

Sept. 17, 1946.

G. R. KILGORE ET AL
ELECTRON DISCHARGE DEVICE

2,407,708

Filed April 24, 1942

2 Sheets-Sheet 1

Fig. 1.

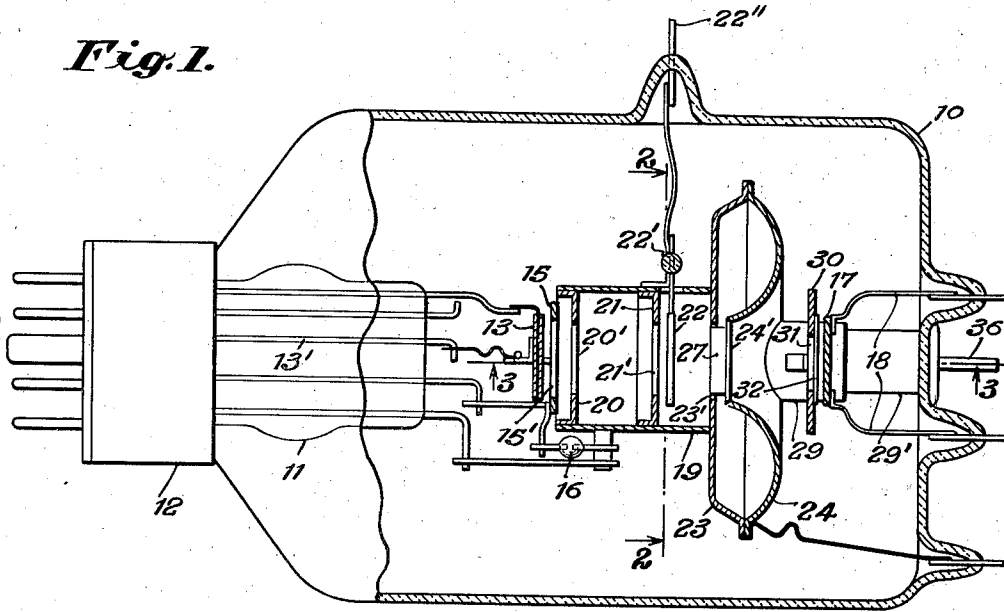


Fig. 2.

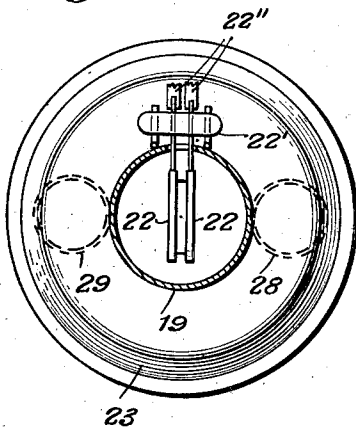


Fig. 3.

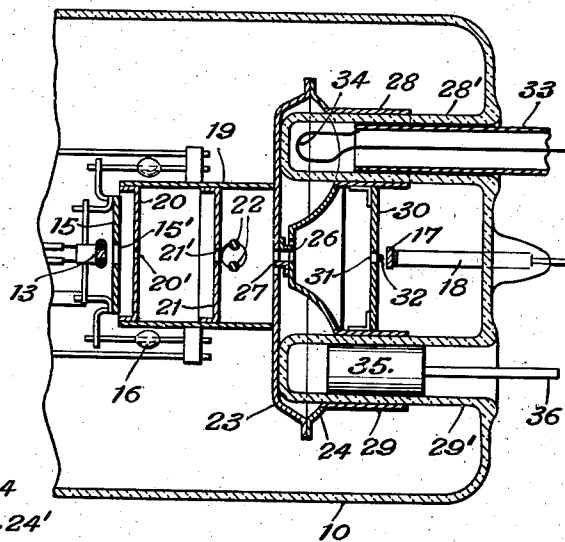
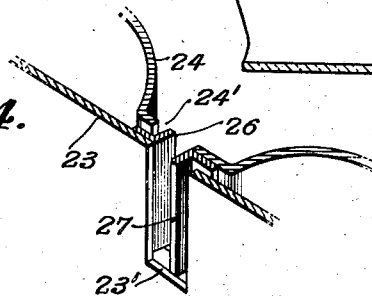


Fig. 4.



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2 Sheets-Sheet 2

Fig. 5.

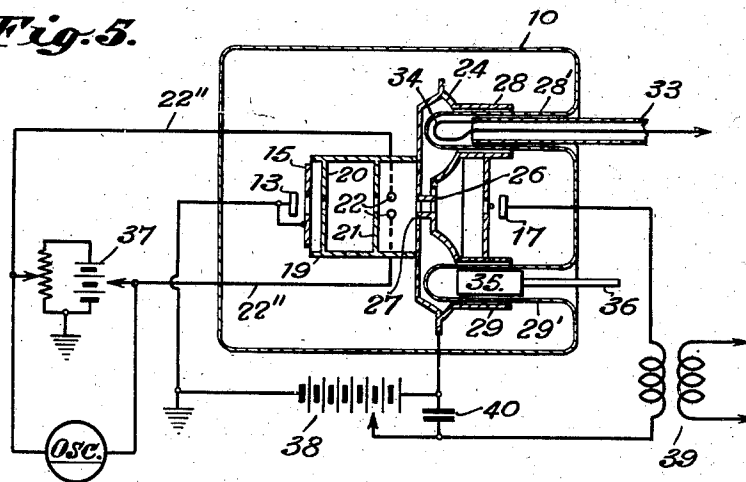


Fig. 6.

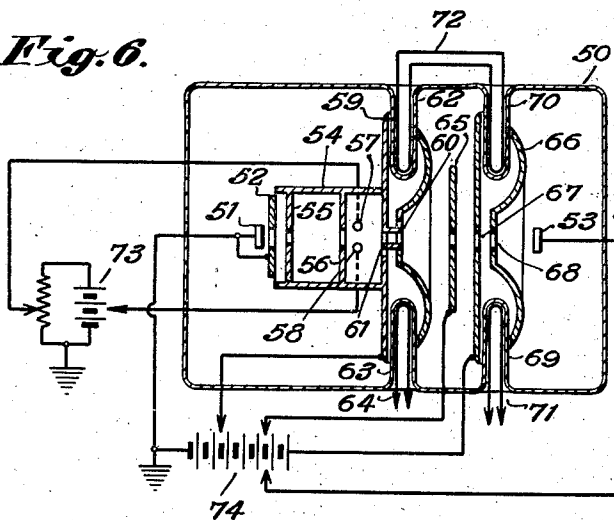


Fig. 8.

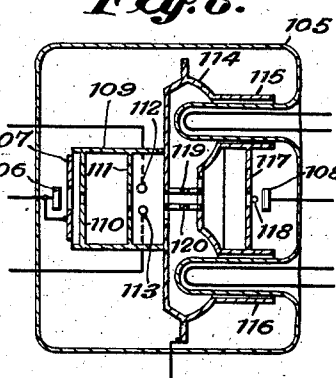


Fig. 7.

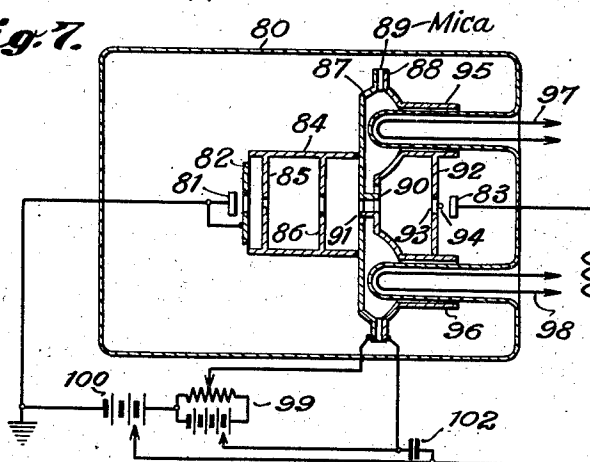
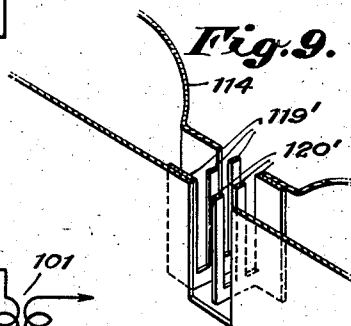


Fig. 9.



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ELECTRON DISCHARGE DEVICE

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Application April 24, 1942, Serial No. 440,300

19 Claims. (Cl. 250—27.5)

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Our invention relates to electron discharge devices, more particularly to such devices utilizing electron beam deflection and useful at ultra high frequencies.

In conventional tubes utilizing beam deflection, a beam of electrons is directed from the cathode toward and between a pair of deflecting electrodes toward an apertured electrode behind which is placed an electron collector. Alternating radio frequency voltages are applied to the deflecting electrodes to cause the electron beam to be deflected across the aperture in the apertured electrode to thus control the amount of current to the collector, which may be used as an output electrode. In such types of tubes the deflection sensitivity drops off as the frequency at which the tube is operated is increased. 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.

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

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

A still further object of our invention is to provide an electron discharge device of the beam deflection type useful at ultra high frequencies and which employs novel low loss input and output electrode systems and circuits.

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

Another object of our invention is to provide an electron discharge device of the beam deflection type useful at ultra high frequencies as an amplifier, oscillator or a mixer.

The novel features which we believe to be characteristic of our invention are set forth with particularity in the appended claims, but the in-

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vention itself will best be understood by reference to the following description taken in connection with the accompanying drawings in which Figure 1 is a longitudinal section of an electron discharge device made according to our invention, Figure 2 is a section taken along the line 2—2 of Figure 1, Figure 3 is a partial longitudinal section of the device shown in Figure 1 turned 90° on its longitudinal axis, Figure 4 is a fragmentary perspective showing details of construction of the deflecting electrodes, Figure 5 is a schematic section of the tube shown in Figure 1 and its associated circuit, Figure 6 is a schematic longitudinal section of a modification of an electron discharge device made according to our invention utilized as an amplifier or oscillator, Figure 7 is a schematic longitudinal section of a still further modification of the electron discharge device shown in Figure 1 and its associated circuit, Figure 8 is a schematic longitudinal section of a still further modification of an electron discharge device made according to our invention, and Figure 9 is a partial perspective in section showing details of construction of Figure 8.

Referring to the drawings, an electron discharge device made according to our invention comprises an evacuated envelope 10 having the usual press 11 and base 12. Supported from the base is the indirectly heated cathode 13, having a lead 13'. Adjacent the cathode is positioned the apertured beam forming and focusing electrode 15 provided with aperture 15'. The electrons are received at the other end of the tube by the output or collector electrode 17 supported on the lead and support wires 18 extending through the envelope.

Positioned between the beam forming and focusing electrode 15 and collector 17 is the beam deflection electrode system including the tubular member 19 provided with transverse apertured discs 20 and 21 having aligned apertures 20' and 21'. Electrically and mechanically secured to the tubular member 19 is the resonant cavity tank circuit or cavity resonator comprising portions 23 and 24 provided with apertures 23' and 24'. Positioned between the member 21 and the portion 23 of the resonant cavity are the beam directing electrode elements 22 supported by means of the glass bead construction 22' and having leads 22'' extending through the wall of the envelope 10.

As best shown in Figures 3 and 4 beam deflecting plates 26 and 27 are positioned adjacent the apertures and electrically connected to and supported by opposite walls of the resonant cavity,

The resonant cavity, as shown in Figure 3, is provided with a pair of apertures from around which extend the tubular extensions 28 and 29 and into which reentrant envelope wells 28' and 29' extend for receiving elements to be described. Supported from and between the tubular members 28 and 29 is the apertured electrode element 30 having aperture 31 and positioned centrally of the aperture the conducting element or wire 32 for providing a double aperture for the purpose of obtaining the desired output voltage-current characteristic.

Extending within the reentrant portion 28' is a coaxial transmission line 33 provided with coupling loop 34 for introducing the signal or control voltage for energizing the resonant cavity. Tuning plunger 35 provided with insulating adjusting handle 36 is mounted to slide within the other reentrant portion 29' within the cavity for bringing about tuning of the resonant cavity.

In Figure 5 is shown the schematic longitudinal section of the tube shown in Figures 1 to 4 inclusive and its associated circuits. Voltage sources 37 and 38 are provided for supplying the necessary biasing voltages to the beam directing electrodes 22 and for supplying the proper positive accelerating voltages to the cavity resonator or resonant cavity tank circuit 23—24 and collector 17. In operation, if the device is to be used as a mixer or oscillator, the oscillator voltage may be applied to the beam directing electrodes 22 as indicated, and the controlling or input signal voltage means of the coaxial line cable 33 to the resonant cavity tank circuit. Thus the beam has applied to it the two alternating voltages of high frequency for producing the intermediate frequency voltage in the output system which may be connected between the collector 17 and the resonant cavity tank circuit. The output circuit includes the primary of transformer 39 and by-passing condenser 40. If desired the electrode 17 may be coated with secondary emitting material and the secondaries collected by the electrode 30.

In operation a beam of electrons generated by cathode 13 and formed and focused into a beam by beam forming member 15 pass through apertured elements 20 and 21 between the electrodes 22. If the tube is used as the oscillator control electrodes the oscillator voltage is applied to the leads 22' connected to these two electrodes. The deflected beam then passes between the deflecting elements 26 and 27 of the resonant cavity tank circuit. Inasmuch as one mode of operation involves the flow of radio frequency current from one aperture radially and outwardly along the inner wall of the resonator and inwardly along the other inner wall to the other aperture, an alternating voltage differential appears between the apertures, and hence deflecting electrodes connected to opposite walls of the cavity at the apertures will provide a transverse deflecting field therebetween. Since these elements 26 and 27 act to shield the beam from the enclosed field within the resonant cavity, the beam is subject substantially to only the transverse field between the deflecting electrode elements 26 and 27. Only transverse deflection of the beam will, therefore, result and substantially no velocity modulation of the beam will take place which latter action is the usual operation which takes place when a beam of electrons is directed through a resonant cavity having opposed apertures. This beam is deflected across the aperture 31 of element 30 and collected by means of

the collector 17. The output current is taken from between the collector 17 and the electrode 30. The input voltage is fed into the coaxial line, and the electromagnetic field of the loop 34 coupled with the interior of the resonant cavity sets up an electromagnetic field which will energize the resonant cavity in the desired manner to bring about voltage differentials between opposite walls of the cavity at the apertures so that deflection will result. By moving the tuning plunger in and out, the frequency of oscillation of the resonant cavity may be adjusted within limits. It is, of course, also possible to apply both the oscillator and signal voltage to the coaxial line, and use electrodes 22 only for initially directing the beam.

In Figure 6 we show a modification of an electron discharge device made according to our invention which may be utilized either as an amplifier or which may be used as an oscillator. In this arrangement we provide an evacuated envelope 50 having at one end thereof the cathode 51 and an apertured beam forming and focusing electrode 52, the electron beam being eventually collected by collector 53 at the other end of the envelope. In this arrangement, positioned between the cathode and collector is a double resonant cavity tank circuit or cavity resonator system for first deflecting the electrons across an apertured electrode and for inductively abstracting energy from the deflected beam. This arrangement comprises tubular member 54 having the successive apertured elements 55 and 56 with the apertures in alignment with the aperture in the beam focusing element 55. The electrodes 57 and 58 direct the beam into the resonator 59. Tubular member 54 is electrically connected to the resonant cavity tank circuit 59 having deflecting electrodes 60 and 61 connected in the manner shown in Figure 3. Positioned intermediate this resonant cavity and the output resonant cavity tank circuit 66 is an apertured electrode 65 across the aperture of which the beam is initially deflected. Current not intercepted passes through the apertures 67—68 in the resonant cavity tank circuit or resonator 66 and induces an alternating voltage within the resonator to energize the resonator in a manner now well understood.

The envelope is provided with a plurality of reentrant portions extending through apertures into the resonant cavities. Within the reentrant portion 63 is extended a coupling loop 64 which may be connected to the input circuit, and the reentrant portion 69 permits the introduction of the output coupling loop 71 within this portion. If the device is to be used as an amplifier the loop 72 extending within reentrant portions 62 and 70 is not utilized, since it is desired to completely shield the two circuits from each other, that is the input circuit from the output circuit. If, however, it is desired to use the device as an oscillator, coupling link 72 may be placed in position so as to feed energy back from the interior of the output resonant cavity tank circuit 66 to the interior of the input cavity tank circuit 59. If desired this coupling link can be made so that its electrical length can be changed so that energy is fed back into the input circuit in proper phase.

The voltage divider arrangement 73 permits proper biasing voltage to be applied to the beam directing electrodes 57 and 58 and the voltage source 74 provides the various positive voltages which are to be applied to the resonant cavity

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tank circuits, the collector and the apertured intermediate electrode 65.

In Figure 7 is shown a still further modification of our invention utilized as a mixer if desired and in which the function of the beam directing electrodes 57 and 58 is taken over by the resonant cavity itself.

In this arrangement the evacuated envelope 80 has at one end thereof the cathode 81, beam forming and focusing apertured electrode 82, and at the other end a collector 83. Positioned between the cathode and collector is the beam deflecting arrangement comprising the tubular element 84 having the apertured discs or partitions 85 and 86. The resonant cavity tank circuit is formed in two parts 87 and 88 insulated from each other by means of insulating ring 89 which may be mica, thus permitting different direct voltages to be applied to the two halves of the cavity by providing a closed hollow tank circuit for confining the radio frequency field. Thus the deflector elements 90 and 91 connected to the opposite walls of the resonant cavity may have applied thereto different voltages for properly centering the beam on the aperture 93 of element 92, divided to provide a double aperture by means of rod 94. The input voltage may be applied by means of the coupling loop 97 and a second loop 98 may be utilized, for example, for applying a local oscillator voltage although a tuning plunger might be used in this case also as in Figure 5. Again the output voltage is taken between collector 83 and the part 88 of the resonant cavity tank circuit by means of the transformer 101 and by-passing condenser 102. Voltage source 100 provides the necessary biasing voltages and divider arrangement 99 permits proper biasing voltages to be applied to deflecting elements 90 and 91.

In Figures 8 and 9 is shown a modification of the device shown in Figure 5 and utilizing deflecting elements for bringing about successive additive deflection. The envelope 105 contains the cathode 106, the beam forming electrode 107 and collector 108. The beam deflecting means comprises tubular member 109 having transverse apertured partitions 110 and 111 and contacting the wall of the resonator 114 between which and the apertured partition 111 are positioned the beam directing electrodes 112 and 113. The resonator 114 is provided with apertures surrounded by tubular extensions 115 and 116 for receiving the usual coupling loops. An apertured plate member 117 provided with rod 118 for providing a double aperture is positioned between tubular extensions 115 and 116.

In accordance with our invention the deflecting electrodes 119 and 120 are provided with a plurality of successive slots forming a plurality of successive deflecting elements 119' and 120', the distance between the centers of the elements being equal to the distance travelled by an electron during a period of the applied controlling voltage. Thus the electrons will be successively and additively deflected in the same direction in passing through the resonator 114, thus increasing the transconductance or the deflecting sensitivity of the tube.

While we have indicated the preferred embodiments of our invention of which we are now aware and have also indicated only one specific application for which our invention may be employed, it will be apparent that our invention is by no means limited to the exact forms illustrated or the use indicated, but that many varia-

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tions may be made in the particular structure used and the purpose for which it is employed without departing from the scope of our invention as set forth in the appended claims.

What we claim as new is:

1. An electron discharge device having a cathode means for providing a beam of electrons and a collector for receiving said beam of electrons, and means positioned between the cathode means and collector and including a hollow resonant conducting member extending transversely of the path of the beam between the cathode means and the collector and having opposed apertures in opposite walls thereof through which the beam is directed during operation of said electron discharge device, and a pair of deflecting elements within said hollow resonant conducting member each of which is separate from and extending transversely of the wall of said hollow resonant conducting member and is electrically connected to an opposite wall of the hollow resonant conducting member next adjacent an aperture for deflecting the beam of electrons in its passage through the hollow conducting member, another portion of the wall of the hollow resonant conducting member having an aperture adapted to receive means for coupling the hollow resonant conducting member to an input circuit, and another portion of the wall of the hollow resonant conducting member having another aperture adapted to receive a tuning plunger for controlling the resonant frequency of the hollow resonant conducting member.

2. An electron discharge device having a cathode means for providing a beam of electrons and a collector for receiving said beam of electrons, and means positioned between the cathode means and collector and including a hollow resonant conducting member extending transversely of the path of the beam between the cathode means and the collector and having opposed apertures in opposite walls thereof through which the beam is directed during operation of said electron discharge device, and a pair of deflecting elements within and separate from the walls of said hollow resonant conducting member each of which is electrically connected to an opposite wall of the hollow resonant conducting member next adjacent an aperture for deflecting the beam of electrons in its passage through the hollow conducting member, another portion of the wall of the hollow resonant conducting member having an aperture adapted to receive means for coupling the hollow conducting member to an input circuit, and another portion of the wall of the hollow resonant conducting member having another aperture to receive a tuning plunger for controlling the resonant frequency of the hollow resonant conducting member, and tubular means extending outwardly from the hollow conducting member around each of the last two mentioned apertures in the other walls of the hollow resonant conducting member.

3. An electron discharge device having a cathode means for providing a beam of electrons and a collector for receiving said beam of electrons, and means positioned between the cathode means and collector and including a hollow resonant conducting member extending transversely of the path of the beam between the cathode means and the collector and having opposed apertures in opposite walls thereof through which the beam is directed during operation of said electron discharge device, and a pair of inwardly directed deflecting elements each of which is elec-

trically connected to an opposite wall of the hollow resonant conducting member adjacent an aperture for deflecting the beam of electrons in its passage through the hollow resonant conducting member, the wall of the hollow resonant conducting member having other apertures positioned on opposite sides of said opposed apertures and adapted to receive means for coupling the hollow resonant conducting member to an input circuit, and to receive a tuning plunger for controlling the resonant frequency of the hollow resonant conducting member, and tubular means extending outwardly from the hollow resonant conducting member around said other apertures, and an apertured conducting element extending between the tubular means and having an aperture registering with the opposed apertures in said hollow resonant conducting member.

4. An electron discharge device having a cathode means for providing a beam of electrons and a collector for receiving said beam of electrons, and means positioned between the cathode means and collector and including a hollow resonant conducting member extending transversely of the path of the beam between the cathode means and the collector and having opposed apertures in opposite walls thereof through which the beam is directed during operation of said electron discharge device, and inwardly directed deflecting elements electrically connected to the walls of the hollow resonant conducting member adjacent the opposed apertures for deflecting the beam of electrons in its passage through the hollow conducting member, the wall of the hollow conducting member having other apertures positioned on opposite sides of said opposed apertures and adapted to receive means for coupling the hollow conducting member to an input circuit, and to receive a tuning plunger for controlling the resonant frequency of the hollow conducting member, and tubular means extending outwardly from the hollow conducting member around each of said other apertures, and an apertured conducting element extending between the tubular means and having an aperture registering with the opposed apertures in said resonant hollow conducting member, and a rod-like element extending across the aperture in the apertured conducting element providing a double aperture.

5. An electron discharge device having a cathode means for providing a beam of electrons and a collector for receiving said beam of electrons, and means positioned between the cathode means and collector and including a resonant hollow conducting member extending transversely of the path of the beam between the cathode means and the collector and having opposed apertures in opposite walls thereof through which the beam is directed during operation of said electron discharge device, and inwardly directed deflecting elements electrically connected to the walls of the resonant hollow conducting member adjacent the apertures for deflecting the beam of electrons in its passage through the resonant hollow conducting member, the wall of the hollow conducting member having other apertures adapted to receive means for coupling the hollow conducting member to an input circuit and to receive a tuning plunger for controlling the resonant frequency of the hollow conducting member, and a conducting enclosure extending between the cathode means and the resonant hollow conducting member and having an apertured element extending transversely of the beam path, the

aperture in said apertured element being aligned with the opposed apertures in the resonant hollow conducting member.

6. An electron discharge device having a cathode means for providing a beam of electrons and a collector for receiving said beam of electrons, and means positioned between the cathode means and collector and including a resonant hollow conducting member extending transversely of the path of the beam between the cathode means and the collector and having opposed apertures in opposite walls thereof through which the beam is directed during operation of said electron discharge device, and inwardly directed deflecting elements electrically connected to the walls of the resonant hollow conducting member adjacent the apertures for deflecting the beam of electrons in its passage through the resonant hollow conducting member, the wall of the hollow conducting member having other apertures adapted to receive means for coupling the hollow conducting member to an input circuit and to receive a tuning plunger for controlling the resonant frequency of the hollow conducting member, and a conducting enclosure extending between the cathode means and the resonant hollow conducting member and having an apertured element extending transversely of the beam path, the aperture in said apertured element being aligned with the opposed apertures in the resonant hollow conducting member, and beam directing elements in said enclosure extending transversely of the path of the beam on opposite sides of the beam path for directing the beam through the opposed apertures in the hollow conducting member and between the deflecting elements.

7. An electron discharge device having a cathode and a beam forming and focusing element positioned next adjacent the cathode for providing a directed beam of electrons and a collector for receiving said electrons, and means positioned between the collector and the beam forming and focusing element, including a cavity resonator extending transversely of the beam path between the cathode and the collector, said cavity resonator being provided with oppositely disposed apertures through which the beam is directed during operation of said device, and deflecting elements electrically connected to and supported by the walls of and within the cavity resonator, and adjacent the apertures and between which the beam of electrons passes during operation of said electron discharge device to be deflected, said cavity resonator having a third aperture and an outwardly extending tubular extension surrounding said third aperture, said tubular extension and aperture being adapted to receive a coupling loop, said cavity resonator having a fourth aperture and an outwardly extending tubular extension surrounding said fourth aperture and adapted to receive a tuning plunger, a tubular member extending between the cavity resonator and the beam forming element, and including a transverse element having an aperture aligned with the oppositely disposed apertures in the cavity resonator, and beam directing elements positioned adjacent said transverse element and on opposite sides of the beam path for directing the beam through the oppositely disposed apertures in the cavity resonator, and an apertured conducting member extending between and supported by said outwardly extending tubular extensions, the aperture in said apertured conducting member being aligned with the apertures in the cavity resonator and registering with the collector.

8. An electron discharge device having a cathode and a beam forming and focusing element positioned next adjacent the cathode for providing a directed beam of electrons and a collector for receiving said electrons, and means positioned between the collector and the beam forming and focusing element, including a cavity resonator extending transversely of the beam path between the cathode and the collector, said cavity resonator being provided with oppositely disposed apertures through which the beam is directed during operation of said electron discharge device, and deflecting elements electrically connected to and supported by the walls of and within the cavity resonator and adjacent the apertures and between which the beam of electrons passes during operation of said electron discharge device to be deflected, said cavity resonator having a third aperture and an outwardly extending tubular extension surrounding said third aperture, said tubular extension and aperture being adapted to receive a coupling loop, said cavity resonator having a fourth aperture and an outwardly extending tubular extension surrounding said fourth aperture and adapted to receive a tuning plunger, a tubular member extending between the cavity resonator and the beam forming and focusing element, and including a transverse element intermediate the ends of said tubular member and having an aperture aligned with the oppositely disposed apertures in the cavity resonator, and beam directing elements positioned adjacent said transverse element and on opposite sides of the beam path for directing the beam through the oppositely disposed apertures in the cavity resonator, and an apertured conducting member extending between and supported by said outwardly extending tubular extensions, the aperture in said apertured conducting member being aligned with the apertures in the cavity resonator and registering with the collector, and a second transverse apertured element closing the end of the tubular member adjacent the beam forming and focusing element.

9. An electron discharge device having an envelope containing cathode means for providing a beam of electrons and a collector for receiving said beam of electrons, and means positioned between the cathode means and collector and including a resonant hollow conducting member extending transversely of the path of the beam between the cathode and the collector and having opposed apertures in opposite walls thereof through which the beam is directed when said electron discharge device is in operation, and inwardly directed deflecting elements positioned within but separate from the walls of said resonant hollow conducting member and electrically connected to the walls of the resonant hollow conducting member next adjacent the apertures for deflecting the beam of electrons in its passage through the resonant hollow conducting member, said resonant hollow conducting member having other apertures adapted to receive means for coupling the resonant hollow conducting member to an input circuit and to receive a tuning plunger for controlling the resonant frequency of the resonant hollow conducting member, said envelope having a reentrant portion extending through each of the other apertures and within the interior of the resonant hollow conducting member.

10. An electron discharge device having an envelope containing cathode means for providing a beam of electrons and a collector for receiving said beam of electrons, and means positioned

between the cathode means and collector and including a resonant hollow conducting member extending transversely of the path of the beam between the cathode and the collector and having opposed apertures in opposite walls thereof through which the beam is directed during operation of said electron discharge device, and inwardly directed deflecting elements positioned within but separate from said resonant hollow conducting member and electrically connected to the walls of the resonant hollow conducting member next adjacent the apertures for deflecting the beam of electrons in its passage through the resonant hollow conducting member, said resonant hollow conducting member having other apertures adapted to receive means for coupling the resonant hollow conducting member to an input circuit and to receive a tuning plunger for controlling the resonant frequency of the resonant hollow conducting member, and tubular means extending outwardly from the resonant hollow conducting member around the other apertures in the resonant hollow conducting member, said envelope having a reentrant portion extending through each of the tubular means into the interior of the resonant hollow conducting member.

11. An electron discharge device having a cathode means for supplying a directed beam of electrons, a first hollow resonant conducting member positioned in the path of the beam and having a pair of aligned apertures in opposite walls through which the beam of electrons is directed during operation of said electron discharge device and a pair of inwardly extending deflecting elements within said hollow resonant cavity member but separate from the walls thereof and each of which is connected to an opposite wall of the hollow resonant conducting member next adjacent the aperture and between which elements the beam is directed during operation of said electron discharge device, and a second hollow resonant conducting member in the path of said beam and having an aperture aligned with the apertures in the first hollow resonant conducting member and through which said beam can be directed during operation of said electron discharge device, and a conducting member positioned between the hollow resonant conducting members and having an aperture aligned with the apertures in the hollow resonant conducting members.

12. An electron discharge device having a cathode means for supplying a directed beam of electrons and a collector for receiving said electrons, and a first resonant hollow conducting member positioned between the cathode means and collector and having a pair of aligned apertures in opposite walls through which the beam of electrons is directed during operation of said electron discharge device and a pair of deflecting elements extending within and transversely of the walls of the resonant hollow conducting member and each of which is connected to an opposite wall of the resonant hollow conducting member next adjacent the aperture and between which elements the beam is directed during operation of said device, and a second resonant hollow conducting member positioned between the first resonant hollow conducting member and said collector and having oppositely disposed apertures aligned with the apertures in the first resonant hollow conducting member, and a conducting plate member positioned between the resonant hollow conducting members and having an aperture aligned with the apertures in the resonant

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hollow conducting members, said resonant hollow conducting members having other apertures, and a connecting coupling link extending within the other apertures for transferring energy between said resonant hollow conducting members.

13. An electron discharge device having a cathode means for supplying a directed beam of electrons and a collector for receiving said electrons, and a first resonant hollow conducting member positioned between the cathode means and collector and having a pair of aligned apertures in opposite walls through which the beam of electrons is directed during operation of said electron discharge device and a pair of deflecting elements separate from and extending transversely of the walls of the resonant hollow conducting member and each of which is connected to an opposite wall of the resonant hollow conducting member adjacent the aperture and between which elements the beam is directed during operation of said device, and a second resonant hollow conducting member positioned between the first resonant hollow conducting member and said collector and having oppositely disposed apertures aligned with the apertures in the first resonant hollow conducting member, and a conducting plate member positioned between the resonant hollow conducting members and having an aperture aligned with the apertures in the resonant hollow conducting members, said resonant hollow conducting members having other apertures, said other apertures being adapted to receive a coupling loop for driving the first resonant hollow conducting member and an output coupling loop for extracting energy from the second resonant hollow conducting member.

14. An electron discharge device having an envelope containing at one end a cathode means for supplying a beam of electrons, and a collector for receiving said electrons, a pair of successive cavity resonators, each of which has oppositely disposed apertures through which the beam of electrons is directed during operation of said electron discharge device, the cavity resonator next adjacent the cathode having inwardly directed deflecting elements separate from the walls of said last cavity resonator and connected to opposite walls next adjacent the apertures for periodically deflecting the beam of electrons, and a conducting member positioned between the cavity resonators and having an aperture aligned with the apertures in the cavity resonators each of said cavity resonators being provided with an aperture in another portion of the wall of the cavity resonator, said envelope having a reentrant portion extending within each of said last named apertures, each of said reentrant portions being adapted to receive a coupling loop.

15. An electron discharge device having a cathode for forming a beam of electrons and a collector for said electrons, and means positioned between the cathode and collector and including a resonant hollow conducting member having aligned apertures in opposite walls thereof and through which the electron beam is to be directed, and a pair of deflecting elements within said resonant hollow conducting member, each electrically connected to an opposite wall of the resonant hollow conducting member and positioned adjacent an aperture, said resonant hollow conducting member comprising a pair of electrically insulated portions each of which includes one wall supporting a deflecting element.

16. An electron discharge device having a cathode for forming a beam of electrons and a col-

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lector for said electrons, and means positioned between the cathode and collector and including a resonant hollow conducting member having aligned apertures in opposite walls thereof and through which the electron beam is directed during operation of said electron discharge device, and a pair of deflecting elements within said resonant hollow conducting member, each electrically connected to an opposite wall of the resonant hollow conducting member and positioned adjacent an aperture, said resonant hollow conducting member comprising two electrically insulated portions, each of which includes one wall supporting a deflecting element, and an apertured plate positioned between the resonant hollow conducting member and the collector and across which the electron beam is deflected during operation of the device, the aperture in said apertured plate registering with the apertures in said resonant hollow conducting member.

17. An electron discharge device having a cathode for forming a beam of electrons and a collector for said electrons, and means positioned between the cathode and collector and including a resonant hollow conducting member having aligned apertures in opposite walls thereof and through which the electron beam is directed during operation of said electron discharge device, and a pair of inwardly directed deflecting elements each supported by an opposite wall of the resonant hollow conducting member and positioned adjacent the apertures, said resonant hollow conducting member comprising two electrically insulated portions, and a conducting enclosing member extending between the cathode and the resonant hollow conducting member and having a transverse apertured element with the aperture in alignment with the apertures in the resonant hollow conducting member, and an apertured plate positioned between the resonant hollow conducting member and the collector and across which the electron beam is deflected during operation of the device.

18. An electron discharge device having a cathode means for supplying a directed beam of electrons, a first hollow resonant conducting member positioned in the path of the beam and having a pair of aligned apertures in opposite walls through which the beam of electrons is directed during operation of said electron discharge device, and a pair of inwardly extending elements separate from and transverse to the walls of said first hollow resonant conducting member and each of which is connected to an opposite wall of the hollow resonant conducting member adjacent an aperture and between which elements the beam is directed during operation of said electron discharge device, and a second hollow resonant conducting member in the path of said beam and having an aperture aligned with the apertures in the first hollow resonant conducting member and through which said beam of electrons can be directed.

19. An electron discharge device having a cathode means for supplying a directed beam of electrons, a first hollow resonant conducting member positioned in the path of the beam and having a pair of aligned apertures in opposite walls through which the beam of electrons is directed during operation of said electron discharge device, and a pair of inwardly extending elements separate from the walls of and within said first hollow resonant conducting member each of which is connected to an opposite wall of the hollow resonant conducting member adjacent

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an aperture and between which elements the beam is to be directed, and a second hollow resonant conducting member in the path of said beam and having an aperture aligned with the apertures in the first hollow resonant conducting member, each of said hollow resonant conducting members being provided with another aperture

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and coupling means extending between said hollow resonant conducting members and through the last mentioned apertures for transferring energy between said hollow resonant conducting members.

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