

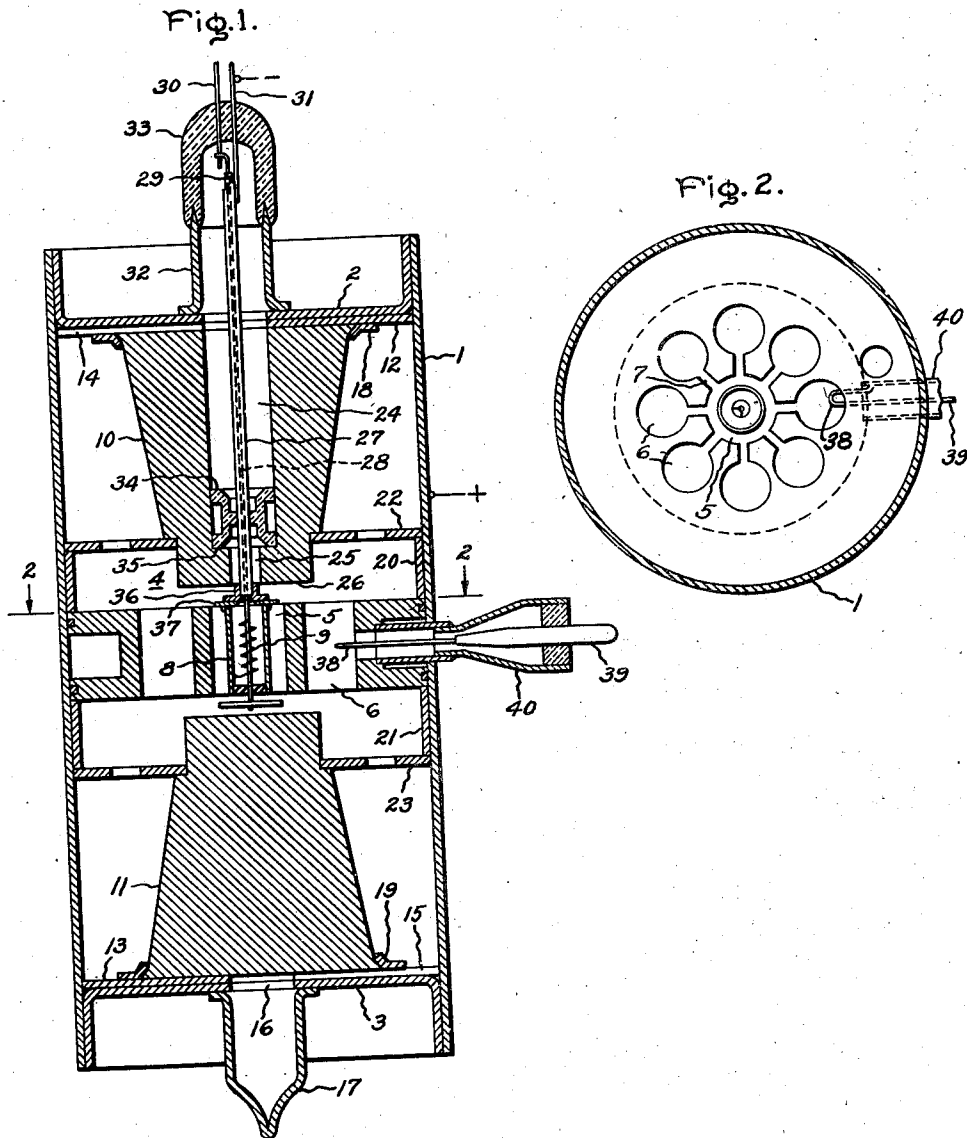
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MAGNETRON

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MAGNETRON

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My invention relates to high frequency electric discharge devices and more particularly to ultra high frequency magnetrons of the space resonant type.

In the development of ultra high frequency electric discharge devices, and particularly in the effort to increase the operating frequency of discharge devices of this nature, the incident decrease in the dimensions of the cooperating electrodes and associated structure has entailed certain limitations as to the magnitude of voltages which may be used in the higher frequency devices. In accordance with the teachings of my invention described hereinafter, I provide a new and improved structure for an electric discharge device of the magnetron type wherein the operating frequency may be substantially increased, and wherein the structure is arranged and positioned so that a reduction in the operating voltage of the device is not required.

It is an object of my invention to provide a new and improved ultra high frequency electric discharge device.

It is another object of my invention to provide a new and improved ultra high frequency electric discharge device of the magnetron type.

It is a further object of my invention to provide a new and improved ultra high frequency magnetron wherein the cathode structure may be supported centrally with respect to a magnetic pole piece, and wherein the magnetic field distortion is reduced or substantially eliminated.

It is a still further object of my invention to provide a new and improved structure for an ultra high frequency electric discharge device of the magnetron type wherein the relative dimensions of the cathode structure and the magnetic pole piece obtain a desired configuration of the magnetic lines of force within the space discharge region, thereby producing a focusing effect upon the electrons constituting the space discharge or limiting the divergence of the electrons at the ends of the space discharge region.

Briefly stated, in the illustrated embodiment of my invention I provide a new and improved ultra high frequency magnetron wherein a cathode is supported centrally with respect to a longitudinal magnetic pole piece by means of cathode supporting structure extending through a longitudinal channel in the pole piece. Magnetic field distortion is reduced, or substantially eliminated, or controlled in configuration by the provision of a restricted opening in the channel at the magnetic pole piece face. In this manner, the relative dimensions of the cathode and the magnetic pole piece may be employed to obtain a magnetic field in which the magnetic lines of force are substantially parallel within the space discharge region, or the relative dimensions may be chosen to produce a "barreling" effect which tends to

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focus the electrons of the space discharge at the ends of the space discharge region, and consequently limits the divergence of the electrons so that only inappreciable numbers of electrons impinge on the magnetic pole face.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Fig. 1 illustrates in cross sectional view an embodiment of my invention as applied to an ultra high frequency magnetron of the type disclosed and broadly claimed in a copending patent application Serial No. 447,903 of Elmer D. McArthur, filed June 22, 1942 and which is assigned to the assignee of the present application. Fig. 2 is a cross sectional plan view of the anode structure.

Referring now to Fig. 1 of the accompanying drawing, I have there illustrated my invention as applied to an electric discharge device, such as an ultra high frequency magnetron, including an elongated cylindrical container the lateral wall structure of which is provided by a single metallic tube 1 which consists of a ferro-magnetic material such as cold rolled steel, or the like. The ends of the container or tube 1 are closed by flanged members 2 and 3 which are welded or otherwise hermetically sealed to the inner surface of tube 1. Within the container and approximately at its central portion there is provided an anode structure 4 shown in detail plan view in Fig. 2. The anode structure 4 is preferably of circular configuration provided with an enlarged central opening 5 and a plurality or series of smaller openings 6 arranged symmetrically about the central opening. The central opening 5 is joined to the openings 6 by means of radially extending slots 7.

The anode structure 4, which may preferably consist of copper, is supported by being brazed to the inner surface of tube 1. Within the opening 5 of the anode structure there is provided a thermionic cylindrical cathode which may be of the indirectly heated type comprising a metallic sleeve or cylinder 8 of nickel or molybdenum which is coated externally with a suitable activating material, such as barium oxide. Within the cylinder 8 there is provided a filamentary cathode heating element 9 by which the cathode is maintained at an emissive temperature.

In operating the device, a space discharge is assumed to be developed in the region defined between the cathode cylinder 8 and the surrounding anode structure 4 by application of a suitable potential between the anode structure and the cathode. The electrons which compose this space charge are given a spiral or orbital motion by a magnetic field produced by means to be described presently, and the resultant electron oscil-

lation, or oscillations, about the cathode produce excitation of the anode structure at its resonant frequency or harmonics thereof. The anode structure may be considered as consisting of a plurality of mutually coupled units in each of which the inductance is provided by the wall surface of openings 6 and the capacitance is provided principally by the opposite surfaces of the slots 7.

There is provided within the tube 1 means for producing a magnetic field. This means may comprise a pair of longitudinally spaced magnetic pole pieces 10 and 11. Optionally, the magnetic pole pieces 10 and 11 may be permanently magnetized. When it is desired to use permanently magnetized pole pieces, these members may be constructed of a suitable metal or alloy having high coercive force and a high energy factor, such as alloys, or groups of alloys, of aluminum, nickel and cobalt.

In order to provide relatively low reluctance connections between the base extremities of the respective pole pieces 10 and 11, the pole pieces may be seated upon relatively thick disk-like members 12 and 13 constructed of a ferromagnetic material, such as steel. These members are provided with slots 14 and 15 in order to afford suitable passages for the evacuation of the discharge device. Passage 15 is in communication with an opening 16 in flanged part 3, and a suitable tubulation 17 may be employed for sealing the discharge device structure after evacuation.

To secure the pole pieces 10 and 11 firmly to the base members, use may be made of clamping rings 18 and 19 which are slipped over the pole pieces and welded to the base members. Accurate spacing of pole pieces 10 and 11 with reference to the anode structure may be obtained by the use of spacing rings 20 and 21 used in the manner illustrated. As shown in Fig. 1, each of these rings is interposed between one surface of anode structure 4 and a surface of apertured disks 22 and 23, each disk in turn being in abutment with an appropriately formed shoulder provided by the adjacent pole pieces.

As a means for supporting the cathode structure centrally with respect to the anode structure 4, I may employ a concentric cable construction broadly disclosed and claimed in my copending patent application Serial No. 465,424, filed November 13, 1942, and which is assigned to the assignee of the present application. Referring more specifically to Fig. 1 of the drawing, I provide a concentric cable construction which extends through a longitudinal channel 24 in the magnetic pole piece 10. This channel is preferably circular in cross section and is provided with a restricted section 25 in the vicinity of the pole face 26. The diameter of the channel opening in the vicinity of section 25 is preferably equal to or less than the diameter of the cathode cylinder 8. By the choice of the relative dimensions of the restricted section 25 and the cathode diameter, I provide means for controlling the configuration of the magnetic field within the space discharge region defined by the surface of cathode cylinder 8 and the opposite or cooperating face of the anode structure 4.

For example, by choosing the relative dimensions of the restricted opening at 25 and the cathode diameter, the magnetic field may be controlled so that the magnetic lines of force within the space discharge region are substantially parallel. Furthermore, the relative dimensions may be chosen so that the magnetic lines of force

within the space discharge region tend to "barrel" outwardly, thereby exerting a focusing effect on the electrons constituting the space discharge and minimizing the divergence of the electrons at the top and bottom of the space discharge region. In either instance, that is by maintaining the magnetic field lines of force substantially parallel or by producing the outward barreling effect, the divergence of the electrons at the ends of the space discharge region is minimized.

Considering more particularly the cathode supporting structure, I provide a concentric cable construction including an outer tubular metallic conductor 27, an inner conductor 28 and an interspaced tubular insulator 29, conductors 27 and 28 being connected to externally accessible lead-in wires 30 and 31 which are sealed by means of any suitable sealing structure, such as a flanged metallic cylinder 32 terminated by a glass bead seal 33.

A suitable insulator 34 is positioned within channel 24 for supporting the concentric cable construction centrally within the channel, and is preferably positioned in abutment with a shoulder 35 of the restricted section 25. It will be noted that the outside diameter of the tubular conductor 27 is chosen to afford sufficient spacing between the wall of restricted section 25 and conductor 27 so that the device may be operated at substantially high voltages.

The cathode structure is supported by the concentric cable construction through a flanged and apertured collar 36 which is attached to a metallic disk 37, the latter of which is provided with a plurality of metallic tabs which are welded or soldered to cathode cylinder 8. One terminal of the filamentary cathode heating element 9 is connected to the inner conductor 28, and the other terminal is connected to the outer conductor 27 by being connected to the cathode cylinder 8. Of course, it is to be appreciated that the upper terminal of the cathode heating element 9 which is connected to the inner conductor 28 is displaced from and electrically insulated from the collar 36 and disk 37.

Energy may be extracted from the discharge device by employing a suitable output electrode means, such as a loop 38 which extends into one of the openings 6 and which constitutes an extension of an inner conductor 39 comprising one part of a concentric cable construction comprising conductor 39 and an outer tubular conductor 40.

While I have shown and described my invention as applied to a particular device and as embodying various elements, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. An electric discharge device of the magnetron type comprising a plurality of enclosed electrodes including a cathode and an anode structure substantially surrounding said cathode and having opposed end faces, means for establishing a magnetic field comprising a pole piece having a pole face substantially parallel to an end face of said anode structure, said pole piece having a longitudinal channel extending there-through and terminated in the plane of said pole face, cathode supporting structure extending

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through said channel, said channel having a restricted section in the vicinity of said pole face, and an insulating supporting structure for said cathode structure positioned within said channel and in abutment with a shoulder of said restricted section.

2. An electric discharge device of the magnetron type comprising a plurality of enclosed electrodes including a cylindrical cathode and an anode structure substantially surrounding said cathode and having opposed end faces, means for establishing a magnetic field comprising a pole piece having a pole face substantially parallel to an end face of said anode structure, said pole piece having therein a longitudinal channel extending through said field piece and terminated at the face thereof in a restricted portion the dimension of which is equal to or less than the diameter of said cathode, and means extending through said channel supporting said cathode.

3. An electric discharge device of the magnetron type comprising a plurality of enclosed electrodes including a cylindrical cathode and an annular anode structure substantially surrounding said cathode, means for establishing a magnetic field comprising a pole piece having a pole face positioned near said anode structure and having therein a longitudinally extending channel terminated at the face, said channel having a restricted section of a dimension substantially less than the transverse dimension of said cathode to minimize the magnetic field distribution, and means extending through said channel supporting said cathode.

4. An electric discharge device of the magnetron type comprising a plurality of enclosed electrodes including a cathode having an emitting surface and an anode structure substantially surrounding said cathode and having opposed end faces, means for establishing a magnetic field comprising a pole piece having a pole face substantially parallel to an end face of said anode structure, said pole piece having therein a longitudinally extending channel terminated at the face thereof in a restricted section, the dimension of said section being equal to or less than the transverse dimension of the emitting surface of said cathode so that the magnetic field tends to focus the electrons constituting the space discharge between said cathode and said anode structure at the ends of the space discharge region, and means extending through said channel for supporting said cathode.

5. An electric discharge device of the magnetron type comprising a plurality of enclosed electrodes including a cylindrical cathode and an annular anode structure substantially surrounding said cathode, means for establishing a magnetic field comprising a pole piece having a pole face positioned near said anode structure and having therein a longitudinally extending channel terminated at said pole face, said channel having a restricted section of a diameter substantially less than the transverse dimension of said cathode thereby controlling the configuration of the magnetic field to limit the divergence of the electrons constituting the space discharge at the ends of the space discharge region defined by said cathode and a cooperating surface of said anode structure.

6. An electric discharge device of the magnetron type comprising a plurality of enclosed electrodes including a cathode having an emit-

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ting surface and an anode structure substantially surrounding said cathode and having opposed end faces, means for establishing a magnetic field comprising a pole piece having a pole face substantially parallel to an end face of said anode structure, said pole piece having therein a longitudinal channel extending therethrough and terminating at the face thereof, and means extending through said channel supporting said cathode, said channel having a restricted section in the vicinity of said pole face, the diameter of said section being no greater than the diameter of said cathode to limit the magnetic field distortion within the space discharge region defined by said cathode and said anode structure.

7. An electric discharge device of the magnetron type comprising a plurality of enclosed electrodes including a cathode having an emitting surface and an anode structure substantially surrounding said cathode and having opposed end faces, means for establishing a magnetic field comprising a pole piece having a pole face substantially parallel to an end face of said anode structure, said pole piece having a longitudinal channel extending therethrough and terminated in the plane of said pole face, cathode supporting structure extending through said channel, said channel having a restricted section in the vicinity of said pole face, the diameter of said section being no greater than the diameter of said cathode to minimize the magnetic field distortion within the space discharge region defined between said cathode and said anode structure, and an insulator within said channel maintaining said cathode supporting structure in spaced relation thereto.

8. An electric discharge device of the magnetron type comprising a plurality of enclosed electrodes including a cathode having an emitting surface and an anode structure substantially surrounding said cathode, a permanently magnetized pole piece having a face thereof substantially parallel to the plane of said anode structure and having therein a longitudinal channel extending therethrough and terminated at said face, cathode supporting structure extending through said channel, said channel having a restricted section in the vicinity of said pole face, the diameter of said section being no greater than the diameter of said cathode, and insulating means maintaining said cathode supporting structure in spaced relation with respect to the wall of said channel.

9. An electric discharge device of the magnetron type comprising a plurality of enclosed electrodes including a cylindrical thermionic cathode having an emitting surface and an annular anode structure having a central opening within which said cathode is located, said anode structure having opposed end faces, a permanently magnetized pole piece having a pole face substantially parallel to an end face of said anode structure, a longitudinal channel extending through said pole piece and having a section in the vicinity of said pole face, the diameter of said section being no greater than the diameter of said cathode to limit the magnetic field distortion, cathode supporting structure extending through said channel and a supporting insulator for said cathode supporting structure positioned within said channel and spaced from said restricted section.

RALPH J. BONDLEY.