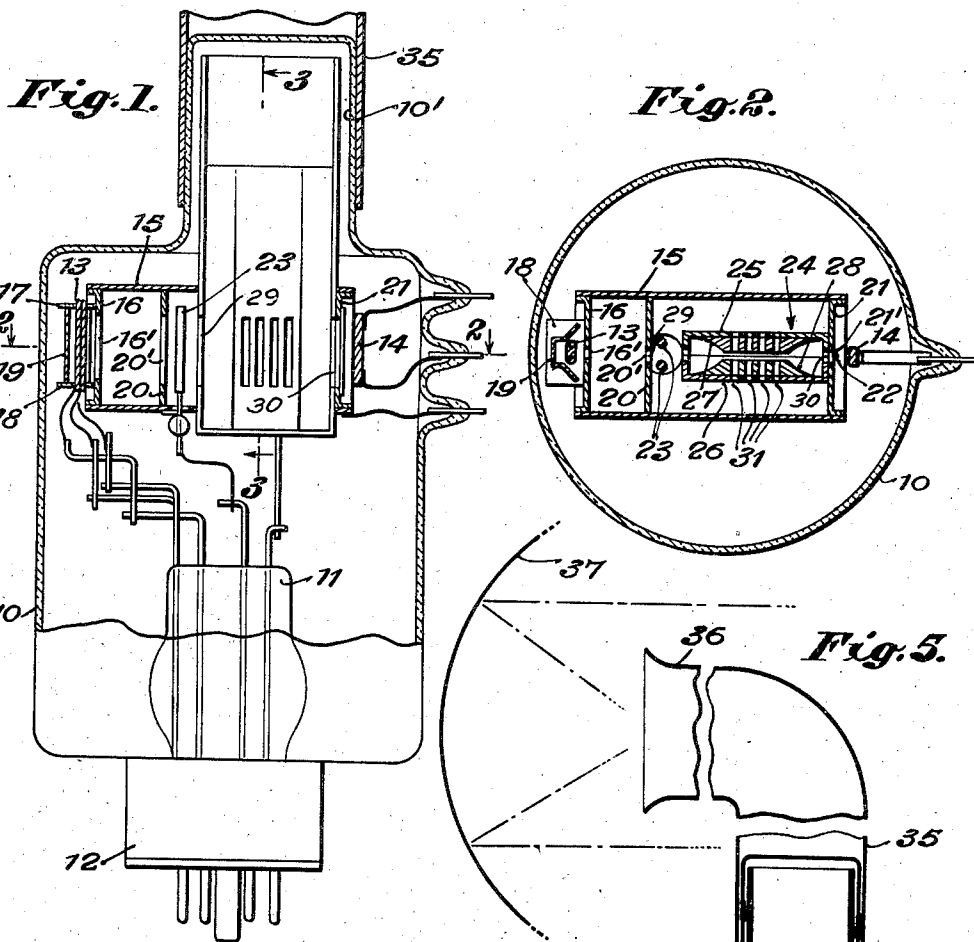
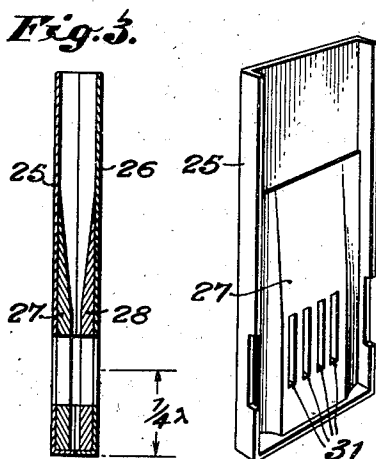
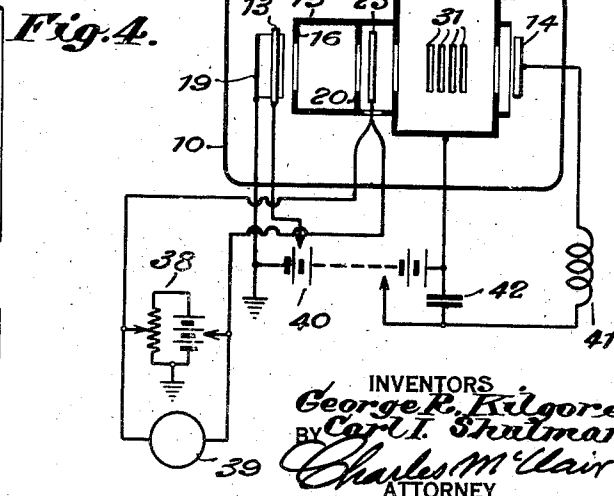


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ELECTRON DISCHARGE DEVICE

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ELECTRON DISCHARGE DEVICE

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

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

One of the problems in connection with an

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electron discharge device of this type is to apply the high frequency radio voltages to the deflecting electrodes. Due to the high frequency at which these devices operate, the leads usually form part of the high frequency circuit and it is important to place the seal at the proper points so that radio frequency voltages will not appear across the glass of the envelope to introduce losses and otherwise interfere with the signal or radio frequency voltage being applied to the deflecting electrodes. This becomes more difficult when it is desired to use circuits involving closed conductors such as coaxial lines which are most suitable for use at ultra high frequencies to prevent radiation losses.

It is, therefore, another object of our invention to provide an electron discharge device of the type described having electrode structures and circuit means which can be readily coupled to said structures and which will eliminate the problems brought about by seals extending through the envelope of the electron discharge device, but yet which will at the same time permit the use of circuits having little or no radiation losses.

As pointed out above, it is desirable when utilizing an electron discharge device at ultra high frequencies to employ circuit elements having low radiation and resistance losses. Closed hollow conductors have been found most suitable for this use and coaxial lines have been commonly used. However, it is necessary to utilize insulation between the inner and outer conductors of a coaxial line and it is also necessary to utilize such insulators as seals where the coaxial line passes through a tube envelope. In high frequency applications it is common to utilize the same circuit and antenna system for reception and transmission and thus a device used in a receiver may be subjected at times to high power with a resulting breakdown across insulators, particularly the seals of the electron discharge devices utilized in the receiver. A hollow wave guide is a desirable means for use in receiving and transmitting high frequency radio energy since the use of such guides results in a lower field intensity within the guide, thus reducing or preventing breakdown in any insulation used and at the same time provides a circuit which has low radiation and resistance losses. However, to couple such a wave guide with an electron discharge device, particularly the control electrodes, presents a problem.

It is, therefore, another object of our invention to provide an electron discharge device in which

the electrodes may be readily coupled to a wave guide.

The novel features which we believe to be characteristic of our 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 side elevation partially in section of an electron discharge device made according to our invention and showing details thereof, Figure 2 is a section taken along the line 2—2 of Figure 1, Figures 3 and 4 show details of the deflecting electrode system utilized in the structure shown in Figures 1 and 2, and Figure 5 is a schematic diagram of an electron discharge device made according to our invention and its associated circuit.

The electron discharge device made according to our invention and shown in Figure 1 comprises an envelope 10 containing the usual press 11 and base 12. The electrode system is supported from the press by a plurality of leads and supporting wires and includes an indirectly heated cathode 13 positioned at one side of the envelope, and collector 14 positioned at the other side. The intermediate electrode system includes the tubular member 15, having transverse partitions 16, 20 and 21, these being provided with elongated apertures 16', 20' and 21'. Mounted adjacent the aperture 16' and supported from member 15 is the cathode assembly which includes the cathode 13 and the insulator spacers 17 and 18, preferably of mica, and also the beam forming and beam directing electrode 19. The electrons from the cathode 13 pass through the apertures 16' and 20' between a pair of beam directing electrode members 23, which may be used to direct the beam or may be used for other purposes, for example, to apply a local oscillator voltage to the electron beam passing to the collector.

In accordance with our invention we position between the beam collecting means and collector, the beam deflecting electrode system comprising the tubular member 24 of flat rectangular cross section comprising a pair of sections 25—26, as best shown in Figures 3 and 4, secured together to provide entrance apertures 29 and 30 through which the beam is directed between the elements 27 and 28 forming the beam deflecting electrodes. Elements 27 and 28 are gradually increased in thickness but spaced to provide a passageway therebetween for the beam. The reason for the increase in thickness is to get a maximum field intensity at the deflecting plates. These elements 27 and 28 and the tubular member comprising elements 25 and 26 have a plurality of successive slots 31 registering with the path of the electrons between the elements, the midpoint of the solid portions between the slots being spaced a distance equal to the distance travelled by an electron during a period of the applied signal or controlling radio frequency voltage or a multiple of this distance. The apertures 29 and 30 are aligned with apertures 16' and 20', and aperture 21' in transverse element 21. A rod-like or filament-like element 22 lying longitudinally of the elongated aperture 21' provides a double aperture across which the beam is deflected. This double aperture results in the desired signal voltage-output current characteristic desired for certain applications.

The deflecting electrode system is extended upwardly into the neck 10' of the envelope, the upper end of tubular member 24 being open at the

upper end as shown in Figure 3. The surface of the envelope lies close to the surface of the extension to permit the telescoping of the wave guide 35 over the tube envelope to couple this element with the tubular member within the tube. The arrangement of this wave guide and the associated circuit is best shown in Figure 5 which will be discussed below.

In the operation of the device made according to our invention electrons from the cathode 13 are formed into a directed beam by means of member 19 and apertured element 16 so that the beam is directed through apertured element 20 between members 23 which may be biased to direct the beam of electrons through the beam deflecting electrode system and through the apertured element 21 to collector 14, and may also be used to receive and apply a local oscillator voltage to the beam. The distance between centers of the solid portions between slots 31 of the deflecting elements 27 and 28 is equal to the distance travelled by an electron during a period of the applied controlling voltage. As an electron in the beam passes between the elements formed by the solid portions, intermediate the slotted portions 31, of the deflecting electrode system, it comes under the influence of each successive pair of elements for approximately a half period at half-period intervals. Since the voltage on the deflecting electrodes during half-period intervals passes through 180°, and since the electron is subjected to substantially no deflecting field while passing by the slots, deflection of the electron will be additive or in the same direction while subjected to the field between each pair of successive deflecting elements, thus the effective transconductance is increased substantially in direct ratio to the number of successive pairs of deflecting elements.

In the arrangement shown the input circuit within the envelope of the device is combined with the deflecting elements to greatly simplify the electrode system and to provide a unitary structure. Because of the shielding arrangement of the tubular members 25—26 and their extensions, the input circuit and deflecting electrodes are well shielded from the output electrode system so that little if any interaction results, particularly since the external input circuit is closely coupled to the upper extension of the deflecting electrode system. The distance from the closed lower end of the combined deflecting electrode system and input circuit to the line midway between the ends of the slots or elongated apertures 31 is equal to a quarter wave length of the applied radio frequency voltage as measured in the wave guide which is a function of the wave guide dimensions, so that maximum voltage will appear between the two halves of the deflecting electrode system.

The arrangement of the tube in combination with the input and output circuit and local oscillator circuit is shown in Figure 5. The bias on the beam directing and oscillator electrodes 23 is applied from the source 38. These electrodes may also be connected to the local oscillator 39. The beam forming and beam directing electrode 19 is maintained at a negative potential with respect to the cathode, whereas the deflecting electrode system and beam focusing system is maintained at a positive potential with respect to the cathode, the collector 14 being maintained at a lower potential than the deflecting electrode. The source of voltage 40 provides these necessary biasing potentials. An output circuit comprising

the coil 41, and condenser 42 is connected between electrode 14 and transverse element 21 of member 15. The ultra short waves may be intercepted and focused into the wave guide 36 by reflector 37. The extension 35 of the wave guide is coupled through the envelope to the extension of the combined circuit and deflecting electrode system 25. These waves are directed down into the combined input and deflecting electrode system 24 to deflect the beam of electrons as it passes between the elements of the electrode system.

Thus with the arrangement shown it is possible to eliminate the necessity for seals and it is also possible to provide by the use of a wave guide an effective non-radiating input system which is completely shielded from the output as well as from the local oscillator circuit.

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 variations 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 for supplying a beam of electrons and means for receiving said beam of electrons, a beam deflecting electrode system positioned between said cathode and beam receiving means and including an elongated hollow member having oppositely disposed apertures, through which the beam is to be directed, said apertures being aligned along an axis transverse to the longitudinal axis of said elongated hollow member, one end of said elongated hollow member being closed and the other end open, said open end being adapted to be coupled to a hollow wave guide, said elongated hollow member having deflecting means positioned between said apertures on opposite sides of the beam path.

2. An electron discharge device having a cathode for supplying a beam of electrons, and a collector for receiving said electrons, and a deflecting electrode system positioned between the cathode and the collector and including an elongated hollow conducting member having one end closed and the other end open, said member having near its closed end a plurality of successively positioned oppositely disposed aligned apertures forming a plurality of successively positioned oppositely disposed deflecting elements between which the beam of electrons is to be directed, the open end of said elongated hollow conducting member being adapted to be coupled to a hollow wave guide.

3. An electron discharge device having a cathode for supplying a beam of electrons and a collector for receiving said electrons, and a deflecting electrode system positioned between the cathode and collector and including an elongated hollow conducting member closed at one end and open at the other, and extending transversely of the path of said beam and through which said beam is to be directed, said hollow closed conducting member having a plurality of oppositely disposed aligned apertures coextensive with each other and successively positioned along the path of the beam between the cathode and the collector, the open end of said hollow conducting

member being adapted to be coupled to a hollow wave guide.

4. An electron discharge device having an envelope containing a cathode for supplying a beam of electrons and a collector for receiving said electrons, and a deflecting electrode system positioned between the cathode and collector and including an elongated hollow conducting member closed at one end and open at the other, and extending transversely of the path of said beam and through which said beam is to be directed, said hollow closed conducting member having a plurality of oppositely disposed aligned apertures coextensive with each other and successively positioned along the path of the beam between the cathode and the collector, said envelope having an elongated extension, the open end of said hollow conducting member being positioned within the elongated extension of said envelope and adapted to be coupled to a hollow wave guide.

5. An electron discharge device having a cathode for supplying a beam of electrons and means for receiving said beam of electrons, means intermediate said cathode and said beam receiving means and including a tubular member having its longitudinal axis coaxial with the path of the electron beam between the cathode and the receiving means and provided with a plurality of transverse conducting members having aligned apertures through which the beam is directed, and a beam deflecting electrode system positioned between a pair of said transverse members and including an elongated hollow member extending within the tubular member and having a plurality of oppositely disposed apertures positioned successively along and on opposite sides of the beam path, one end of said elongated hollow conducting member being closed and the other end open and adapted to be coupled to a hollow wave guide.

6. An electron discharge device having a cathode for supplying a beam of electrons and means for receiving said beam of electrons, means intermediate said cathode and said beam receiving means and including a tubular member having its longitudinal axis coaxial with the path of the electron beam between the cathode and the receiving means and provided with a plurality of transverse conducting members having aligned apertures through which the beam is directed, and a beam deflecting electrode system positioned between a pair of said transverse members and through which the beam of electrons is to be directed, and including an elongated hollow member extending within the tubular member and having apertures on opposite sides of the beam path and oppositely disposed, one end of said elongated hollow member being closed and the other end open and adapted to be coupled to a hollow wave guide.

7. An electron discharge device having an envelope containing a cathode for supplying a beam of electrons, and a collector for receiving said electrons and a deflecting electrode system positioned between the cathode and collector and including an elongated hollow conducting member closed at one end and open at the other end and extending transversely of the path of said beam and through which said beam is to be directed, said hollow conducting member having near its closed end a plurality of oppositely disposed aligned apertures coextensive with each other and positioned along the path of the beam between the cathode and collector, the open end of said hollow conducting member being adapted

to be coupled to a wave guide, the interior surfaces of said hollow conducting member on opposite sides of the beam path converging toward each other toward the closed end of the hollow conducting member but spaced to provide a gap between said surfaces to provide a space through which said beam is to be directed, the distance from the closed end of the hollow conducting member to the midpoint of said apertures being substantially equal to a quarter wave length of the control voltage applied to said deflecting electrode system during operation of said electron discharge device.

8. An electron discharge device having a tubular member provided with a plurality of transverse apertured members with the apertures aligned, a beam supplying and beam forming assembly positioned at one end of said tubular member and comprising a cathode and a beam forming electrode partially surrounding said cathode for directing a beam of electrons through the apertured transverse member at one end of said tubular member, and a collector opposite the other end of said tubular member for receiving said beam of electrons, and a deflecting electrode system comprising a hollow conducting member of rectangular cross section extending within the tubular member and having apertures aligned with the apertures of said transverse members and through which said beam is to be directed, said hollow conducting member being closed at one end and open at the other and having a plurality of successively positioned oppositely disposed apertures positioned along the path of the beam and on opposite sides thereof providing a plurality of successively positioned electrode elements for deflecting said beam.

9. An electron discharge device having an envelope containing a tubular member provided with a plurality of transverse apertured members with the apertures aligned, a beam supplying and beam forming assembly positioned at one end of said tubular member and comprising a cathode and a beam forming electrode partially surrounding said cathode for directing a beam of electrons through the apertured transverse member at one end of said tubular member, and a collector opposite the other end of said tubular member for receiving said beam of electrons, and a deflecting electrode system comprising a hollow conducting member of rectangular cross section extending within the tubular member and having apertures aligned with the apertures of said transverse members and through which said beam is to be directed, said hollow conducting member being closed at one end and open at the other and having a plurality of successively positioned oppositely disposed elongated apertures positioned along the path of the beam and on opposite sides thereof providing a plurality of successively positioned electrode elements for deflecting said beam, said envelope having an elongated extension, the open end of said hollow conducting member extending within said extension and being adapted to be coupled to a hollow wave guide.

10. An electron discharge device having a tubular member provided with a plurality of transverse apertured members with the apertures aligned, a beam supplying and beam forming assembly positioned at one end of said tubular member and comprising a cathode and a beam forming electrode partially surrounding said cathode for directing a beam of electrons through

the apertured transverse member at one end of said tubular member, and a collector opposite the other end of said tubular member for receiving said beam of electrons, and a deflecting electrode system comprising a hollow conducting member of rectangular cross section extending within the tubular member and having apertures aligned with the apertures of said transverse members and through which said beam is to be directed, said hollow conducting member being closed at one end and open at the other and having adjacent its closed end a plurality of successively positioned oppositely disposed elongated apertures positioned along the path of the beam and on opposite sides thereof providing a plurality of successively positioned electrode elements for deflecting said beam, the inner surfaces of the hollow conducting member converging toward each other toward the closed end, but spaced apart providing a gap between said surfaces to provide a space through which the beam may be directed.

11. An electron discharge device having a tubular member provided with a plurality of transverse apertured members with the apertures aligned, a beam supplying and beam forming assembly positioned at one end of said tubular member and comprising a cathode and a beam forming electrode partially surrounding said cathode for directing a beam of electrons through the apertured transverse member at one end of said tubular member, and a collector opposite the other end of said tubular member for receiving said beam of electrons, and a deflecting electrode system comprising a hollow conducting member extending within the tubular member and having apertures aligned with the apertures of said transverse members and through which said beam is to be directed, said hollow conducting member being closed at one end and open at the other and having adjacent its closed end a plurality of successively positioned oppositely disposed elongated apertures positioned along the path of the beam and on opposite sides thereof providing a plurality of successively positioned electrode elements for deflecting said beam, the distance from the closed end of said hollow conducting member to the midpoint of said apertures being substantially equal to a quarter wave length of the alternating voltage applied to said deflecting electrode system.

12. An electron discharge device having an envelope containing a cathode for supplying a beam of electrons, and a collector for receiving said electrons and a deflecting electrode system positioned between the cathode and collector and including an elongated hollow conducting member closed at one end and open at the other end and extending transversely of the path of said beam and through which said beam is to be directed, said hollow conducting member having near its closed end a plurality of oppositely disposed aligned apertures coextensive with each other and positioned along the path of the beam between the cathode and collector, the open end of said hollow conducting member being adapted to be coupled to a wave guide, the interior surfaces of said hollow conducting member on opposite sides of the beam path converging toward each other toward the closed end of the hollow conducting member but spaced apart providing a gap between said surfaces to provide a space through which said beam is to be directed.

13. An electron discharge device having an envelope containing a cathode for supplying a

beam of electrons, and a collector for receiving said electrons, and a deflecting electrode system positioned between the cathode and collector and including an elongated hollow conducting member of rectangular cross section and closed at one end and open at the other end and extending transversely of the path of said beam and through which said beam is to be directed, said hollow conducting member having near its closed end a plurality of oppositely disposed aligned apertures coextensive with each other and positioned along the path of the beam between the cathode and collector, the open end of said conducting member being adapted to be coupled to a wave guide, the interior surfaces of said hollow conducting member on opposite sides of the beam path converging toward each other toward the closed end of the hollow conducting member but spaced apart providing a gap between said surfaces to provide a space through which said beam is to be directed, and a pair of beam directing elements positioned between the hollow conducting member and said cathode.

14. An electron discharge device having a cathode for supplying a beam of electrons and means for receiving said beam of electrons, a beam deflecting electrode system positioned between said cathode and beam receiving means, and including an elongated hollow member having oppositely disposed apertures through which the beam is to be directed, said apertures being aligned along an axis transverse to the longitudinal axis of said elongated hollow member, one end of said elongated hollow member being closed and the other end open, said open end being adapted to be coupled to a hollow waveguide, said apertures being intermediate the closed and open ends of said elongated hollow member, said elongated hollow member having deflecting means positioned between said apertures on opposite sides of the beam path.

gated hollow member having deflecting means positioned between said apertures on opposite sides of the beam path.

15. An electron discharge device having a cathode for supplying a beam of electrons and means for receiving said beam of electrons, a beam deflecting electrode system positioned between said cathode and beam receiving means and including an elongated hollow member having oppositely disposed apertures through which the beam is to be directed, the longitudinal axis of said hollow member being perpendicular to the beam path, one end of said hollow member being closed and the other end open, said open end being adapted to be coupled to a hollow wave guide, said apertures being adjacent the closed end of said elongated hollow member, said hollow member having deflecting means positioned between said apertures on opposite sides of the beam path.

16. An electron discharge device having a cathode for supplying a beam of electrons and means for receiving said beam of electrons, a beam deflecting electrode system positioned between said cathode and beam receiving means and including an elongated hollow member having oppositely disposed apertures through which the beam is to be directed, the longitudinal axis of said hollow member being perpendicular to the beam path, one end of said hollow member being closed and the other end open, said open end being adapted to be coupled to a hollow wave guide, said apertures being adjacent the closed end of said elongated hollow member, the inside surfaces of said hollow conducting member adjacent the apertures converging toward the closed end of the hollow member.

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