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K. FRITZ

2,130,124

ELECTRON DISCHARGE DEVICE

Filed Oct. 28, 1936

Fig. 1

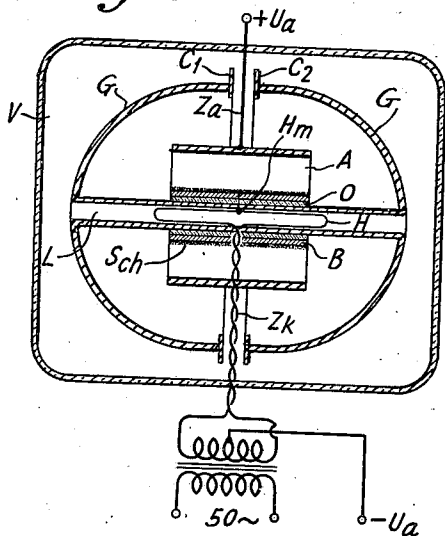


Fig. 2

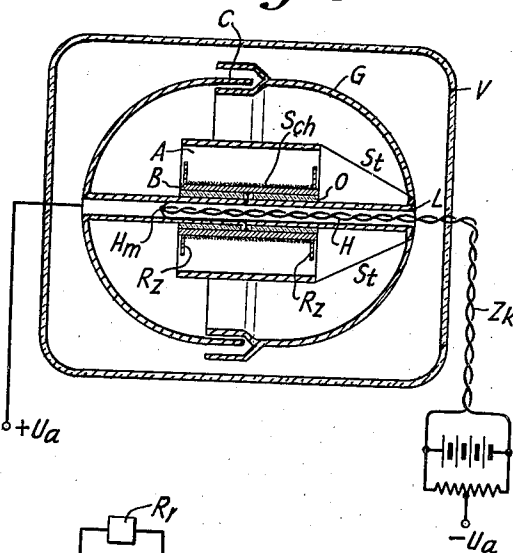


Fig. 3

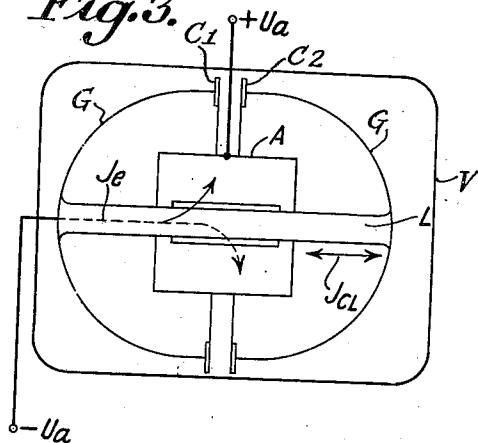


Fig. 4

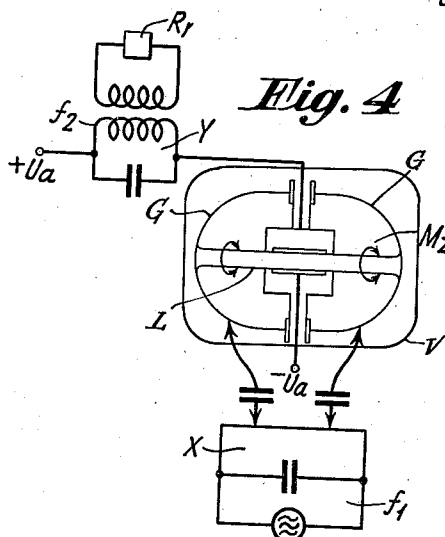


Fig. 5

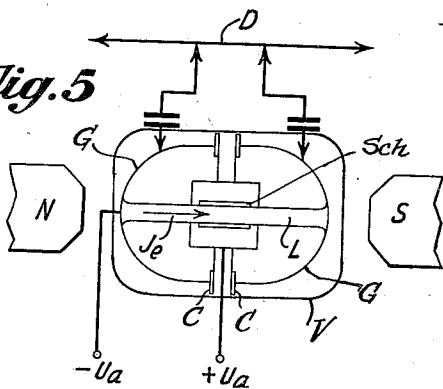
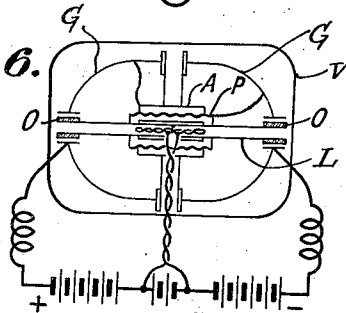


Fig. 6



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ELECTRON DISCHARGE DEVICE

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10 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices and particularly to such devices for use at high frequencies wherein the oscillating circuit of the tube is built in the envelope of the tube.

The object of my invention is to provide an improved electron discharge device particularly suitable for use at high frequencies.

The short-wave tube according to the invention, wherein the produced frequency is determined by a more or less closely screened oscillating circuit, whose housing is disposed in concentric-symmetry with the internal conductor-like inductance, is provided inside the oscillating circuit with a discharge system arranged in such a manner that the emitting layer is positioned directly or indirectly along a larger part of the inductance and that the other electrodes are arranged co-axially therewith.

The present invention has a number of advantages. Energy cannot be radiated away either through the electrode system or through the oscillating circuit. The operating potentials can be supplied in neutral planes or zones rendering superfluous a choking of the lead-in lines.

A further advantage occurs, when use is made of the tube under consideration as a magnetron. If correctly dimensioned with respect to ohmic conductivity, skin effect and so forth, poorly radiating oscillating circuits exhibit selectivities

$$= \frac{J/\text{wattless current}}{J/\text{energy current}}$$

of about 300 or more so that a resonance current of about 100 amperes may be obtained with an exciting current of about .3 ampere. This current flows through the conductor-like inductance which is at the axis of the symmetrically developed oscillating circuit and produces a circular-symmetrical magnetic field that controls the magnitude of the discharge current leaving the cathode in such a manner that with small values of the oscillating current the electrons can go to the plate while in the case of large values they are bent back. The relationship between current intensity J for the production of the magnetic field, plate potential U_a , diameter of plate D and of cathode d is given by Hull's formula:

$$U_a = .0188 J^2 \left(\log_{10} \frac{D}{d} \right)^2$$

U_a is that plate potential at which there just appears a noticeable plate current for the calculated J . For

$$\frac{D}{d} = 10 \text{ and } J_{\text{res}} = 100 \text{ Amperes}$$

the plate potential is according to the calculation = 200 volts. By increasing the time of stay of the electrons near the inductance L the required size of the control current can be materially reduced still further. Suitable means for

this purpose are magnetic fields of constant intensity and direction, generated exteriorly or interiorly of the oscillating circuit, for example by a direct current made to flow through the inductance, if necessary separately from the other current. The stay of the electrons in the vicinity of the current-carrying inductance can however also be increased in its duration by the generation of artificial or genuine space discharge phenomena.

It has been previously proposed by the prior art to control the current distribution in a magnetron having several plates by means of a circular-symmetrical alternating magnetic field. The present invention differs therefrom in that the current between the cathode and anode is controlled in its size. The use of an emission current control has the advantage that the cathode surface can without difficulty be made relatively large with the result that a desired high output can easily be insured with standard cathodes and cathode materials. Cathode and anode have, in a tube according to the invention, practically the same axial expanse. Hence, the emission current density per mm^2 of cathode surface can be kept within normal limits.

A tube made according to the invention can be operated in feed-back coupling (self-excitation) or as amplifier (master excitation). It may also be utilized for frequency-doubling. In such case however, no supplementary magnetic fields may be made use of since then two maxima and therefore two minima of the emission current do not occur per oscillation of an alternating current.

In master-excited circuits (amplifiers and frequency multipliers) the transit time of the electrons is of no decided importance. In self-excited circuits the phase difference between current and potential necessary for the continuous excitation of oscillations must be equalized with the aid of the plate continuous potential as known in the prior art.

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. 1-3 are schematic diagrams of different modifications of tube constructions according to my invention and Figs. 4-6 circuit arrangements which may be used with the tubes made according to my invention.

In Fig. 1 the discharge vessel or envelope V contains the oscillating circuit consisting of the straight, tubular or leader-like inductance L and the mutual capacity C_1 , C_2 of hollow, semi-spherical or cup-shaped conducting parts G . The open ends of parts G are positioned to face each

other to form a symmetrical housing around the conductor L. The discharge system proper is disposed inside the oscillating circuit L—G—C₁—C₂—G. The emitting layer S_{ch} is for instance applied to a metallic sleeve B which may be supported by tubular conductor L with insertion of an insulating layer O. The heating element H, whose electric center point H_m is connected with the emitting layer S_{ch}, may now be disposed as shown within conductor L. The wires of heating element H are suitably wound bifilarly so that the magnetic field of the heating current cannot act upon the discharge action. The halves of the screening housing G of oscillating circuit L—G—C₁—C₂—G are spaced at their rims so that a plane passing through the space is at right angles to conductor L approximately at the center of the symmetrical oscillating circuit. In this electrically neutral plane are disposed the leads Z_a which connect the positive side of the plate potential source +U_a with plate A, and leads Z_k which conduct the heating potential to heating element H and connect beside the emitting layer S_{ch} with the negative pole of plate potential source —U_a.

Fig. 2 shows a modification. While housing G is again separated electrically in the centerplane, it is however fully closed capacitatively by the ends of housing parts G which interleave with each other, the interleaved parts providing capacity C. This form shows the plate potential connected through supports S_t and above all, which is more important, through conductor L. This has the result that the emission current, varying in high-frequency rhythm, flows through a part of the oscillating circuit L—G—C and excites the latter to self-oscillations. Thus there can be built with this tube a self-excited circuit scheme. In order to prevent movement of the electrons directly to conductor L, guiding shields R_z are attached to the sides of sleeve B supporting the emitting layer S_{ch}. The heating potential is supplied through the interior of conductor L by means of a lead Z_k which is suitably twisted so that the magnetic field produced by the heating current can have no effect on the discharge action proper. This heater wire H is connected at H_m to the sleeve B and coating S_{ch}.

Fig. 3 shows a tube similar to Fig. 1 with the difference that the energizing emission current J_e must flow partly only through inductance L and this prior to its reaching the cathode and not through the heating circuit (not shown) which in this case is electrically insulated from the electrodes. Oscillating current J_{ol} which at resonance is a multiple of energizing current J_e traverses of course the entire oscillating circuit LC, exactly as in the example of Fig. 2.

In Fig. 4 is shown a master control circuit arrangement, making use of a tube made according to the invention. Under the assumption that no magnetic field is present, which traverses the discharge path, there appears in output circuit Y the double frequency f₂ of the control frequency f₁ which is sent by control sender X through inductance L. The reason for this frequency-doubling effect is due to the fact that there occur, per oscillation of the fundamental frequency, f₁, two maxima of the circular alternating magnetic field M_z produced by current in conductor L and accordingly, two minima in emission current J that excites output circuit Y. If no doubling of frequency is to occur, care must be taken to establish a constant magnetic "advance field" which must be greater than the peak value of the

alternating magnetic field. The useful output may be brought to a receiver of any type, R_n, for instance inductively.

Fig. 5 represents a self-excited circuit arrangement. Emission current J_e must, on its way to the emitting layer S_{ch} of the cathode, flow partly through conductor L and accordingly energizes oscillating circuit LC in high-frequency rhythm. A magnetic field generated by magnets N—S, whose lines of force have a course parallel to inductance L, causes the produced frequency to coincide numerically with the control frequency. A radiator in form of a dipole D is coupled capacitatively with the oscillating circuit.

Although in the description mention has been made so far mostly of magnetrons, this shall not mean that the tube according to the invention can be operated only in magnetron-circuit arrangement. The main advantages cited in the beginning, that is the complete freedom from radiation and the possibility of feeding the operating potentials in simple manner in neutral zones, appear also if for instance the tube is energized in a standard feed-back coupling arrangement.

Fig. 6 shows a circuit arrangement of this type. Conductor L is at its ends electrically separated from the housing by insulating intermediary layers O. Plate A is connected with the one half of the housing, Grid P with the other half. The reaction coefficient can be chosen at will by the suitable selection of taps on the shell of the housing or on the conductor L.

In order to assure sinusoidal character and to prevent an irregular current distribution the housing of the oscillating circuit is suitably constructed in the manner that its generatrix shows no non-uniformities, aside from the separating seam at right angle to conductor L. The passage from housing G to conductor L may be made in a manner to insure the gradual change of the wave resistance.

The invention is not limited to only the embodiments by way of example here cited and illustrated. Any desired electric and magnetic modulation methods may for instance be used. The electrodes proper may be provided with arrangements for cooling and with devices for increasing heat radiation.

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 an elongated conducting member, oppositely disposed hollow conducting members each open at one end and supported on said elongated conducting member with the open ends facing each other and forming a symmetrical housing around said elongated conducting member, and a plurality of electrodes including a cathode surrounding and coaxial with said elongated conducting member and positioned within said housing, said cathode being supported on said elongated conducting member.

2. An electron discharge device having an envelope containing an elongated conducting mem-

ber, a pair of like oppositely disposed hollow conducting members open at one end and electrically connected to and supported on said elongated conducting member, the open ends of said hollow conducting members facing each other and forming a symmetrical housing around said elongated conducting member, the open ends of said hollow conducting members overlapping but spaced from each other, a cathode and an anode surrounding and coaxial with said elongated conducting member and positioned within said housing.

3. An electron discharge device having an envelope containing a tubular conducting member, a pair of like oppositely disposed cup-shaped conducting members supported on said tubular conducting member, the open ends of said cup-shaped conducting members being spaced from each other and facing each other and forming a symmetrical housing around said tubular conducting member, a cathode supported around said tubular conducting member and an anode coaxial with said tubular member said cathode and anode being within said housing and a heater for said cathode positioned within said tubular conducting member.

4. An electron discharge device having an envelope containing a tubular conducting member, a pair of like oppositely disposed cup-shaped conducting members supported on said tubular conducting member, the open ends of said cup-shaped conducting members facing each other and forming a symmetrical housing around said tubular conducting member, the open ends of said cup-shaped member being spaced from each other in a plane at right angles to said tubular member, a cathode supported around and coaxial with said tubular conducting member and an anode coaxial with said tubular conducting member said cathode and anode being within said housing and a heater for said cathode positioned within said tubular conducting member, and leads for said heater extending through the space between said cup-shaped members and a lead for said anode extending through said space between said cup-shaped members.

5. An electron discharge device having an envelope containing a tubular conducting member, a pair of like oppositely disposed cup-shaped conducting members supported on said tubular conducting member, the open ends of said cup-shaped conducting members facing each other and forming a symmetrical housing around said tubular conducting member, the open ends of said cup-shaped members being spaced from each other, a cathode supported around and coaxial with said tubular conducting member and an anode coaxial with said tubular conducting member, said cathode and anode being within said housing and a heater for said cathode, positioned within said tubular conducting member, the midpoint of the heater being electrically connected to said cathode.

6. An electron discharge device having an envelope containing a tubular conducting member, a pair of like oppositely disposed cup-shaped conducting members supported on said tubular conducting member, the open ends of said cup-shaped conducting members being spaced from each other and facing each other and forming a symmetrical housing around said tubular con-

ducting member, a cathode supported around and coaxial with said tubular conducting member and an anode coaxial with said tubular conducting member said cathode and anode being within said housing, a heater for said cathode, positioned within said tubular conducting member, and shields mounted at the ends of said cathode transverse to said cathode and said tubular conducting member.

7. An electron discharge device having an envelope containing a tubular conducting member, a pair of like oppositely disposed cup-shaped conducting members supported on said tubular conducting member, the open ends of said cup-shaped conducting members being spaced from each other and facing each other and forming a symmetrical housing around said tubular conducting member, a cathode supported around and coaxial with said tubular conducting member and an anode coaxial with said tubular conducting member said cathode and said anode being within said housing and a heater for said cathode positioned within said tubular conducting member, and a grid positioned between the cathode and the anode.

8. An electron discharge device having an envelope containing an elongated conducting member, a pair of like open-ended oppositely disposed hollow conducting members supported on said elongated conducting member, the open ends of said hollow conducting members facing each other and forming a symmetrical housing around said elongated conducting member, the open ends of said hollow conducting members overlapping but spaced from each other, a cathode and an anode coaxial with said elongated conducting member and positioned within said housing, said anode being supported from one of said hollow conducting members.

9. An electron discharge device having an envelope containing a tubular conducting member, a pair of like oppositely disposed cup-shaped conducting members supported on said tubular conducting member, the open ends of said cup-shaped conducting members being spaced from each other and facing each other and forming a symmetrical housing around said tubular conducting member, a plurality of electrodes positioned around and coaxial with said tubular conducting member within said housing, one of said electrodes being electrically connected to said tubular conducting member, and a lead connected to said tubular conducting member.

10. An electron discharge device having an envelope containing a tubular conducting member, a pair of like oppositely disposed cup-shaped conducting members supported on said tubular conducting member, the open ends of said cup-shaped conducting members being spaced from each other and facing each other and forming a symmetrical housing around said tubular conducting member, a cathode supported around and coaxial with said tubular member and an anode coaxial with said tubular member said cathode and anode being within said housing and a heater for said cathode positioned within said tubular conducting member, and leads for said heater non-inductively wound to prevent inductive interference within the discharge device by heating current in said leads.

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