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ELECTRON DISCHARGE DEVICE

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Fig. 1

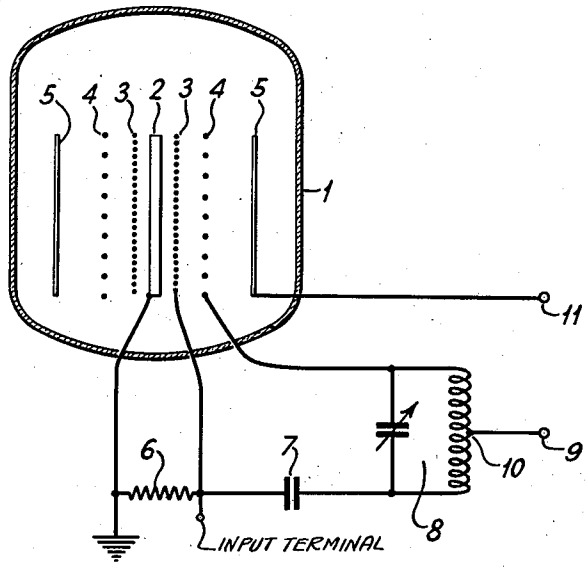
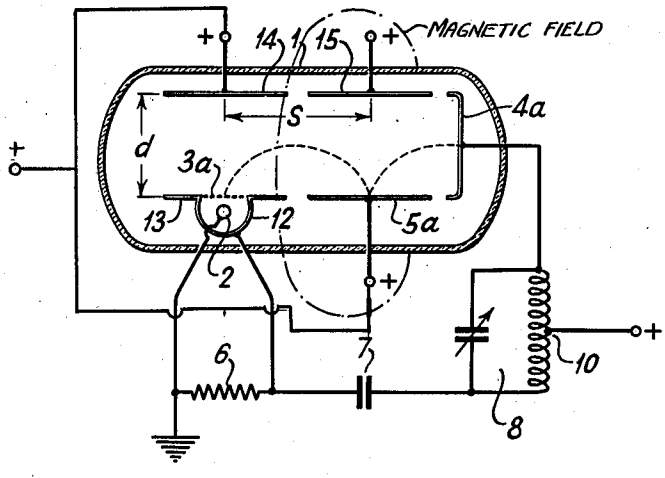


Fig. 2



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ELECTRON DISCHARGE DEVICE

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6 Claims. (Cl. 250—27)

This invention relates to electron discharge device circuit arrangements and has for its object to provide improved electron discharge device arrangements capable of generating or amplifying very high frequencies down to 50 cms. or thereabouts in wave length.

When it is sought to employ a normal thermionic valve for very high frequency operation, the transit time of electrons in passing from the control electrode or grid to the anode becomes appreciable in comparison to the periodic time of the oscillations handled and an upper limiting frequency is soon reached. The effect of finite electron transit times from control grid to anode manifests itself in two main ways.

(1) Grid conductance increases with frequency and, as a result, a limit is reached when the grid conductance becomes equal to or greater than the mutual conductance and de-amplification or failure to maintain oscillation occurs.

(2) When the frequency is so high that the oscillation periodicity becomes comparable to the electron transit time from control grid to anode, correct phase relationship for oscillation is not maintained between anode and control grid and power is lost.

Numerous attempts have been made to avoid the frequency limits of ordinary valves by using in ordinary back-coupled circuits more or less special valves with very small electrodes and minute inter-electrode clearances; or by using Barkhausen-Kurz or Gill-Morell oscillators; or by using magnetron oscillators; or by employing various forms of dynatron oscillators. In general, however, the known proposals have involved the use of electron discharge devices which are difficult to manufacture commercially and/or are difficult to operate stably to give reasonably large power outputs. The present invention seeks to provide improved circuits in which valves with normal, conveniently large electrodes and electrode spacings can be employed for very high frequency operation with ordinary back coupling, i. e. without resorting to the use of dynatron effects, magnetron oscillator effects, or Barkhausen-Kurz or Gill-Morell oscillator effects.

According to this invention a very high frequency electron discharge device circuit arrangement employing an electron discharge device having a control electrode or grid and an output anode is characterized in that (1) the effective electron path from control electrode to output anode includes at least one secondary emissive electrode surface at which electron multiplication occurs and (2) the said electron path is of such length and the operating parameters are such that the effective electron transit time along said path from control electrode to anode is equal to one whole period of the operating frequency or an integral multiple thereof. The first of these two provisions, which in combination characterize this invention, meets the difficulty of increasing grid conductance by utilizing electron multiplication greatly to increase mutual conductance and the second ensures that, although there is a delay of 360° (or a multiple thereof) between control electrode and anode, the correct phase relation is maintained.

The invention is illustrated in the accompanying drawing which shows diagrammatically in Figs 1 and 2 two embodiments thereof.

Referring to Fig. 1, there is employed in the arrangement therein shown an electron discharge device comprising within an evacuated envelope 1, a linear thermionic cathode 2 of any convenient type which is coaxially surrounded by a fine mesh grid 3 (the control grid) in turn coaxially surrounded by a very open mesh grid 4 which acts as the output anode, the grid 4 being coaxially surrounded by a cylindrical electrode 5 of solid material whose inner surface is rendered highly secondarily emissive, e. g. it is coated with a caesiated silver deposition as well known per se. Input or control potentials from an external source or obtained by back coupling with the anode circuit (the circuit of the open mesh grid 4) are applied between the control grid 3 and the cathode 2. For example, as shown, a resistance 6 may be connected between the control grid 3 and the cathode 2 and the said control grid 3 may be connected through a coupling condenser 7 in series with a parallel tuned circuit 8 resonant at the operating frequency, to the output anode 4. Positive potential (e. g. 400 volts relative to the cathode 2) is applied at 9 via a center tap 10 on the inductance of the tuned circuit 8 to the output anode 4 and a lower positive potential (e. g. 200 volts relative to the cathode 2) is applied at 11 to the secondary emitting electrode 5. In operation, electrons in a stream whose intensity is controlled by the control grid 3 proceed through the output anode 4 to the secondary emitting electrode 5 from which an amplified electron stream returns to and is taken up by the output anode 4. The complete transit time from the control grid to the secondary emitter electrode and back to the output electrode being equal to one period of the operating frequency or a multiple thereof.

In the modification shown in Fig. 2, a linear

thermionic cathode 2 is centrally positioned in a part cylindrical channel 12 integrally formed with a flat plate 13 whose surface is in a plane parallel to the axis of said channel. The channel embraces about three quarters of a cylindrical surface so that it has an opening running parallel to the channel axis, the flat plate 13 with which the channel is integrally formed consisting of two similar parts, one on each side of the channel opening. Situated across the said opening and substantially co-planar with the said plate is a grid or mesh 3a which is in connection with said plate. Also substantially co-planar with the said plate and to one side thereof is a secondary emitter electrode 5a with a caesiated or similar surface. Opposite the plate 13 is a first field electrode 14 which is connected to the secondary emitter electrode 5a and opposite the said emitter electrode 5a (facing the emitter surface thereof) is a second field electrode 15 the two field electrodes 14, 15, lying in a plane parallel to the common plane of the plate 13 and the secondary emitter electrode 5a. An output electrode 4a is situated at right angles to the two parallel planes just mentioned lying to one side of the second field electrode 15 and the emitter electrode 5a and across the space which is between them. In use as an oscillator a resistance or other suitable impedance 6 is connected between the cathode 2 and the control electrode (the channel 12—the flat plate 13—mesh 3a structure) and the said electrode is connected to the output anode 4a through a coupling condenser 7 in series with a parallel tuned circuit 8 resonant at the operating frequency. A positive potential (about 200 volts, say) is applied to the first field electrode 14 and to the electrode 5a; a higher positive potential (about 400 volts, say) is applied to the second field electrode 15; and a still higher positive potential (about 600 volts, say) is applied via a center tap 10 on the inductance of the parallel tuned circuit 8 to the output anode 4a. All these potentials are relative to the cathode. A magnetic field is applied to traverse the inter-electrode space so that, under the applied magnetic and electric fields electrons leaving the mesh or grid 3a pass in substantially cycloidal paths (as indicated in broken lines) to the secondary emitter electrode 5a the amplified electron stream resulting passing thence to the output anode 4a. The arrangement is such that the total time to travel from the mesh 3a to the emitter electrode 5a and thence to the output anode 4a is equal to one period of the operating frequency or a multiple thereof. The time taken (t) for one cycloidal path is given substantially by the equation.

$$t=\frac{s}{956\times10^4\times\pi\sqrt{\frac{E}{d}}}$$

where s and d are the dimensions shown on Fig. 2 and E is the difference between the voltage of the electrode at one end of the cycloidal path and the voltage of the electrode at the other.

In each of the two embodiments illustrated there is only one stage of electron multiplication between control grid and output anode but the invention is not limited to this and there may be any desired number of stages. The embodiment of Fig. 2 lends itself particularly well to modification to secure such multi-stage electron multiplication for any number of co-planar secondary emitter electrodes such as 5a (each with its own associated opposed field electrode such as 15) may be provided between the control grid and the output anode.

By the term "multiple of one period of the operating frequency" used in the specification and in the appended claims is meant any multiple including one.

What is claimed is:

1. In a very high frequency electron discharge device circuit arrangement employing an electron discharge device having an electron producing cathode, a control electrode and an output anode arranged in the order named with respect to said cathode, and a secondary emissive electrode surface at which electron multiplication occurs located in the effective electron path from said control electrode to said output anode, means for producing an effective electron transit time along said path from said control electrode to said anode equal to an integral multiple of one whole period of the operating frequency, including means for applying a predetermined positive potential to said secondary emissive electrode and a greater predetermined positive potential to said output anode relative to said cathode.

2. In a very high frequency electron discharge device circuit arrangement employing an electron discharge device having a cathode, a control electrode in the form of a close mesh grid coaxially surrounding said cathode, an output anode in the form of an apertured electrode coaxially surrounding said control grid, and a secondary emissive electrode at which electron multiplication occurs coaxially surrounding said anode, said secondary emissive electrode being located in the effective electron path from said control electrode to said output anode, means for producing an effective electron transit time along said path from said control electrode to said secondary emissive electrode and back to the anode equal to an integral multiple of one whole period of the operating frequency, including means for applying a positive potential to said output anode and a less positive potential to said secondary emissive electrode relative to said cathode.

3. In a very high frequency electron discharge device circuit arrangement employing an electron discharge device having a cathode located behind a substantially planar apertured electrode forming a control grid, a first field electrode opposite said control electrode, a secondary emissive electrode coplanar with said control electrode, a second field electrode opposite said emissive electrode and coplanar with said first field electrode, an output anode at right angles to the planes of and to one side of the field electrodes and the other electrodes and located between said planes, means for producing an effective electron transit time between said control electrode and the said output anode equal to an integral multiple of one whole period of the operating frequency including means for maintaining said control electrode at a negative potential to said cathode, and for maintaining said second field electrode at a higher positive potential than both said first field electrode and said secondary emissive electrode relative to said cathode, and for maintaining said output anode at a still higher positive potential than any of said previous electrodes relative to said cathode.

4. A high frequency electron discharge device circuit in accordance with claim 3, including an input impedance between the cathode and control electrode for maintaining said control electrode negative with respect to said cathode, and a tuned circuit resonant at the operating frequency con-

nected between said output anode and said control electrode.

5. A high frequency electron discharge device circuit in accordance with claim 3, including means for producing a magnetic field in the space between said electrodes, whereby the electrons leaving said control electrode are caused, under the influence of the magnetic and electric fields, to traverse a cycloidal path to said secondary emissive electrode.

6. An electron discharge device comprising a cathode, a control electrode, an apertured anode, and a secondary emissive electrode in the order named, the surface of said secondary emissive electrode nearest said apertured anode being coated with highly electron emissive material, and means for producing an effective electron transit time from said control electrode to said secondary emissive electrode and back to said apertured anode equal to an integral multiple of one whole period of the operating frequency, including means for applying to said electrodes potentials of suitable predetermined values.

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