March 1, 1949. P. W. FORSBERGH, JR 2,463,372

CATHODE STRUCTURE FOR MAGNETRONS

Filed Oct. 3, 1945

FIG. 1.

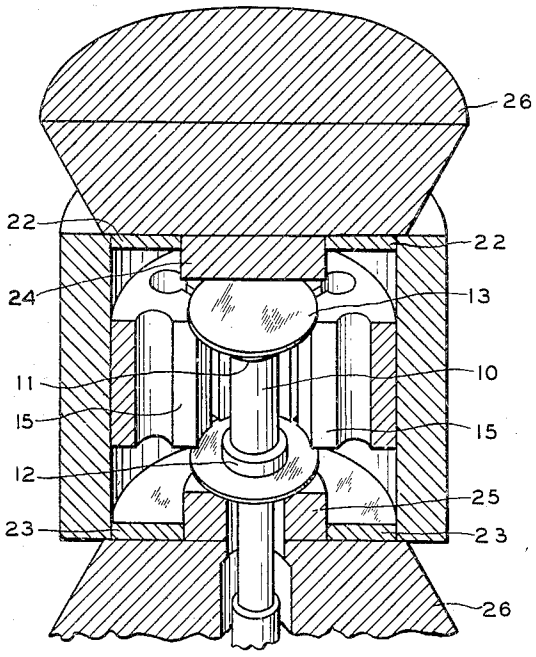


FIG. 2.

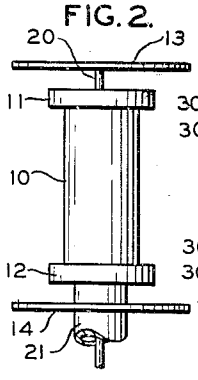


FIG. 3.

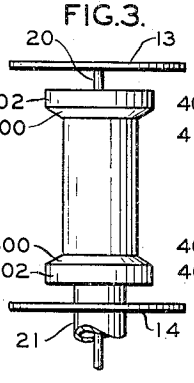


FIG. 4.

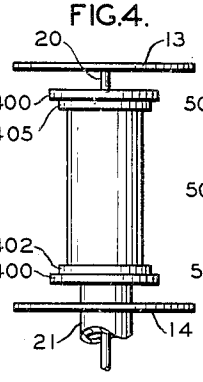


FIG. 5.

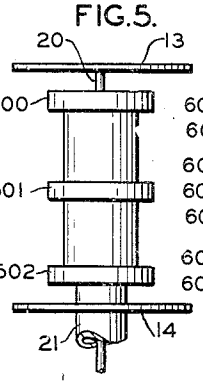


FIG. 6.

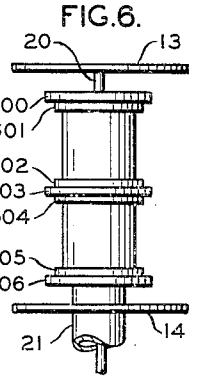


FIG. 7.

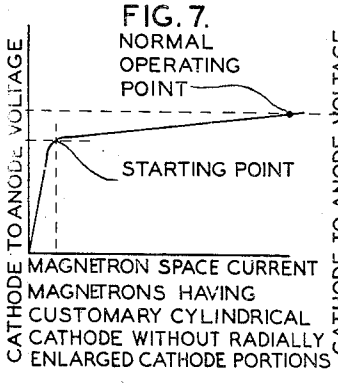
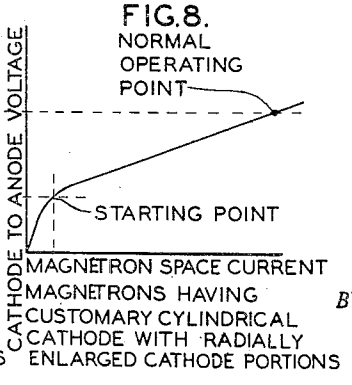


FIG. 8.



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Patented Mar. 1, 1949

2,463,372

UNITED STATES PATENT OFFICE

2,463,372

CATHODE STRUCTURE FOR MAGNETRONS

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Application October 3, 1945, Serial No. 620,126

8 Claims. (Cl. 250—27.5)

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The invention relates to improvements in electrical apparatus and more particularly to improvements in magnetrons.

In the pural cavity magnetron, the anode of which is constructed in several segments and disposed about a central cathode, several modes of radio frequency oscillations are possible. Certain magnetron designs were characterized by operation in a mode other than the desired high efficiency mode, this phenomenon being termed "moding."

An important object of the invention is to improve these magnetrons so that the operation is substantially free of such moding defects.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this specification and in which like numerals are employed to designate like parts throughout the same:

Fig. 1 is a cut-away isometric view of a portion of a magnetron embodying the invention;

Figs. 2 through 6 are side views of cathodes embodying the invention;

Fig. 7 is a voltage vs. current characteristic curve for a magnetron which does not embody the invention; and

Fig. 8 is a voltage vs. current characteristic curve for a magnetron embodying the invention.

Referring to Fig. 1, the numeral 10 designates the main cathode which is cylindrical in construction. At the opposite ends of the main cathode 10 are radially expanded end portions 11 and 12, which are also illustrated in Fig. 2. In the preferred embodiment shown, the radially expanded end portions 11 and 12 are shown as larger diameter steps or rings on the main cathode 10, but they may be tapered sections 300 combined with ring sections 302, discs 400, 402, Fig. 4, or equivalent means for creating a minor electron source radially closer to the anode segment 15 than is the anode-facing surface of the main cathode 10. Although the radially expanded sections or rings are preferably located at the ends of the cathode, as illustrated in Figs. 1 through 4, it is obvious that alternatively one or more radially expanded sections may be placed at any intermediate position between the ends of the cathode. This is illustrated in Figs. 5 and 6. In Fig. 5 three rings 500, 501 and 502 are used which furnish the necessary electrons during the starting portion of the operating period of the magnetron. In Fig. 6 the number of rings has been enlarged to seven, two rings 600 and 601 on top, rings 602, 603 and 604

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in the middle, and two rings 605 and 606 at the bottom.

Referring to Fig. 2, the main cathode 10 and the radially expanded end portions 11 and 12 may be coated with electron emitting material, such as a mixture of barium and strontium carbonates, prior to the exhaust of the tube. However, the radially expanded end portions 11 and 12 may be left uncoated if desired.

Members 13 and 14 designate end shields thermally isolated from the cathode structure 10 for the purpose of maintaining the end shields 13 and 14 relatively cool with respect to the cathode, and electrically connected to the cathode 10 by conductors 20 and 21. Members 22 and 23 and pole pieces 24 and 25 are used to seal the magnetron. Permanent magnet 26 furnishes the necessary magnetic fluid. The end shields 13 and 14 tend to minimize undesirable electron leakage to lids 22, 23 and pole pieces 24 and 25.

The operation of the improved magnetron cathode structure is as follows:

The essential feature of the invention is to provide a minor source of electrons (here shown as radially expanded or radially enlarged portions), radially closer to the anode 15 than is the remaining coated cylindrical surface of the main cathode 10, which acts as the major source of electrons.

The radially enlarged portions serve to decrease moding and thus to stabilize the operation of the magnetron. The following hypothesis is advanced to explain the operation of these cathode structures:

In general, the desired mode of operation for the magnetron is that in which alternate anode segments 15 are positive and negative. This mode is termed the pi-mode. In the usual operation, the magnetron is pulsed by approximately square pulses of voltage. If the applied voltage rises too rapidly past the starting voltage range of the pi-mode, the pi-mode will not start unless its starting speed can be increased. The major effect of the enlarged electron emitting sections, such as 11 and 12, is probably to raise the noise level from which the radio frequency buildup of the pi-mode start, and hence lower the starting time. The radially enlarged end portions (or the equivalent means of creating a minor electron source radially closer to the anode segments 15 than in the main cathode 10), may be made electron emissive either by being coated with electron emitting material prior to the evacuation of the magnetron, or when not coated with electron emissive material, the radially enlarged end sec-

tions become electron emissive due to contamination with the emissive material which is evaporated, sputtered or surface-diffused from the main cathode 10 during the usual steps of processing the magnetron.

The effect of this invention on the voltage vs. current characteristic curves of the magnetron is illustrated in Figs. 7 and 8.

a. Magnetrons having the customary cylindrical cathode (that is, without radially enlarged cathode section or "step"), Fig. 7, and

b. Magnetrons having a cylindrical cathode with radially enlarged sections (that is, having a "step" cathode), Fig. 8.

Comparison of these two curves reveals the fact that the "Starting point" in Fig. 8 is reached at a much lower voltage than the same point in Fig. 7. Therefore with the rate of voltage change

$$\left(\frac{dv}{dt}\right)$$

remaining constant in both cases, the magnetron having "stepped" cathode will reach the operating point quicker without drifting into the other than pi-mode oscillations.

Heretofore, the chief known method of improving the mode stability of magnetrons was to obtain cathodes of high primary emission. This involved close supervision of the cathode manufacture and extremely careful control of impurities in the cathode materials.

Excellent magnetrons have been made, even though cathodes of low primary emission were used, with the present improved cathode structure having radially enlarged end sections. The mode stability has been improved appreciably and the efficiency is essentially unimpaired. This magnetron cathode structure may be used to reduce the stringenecy of manufacture of cathode emission materials.

While there has been described what is at present considered to be a preferred embodiment of this invention, it will be obvious that various changes and modifications may be made therein without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. A magnetron comprising, a main cylindrical cathode having an electron emissive layer constituting a major source of electrons, an anode concentrically disposed with respect to said cathode, at least one radially enlarged portion on said emissive layer, said portion being thermally at substantially the same thermal level as said cathode but mechanically nearer to said anode, said portion constituting a minor source of electrons, and disc-shaped metallic end shields disposed at the opposite ends of said cathode and thermally insulated therefrom, said end shields being electrically connected to said cathode, the diameter of said end shields being greater than the diameter of said enlarged portion.

2. A magnetron having a cathode including a main cylindrical part and a plurality of radially enlarged ring portions, said ring portions constituting direct metallic extensions of said metallic cylindrical part, said main cylindrical part and said radially enlarged portions all being coated with electron emissive material, whereby said cathode structure serves to minimize moding of the magnetron.

3. A magnetron having a cathode structure including a main cylindrical cathode with an electron emissive layer on the outer surface of said cathode, three radially enlarged cathode portions on the outer surface of said cathode for minimizing moding in said magnetron, said electron-emissive layer also extending over said radially enlarged cathode portions, and metallic end shields thermally insulated from but electrically connected to said cathode.

4. A thermionic tube including an anode having a plurality of elements disposed along a cylindrical surface, an indirectly heated cathode concentrically disposed with respect to said anode, said cathode comprising a right metallic cylinder, an electron emissive layer on the entire surface of said cylinder facing said anode, said cathode having more than two axially spaced ring-shaped portions radially extending toward said anode beyond the remaining portion of said layer, said ring-shaped portions constituting direct, metallic radial extensions of said metallic cylinder and acting as the major source of electrons during the starting portion of the operating period of said tube.

5. A thermionic tube as defined in claim 4 in which said ring-shaped portions lie in the respective planes parallel to each other and perpendicular to the longitudinal axis of said cylinder.

6. A magnetron comprising an anode, a cylindrical cathode in coaxial relationship with respect to said anode, said cathode including a hollow metallic cylinder, a radially displaced portion on and constituting a direct, metallic extension of said metallic cylinder, said portion being of smaller axial length than the remaining portion of said cathode and nearer to said anode than said remaining portion, and an electron emissive layer on the entire anode side of said cylinder whereby said radially displaced portion constitutes a minor source of electrons while the remaining portion of said cathode constitutes a major source of electrons.

7. A magnetron as defined in claim 6 which also includes metallic end shields at the opposite ends of said cylinder, said end shields being thermally insulated from but electrically connected to said cathode.

8. A magnetron including an anode, a cathode having a metallic cylinder in coaxial relationship with respect to said anode, a plurality of radially displaced ring-shaped portions on and constituting a direct metallic extension of said metallic cylinder, said ring-shaped portions being nearer to said anode than the remaining portion of said anode and having the combined area smaller than the remaining area of said cathode, and an electron emissive layer on the entire surface of said metallic cylinder facing said anode.

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