element positioned between the other apertures on the opposite sides of said resonator from the deflecting electrodes, said last tubular member being connected to one of the coaxial tubular members and extending toward the other of the coaxial tubular members but spaced therefrom to provide a gap, and means positioned between the cathode means and said coaxial tubular members for focusing said electron beam through the apertures in said tubular members, and including a pair of centering and focusing electrodes positioned on opposite sides of the beam path between the cathode and the coaxial tubular members.

10. An electron discharge device having means including a cathode for supplying a beam of electrons along a beam path, a hollow annular resonator positioned in the path of said beam,

said resonator having a transverse section of the form of an annulus in the plane of the beam path and confining an annular space, the walls of said resonator being provided with a pair of registering apertures in that portion of the resonator adjacent said cathode, another wall of said resonator being provided with another aperture registering with said pair of apertures, the path of the

beam of electrons being directed through said apertures, and a pair of deflecting electrodes positioned within the annular space confined by the resonator between the pair of registering apertures and adjacent said apertures for deflecting the beam of electrons across the other aperture.

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