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UNITED STATES PATENT OFFICE

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HIGH FREQUENCY MAGNETRON APPARATUS

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The present invention relates to the construction and operation of electron discharge apparatus and more particularly to devices in which the direction and flow of electrons are controlled by combined magnetic and electrostatic fields in such a manner as to produce a negative resistance characteristic, indicative of the ability to produce oscillations when connected in appropriate circuits.

Apparatus of this character employs a source of electrons and one or more pairs of symmetrically arranged electron receiving surfaces, the travel of electrons being directed by a suitably applied electrostatic field and an externally located solenoid. The electron receiving surfaces constitute anodes which usually take the form of segments of a cylinder, while the source of electrons consists of a filament disposed in the longitudinal axis of the cylinder. A device of this sort may be termed, for convenience, a "split anode magnetron" and examples of construction are disclosed and claimed in an application Serial No. 285,008, filed in the name of K. Okabe, June 13, 1928, entitled "Extra short wave generating apparatus", also described by H. Yagi in an article entitled "Beam transmission of ultra short waves" appearing in Proc. of the I. R. E. Vol. 16, June, 1928, pp. 735–6, and by K. Okabe in an article entitled "On short wave limit of magnetron oscillations" appearing in the Proc. of the I. R. E., Vol. 17, April 1929, pp. 652–659 inclusive. It is stated in these disclosures that the split anode magnetron offers an advantage over electrostatically controlled electron discharge devices in that the interelectrode capacity is comparatively small and hence when the device is connected in suitable circuits oscillations of short wave lengths and of considerable amplitude may be generated.

It has been found in practice that while apparatus of this kind is capable of producing oscillations of a much higher frequency than is possible in a three-electrode grid controlled type of device, in view of the very small value of the interelectrode capacity referred to hereinbefore, there is still present sufficient capacity to preclude the production of oscillations of the shortest wave lengths useful in radio transmission and reception e. g. of an order less than a few meters. An object of the present invention is to provide a magnetron of the split anode type with an electrode construction which offers the minimum electrostatic capacity. This object is attained in brief, by providing relatively flat anodes instead of cylindrical members and presenting each anode edgewise, or substantially so, to the cathode.

It has been found further that the cylindrical form of anode in addition to failing to offer a minimum capacity also tends to heat unevenly over the surface. The hottest portion of each anode resides in a restricted region along one axial edge while the remainder runs comparatively cool and it is apparent that the maximum output, determined by the temperature of the hottest portion, is considerably lower than when the entire surface of the anode runs uniformly at the maximum elevated temperature. Accordingly, another object of the invention is to provide an improved electrode construction and arrangement in which the anode members are heated evenly whereby the output may be maintained at an optimum value. I have discovered that a flat anode construction lends itself particularly well to this object under operating conditions as well as to the previously stated object. Other objects and features of the invention will be apparent as the specification is perused in connection with the accompanying drawings in which Fig. 1 is a side elevational view of an improved form of magnetron showing also a cross section of the solenoid accessory and associated circuits; Fig. 2 illustrates a cross-section of the device shown in Fig. 1 taken along the line 2—2; while Figs. 3 and 4 are graphs depicting certain operating characteristics of the magnetron.

Referring to Fig. 1, numeral 1 designates a highly evacuated envelope containing a cathode in the form of a longitudinally disposed rectilinear filament 2, supported at one end from the press 5 by means of an anchor wire 6 and a tension spring 7. About the spring and attached to the upper filament

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Fig. 1.

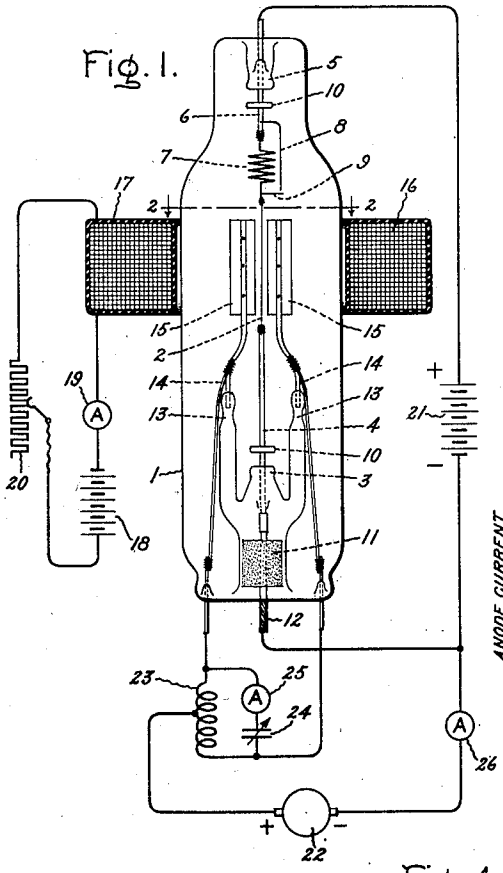


Fig. 2.

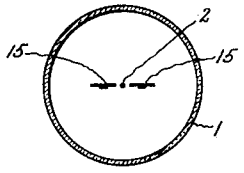


Fig. 3.

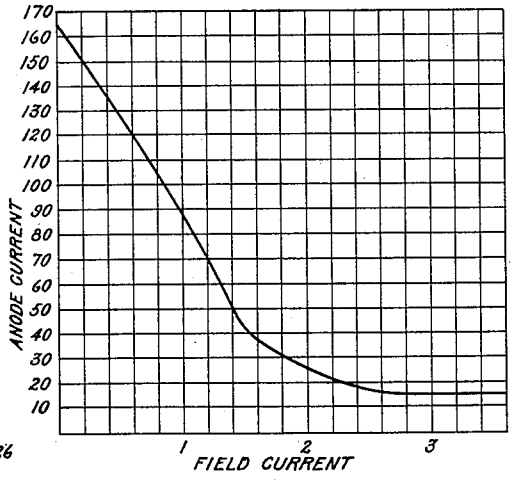
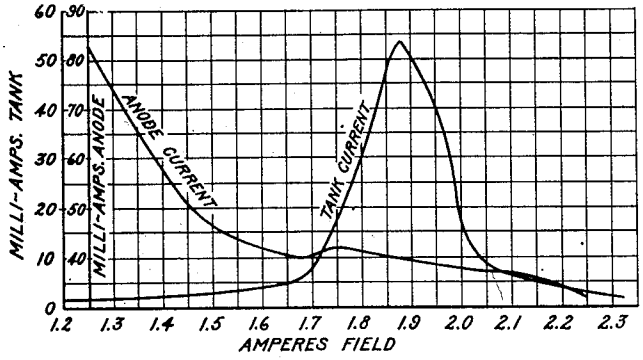


Fig. 4.



Inventor:
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be increased in a regular manner until the current drawn from the tank circuit causes the anodes to assume a temperature limited only by the melting or deforming point. Under these conditions the load current may attain an optimum value for the particular size of tube and electrode arrangement without danger of melting or otherwise damaging the anodes.

While I have described my invention with reference to a particular embodiment in which the anodes are located in a plane common to the filamentary cathode, it is evident that the advantages of my discovery also apply to those modifications in which the plane of the anodes does not contain the cathode or in which the anodes themselves do not lie in the same plane. From a purely efficiency standpoint and apart from the interelectrode capacity or frequency consideration, the most effective position of the anodes may be such that the surface intercepts the path of electrons at an angle substantially normal thereto. The electron paths take the form of spirals having their origin at the cathode and the size of which is determined by the instantaneous effect of the electrostatic and magnetic fields. It is apparent that as the electrodes are moved, if necessary, out of line with one another, i. e. positioned in different planes, in order to adapt their surfaces to the various electron paths, the projected area of each plate-like anode presented to the cathode or to one another becomes greater and the maximum frequency of the generated oscillations is correspondingly reduced. However, it will be understood that notwithstanding the increased capacity under these conditions, the flat form of anode offers a decided decrease in capacity effect over the cylindrical form. My invention is therefore not limited to a uniplanar arrangement of electrodes but contemplates all positions of the flat anode in which advantage is taken to reduce inter-electrode capacity by reason of the anode configuration.

What I claim as new and desire to secure by Letters Patent of the United States is:—

1. In a device for generating oscillations, an evacuated envelope containing a cathode, a plurality of anodes, means for producing a cooperating magnetic field, a resonant circuit connected across the anodes and a connection between said circuit and the cathode, said anodes being substantially flat and lying in the plane of the cathode whereby the operating efficiency of the device is maintained at an optimum value.

2. In a device for generating oscillations, an evacuated envelope containing a cathode, a plurality of substantially flat anodes presented edgewise to the cathode, means for producing a cooperating magnetic field, a circuit containing inductance and capacitance connected across the anodes, and a connection between the inductance and the cathode.

3. In a device for generating oscillations, an evacuated envelope containing a cathode, a plurality of anodes symmetrically disposed with respect to the cathode, means for producing a cooperating magnetic field, a circuit containing a concentrated inductance and concentrated capacitance connected across the anodes, and a connection between said circuit and the cathode, said anodes being constituted of plates arranged in a single plane and presented edgewise to the cathode.

4. In a device for generating oscillations, an evacuated envelope containing a rectilinear, filament, a plurality of substantially flat anodes presented edgewise to the filament, a solenoid disposed about the envelope in such a manner that the magnetic lines of force traverse the space between the filament and the anodes in a direction parallel thereto, a resonant circuit connected between the anodes, a connection between said circuit and the filament, said anodes being arranged in a single plane common to the filament.

In witness whereof, I have hereunto set my hand this 27th day of August, 1929.

ELMER D. McARTHUR.