July 6, 1948. R. J. BONDLEY 2,444,419

MAGNETRON

Filed Dec. 24, 1942

Fig. 1.

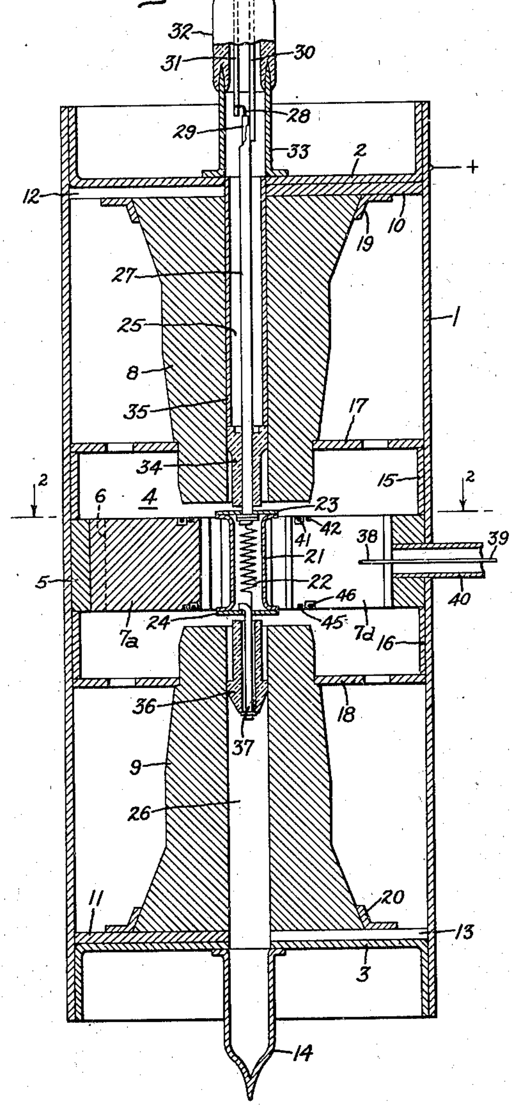
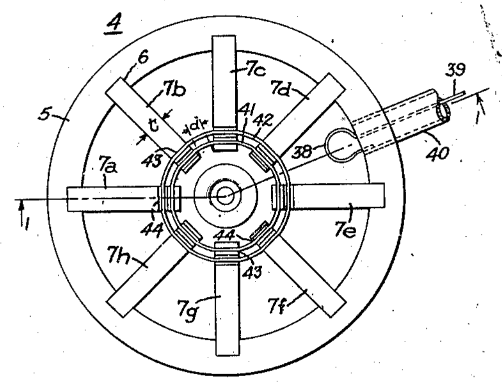


Fig. 2.



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Patented July 6, 1948 2,444,419

UNITED STATES PATENT OFFICE

2,444,419

MAGNETRON

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Application December 24, 1942, Serial No. 470,040

4 Claims. (Cl. 250—27.5)

1

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

With the ever increasing demand for higher frequencies and because of the desirability of using discharge devices of the magnetron type for this purpose, there has been evidenced a decided need for simplified electrode structure which permits facility in factory production and which affords improvements in the operating characteristics of devices of this type. In accordance with the teachings of my invention described hereinafter, I provide a new and improved structure for an ultra high frequency magnetron wherein the anode structure is of simple construction and arrangement and whereby the electrical operating characteristics of the magnetron are substantially improved.

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 magnetron.

It is a further object of my invention to provide new and improved anode structure for an ultra high frequency magnetron.

It is a still further object of my invention to provide a new and improved anode structure for an ultra high frequency magnetron which defines a plurality of space resonant regions or cavities, and in which the various space resonant regions are effectively coupled by using a simple arrangement of parts.

Briefly stated, in the illustrated embodiment of my invention I provide an ultra high frequency magnetron comprising a centrally located cathode, which may be of the thermionic type, substantially surrounded by an annular anode structure. The anode structure comprises an annular metallic member or ring which supports a plurality of circumferentially spaced inwardly extending or radial vanes which may be positioned at one extremity in slots provided by the ring. The vanes have a substantially uniform thickness and are of such number and thickness relative to the diameter of the supporting ring to produce an effective concentration, at their inner extremities, of the electric component of the electromagnetic oscillations in the various space resonant regions defined by adjacent vanes, so that there is an effective interchange of energy between the space resonant regions and the oscillating or gyrating electric

2

discharge or space charge of the device. More particularly, the thickness of the vanes is preferably equal to or greater than the distance between adjacent vanes at the ends facing the cathode so that the electric component of the field is properly concentrated or positioned relative to the space discharge thereby assuring an effective transfer of energy from the space charge to the various space resonant regions from which the ultra high frequency energy may be extracted for utilization purposes in an external circuit.

In accordance with another feature of my invention, I provide unique means for coupling the various space resonant regions. This structure comprises a single circular conductor or a plurality of concentric circular conductors lying in grooves at either the top or the bottom, or both, of the radial vanes, and preferably in the plane of the top or bottom of the annular anode structure.

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 an embodiment of my invention as applied to an ultra high frequency magnetron construction 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 and is now United States Patent No. 2,412,824, issued December 17, 1946. Fig. 2 is a plan view of the anode structure.

Referring now to Fig. 1 of the accompanying drawing, my invention is there illustrated as applied to an ultra high frequency magnetron including an elongated cylindrical container, the lateral wall of which is provided by a single metallic tube 1 which consists of a ferromagnetic 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 joined to the inner surface of tube 1.

Within the container and approximately at its central region I provide an anode structure 4, which is shown in plan view in Fig. 2 and which comprises a metallic annular member or ring 5 preferably constructed of copper or brass and which is provided with a plurality of annularly spaced slots 6 into which are fitted inwardly extending radial-type vanes 7a—7h inclusive, thereby defining a plurality of space resonant regions or cavities which are energized by an oscillating or gyrating space charge established between the ends of the radial vanes and a cathode structure to be described presently.

The diameter of the ring 5, the number of radial vanes and the thickness thereof are preferably chosen so that the thickness of the vanes is equal to or greater than the distance between the inner extremities of the vanes facing, or immediately opposite, the cathode structure. More particularly, referring to Fig. 2, the distance t is preferably greater than the distance d.

In order to establish a magnetic field, I employ magnetic means which may comprise a pair of permanently magnetized magnetic pole pieces 8 and 9 spaced longitudinally along the axis of the discharge device, and which are respectively seated upon metallic disks 10 and 11 of ferromagnetic material and which in turn are provided with radially extending passages 12 and 13 to facilitate extraction of air or gas during the evacuation process. Passage 13 and the entire device after exhaust may be sealed by means of a metallic tubulation 14 attached to the flanged member 3.

The anode structure may be firmly positioned by means of a pair of annular spacing members 15 and 16 which abut the ring 5 and which also are in engagement with a pair of transverse supporting disks 17 and 18 which engage suitably formed shoulders provided by magnetic pole pieces 8 and 9. Supporting rings 19 and 20 adapted to be slipped over the pole pieces 8 and 9, respectively, may be welded or soldered to these members and base disks 10 and 11.

There is provided centrally within the anode structure 4 a cathode, such as a thermionic cathode, which may include a flanged metallic cylinder 21, preferably constructed of nickel or molybdenum, and which is coated with an electron emissive material such as barium oxide. There is also provided a filamentary cathode heating element 22 within cylinder 21. The ends of cylinder 21 are closed by means of apertured disks 23 and 24 to receive cathode supporting structure, and connecting means for supplying energizing current to the heating element 22.

The cathode structure may be supported by means of a concentric cathode construction which extends through longitudinal channels 25 and 26 in magnetic pole pieces 8 and 9, respectively. Referring to the concentric cable construction, there is provided a tubular metallic outer conductor 27, an inner conductor 28 and an interspaced tubular insulator 29. Externally accessible terminals for conductors 27 and 28 are provided by lead-in wires 30 and 31 which are anchored in a glass bead or seal 32. The seal 32 may be supported by a flanged metallic cylinder 33 which is welded or soldered to member 2 and is also, of course, in sealed engagement with seal 32.

As a means for centering and positioning the concentric cathode construction, I employ within the vicinity of the pole face of pole pieces 8 an insulator 34 which firmly engages outer conductor 27 and which is also in engagement with the wall of channel 25. Insulator 34 may be positioned longitudinally within channel 25 by means of a copper tube 35 which abuts the upper end of insulator 34. At the lower extremity, the cathode structure may be supported and centered by means of an additional insulator 36 within channel 26, and is provided with a centering pin 37 which extends through the aperture in disk 24 and is turned over, thereby forming a firm lower support for the cathode.

It will be noted that the upper terminal of the cathode heating element 22 is connected to the inner conductor 28, and that the lower terminal is connected to the disk 24, thereby completing the energizing circuit for the heating element through cylinder 21, disk 23 and outer conductor 27.

Certain features of the concentric cathode construction and the insulating support therefor are disclosed and claimed in my copending patent application Serial No. 465,424, filed November 13, 1942 and now United States Patent No. 2,406,277, issued August 20, 1946, and in a copending patent application of George M. White, Serial No. 465,401, also filed November 13, 1942 and now United States Patent No. 2,406,276, issued August 20, 1946, both of which are assigned to the assignee of the present application.

As a means for extracting high frequency energy from the various space resonant regions, suitable output electrode means are provided which may take the form of a loop 38 comprising an extension of an inner conductor 39 constituting a part of a concentric transmission line including conductor 39 and an outer tubular conductor 40.

I provide an improved coupling structure for the various space resonant regions defined by the radial vanes shown in plan view in Fig. 2. This coupling means may comprise a single or a plurality of circular metallic conductors which are in electrical contact with the vanes 7, preferably as close to the inner extremities thereof as mechanical expediency will warrant. For example, I provide circular conductors 41 and 42 lying in grooves 43 and 44 so as to be substantially flush with the upper surface, or top surface, of the anode structure 4.

Conductor 41 is electrically connected to vanes 7a, 7c, 7e and 7g, being in electrical contact with the walls of grooves 43 and not being in contact with the alternate or intermediate vanes due to the fact that grooves 44 are of sufficient size to permit the passage of the conductor therethrough without contacting the intermediate vanes. Conductor 42, on the other hand, electrically connects vanes 7b, 7d, 7f and 7h, not being in contact with the vanes 7a, 7c, 7e and 7g. The plan of coupling the vanes 7a—7h, inclusive, may be in accordance with that disclosed and claimed in my copending patent application Serial No. 462,123, filed October 15, 1942 and which is assigned to the assignee of the present application.

Conductors 41 and 42 need not be continuous, and the length thereof, or the number of vanes to which each of these conductors, is connected may be chosen to establish the desired mode of operation of the discharge device as a whole so that the operating frequency or mode is determinable.

If desired, a similar coupling structure may be provided in the bottom of the anode structure. Such an arrangement is illustrated in Fig. 1 wherein additional coupling conductors 45 and 46 are shown lying in grooves or slots in the bottom plane of the anode structure 4.

An important feature of apparatus built in accordance with my invention is the increased efficiency obtainable by the proper dimensioning of the radial vane thickness with respect to the spacing therebetween at the region immediately opposite the cathode whereby there is an effective concentration of the electric field incident to the electromagnetic fields within the respective space resonant regions. In this manner there is provided efficient transmission of energy from the oscillating space discharge to the space resonant regions.

Another important advantage is the provision of the coupling means at the extremities of the radial vanes, which positioning accomplishes most effective coupling of the various regions. One of the desirable objects of any coupling means in a device of this type, of course, is the frequency selection or the mode of operation at which it is desired to operate the device as a whole. With the coupling means at the inner extremities of the radial vane **7**, I have found that the frequency selection or mode of operation is highly discriminatory or predeterminable.

A further advantage of apparatus built in accordance with my invention is the simplified construction which lends itself to factory production methods and apparatus. It will be readily apparent upon inspection of the structure that the ring **5** may be readily slotted to receive the radial vanes **7** and that the radial vanes may be easily inserted into the slots **6** so provided. Furthermore, as concerns the machining operations of the grooves **43** and **44** which receive the circular and flexible coupling conductors **41** and **42**, the vanes **7** may be slotted or grooved prior to insertion into the grooves **6**, and due to the fact that the vanes are rectilinear in configuration a relatively large number of similar vanes may be machined in one operation by placing the vanes in juxtaposition in the grooving or slotting machine.

While I have shown and described my invention as applied to a particular device, 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 an envelope, a plurality of electrodes within said envelope including a cathode and an open-ended cylindrical anode structure surrounding said cathode, said anode structure comprising an annular ring portion and a plurality of vanes extending radially inwardly from said cylindrical portion, the inner ends of said vanes and said cathode bounding a substantially annular interelectrode space, means coupling together the cavity resonators defined by said vanes, said means comprising on each end of said anode structure a pair of annular metallic rings near the ends of said vanes facing said cathode, one of said rings in each of said pair being electrically connected to alternate vanes, the other of said rings in each said pair being electrically connected to the vanes intermediate between said alternate vanes.

2. A device as in claim 1 including within said envelope magnetic members adjacent the opposite ends of said anode structure for establishing a magnetic field in the region between said cathode and said anode structure.

3. An electric discharge device of the magnetron type comprising an envelope, a plurality of electrodes within said envelope including a cathode and an open-ended cylindrical anode structure surrounding said cathode, said anode structure comprising an open-ended metallic cylinder and a plurality of vanes extending radially inwardly from said cylinder, said vanes having uniform thickness substantially greater than the distances between adjacent vanes at their inner extremities, the ends of said vanes and said cathode bounding an annular interelectrode space, means coupling together the cavity resonators defined by said vanes, said means comprising on each end of said anode structure a pair of concentric annular metallic rings positioned within grooves in said vanes near the ends of said vanes facing said cathode, one of said rings in each of said pair being electrically connected to alternate vanes, the other of said rings in each said pair being electrically connected to the vanes intermediate between said alternate vanes.

4. A device as in claim 3 including within said envelope magnetic members adjacent the opposite ends of said anode structure for establishing a magnetic field in the region between said cathode and said anode structure.

RALPH J. BONDLEY.

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