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ELECTRON DISCHARGE DEVICE

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Fig. 1

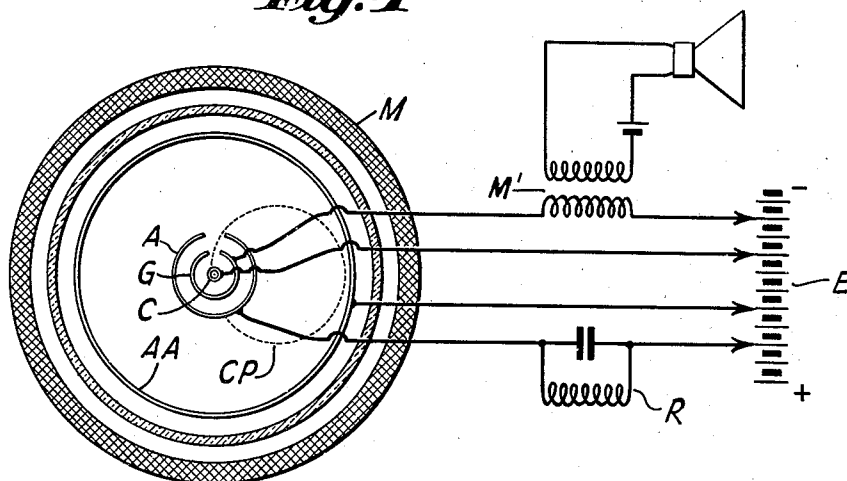
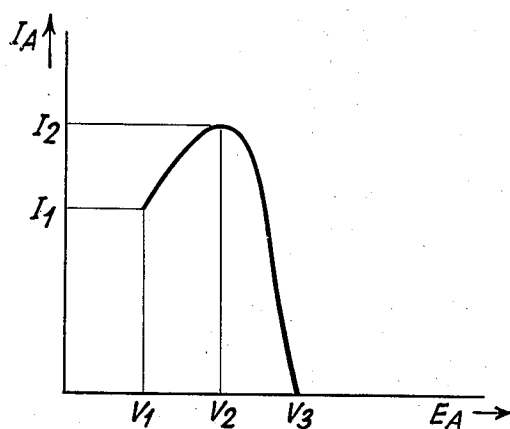


Fig. 2



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ELECTRON DISCHARGE DEVICE

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3 Claims. (Cl. 250—27.5)

This invention relates to electron discharge tubes and has for its object to provide an improved form of tube suitable for use for generating ultra-high frequency oscillations with relatively large outputs.

Although the invention is not limited to its application to the provision of tubes for oscillation generation at any particular frequency it is well suited for the provision of ultra-high frequency oscillations in the region of 20 to 100 cms. in wavelength, and, as will be seen later, provides tubes which will produce such oscillations by virtue of inherent negative resistance characteristics without relying upon secondary emission effects.

As is well known great practical difficulties are experienced in satisfactorily producing high power ultra-high frequency oscillations at frequencies of the order above mentioned. When ordinary triodes are sought to be used for this purpose inherent and serious difficulties arise due to the finite electron transit times in the valve and due to space charge effects. Although various magnetron tube arrangements, arrangements of the Barkhausen Kurz and Gill Morell type and other arrangements which will operate at very high frequencies are known, the known arrangements are usually comparatively unstable, inefficient, complex and almost always are difficult to modulate.

The present invention seeks to provide improved tubes which will produce high frequency oscillations by inherent negative resistance effects without depending on secondary emission effects, and which in contrast with known magnetron arrangements, lend themselves to satisfactory and efficient modulation.

According to this invention an electron discharge tube oscillator comprises a tube having an electron gun system including at least a cathode, an apertured control electrode and an apertured accelerator anode said last two electrodes having apertures aligned with the cathode, and an additional anode electrode external to the gun and having a surface out of the direct line from the cathode through the two aligned apertures; and means for applying a magnetic field in a direction approximately at right angles to the said direct line whereby electrons passing from the cathode through the two said aligned apertures do not proceed in said direct line but in a path which is bent round towards the aforementioned surface of the external anode.

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 transverse section of an electron discharge device made according to my invention and Figure 2 is a graph showing certain characteristics of a tube made according to my invention.

Referring to Figure 1, which is a schematic cross section of one form of tube for use in carrying out this invention there is employed a straight cathode which may be and preferably is of the indirectly heated equi-potential type said cathode being concentrically positioned within a cylindrical control electrode G which is in turn concentrically positioned within an accelerator anode A also of cylindrical shape. The control electrode G is close to the cathode and the accelerator anode A is close to the control electrode. Each of these electrodes G and A consists of a substantially cylindrical plate which may be either closed or open at its ends having a slot or gap running parallel to the cathode, the two slots or gaps (one in the control electrode and the other in the accelerator anode) being substantially of the same length as the cathode and co-planar therewith. The electrodes just mentioned constitute an electron gun which is concentrically surrounded by an external cylindrical anode AA whose radial distance from the cathode is considerably greater than that of the accelerator anode A. The external anode may be either open or closed at its ends as may be desired. A magnetic field generated in any convenient way by means for example of electromagnet coil M, is applied to thread the electrode system above described with its lines of force running parallel or substantially parallel to the length of the cathode.

With the above described construction, if the control electrode G be at a small negative potential relative to the cathode C (or at cathode potential) and the accelerator anode A be at some positive potential of, say, 50 to 500 volts a flat ribbon sectioned beam of electrons will be produced. These voltages may be applied from a source E. The characteristic connecting the voltage E_A on the anode A with the current I_A to this anode will be of the general form shown in Figure 2. The intensity of the beam, for a given value of accelerator anode potential, will be dependent upon the potential of the control electrode G and will be capable of being modulated by modulating the control electrode potential. If the same positive potential is applied to the external anode as is applied to the accelerator anode, the beam emerging from the gun will be bent round into a circular path such as CP (shown dotted) whose diameter depends, among other things, upon the intensity of the applied magnetic field. Accordingly with a suitable value of applied magnetic field and equal positive potentials V_1 on the accelerator

and external anodes, it is possible to cause the electron beam to travel in a circular path back to the accelerator anode to strike the said anode along a line nearly opposite the aperture through which the beam is projected, said circular path just failing to touch the external anode. In this condition there will be zero current to the external anode, since all the current will flow to the accelerator anode. The value I_1 of this current will depend, among other things, upon the accelerator anode potential. With increase in accelerator anode potential (assuming the external anode potential to remain fixed) the current produced by the electron gun will increase but at the same time the electron path will approach nearer and nearer to the external anode until finally for a potential V_2 corresponding to an accelerator anode current I_2 the electron path touches the external anode AA. Any increase in accelerator anode potential beyond this point increases the current to the external anode but decreases that to the accelerator anode until, for some maximum value V_3 of potential on the accelerator anode, the current thereto is practically zero all the current now flowing to the external anode. Accordingly for a range of accelerator anode voltages between a lower value V_2 at which maximum current I_2 flows to the accelerator anode and a higher value V_3 at which substantially zero current flows to the accelerator anode, the accelerator anode characteristic will contain a negative resistance portion; that is to say, its slope will be downward. Thus a resonant circuit or device such as R consisting of a condenser and inductance connected in the accelerator anode circuit may be excited to generate and sustain oscillations.

It may be noted that the electron path is circular only when the accelerator and external anodes are at the same potential but despite non-circularity of path at other potential relations, increase in accelerator anode potential will cause the electrons to approach nearer the external anode.

In order to obtain maximum steepness of the negatively sloping part of the characteristic curve it is preferred so to adjust the various parameters that the electron path just fails to touch the external anode when the two anodes are at equal potential. The path will then be circular and there will be obtained the advantage of the well known property that electrons emerging from the gun with a relatively wide angle of divergence will be brought to a focus on the other end of the path diameter of which the cathode is at one end. This, of course, involves that there will be a maximum change in accelerator anode current for a given change of accelerator anode voltage. Moreover, there will be maximum shift of focus for a given change in electron velocity.

There are two main advantages of a system as described above (1) modulation is easily effected by the application of modulating potentials to the control electrode by means of a modulating circuit M', and (2) although the electron current alternates between the accelerator and external anodes, one "robbing" the other, the electron beam does not have to traverse abrupt edges as is the case in those known oscillating electron beam generator systems wherein an electron beam has to cross the boundary between two collector anodes at each half cycle. Since in the present system there are no sharp electrode edges which the electron beam has to traverse, the difficulties

of burning due to high current changes at those edges are avoided and undesired secondary electron emission effects are minimized. Such electron emission as may occur will be dealt with by the applied magnetic field which will cause secondary electrons to return to the electrode of origin. If desired, either or both of the two anodes of the tube may be carbonized and fitted with a cooling fin or fins to minimize secondary emission to assist to dissipate heat due to electron bombardment and to assist in temperature equalization on the external anode, since owing to the fact that the electrons will bombard only a limited, localized area on this anode, there will be a tendency to form steep temperature gradients thereon.

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 tube having a straight thermionic cathode, a pair of solid concentric electrodes surrounding and coaxial with said cathode and including a control electrode and an accelerator anode, said control electrode and said accelerator anode each having a single slotted aperture parallel to said cathode, said apertures being aligned and a cylindrical anode surrounding said cathode and said concentric electrodes and coaxial with said cathode, and means for inducing a magnetic field parallel to said cathode and between said cathode and cylindrical anode.

2. An electron discharge tube having a straight thermionic cathode, a pair of solid concentric electrodes surrounding and coaxial with said cathode and including a control electrode and an accelerator anode, said control electrode and said accelerator anode having aligned slotted apertures parallel to said cathode and a cylindrical anode surrounding said cathode and said concentric electrodes and coaxial with said cathode, the spacing between the control electrode and accelerator anode being relatively close and the spacing between the cylindrical anode and the other electrodes being large in comparison to the spacing between the control electrode and accelerator anode, and means for inducing a magnetic field parallel to said cathode and between said cathode and cylindrical anode.

3. An electron discharge tube having a straight thermionic cathode, a pair of solid concentric electrodes surrounding and coaxial with said cathode and including a control electrode and an accelerator anode, said control electrode and said accelerator anode each having a single slotted aperture parallel to said cathode, said apertures being aligned and a cylindrical anode surrounding said cathode and said concentric electrodes and coaxial with said cathode, the slots in the control electrode and the accelerator anode being of substantially the same length as said cathode and parallel therewith, and means for inducing a magnetic field parallel to said cathode and between said cathode and cylindrical anode.