April 23, 1940. K. FRITZ 2,198,334

ELECTRON DISCHARGE DEVICE

Filed June 2, 1938

Fig. 1

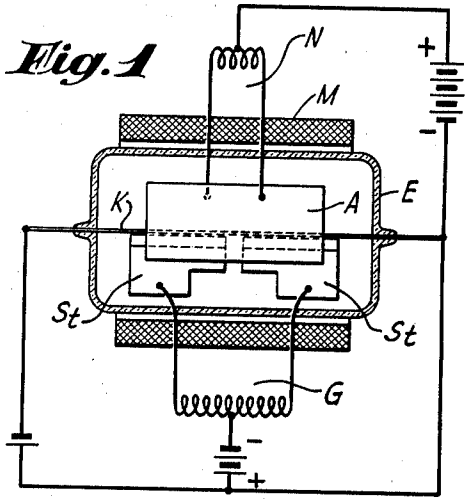


Fig. 2

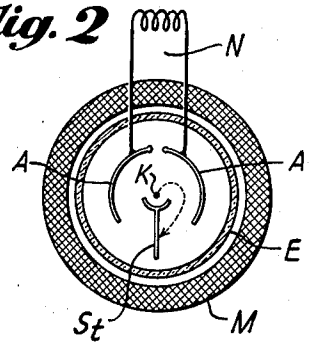


Fig. 3

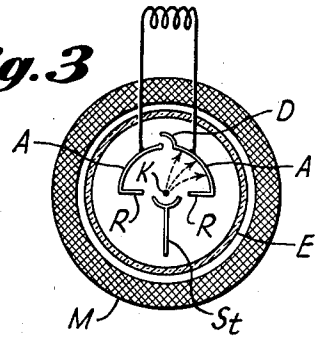


Fig. 4

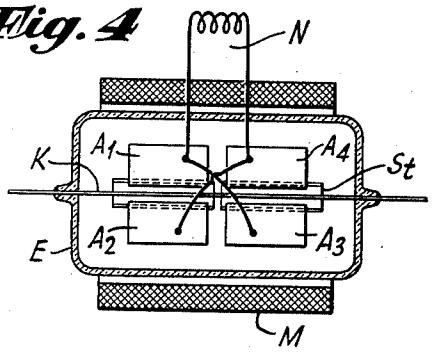


Fig. 6

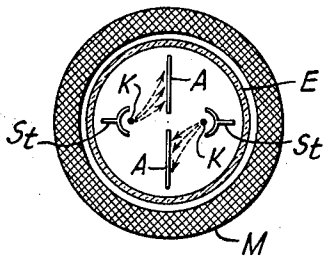
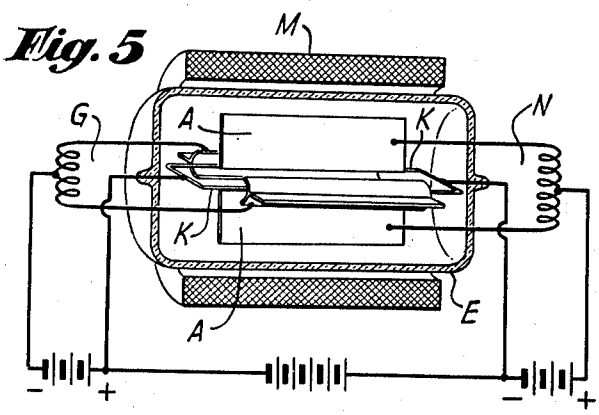


Fig. 5



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ELECTRON DISCHARGE DEVICE

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Application June 2, 1938, Serial No. 211,342
In Germany June 9, 1937

9 Claims. (Cl. 250—27.5)

The present invention relates to an electron discharge tube, more particularly to such a tube suitable for amplification and frequency multiplication at very high frequencies.

Push-pull tubes are known in which two respective anodes and two respective control electrodes are arranged symmetrically to a common cathode. In these tubes the control electrodes are arranged between the cathode and the associated anode. When utilizing such tubes for the amplification of ultra-short waves, there is the disadvantage that in accordance with the phase position of the control potential the electrons are additionally accelerated or slowed down by the alternating control potentials of the control electrodes. In case of ultra-short waves a loss-free control is no longer possible owing to the influence of the electron transit time. Despite the negative biasing potential of the control electrode the control voltage source is from time to time subjected to a damping action.

Moreover, triode tubes are known in which the control electrodes instead of being arranged between the cathode and the anode, are placed outside the direct discharge path, i. e. outside the cathode-anode path. These tubes are sometimes termed plation tubes.

The object of the present invention is to provide an electron discharge tube particularly suitable for use as an amplifier or frequency multiplier at high frequencies. Another object of my invention is to provide such a tube in which the space charge is controlled by influencing the electron course in the immediate vicinity of the cathode, and in which at the same time a control of the distribution of the current is carried out.

Briefly an electron discharge tube according to one form of the present invention is provided with a cathode and a plurality of anodes, and control electrodes placed outside the discharge path, i. e. outside the cathode-anode space. In one embodiment two anodes of the same type are placed symmetrically and parallel to the cathode, or cathodes, and the control electrodes are arranged at the side of the cathode away from the anode.

The control electrodes are de-coupled electrostatically from the anode (output electrodes). The capacities of the anodes relative to their respective control electrode and vice versa are identical to each other, so that neither a displacement current passing from the amplifier input to the amplifier output can be formed, nor can such current flow in the opposite direction.

The anodes (output electrodes) are de-coupled relative to the cathode by means of the electrons, i. e. the alternating potentials of the anodes excited in phase opposition counteract each other as to action upon the cathode and cannot influence the course of the electrons in a reactive manner.

A magnetic field may be induced around the electrodes and parallel to the cathode for control purposes. An auxiliary electric field might also serve this purpose.

The tube according to the invention combines the advantages of space charge control effective up to very short waves, with the advantages of a symmetrical mounting of the power electrodes with respect to the magnetic fields. By subdividing of the anode, one or several symmetry planes are obtained into which the cathode and the control electrodes are placed. The control proper is provided by negatively biased control electrodes which influence the space charge at the cathode.

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 schematic side view of one form of electron discharge device made according to my invention, Figure 2 is an end view of Figure 1, Figure 3 is an end view of a modification of an electron discharge device made according to my invention, Figure 4 is a side view of a still further modification of an electron discharge device made according to my invention, Figure 5 is a schematic view in perspective of another electron discharge device and associated circuit made according to my invention, and Figure 6 is an end view of the tube shown in Figure 5.

Figures 1 and 2 show a tube according to the present invention. An elongated cathode K has the co-extensive anodes A placed parallel thereto. These anodes are connected to an output circuit N. The control electrodes *St* are axially displaced and disposed adjacent each other alongside the cathode and are connected to opposite ends of the input circuit G comprising an inductance and a condenser if necessary.

Figure 2 shows an end view of the tube from which the shape of the electrodes can be more readily seen. The anodes A consist of cylindrical segments arranged on a cylindrical surface coaxially of the cathode. The control electrodes *St* likewise have the shape of cylindrical segments. But the radius of the control segments is much smaller. In the construction of the anodes shown in Figure 2 it is advisable to provide the control electrodes with radially disposed sheet metal

blades or extensions which are extended outside the discharged space. These blades or shields are intended to prevent the electrons leaving the cathode K from circumventing the control electrode. The electrodes are mounted within the evacuated envelope E.

Figure 3 shows another form of construction of the tube according to the invention. The sheet metal blades or shields at the control electrodes are here omitted. In order to confine the electrons to the discharge space the anodes A are provided with radially disposed extensions R. The surface separating the anodes is covered up by an overlapping part or lip D at the place opposite the cathode which measure is intended to prevent electrons from impinging on the wall of the vessel.

In order to provide a proper adjustment of the current distribution constant electrical or magnetic auxiliary fields are employed. These auxiliary fields are to deviate the electrons at right angles to the axis of the system. The magnetic field is generated by a coil M which may be positioned around the tube envelope.

An electrical auxiliary field is produced in the form of a cross field if the two anodes have impressed thereon different biasing potentials relative to the cathode. If a magnetic auxiliary field is used the lines of force must pass parallel to the axis of the system (cathode) so as to cause a deviation of the electrons at right angle thereto.

If in tubes according to Figures 1 to 3 an electrical or magnetic cross field is employed, a frequency doubling will be obtained automatically since in accordance with the direction of the auxiliary field, the electrons will always be deviated in a curved path towards the right or the left, and charge during both half cycles of the alternating control potential the same output electrode.

If an amplification is intended (without frequency multiplication) two different steps can be taken in utilizing the idea of the present invention using either of the tubes according to Figure 1 or 3. The anode is divided up into a total number of four parts by dividing the anodes transversely to the axis of the electrode system, and connecting these parts crosswise in accordance with Figure 4. When using a magnetic auxiliary field, a pure amplifying action will be obtained, since during the one-half wave of the alternating control potential the anode group A_1, A_3 will be charged, and during the other half wave it is the other anode group A_2, A_4 that receives the charge. In the forms shown in Figures 1 to 3, the same anode segment receives the current at all times. The other anode segment serves as a capacity neutralizer.

Another appropriate amplifier tube is shown in Figures 5 and 6. In this mode of construction two cathodes are required arranged in parallel and in the same plane. The anodes consist of two plates disposed in a plane at right angles to a plane through the cathodes. The control electrodes have the form of cylindrical segments having a small radius, and they are disposed in such manner that the plane in which the cathodes are situated intersects the control electrodes in the apex of the segments. The construction of a tube according to Figure 5 furthermore has the advantage that the lead-ins for the electrodes can be arranged in the direction of the axis of the electrode system whereby the lead-ins for the control electrodes and those for the anodes are arranged in two planes at right angle to each other. The cathodes may at will be connected in series or in parallel. The tube envelope E surrounds the discharge space and on the outside of the tube envelope a magnetic field winding M is arranged which produces a magnetic field extending parallel to the axis of the electrode system. The magnetic fields are relatively weak.

Figure 6 is an end view of a tube shown in Figure 5. This figure reveals the approximate paths of the electrons subjected to the influence of a constant, weak magnetic field. The magnitude of the magnetic field is such that at no time will the electron movement be reversed in front of the anode, i. e. at no time will the emission current be suppressed.

Obviously, the idea of the invention is not limited to frequency doubling or amplification at the frequency ratio of 1:1 but may be utilized also to advantage for a frequency multiplication of larger proportion. In the oscillatory state, i. e. in the operating state there is always assured a compensation of the reaction of the alternating plate potentials upon the control of the space charge owing to the completely symmetrical arrangement.

The compensation currents passing across the cathode line and having primarily a pulsation component whose frequency is the double control frequency, are rendered ineffective either by means of a possibly favorable grounding, or they are rendered useful through a suitable tuning of the cathode line.

By means of my invention which positions an anode segment adjacent an output anode segment of opposite alternating potential, the input to output capacity is neutralized and the plate impedance increased.

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 device having an envelope containing a straight thermionic cathode for emitting electrons, a pair of laterally spaced coextensive anodes parallel to and on one side of said cathode, and a control electrode on the other side of said cathode and closer to said cathode than said pair of laterally spaced coextensive anodes, said control electrode comprising only a single element, and means for causing electrons from the cathode to move toward one only of said anodes.

2. An electron discharge device having an envelope containing a straight thermionic cathode, a pair of laterally spaced anodes parallel to and on one side of said cathode, and a control electrode on the other side of said cathode, said control electrode comprising only a single element and extending over more than 90° of the projected area of the surface of said cathode and being closer to said cathode than said pair of anodes, and electromagnetic means for inducing an electro-magnetic field parallel to and around said cathode.

3. An electron discharge device having an envelope containing a straight thermionic cathode,

a pair of coextensive arcuate shaped laterally spaced anode segments on one side of said cathode and adjacent each other and parallel to said cathode, only a single arcuate shaped control electrode on the opposite side of said cathode directly opposite from said anode segments and closer to said cathode and said anode segments, and means for producing a magnetic field parallel to and surrounding said cathode whereby electrons from the cathode will move to one only of said anode segments.

4. An electron discharge device having an envelope containing a straight thermionic cathode, a pair of coextensive laterally spaced anode segments on one side of said cathode, a pair of control electrodes on the other side of said cathode from said anodes each control electrode being spaced axially from the other along said cathode, and means for inducing a magnetic field around and parallel to said cathode.

5. An electron discharge device having an envelope containing a straight thermionic cathode, two pairs of adjacent anode segments on one side of said cathode and each pair being spaced axially along said cathode from the other pair, a pair of control electrodes on the other side of said cathode from said anode segments, each control electrode being oppositely disposed to a pair of anode segments, and electrical means connecting diagonally positioned segments of different pairs of anode segments, and means for inducing a magnetic field parallel to and around said cathode.

6. An electron discharge device having an envelope containing a pair of flat rectangular shaped anode segments lying in a common plane, a straight thermionic cathode on each side of the plane passing through said anode segments, and a control electrode closely adjacent each cathode, said cathodes and control electrodes lying in a plane perpendicular to a plane passing through the anode segments and passing through the space between the anode segments, and a magnetic field producing means surrounding said envelope.

7. An electron discharge device having an envelope containing a straight thermionic cathode, arcuate shaped laterally spaced anode segments co-extensive with each other and adjacent each other on one side of said cathode, and an arcuate shaped control electrode on the other side of said cathode from said anode segments and closer to said cathode than said anode segments, said control electrode comprising only a single element and extending over substantially 180° of the projected area of the surface of said cathode, and a fin-like member extending radially from said control electrode.

8. An electron discharge device having an envelope containing a straight thermionic cathode, arcuate shaped anode segments co-extensive with each other and adjacent each other on one side of said cathode, and an arcuate shaped control electrode on the other side of said cathode from said anode segments, and a fin-like member extending radially from said control electrode, radial lip members on said anode segments along the non-adjacent edges of said anode segments extending towards said cathode, and a spaced overhanging lip bridging the space between the two adjacent edges of the anode segments.

9. An electron discharge device having an envelope containing a pair of flat rectangular shaped co-extensive anode segments lying in a common plane, a cathode on each side of the plane passing through the anode segments and a control electrode adjacent each cathode, said cathodes and control electrodes lying in a plane perpendicular to the plane passing through said anode segments, and lead-ins for said anode segments and said control electrodes, the lead-ins of the anode segments and control electrodes lying in planes perpendicular to each other.

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