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K. FRITZ

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ELECTRON DISCHARGE DEVICE

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Fig. 1

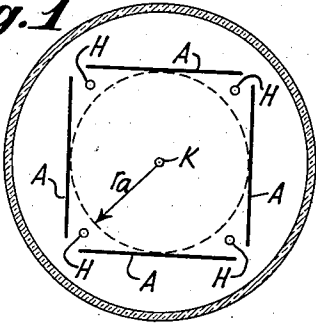


Fig. 2

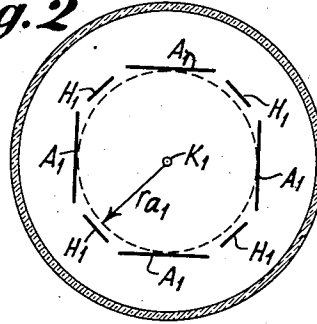


Fig. 3

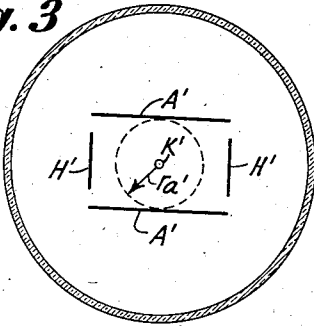


Fig. 4

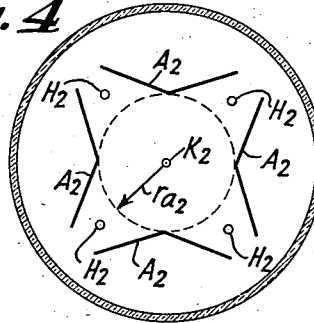


Fig. 5

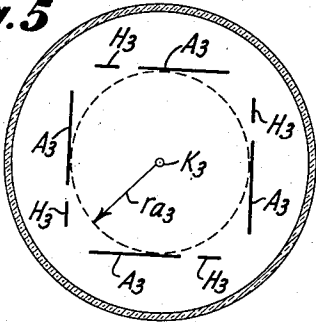


Fig. 6

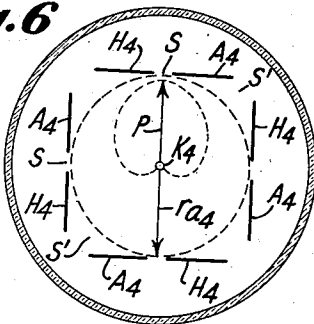
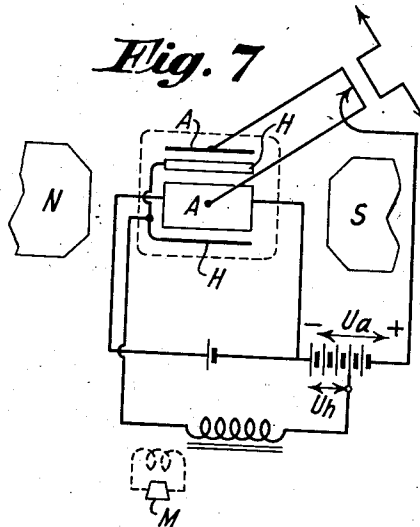


Fig. 7



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ELECTRON DISCHARGE DEVICE

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8 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices more particularly to magnetrons in which the electron flow from the cathode to the anode is subjected to the action of a magnetic field.

5 The mounting of the discharge system, especially the shaping and positioning of the electrodes in the present invention is based upon novel viewpoints, which take into proper consideration the paths which the electrons travel subject to the action of a magnetic field extending parallel
10 to the axis of the system. The purpose of the invention is the production of a greater working slope in order that smaller control or modulation powers may be made to suffice in practice.

15 In the prior art, in magnetron tubes which are furnished with arcuate anodes placed concentrically with reference to the cathode, auxiliary electrodes of similar form may be mounted in the gaps between the anodes so that both kinds
20 of electrode come to be placed on a circular cylinder and will be at the same distance from the cathode as from the anode.

It is also known from the prior art to use plane electrodes in magnetrons positioned upon the sides
25 of a rectangle. In this case arrangements were made so that the anodes (working electrodes or active electrodes) were placed at a greater distance from the cathode than the auxiliary electrodes so that, more particularly when operating
30 with a positive biasing voltage, the auxiliary electrodes absorbed a considerable part of the emission current, and caused considerable interference in the discharge process between the anodes and the cathode. What would also appear
35 important is to point out that these auxiliary electrodes merely served to provide "spatial" closure for the discharge system in order that no electrons would bombard the walls of the tube envelope.

40 The object of my invention is to provide an electron discharge device of the magnetron type having improved control means.

45 The magnetron tube here disclosed comprising a cathode, several anodes placed parallel to the axis of the system, and auxiliary electrodes has this novel feature that the anodes (or working electrodes) or their regular extensions are so formed and disposed that they touch an imaginary circular cylinder concentric to the
50 cathode at only one or at only a few places, while not coinciding therewith, at least not completely, and that the auxiliary electrodes are mounted outside the said imaginary circular cylinder. In order that the effect of the auxiliary electrodes
55 may be made as great as possible they are mount-

ed inside an area which, when viewing a section at right angles to the cathode, is bounded on the one hand by the circle about the cathode, and, on the other hand, by the anodes or their extensions.

5 In other words, this novel disposition makes it feasible to abandon the conventional magnetron construction in which, between the cathode and the anode no further electrodes are mounted. Hence, in this special instance, the auxiliary electrodes may be accommodated inside the discharge
10 space without the risk of their absorbing appreciable current even when a positive biasing voltage is impressed upon them. The physical explanation of this fact will be found below.

15 The magnetron arrangement according to the invention is preferably so made that (1) the anodes (the working electrodes) are disposed upon the sides of a parallelepiped, and that (2) the axially directed magnetic field and the operating potentials are so chosen that the electrons
20 on their trajectories or paths about the centrally positioned cathode roughly are tangent to the anodes; and that (3) the auxiliary electrodes are provided at those points of the discharge system which are devoid of circulating electrons or nearly so.

25 The discharge space proper may be regarded as only in the interior of the imaginary cylinder which must be conceived as the path boundary of the circulating electrons. However, owing to the fact that the auxiliary electrodes come closer to the discharge area or region the electrons will be subjected more markedly than heretofore by the electrical auxiliary fields. Hence, the control
35 or modulation fields which must be made available are smaller, i. e., the slope

$$\frac{d(J_1 - J_2)}{dU_{ii}}$$

40 of the characteristic is steeper, where $J_1 - J_2$ is the amplitude difference of the component anode currents when subject to the action of a control potential U_{ii} .

45 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 Figs.
50 1 to 6 inclusive are diagrammatic transverse sections of different forms of electron discharge devices embodying my invention and Fig. 7 is a diagram of a circuit including an electron discharge device made according to my invention. 55

In Figs. 1 to 7 are shown exemplified embodiments of the basic idea of this invention. In Fig. 1 the anodes for anode segments A are disposed along the sides of a quadrangle. The circle about the cathode K with radius r_a indicates the points beyond which the electrons will be unable to travel, provided that the magnetic field is suitably proportioned, and that the working voltage has been made of a suitable value. The auxiliary electrodes H are mounted outside the bounds of the said circle, so that they will be unable to absorb any appreciable current even in the presence of a positive biasing potential.

Fig. 2 shows a tube which is similar to that of Fig. 1. The anode portions A, of the anodes which are in positions posterior in reference to the auxiliary electrodes H, are shortened so as to diminish capacitance between them. As a matter of fact, these particular portions of the plates may be dispensed with inasmuch as they do not produce any appreciable effect upon the discharge process and action owing to the shielding set up by the auxiliary electrodes H. The auxiliary electrodes themselves may be made of any desired form at all.

Fig. 3 shows the section laid through a rectangular electrode system. The anodes A' are located upon the long sides and the auxiliary electrodes H' on the short sides of a rectangle.

The anodes of the magnetron tube need not be of planar configuration, but they may be made of any desired forms. The only factor which is important is that the anodes should not entirely come close to the boundary cylinder around the cathode, but should at some places be spaced therefrom in order to afford room for the mounting of the auxiliary electrodes.

Fig. 4 shows an exemplified embodiment in which the anodes A₂ which touch the circle about the cathode along a medium line, are not made planar or flat, but so shaped that the parts of the anode located at both sides of the tangent point are "replicas" of one another.

If the auxiliary electrodes are moved out on the anode surface, there results a construction as shown by way of example in Fig. 5. The anodes are flat and planar, and they touch the circle described about the cathode at one lateral edge. The auxiliary electrodes are positioned in the extended planes of the surface of the anodes, the tangent being the edge of the anodes.

Now, it would be feasible to go one step further by making the anodes and the auxiliary electrodes of like size while placing them symmetrically with respect to a diameter of the circle about the cathode so that the tangent point coincides with the gap between the anode A₄ and the corresponding auxiliary electrode H₄ as in Fig. 6. In this latter disposition it should be observed that owing to the direction of travel of the electrons under the influence of a magnetic field as here chosen the electrodes H₄ are not electrically equivalent to the working electrodes A₄. Inasmuch as the electrons pass over essentially in the center of the side surface of the square, the slot S is not equivalent to the slot S'. By a suitable choice of the working conditions any undesired current control action by the anodes upon the auxiliary electrodes is readily preventable, for instance, the auxiliary electrodes H₄ can be operated at a D. C. voltage about 10 to 20 percent lower than the anode D. C. voltage.

The "electronic decoupling" of the anodes and the control electrodes could be further assisted

by an unsymmetrical shift of the slot S with reference to the slot S'.

Fig. 7 shows a magnetron circuit arrangement using the tube here disclosed. This circuit scheme could be used for producing amplifying and receiving electrical oscillations, as a relay, and the like. The outside magnets N—S set up a constant steady field whose lines of force extend parallel to the cathode K. The anode potential U_a and the magnetic field are so chosen that the major part of the electrons on their paths or orbits will just about skirt the anode A, and that the points where auxiliary electrodes H are mounted remain free from electrons, or nearly so. The auxiliary electrodes H are preferably impressed with a positive potential U_b for biasing, and this potential will usually be less than the anode potential. This auxiliary electrode potential may be superposed upon the master potential, the modulation potential, or the incoming (signal) potential, etc.

Practical experience has shown that it is desirable in reception with the magnetron to have ways and means available so that regeneration and rectification may be regulated independently of each other. This problem may be solved in a particularly advantageous manner with the use of a tube as here disclosed.

In Fig. 7 the microphone M may be replaced by a telephone receiver or an A. F. amplifier, or else if an intermediate circuit is provided an I. F. amplifier. The RF voltages which are picked up by antenna E coupled to circuit F connected between the anodes A are superposed upon the anodes A, the anode system serving primarily for regeneration. Rectification itself is practically effected only by the aid of the auxiliary electrodes H. The separation of the two actions which are fundamentally independent of each other, affords a chance to choose for both functions such operating points as will be of most advantage, and this has heretofore been hardly feasible.

The working conditions, that is to say, magnetic field and biasing potential of the auxiliary electrodes and anodes are preferably so chosen that the auxiliary electrodes, in the absence of incoming or signal voltages, absorb only a small current or no current at all. As soon as a signal alternating voltage happens to be superposed upon the anode potential, the auxiliary electrode current rises roughly in direct proportion to the incoming voltage inasmuch as the paths of the electrons during the periods of positive RF alternations are "curved open" or expanded so that they present larger diameters than when in quiescent state.

What may be most advantageously used for the reception is a super-regeneration method. The anode potential, for instance, has imposed upon it a supersonic variation or super-regenerative bias volt so that the anode system will oscillate between the incipency and discontinuance of oscillations, provided the working point has been suitably chosen. Then a rectifier action is noted in the auxiliary electrode circuit as described above. However, this does not mean that the biasing frequency may not be applied to the auxiliary electrodes, if desired.

The basic idea of the invention is not confined to the embodiments here indicated by way of example. The anodes may be made of any desired form provided that at some local points they are so far spaced from the cathode that between them and the cathode there remain a

suitable number of places free from electrons suited to accommodate the auxiliary electrodes.

The various auxiliary electrodes may also be impressed with RF control potentials which are shifted in their phase relations as in a transmitter amplifier. The modulation voltages need not exclusively be applied to the auxiliary electrodes, in fact, recourse could be had to a combination modulation in which upon the anode potential and the auxiliary electrode potential modulation waves are superposed in phase or in phase opposition.

What I claim as new is:

1. An electron discharge device having an envelope containing a straight cathode, a plurality of anodes surrounding and parallel to said cathode, and auxiliary electrodes positioned between said anodes, said anodes touching the surface of an imaginary cylinder having said cathode as its axis, said auxiliary electrodes lying outside of said imaginary cylinder and means for producing a magnetic field parallel to said cathode.

2. An electron discharge device having an envelope containing a straight cathode, a plurality of anodes surrounding and parallel to said cathode, and auxiliary electrodes positioned between said anodes, said anodes having a portion touching the surface of an imaginary cylinder having the cathode as an axis, the other portion of said anode being spaced from the surface of the cylinder, said auxiliary electrodes lying outside of said imaginary cylinder and inside the space bounded by the anodes or their extensions, and means for producing a magnetic field parallel to said cathode.

3. An electron discharge device having an envelope containing a straight cathode, a plurality of anodes surrounding and parallel to said cathode, and auxiliary electrodes positioned between said anodes and parallel to said cathode, said anodes touching the surface of an imaginary cylinder having said cathode as an axis, said auxiliary electrodes lying outside of said imaginary cylinder, said anodes and said electrodes forming an enclosure about said cathode, and means for producing a magnetic field parallel to said cathode.

4. An electron discharge device having an envelope containing a straight cathode, a plurality of flat anodes surrounding and parallel to said cathode, said anodes being tangent at their midpoint to the surface of an imaginary cylinder having the cathode as an axis, and auxiliary electrodes positioned between said anodes and lying outside of said imaginary cylinder, and means for producing a magnetic field parallel to said cathode.

5. An electron discharge device having an envelope containing a straight cathode, a plurality of flat rectangular anodes surrounding and parallel to said cathode and touching the surface of an imaginary cylinder having the cathode as an axis, said anodes forming a rectangle about said cathode, and auxiliary electrodes positioned between said anodes and outside of said imaginary cylinder in the corners of said rectangle, and means for producing a magnetic field parallel to the cathode.

6. An electron discharge device having an envelope containing a straight cathode, a plurality of anodes surrounding and parallel to said cathode, and auxiliary electrodes positioned between said anodes, said anodes touching the surface of an imaginary cylinder having said cathode as its axis, said auxiliary electrodes lying outside of said imaginary cylinder and means for producing a magnetic field parallel to said cathode, a source of voltage connected between said anodes and said cathode, and a source of voltage connected between said cathode and said auxiliary electrodes, said voltages and magnetic field being so chosen that the electron paths do not extend beyond the surfaces of the imaginary cylinder whereby said auxiliary electrodes lie in spaces substantially free from electrons.

7. An electron discharge device having an envelope containing a straight cathode, a plurality of anodes surrounding and parallel to said cathode, and auxiliary electrodes positioned between said anodes, said anodes touching the surface of an imaginary cylinder having said cathode as its axis, said auxiliary electrodes lying outside of said imaginary cylinder and means for producing a magnetic field parallel to said cathode, a source of voltage connected between said anodes and said cathode, and a source of voltage connected between said cathode and said auxiliary electrodes, said voltages and magnetic field being so chosen that the electron paths do not extend beyond the surfaces of the imaginary cylinder whereby said auxiliary electrodes lie in spaces substantially free from electrons, a circuit connected between said anodes and said source of anode voltage, and a circuit connected between said auxiliary electrodes and said auxiliary electrode voltage supply, said anodes providing regeneration and said auxiliary electrodes rectification independently of each other.

8. An electron discharge device having an envelope containing a straight cathode, a plurality of anodes surrounding and parallel to said cathode, and auxiliary electrodes positioned between said anodes, said anodes touching the surface of an imaginary cylinder having said cathode as its axis, said auxiliary electrodes lying outside of said imaginary cylinder and means for producing a magnetic field parallel to said cathode, a source of voltage connected between said anodes and said cathode, and a source of voltage connected between said cathode and said auxiliary electrodes, said voltages and magnetic field being so chosen that the electron paths do not extend beyond the surfaces of the imaginary cylinder whereby said auxiliary electrodes lie in spaces substantially free from electrons, a circuit connected between said anodes and said source of anode voltage, and a circuit connected between said auxiliary electrodes and the auxiliary electrode voltage supply, said anodes providing regeneration and said auxiliary electrodes rectification independently of each other, the magnetic field and biasing voltage of the auxiliary electrodes being so adjusted that in the absence of radio frequency signal potentials the auxiliary electrodes absorb a minimum of current.

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