March 15, 1938. K. FRITZ 2,111,263

MAGNETRON

Filed Nov. 16, 1935

Fig. 1

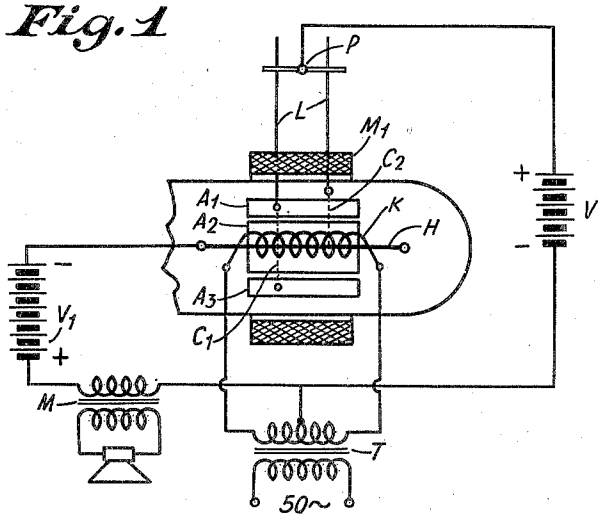


Fig. 2

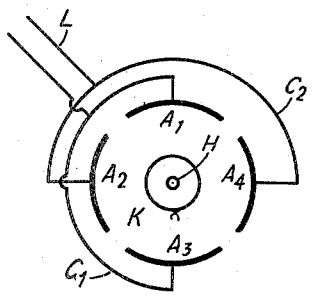


Fig. 4

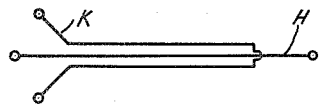


Fig. 3

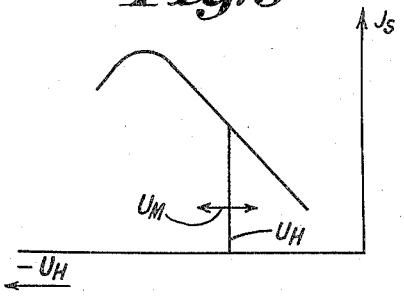


Fig. 5

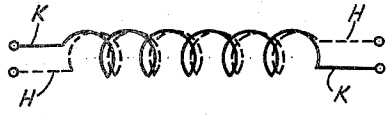
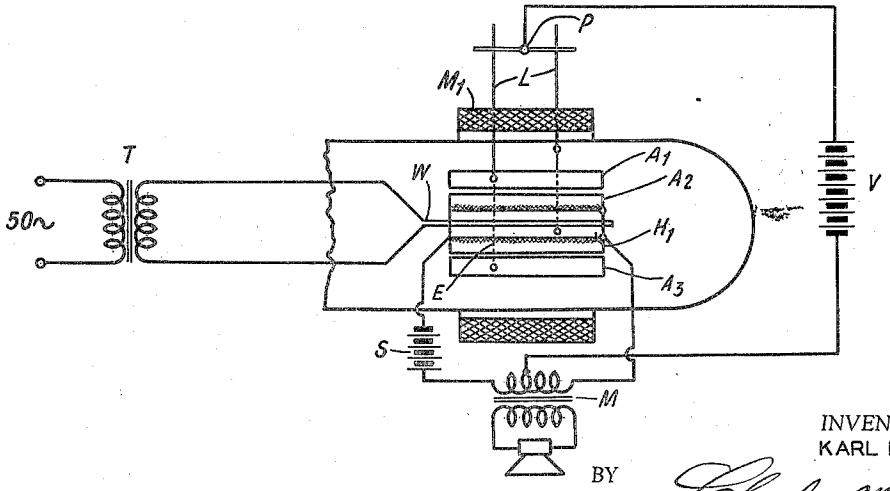


Fig. 6



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2,111,263

MAGNETRON

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Application November 16, 1935, Serial No. 50,128
In Germany November 30, 1934

8 Claims. (Cl. 179—171)

My invention relates to electron discharge devices of the magnetron type, in which the electrode system is positioned within a magnetic field, and more particularly to means for modulating such devices during operation of the device.

The present invention is particularly concerned with the disposition of an auxiliary electrode within a magnetron tube having a cathode and a multi-section anode, the auxiliary electrode being mounted close to and preferably surrounding the cathode.

Normal regenerative circuit schemes comprising a negatively biased grid are known in which a supplementary magnetic field is provided to alter the characteristics of the tube, such as the slope or mutual conductance (S) and the gain-reciprocal ($1:\mu$) or control factor (D).

Magnetron arrangements are also known in the prior art which make use of triodes and in which the generation of oscillations is insured by the aid of a statically determinable negative resistance occasioned by a magnetic field. In this instance, the grid mounted between the anode and the cathode must be impressed with a positive potential in order that oscillations or wave generation may take place. Such a grid may be referred to as a space-charge grid.

Space-charge grids of this kind take a considerable current because of the high positive potential at which they are operated, and this current may become larger than the plate or anode current. Normally cathodes are operated at the saturation point so that a loss of power takes place because the grid current which is taken from the total emission current reduces the output current and thus the efficiency of the tube is low.

Non-dissipative control action for the purposes of modulation is not possible with the above electrode arrangement inasmuch as the grid-cathode path assumes finite resistance values, with the result that a load is put on the source of control potential or the modulation source. In reception work a grid can be used to advantage by making it to fulfill certain auxiliary functions, such as the supply of a periodical biasing potential for example in super-regeneration work. Since the grid in such an arrangement may be impressed with a positive biasing voltage, it follows that, since grid current flows, the generator of the biasing potential is called upon to supply a certain amount of power.

One object of my invention is to provide an improved electron discharge device of the magnetron type, the output of which can be efficiently and easily modulated by an auxiliary electrode.

A magnetron constructed according to this invention comprises a cathode, multi-segment anode, and an auxiliary electrode disposed adjacent or with reference to the anode, posteriorly of the cathode. In the case of cylindrical electrode systems, the cathode would then be located between the anode and the auxiliary electrode. The auxiliary electrode would preferably be made of a rectilinear conductor having terminals or connection points bilaterally, in order that an electrical as well as a magnetic auxiliary field may be created in the immediate proximity to the cathode.

Both experimentally as well as theoretically it has been found that, most particularly in a magnetron having a multi-section anode, for example a four-segment anode, an increase in the diameter of the active cathode surface is possible, since the electrons will be effectively and positively controlled by the alternating potentials of the anodes only when they are placed comparatively close to the anodes. In the neighborhood of the cathode, if the anode is split into several parts, the control action of the geometrically adjacent anode segments or parts oscillating in phase opposition or push-pull fashion, electrically speaking, will more or less neutralize one another. As a consequence, in the case of an anode split more than twice, especially in an anode comprising four segments and more, it is possible to increase the active cathode diameter, without appreciably impairing the radio frequency control mechanism. This has the advantage that more space can be made available for the auxiliary electrode which should preferably be mounted inside 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 shows one form of magnetron and circuit arrangement made in accordance with my invention; Figure 2 is a section taken perpendicularly to the longitudinal axis of the magnetron shown in Figure 1; Figure 3 is a graph showing the electrical characteristics of the magnetron shown in Figures 1 and 2; Figures 4 and 5 show modifications of the cathode and auxiliary electrode for the magnetron shown in Figure 1; and Figure 6 shows a further modification of

a magnetron and circuit arrangement made in accordance with my invention.

In the circuit shown in Figure 1, the magnetron which can be modulated is provided with an auxiliary electrode mounted within a helical cathode. The mount assembly comprises an anode, a cathode within the anode and an auxiliary electrode. The anode is of the four-section type, three of the sections A_1, A_2 and A_3, being shown. The cathode K has positioned within it the auxiliary electrode H, which has the form of a rectilinear conductor. As shown in Figures 1 and 2 the anode parts or segments A_1 and A_3, and A_2, A_4, are inter-connected by means of clips or connecting conductors C_1 and C_2. United with these two groups of anode segments is the Lecher-wire line L whose electrical center P is associated with the positive pole of the anode voltage source V. The cathode K is connected to a source of the heating current, for example, the secondary winding of a heating or filament transformer T. The center tap of the filament winding is connected with the negative pole of the anode voltage source V, and through a modulation transformer M with the positive terminal of the voltage source V_1 of the auxiliary electrode H, the latter being connected with the negative pole of the said source. The constant magnetic field extending along the auxiliary electrode H is generated by the magnet M_1.

Figure 3 shows the modulation characteristic of a magnetron of the kind shown in Figure 1, in which the radio frequency current J_S (ordinate) is plotted against the negative potential applied to the auxiliary electrode H. U_H is the constant negative D. C. biasing potential, and U_M the alternating potential of modulation frequency.

In the arrangement shown in Figure 1 in which the "grid" and the cathode, as it were, have changed their relative positions, the following advantages are obtained: The production of oscillations is an arrangement predicated upon the magnetron principle for its operation takes place in the presence of optimum operating conditions since there is no disturbing element between anode and cathode. Modulation, that is the control action or influence upon the strength of the anode current, is effected without energy dissipation since the auxiliary electrode has a negative biasing voltage so that no grid current is able to flow. In a tube actually built for a wavelength of 50 centimeters, the plate potential V was +1200 V., the negative biasing potential V_1 of the auxiliary electrode was −250 V., and the modulation voltages $U_M = \pm 200$ V.

In Figure 4 the auxiliary electrode H is disposed in the plane of the two bifilar thermionic cathode wires K.

In Figure 5 the auxiliary electrode H and the cathode K are in the form of a double helix or spirals interwound, the coils being of the same diameter.

In the circuit shown in Figure 6 the auxiliary electrode H_1 is employed to generate an auxiliary magnetic field in the immediate vicinity of the cathode. An indirectly heated cathode is used. The support for the electron-emitting coating or film E is a metallic bushing or sleeve H_1 made of material free from ferromagnetism and also acts as the auxiliary electrode H of Figures 1, 2, 4 and 5 heated by the heater W. The sleeve H_1 has a pair of terminals and is connected to the secondary winding of a modulation transformer M. The resulting circular magnetic modulation field controls the course of the electrons, that is the electrons are turned with reference to the main magnetic field. Inasmuch as the circular field decreases rapidly in outward direction, an arrangement of the kind shown in Figure 6 has proved particularly advantageous.

With the use of a magnetically acting auxiliary electrode, it is necessary to provide a D. C. source S in the modulation circuit designed to furnish a constant "bias" current to flow through the auxiliary electrode. If the said magnetic biasing voltage were absent, then two crests or peaks would arise in the oscillation current for each oscillation of the modulation frequency; in other words, there would occur a doubling of the modulation frequency.

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, means for generating a magnetic field within said envelope, a mount assembly positioned within said envelope and comprising a cathode, a multi-section anode surrounding the cathode and an auxiliary electrode, the auxiliary electrode being disposed inside the cathode, means for biasing said auxiliary electrode negatively with respect to the cathode, an input circuit connected between the cathode and the auxiliary electrode and an output circuit connected to said anode.

2. An electron discharge device having an evacuated envelope, a helically wound cathode within said envelope, an auxiliary electrode within said helically wound cathode and coaxial therewith, and an anode surrounding and coaxial with said auxiliary electrode and cathode and comprising a plurality of longitudinal sections, and means for producing a magnetic field along the axis of the electrodes within said envelope, means for biasing said auxiliary electrode negatively with respect to said cathode, an input circuit connected between the cathode and the auxiliary electrode, and an output circuit connected to said anode.

3. An electron discharge device having an envelope, and a mount within said envelope comprising a U-shaped filament cathode, an auxiliary electrode intermediate the legs of said U-shaped cathode and in the same plane therewith and a tubular anode surrounding and coaxial with said auxiliary electrode and comprising a plurality of longitudinal sections, and means for producing a magnetic field along the axis of the electrodes within said envelope, means for biasing said auxiliary electrode negatively with respect to the cathode, an input circuit connected between the cathode and the auxiliary electrode and an output circuit connected to the anode.

4. An electron discharge device having an envelope, a mount assembly within said envelope comprising a metal tubular member having an emitting coating thereon, leads connected to opposite ends of said tubular member, a heater within said tubular member and a tubular anode surrounding and coaxial with said metal tubular

member, said anode comprising a plurality of longitudinal sections, means for applying a biasing voltage to said metal tubular member and means for producing a magnetic field along the axis of said mount, direct voltage means connected to said leads and means associated with said direct voltage means for impressing a modulating voltage on said tubular metal member, and an output circuit connected to said anode.

5. In combination an electron discharge device having an envelope, a mount within said envelope comprising a helically wound cathode, a multi-section anode and an auxiliary electrode, the auxiliary electrode being disposed inside the cathode, means for negatively biasing said auxiliary electrode with respect to said cathode and other means for impressing modulation potentials upon said auxiliary electrode, and an output circuit connected to said anode.

6. In combination an electron discharge device comprising a helical cathode, a straight rod-like auxiliary electrode within said cathode and an anode surrounding and coaxial with said cathode and auxiliary electrode, and comprising a plurality of longitudinal sections, means for biasing said auxiliary electrode negatively with respect to said cathode, means for producing a magnetic field parallel to said rod-like auxiliary electrode, means for impressing modulation voltages upon said auxiliary electrode, and an output circuit connected to the anode.

7. In combination an electron discharge device having an envelope, an electrode mount assembly within said envelope comprising a tubular metal member having an emitting coating thereon, leads connected to opposite ends of said tubular member, a heater within said tubular member, a multi-section anode surrounding and coaxial with said metal tubular member, means for producing a magnetic field along the axis of the electrode mount assembly, means for applying a biasing voltage to said tubular member, direct voltage means connected to said leads and means associated with said direct voltage means for impressing a modulating voltage on said tubular metal member, and an output circuit connected to said anode.

8. An electron discharge device having an evacuated envelope, a mount assembly within said envelope comprising a cylindrically shaped cathode, an auxiliary electrode within said cylindrical cathode and coaxial therewith, and an anode surrounding and coaxial with said auxiliary electrode and comprising a plurality of longitudinal sections, and means for producing a magnetic field along the axis of said mount assembly.

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