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ELECTRON DISCHARGE DEVICE

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Fig. 1.

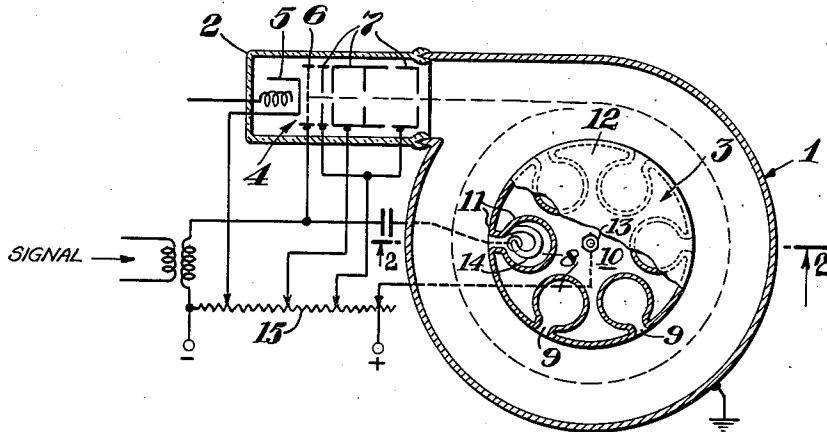
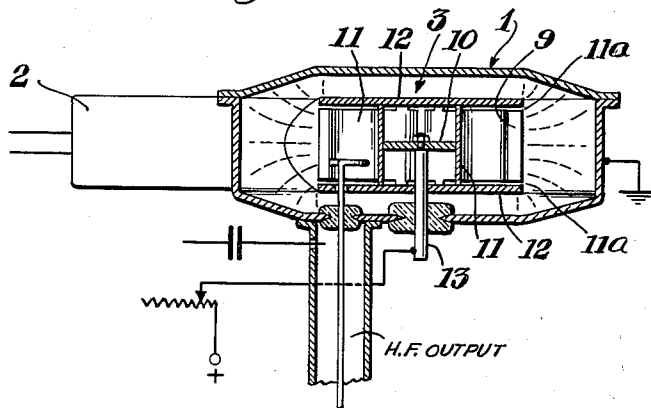


Fig. 2.



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ELECTRON DISCHARGE DEVICE

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4 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices, particularly to devices operable at ultra high frequencies.

Generators or amplifiers of electric waves in the centimeter range generally must avoid lumped inductances and capacitances in the resonant circuits and use instead resonant lines or cavities. The higher the frequency, the smaller becomes the physical dimensions of the tube parts and, accordingly, the lower becomes the power dissipating capacity of the tube. Parallel connected resonant lines or cavities, have required, heretofore, complicated straps and connections which usually introduce undesired impedances.

An object of this invention is an improved electron discharge device for ultra high frequencies.

A more specific object of this invention is a generator, or amplifier, for ultra high frequencies capable of high power.

The invention is defined with particularity in the appended claims and one embodiment thereof is described in the following specification and shown in the accompanying drawing in which:

Fig. 1 is a plan view, with the upper portion of the envelope removed, of the novel electron discharge device of this invention, and

Fig. 2 is an elevational view, sectioned along line 2—2 of Fig. 1.

The envelope of the discharge device of this invention comprises generally, a flattened cylinder 1 with a tangentially extending neck 2. In the particular structural embodiment chosen for illustration, the cylindrical portion of the envelope is of metal and the neck portion is of glass, the two parts being hermetically sealed near the periphery of the cylinder. An all-glass envelope could, of course, be employed if desired. A flattened circular anode 3 is insulatedly mounted in the envelope substantially coaxial with the cylindrical portion of the envelope so that the circular center line of the annular space about the anode is substantially tangential to the straight center line of the neck. For projecting a beam of electrons along the center of the neck, an electron gun 4 of conventional construction is placed at the outer end of the neck. The gun comprises a cathode 5, a control grid 6 and one or more accelerating and focusing electrodes 7.

The unitary cylindrical anode structure is provided with a plurality, preferably an even number, of resonant cavities 8 having openings 9 uniformly spaced along the periphery of the anode. To the electrons which travel in the annular

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space between the anode and envelope, the anode presents a smooth curved surface, impervious except for cavity openings. Structurally, the anode should be light in weight for easy degassing and according to one example may comprise a single flat sheet metal stamping 10 fitted and attached along its edge to a metal ribbon 11. The ribbon extends transversely of the stamping and is shaped to the contour of the anode surface and cavities. The ends of the cavities may be individually covered in spaced relation with small metal discs, or with single large discs 12, of anode diameter spaced from a major portion of the walls 11 as indicated at 11a. The anode structure is supported as a unit on a heavy stud and lead-in conductor 13 and is centered between the sides of the envelope. To deflect the electron beam in a circular path, past the cavity openings, a deflecting electrode may be provided outside and concentric with the anode. The focusing electrode comprises an electrode enclosed within the envelope or formed by the envelope wall itself. The wall of the envelope or, in the case of a separate deflecting electrode, the surface of the deflecting electrode should extend parallel to the face of the anode and radially inward at the top and bottom of the device as shown in Fig. 2 so that the electrostatic field, represented by dotted lines in Fig. 2, will crowd the beam toward the center of the annular space, midway between the ends of the cavity openings.

In operation the anode is maintained at a high positive direct current potential, the outer deflecting electrode is grounded, and the electron gun electrodes are supplied with the usual progressive potentials for accelerating and focusing a small high velocity beam toward, but tangentially to, the anode. As the beam enters the annular anode space, the electrons encounter the radial electrostatic field of the anode and deflecting electrode and are deflected accordingly. The radius of the curved electron path is a function of the potential gradient of the radial field and of the velocity of the electrons entering that field. Hence, the beam may be drawn into a circular path or spiral substantially coaxial with the anode by adjustment of the anode potential for a given electron velocity at the gun. Conversely, the desired circular path may be given the electron beam by adjusting the accelerating potentials at the gun for a given radial gradient at the anode by means of connections to potentiometer 15 connected across a source of direct potential. Further, the angular velocity

of the electrons, or speed of rotation of the beam, may be adjusted to control electron transit time between cavity openings, by proportionately changing in the same direction both the initial electron velocity and the anode gradient. This latter adjustment is important in establishing the electron transit time between cavity openings. The usual space charge clouds of the electron source are confined to the neck portion of the envelope and are well removed from the curved orbit of the beam.

As the electrons traverse the openings of the cavities, oscillatory electromagnetic energy is excited in the cavities, and by adjusting the electron transit time between cavity openings to approximately one half the natural period of the cavities, the phase of oscillation of one cavity may become 180 degrees displaced from the phase of the adjacent cavity. The several cavities are, accordingly, effectively connected in parallel and high frequency energy from the entire anode may be withdrawn from one cavity. An inductive loop 14 is mounted in one cavity and is externally connected through a conductor sealed in the side of the envelope. The loop is shown connected directly into a coaxial cable.

While energy extracted from or given up to the electrons at the cavity openings may, as expected, bunch the electrons, it may be desirable to group the electrons at their source. According to this invention, the control grid potential is modulated by oscillations derived from the output loop, and by properly phasing the feedback energy the electrons may be bunched to minimize out-of-phase excitation of the cavities.

Signal voltages, too, may be applied to the control grid to amplitude modulate the beam and the output high frequency. To reduce reactances in the feedback circuit, it may be desirable to apply the signal voltage to a separate control grid. A signal applied to one of the high potential accelerating electrodes 7 would modulate at signal frequency the velocity of the electrons in the beam and would phase modulate the output high frequency current.

The electron discharge device of this invention is adapted to generate or amplify ultra high frequencies at power levels heretofore unattained. As the electrons give up their energy to the cavities and gradually lose speed, they spiral toward the anode and eventually fall into the anode. The rate at which the electrons spiral inwardly is conveniently controlled by the anode potential. It is desirable to maintain the anode potential sufficiently high to remove the electron after but a few revolutions about the anode, to minimize lagging out-of-phase excitation of the cavities. The rate at which each electron gives up energy and loses speed, or lags, depends of course on such physical factors as the size of the cavity openings, and closeness of electron-to-cavity coupling. Since most of the electron energy may be extracted by the cavities, a comparatively small proportion of the energy is dissipated as heat at the surface of the anode. Further, the surface of the anode is inclined to the path of the oncoming electrons and presents a relatively large area, per unit of space current, for dissipating heat.

The electron discharge device of this invention

is adapted for generation or amplification of large amounts of power at ultra high frequencies, is simple in construction and easy to operate.

We claim:

1. A high frequency generator arrangement comprising a cylindrical anode, including a plurality of cavity resonators with openings facing to the curved outer surface of said anode, said openings being circumferentially spaced along said surface, an electron gun mounted in said device tangentially to a circular path substantially coaxial with said anode, first beam controlling means adjacent said gun for directing said beam tangentially to said circular path, and second beam controlling means comprising a cylindrical metal envelope mounted about said anode and means connected to said anode and said envelope for applying a potential therebetween for deflecting said beam into said circular path.

2. An arrangement, defined in claim 1, having a grid electrode in the path of said beam and means connected to said grid electrode for applying part of the high frequency energy of said output circuit to said grid.

3. An electron discharge device comprising a cylindrical anode including a plurality of cavity resonators with openings facing the curved outer surface of said anode, said openings being circumferentially spaced along said surface, an electron gun mounted in said device tangentially to a circular path substantially coaxial with said anode, means adjacent said gun for controlling the tangential velocity of the electrons in said beam, conductor means mounted about said anode, and means for applying to said anode a potential positive with respect to said conductor means for deflecting the electrons in said beam radially inwardly towards said anode.

4. A high frequency generator arrangement comprising a cylindrical anode having a plurality of cavity resonators with openings facing the curved outer surface of said anode, said openings being circumferentially spaced along said surface, an electron gun mounted in said device tangentially to a circular path substantially coaxial with said anode, an electrode adjacent said gun having means connected thereto for applying a potential for controlling the tangential velocity of the electrons in said beam, and means mounted about said anode for producing a radial electrostatic field for deflecting the electrons in said beam radially inwardly towards said anode.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,084,867	Prinz	June 22, 1937
2,193,602	Penney	Mar. 12, 1940
2,289,220	Smith	July 7, 1942
2,404,212	Bondley	July 16, 1946
2,412,824	McArthur	Dec. 17, 1946
2,422,088	Ferris	June 10, 1947
2,437,279	Spencer	Mar. 9, 1948
2,454,337	Okress	Nov. 23, 1948