Jan. 6, 1953 A. M. CLOGSTON 2,624,863

SELF-MODULATED MAGNETRON

Filed Oct. 10, 1945

Fig. 1.

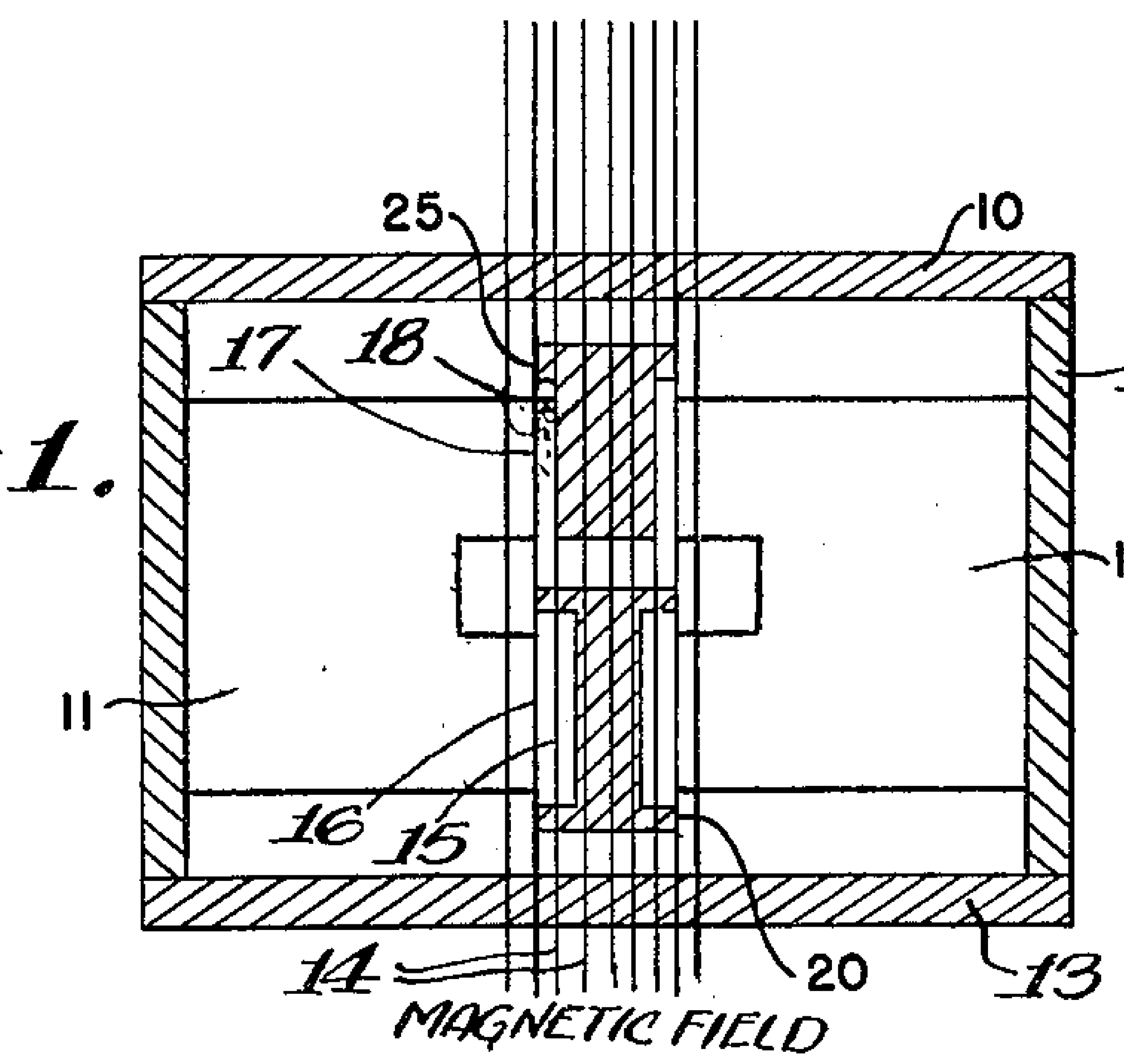


Fig. 2.

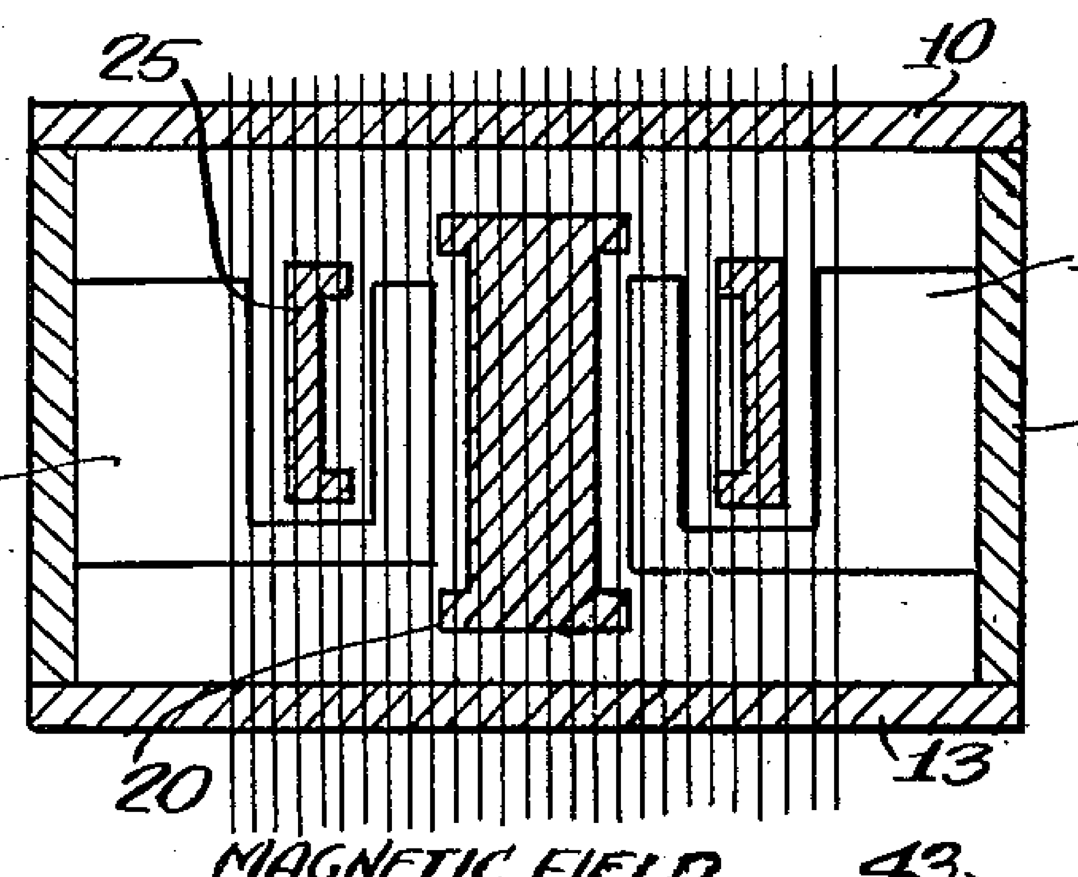


Fig. 3.

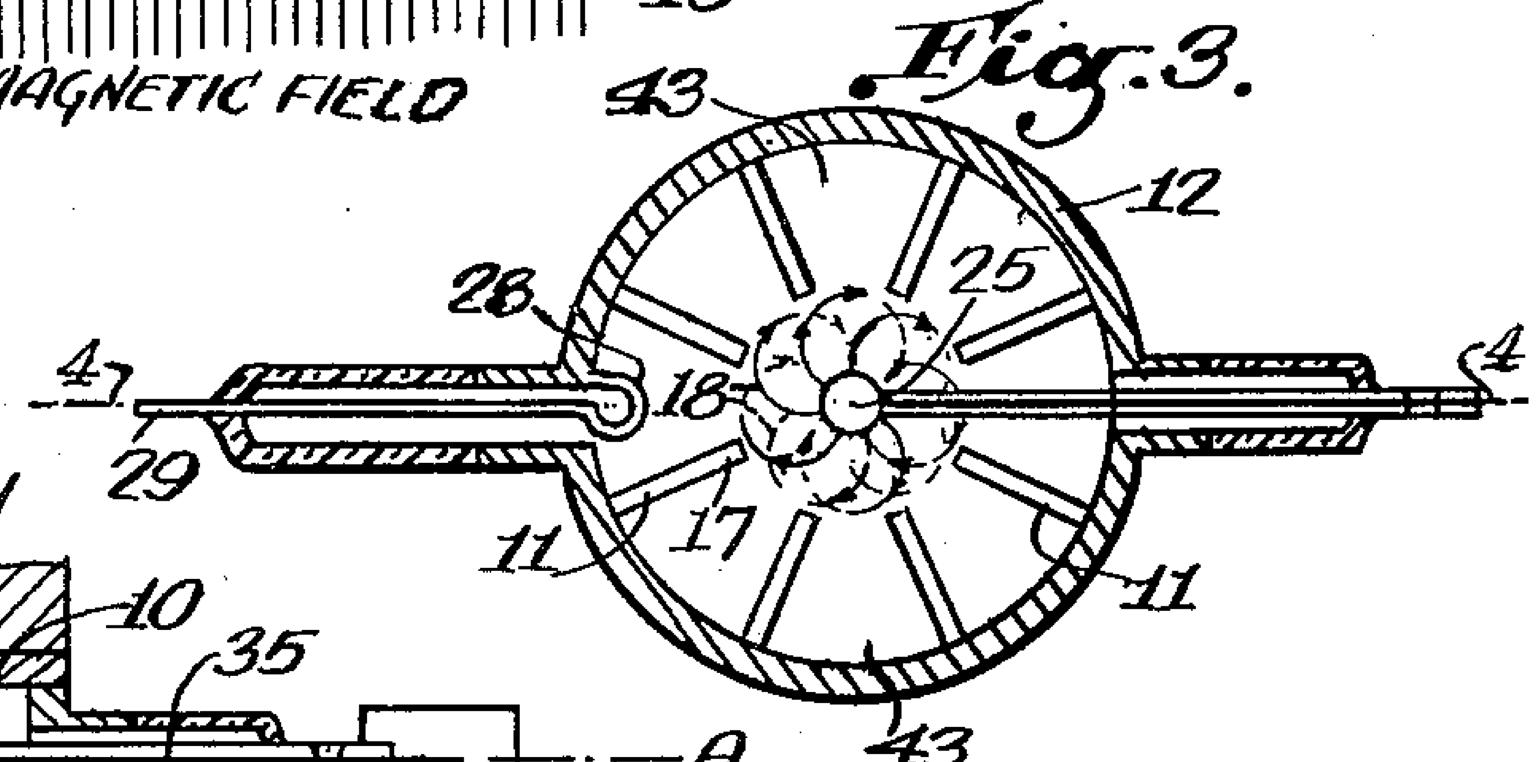
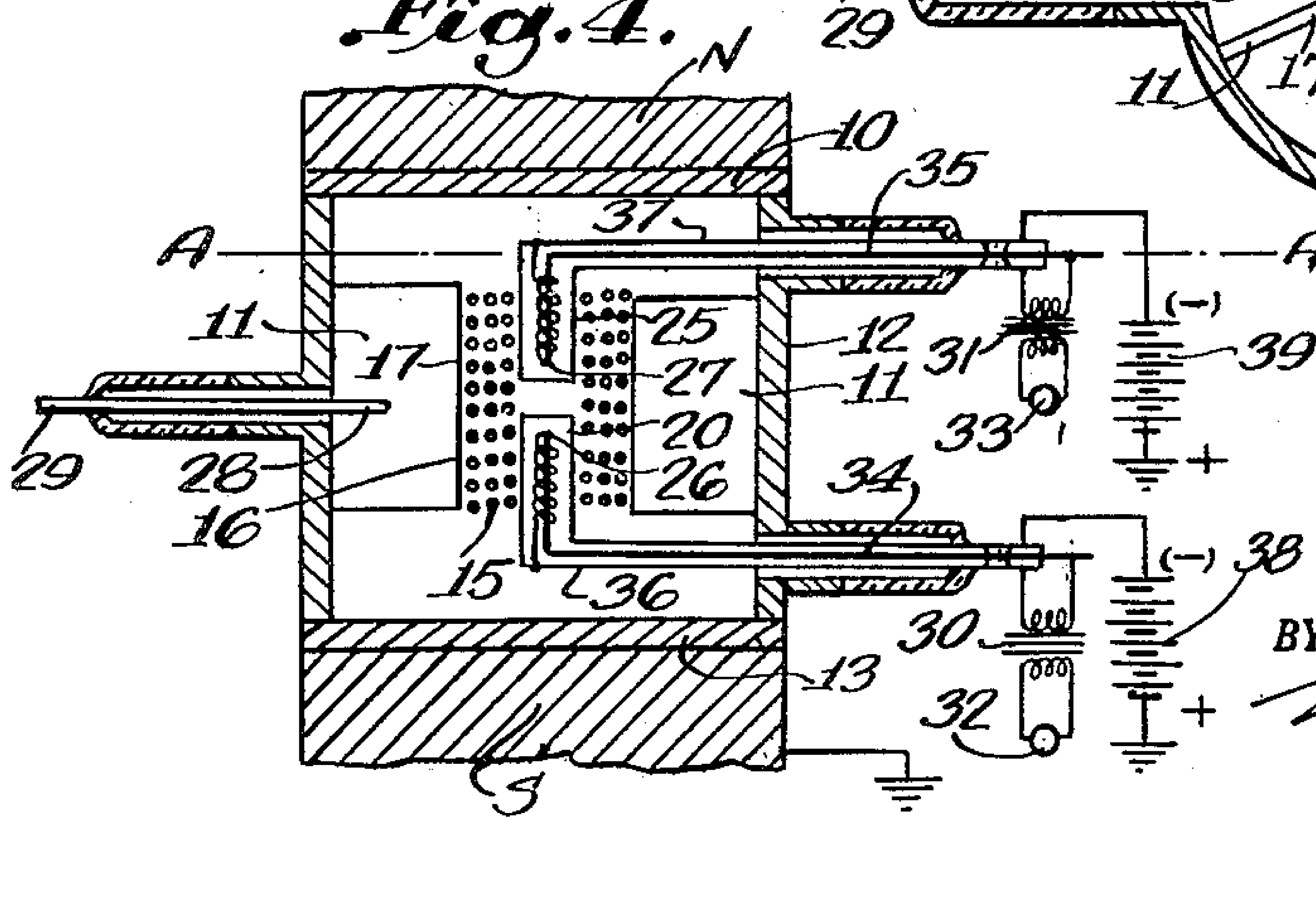


Fig. 4.



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SELF-MODULATED MAGNETRON

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6 Claims. (Cl. 315—40)

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This invention relates in general to thermionic tube apparatus and more particularly to such apparatus embodying the so-called magnetron type of tube.

The use of thermionic tubes in frequency generating apparatus is well known and many such types exist. There are times when it is desirable to vary the frequency output of a particular tube. In some cases this is done by varying the parameters of the circuits associated with the tube in such fashion that the natural period of oscillation thereof is changed. On the other hand, it becomes desirable for some uses of the tube to have the frequency affecting means included within the tube itself and accordingly it is an object of my invention to provide a thermionic tube in which this is accomplished.

One of the tubes which is found to be of considerable use, particularly for generating the higher frequencies, is the so-called magnetron type of tube and when associated with apparatus such as radio object locating apparatus, it is necessary that the frequency be controlled and that some means be provided for varying the natural output frequency of the magnetron in a desired manner. Accordingly it is another of the objects of my invention to provide means included in the magnetron type of tube for affecting and varying the output frequency of the tube.

Apparatus heretofore known to prior art and associated with the magnetron type of tube have had disadvantages such as difficulty in adjustment, maintenance and the like. It is another of the objects of my invention to provide a magnetron type of tube in which the natural frequency output thereof may be varied by thermionic means associated with the tube itself.

In general my apparatus contemplates the provision of a plurality of cathodes within a magnetron type of tube and usually the cathodes are mounted coaxially with respect to each other or concentrically with respect to each other. One of the cathodes is used for the ordinary function of developing radio frequency power in the anode thereof and is operated at a relatively large potential difference with respect to the anode of the tube as is usual. The second cathode which is provided is operated so that the potential established between itself and the anode lies in a region of about half the potential established between the first-mentioned cathode or, as it will be termed, the main cathode and the anode. The emission of electrons from the frequency affecting or secondary cathode into the fringing field of the anode results in a change in the effective resonant frequency of the magnetron cavity. The amount of frequency modulation that results from this arrangement will rise as the relative potential between the anode and the secondary cathode rises until the secondary cathode will tend to take over the radio frequency power generation function of the main cathode.

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My invention will best be understood by reference to the drawing, in which:

Figure 1 is a schematic representation of a magnetron according to my invention having two cathodes arranged end to end on a common axis.

Figure 2 is a schematic representation of a magnetron with two cathodes arranged concentrically.

Figure 3 is a plan view of a magnetron of the type shown in Figure 1 showing the radial vanes and cavities.

Figure 4 is an elevation sectional view taken along the line 4—4 of Figure 3.

Referring to Figure 1, a tubular metal member 12 is closed on top and bottom by the discs 10 and 13 respectively. Vanes 11 rigidly attached to the inner walls of 12 project radially inwardly toward the axis of the cylinder and constitute the anode. In the recess formed between the inner ends of the vanes, two cylindrical cathodes 20 and 25 are mounted end to end on the axis of the anode. These cathodes are of the conventional type having their exterior surfaces coated with suitable thermionic material and are provided with heaters, not shown, to provide the desired thermionic emission. A strong magnetic field is directed along the axis, as shown schematically at 14 and is produced by an external magnet, not shown, whose poles are in contact with top and bottom discs 10 and 13 respectively. The application of a high voltage direct current between cathode 20 and the anode, generates high frequency oscillations in the anode cavities as described later. The function of cathode 25 is to provide a cloud of free electrons in the space 18 between cathode 25 and the upper edges 17 of the anode vanes. The presence of these free electrons in the high frequency field formed between the inner edges of the anode vanes, alters the resonant frequency of the anode cavities.

The structure is shown in more detail in Figures 3 and 4 where the numerals used indicate the same elements as in Figure 1. In Figure 4 which corresponds to Figure 1 the cathodes 20 and 25 are shown provided with heaters 26 and 27. Cathode 20 is supported by coaxial line 36 and is supplied with heating current by central conductor 34 from transformer 30 and source

32. Similarly, cathode 25 is supported by coaxial line 37 and is supplied with heating current by conductor 35 from transformer 31 and source 33.

Radial vanes 11 attached to cylinder 12 form resonant cavities 43 as is known in the art. A high potential direct current source 38 impresses a negative potential on cathode 20 causing electrons to flow from the cathode to the anode vanes. A magnetic field parallel to the axis of the cylinder is provided by magnet poles N and S. The electrons leaving the cathode are deflected by the magnetic field into cardioid shaped paths just grazing the vane tips. For simplicity these means paths are shown circular in Figure 3. With this grazing adjustment oscillations are generated in the resonant cavities 43 by the alternate attraction and repulsion of the vane tips as is well known in the art. Useful energy is abstracted from one of the cavities by magnetic coupling loop 28 and led off by lead 29. The frequency of oscillation is determined by the natural period of the resonant cavity and to some extent by the interaction with the electron cloud in front of the vane tips.

The function of the upper cathode 25 is to provide an additional electron cloud 18 in the space between the upper vane tips 17 and the cathode 25. This electron cloud may or may not engage the vane tips. In either case the free electrons exist in the alternating electric field between the vane tips. Since electrons have mechanical inertia, the electron motion as is well known lags 90 electrical degrees behind the accelerating and retarding alternating electric fields and constitutes lagging currents in the circuit. In other words the electron cloud acts like inductance introduced in series with the inductance inherent in each cavity resonator and therefore changes the natural frequency. Thus by varying the density of the electron cloud in the interspace 18 the frequency of the energy generated by the lower cathode 20 and vane tips 16 may be varied.

The method of varying the frequency is to vary either cathode voltage as applied by source 39 or by varying the emission by varying the supply of heating current from source 33.

Usually the potential difference between the anode 11 and the cathode 25 is in the region of about half the potential established between the anode 11 and the cathode 20. It will be appreciated however that this invention is not limited to the particular value of potential.

By way of example, a magnetron operated in a continuous wave fashion and producing an output frequency whose wavelength was below 100 centimeters having a power output of 17 watts produced a frequency shift of 5 megacycles when a power input of 16.4 watts to the tuning cathode was used.

Referring to Fig. 2, there is shown an alternative form of my invention in which the plural cathodes used are mounted concentrically rather than merely coaxially as shown in Fig. 1. In this showing the cathode 20 which is used to produce radio frequency power is mounted in the space between the vanes as is normal in the art to which this case belongs. The tuning cathode 25 however is mounted in a slot cut in the vanes of the anode as shown in the drawing. Again the tuning cathodes operate in a region of low potential relative to the anode. Electrons emitted by the tuning cathode are caught in the anode fringing field and cause the resonant frequency of the oscillator to change to a degree dependent upon the potential existing between the tuning cathode and the anode. Hence this potential affects the extent of electron emission from the tuning cathode.

By way of example, a magnetron operated in a continuous wave fashion and supplying 32 watts output produces a frequency shift of approximately 5½ megacycles with a tuning power of 8.4 watts. Accordingly it should be noted that the tuning power required for a given shift in frequency is less where the concentric cathode arrangement is used as it is in the case where the coaxial arrangement of cathode is used.

While examples have been given relatively to the use of the magnetron in a continuous wave fashion, it will be appreciated that the arrangement need not necessarily be operated in that fashion but can be used where pulsed operation is utilized.

It will be obvious that there may be departures from the particular showing as made in this specification which will still fall fairly within the spirit of the invention. One such modification, for instance, may be that the two cathodes need not be mounted exactly coaxially, although this is considered at the present time to be a preferable arrangement. Accordingly, I claim all such modifications as fall fairly within the spirit and scope of the invention as identified in the hereinafter appended claims.

What is claimed is:

1. An oscillation generator of the multicavity magnetron type, two cathodes for emitting electrons mounted on a common axis and in cooperative relation with the respective inner edges of a common radial vane system constituting resonant anode cavities, first cathode connected to a source of high direct current potential for generating high frequency oscillations in said resonant anode cavities, coupling means for abstracting useful energy from one of said cavities, and electron means for varying the resonant frequency of the cavities, said means including a source of direct current potential connected to second cathode, whereby an electron cloud is formed in the high frequency field between the second cathode and the inner edges of said vanes.

2. An oscillation generator of the multicavity magnetron type, a single cylindrical anode housing provided with inwardly projecting radial vanes forming a plurality of resonant anode cavities, two cathodes for emitting electrons mounted on a common axis at opposite ends of the interspace between inner edges of said radial vanes, a source of high direct current potential connected to first cathode coacting with lower edges of said radial vanes to generate high frequency currents in said resonant cavities, magnetic coupling means for abstracting useful energy from said resonant cavity system, and electron means for varying the resonant frequency of the cavity system, said electron means including said second cathode connected to a source of direct current potential for forming an electron cloud in the interspace between second cathode and upper edges of said radial vanes.

3. An electron discharge device for generating high frequencies having a first cathode, a single anode and an associated resonant system within a vacuum space having radial inwardly projecting vanes in cooperative relation with said first cathode, means for varying the frequency of said resonant system, said means including a second cathode in cooperative relation with a portion of

said radial vanes, and a source of potential connected to said second cathode, whereby an electron cloud is formed in the high frequency field between the second cathode and the inner edges of said vanes.

4. An oscillation generator of the multicavity magnetron type having a first cathode and a single cylinder anode coaxial with the cathode and having a plurality of inwardly projecting members extending axially beyond said first cathode and with lateral interspaces forming resonant cavities, means for varying the resonant frequency of said cavities, said means including a second cathode coaxial with the first cathode and in cooperative relation with said axially extending members and a source of direct current potential connected to said second cathode whereby an electron cloud is formed in the interspace between the second cathode and said axially extending members.

5. An oscillation generator of the multicavity magnetron type having a first cathode and a single anode with a plurality of resonant cavities whose inwardly projecting edges are coaxial with the cathode and extend axially beyond said first cathode, electron means for varying the resonant frequency of said cavities, said means including a second cathode coaxial with first cathode in cooperative relation with said axially extending edges, and a source of direct current connected to the second cathode whereby an electron cloud is formed in the field between the second cathode and said axially extending edges.

6. An oscillation generator of the multicavity magnetron type having first and second cathodes aligned on the same axis, a single anode having a plurality of resonant cavities with inwardly projecting edges coaxial with and in cooperative relation with said cathodes, said first cathode connected to a source of high direct current potential for generating high frequency oscillations in said resonant cavities, and a second source of direct current potential connected to the second cathode whereby an electron cloud is formed in the interspace between second cathode and a portion of said inwardly projecting edges for varying the resonant frequency of said cavities.

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