June 3, 1958 P. L. SPENCER 2,837,694

ELECTRON DISCHARGE DEVICES

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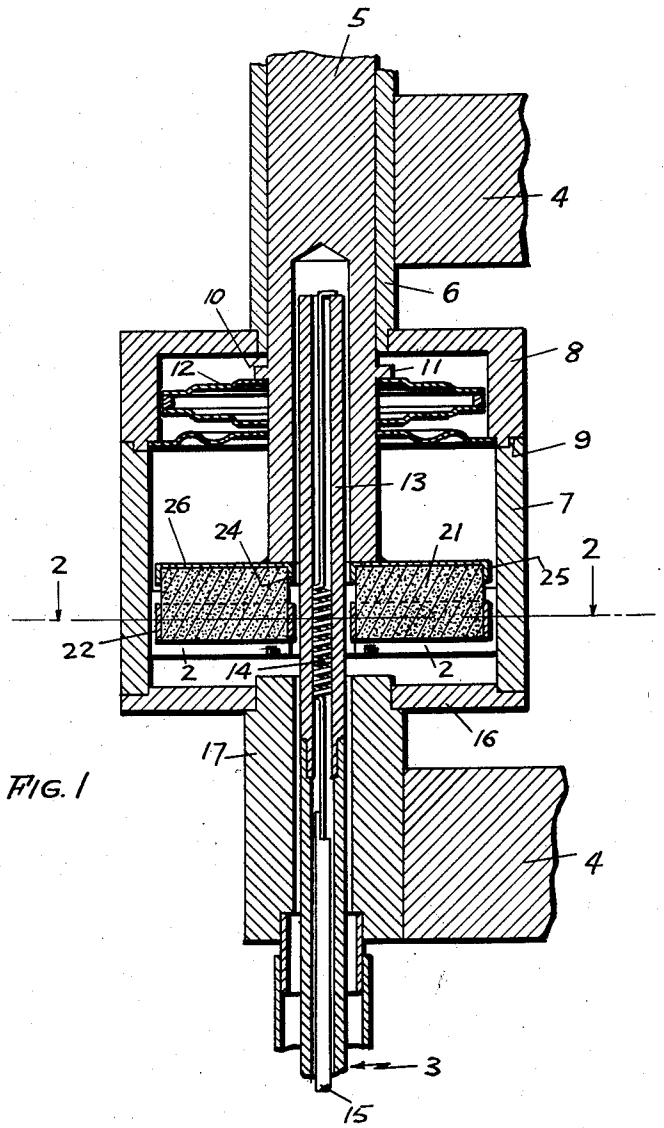



FIG. 1

INVENTOR
PERCY L. SPENCER
BY Elmer J. Gorn
ATTORNEY

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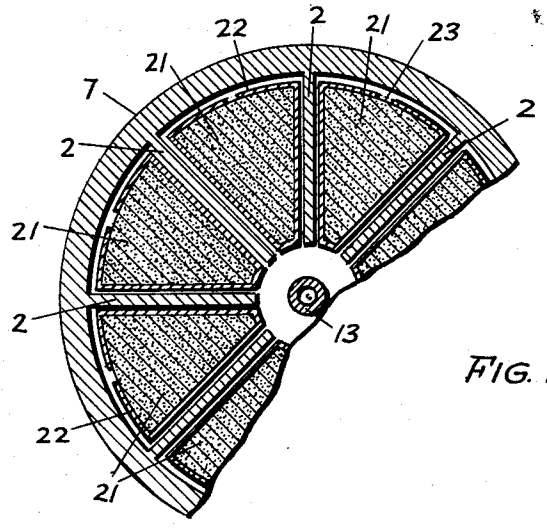



FIG. 2

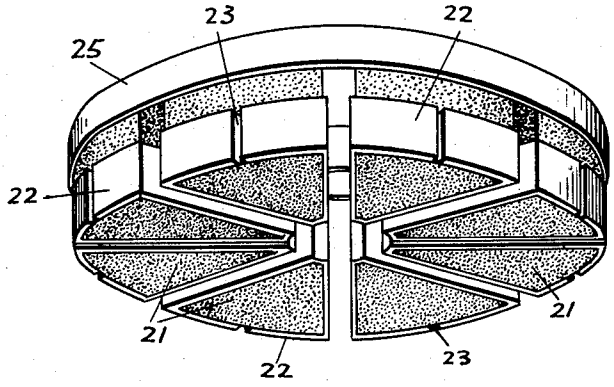



FIG. 3

INVENTOR
PERCY L. SPENCER
BY Elmer J. Gorn
ATTORNEY

United States Patent Office

2,837,694

Patented June 3, 1958



2,837,694

# ELECTRON DISCHARGE DEVICES

Percy L. Spencer, Waban, Mass., assignor to Raytheon Manufacturing Company, Waltham, Mass., a corporation of Delaware

Application September 16, 1954, Serial No. 456,513

8 Claims. (Cl. 315—39.61)

This invention relates to electron discharge devices and more particularly to oscillation generators of the magnetron type.

The invention provides a novel method and structure for tuning a radial vane type of magnetron by producing relative axial motion as between a group of magnetic field controlling elements on the one hand and the radially arranged anode vanes of the magnetron on the other, the degree of axial overlap as between the field controlling elements and the vanes determining the strength of the magnetic field and hence the frequency of oscillation as generated in the resonant cavities defined by said radially arranged vanes and the surrounding cylindrical portion of the anode structure. In the illustrated embodiment the axially movable assembly includes a plurality of wedge-shaped segments of highly magnetically permeable ferromagnetic material, the segments corresponding in number to the number of radially disposed anode vanes and corresponding in width to the lateral spacing of the vanes to permit inter-digitation as between said segments and said vanes and hence a progressive variation in the inductance effect of the entire assembly in accordance with progressive axial positional shift of the segmented portion of the assembly with respect to the axially fixed portion of the assembly. The invention also provides a correspondingly progressive change in the capacitance effect of the assembly by applying a metallic sheathing around the surfaces of the individual segments lying adjacent the lateral surfaces of the interposed vanes, as the resulting relative axial motion of the two sets of metallic capacitance units, namely the copper vanes on the one hand and the copper sheathings of the segments on the other, constitutes in effect a variable condenser with alternate plates having changeable axial relationship with respect to the inter-leaved stationary plates.

More specifically the invention proposes certain improvements in the structure and method of assembly of tuning segments of the general character described, such improvements including particularly the mounting of each individual ferrite segment within a flexible metallic sheath or jacket adapted to wrap around and cover a portion of all four sides of the segment but in such manner as to leave a sufficient space between the converging edges of the enclosing jacket to prevent the flow of current in a continuous circuit around the segment. At the same time the dimensioning of the jacket so that its lateral extent is slightly less than the lateral perimeter of the segment has the advantage that it facilitates the establishment of a firm gripping relationship between the jacket and the enclosed segment, such firm gripping relationship being brought about by a pressing and pinching operation to which the jacket lends itself by reason of its flexibility and its slightly undersized dimensions as compared with the girth of the associated segment.



The material to be used in composing the above-described segments may be any ferrite or feromagnetic material having high magnetic permeability and good permanence qualities together with an ability to withstand temperatures on the order of 700° centigrade. Materials appropriate for the purpose include titanium dioxide, the powdered iron compound marketed under the trade name "ferrox-cube," and any of the commonly used iron oxide compounds of the ferrite family.

A specific embodiment of the invention is presented in the accompanying drawings illustrating a magnetron assembly constructed in a manner to facilitate practice of the above-described arrangement for controlling the frequency of the generated oscillations, the structural details and inter-relationships being such as to achieve the above-described purposes and advantages. Other advantages will become apparent upon examination of said drawings in the light of the following description of the illustrated details. In said drawings the several views are related, one to the other, as follows:

Fig. 1 is a longitudinal sectional view of an electron discharge device of the magnetron type;

Fig. 2 is a partial transverse sectional view along line 2—2 of Fig. 1; and

Fig. 3 is a perspective view of the segmented tuning assembly.

In these drawings there is illustrated a magnetron assembly including anode vanes 2 disposed radially of a cathode structure 3, magnetic means 4 (cooperating with other polar elements to be described) for establishing a magnetic field in a direction perpendicular to the cathode-anode path of electron flow, and a tuning assembly actuated by a magnetic shaft 5 axially shiftable (by exteriorly disposed conventional manual means, not shown) with respect to a surrounding magnetic sleeve 6, the parts 5 and 6 being polar elements cooperating with the externally disposed magnetic means 4, and forming part of the magnetic circuit for establishing the magnetic field above referred to.

The anode structure includes, in addition to vanes 2, a cylindrical body 7 of highly conductive material, such as copper, said body having the vanes 2 integrated therewith in a manner defining a plurality of radially spaced cavity resonators whose natural frequency is a function of the geometry of their physical components. Body 7 is capped by an inverted, centrally apertured cup-shaped cover element 8, and the joint 9 therebetween is hermetically sealed. The above-described magnetic polar element 6 attaches at its lower end to the inner periphery of the centrally apertured cover 8, as indicated at 10. The movable magnetic polar element 5, constituting the tuning control means, is flanged, as indicated at 11, to receive one end of a bellows assembly 12 functioning to maintain a vacuum seal between element 5 and body cylinder 7, the bellows details being more fully described in U. S. Patent No. 2,621,311, issued December 9, 1952.

The cathode assembly includes a metallic rod 13 coated with electron emissive material along the area whose projection embraces the anode vanes 2, the rod 13 being axially bored to receive a cathode heating agent in the form of a coiled resistance wire 14 whose upper end is attached to the upper end of rod 13, and whose lower end is attached to a lead-in connection 15. The heater coil 14 and lead-in 15 are insulated from rod 13 by suitable means, as by coating the parts with Alundum or equivalent insulating material.

The lower end of anode cylinder 7 is closed by a centrally apertured flat plate 16 soldered or otherwise

affixed in sealed relationship thereto. Cathode rod 13, lead-in 15, and magnetic pole piece 17 extend downwardly from plate 16, with pole piece 17 being rigidly sealed to the inner periphery of the plate 16. Cathode rod 13 is insulatingly supported with respect to pole piece 17, as by use of a conventional insulating seal, not shown. A similarly conventional seal, not shown, may be used to support lead-in 15 within the rod 13.

The tuning assembly, as shown best in Fig. 3, includes a plurality of wedge-shaped ferrite segments 21 individually encased in copper sheaths or jackets 22 wrapped around the lower half of all four sides of their respective segments, the jackets being slightly under-sized so that their facing edges do not quite meet, leaving a vertically disposed gap 23 at the medial region of the outer arcuate sides of the segments 21. The upper halves of the segments are secured to inner and outer concentric flanges 24 and 25 of a centrally apertured circular metallic plate 26 whose upper flat surface, adjacent the central aperture, is welded or otherwise permanently attached to the flat annular base of the tuning shaft 5. The individual jacketed segments 21 are of the proper dimensions and spacing to assume interdigital relationship with the anode vanes 2, with the degree of vertical overlap between segments and vanes depending upon the degree of axial displacement imparted to shaft 5 by the exterior tuning control mechanism, not shown.

By constituting segments 21 of high magnetic permeability, low loss material such as titanium dioxide ($TiO_2$), "ferroxcube," or equivalent heat-resistant ferromagnetic, ceramic-like material of high inductance effect, and combining therewith the vertically and horizontally interrupted high-capacitance copper jackets 22, there is produced a tuning method and apparatus capable of achieving wide-range frequency adjustment by progressive, substantial veriation of both the inductance and capacitance characteristics of the magnetic and electric circuits constituted, in part, by said segments 21 and jackets 22, respectively. That is to say, the output frequency is caused to vary in accordance with two conjointly operative tuning factors, namely (1) the predominantly magnetic effect of the progressive variation in magnetic field strength as the inductance-controlling permeable segments 21 shift axially along the respective radially disposed cavities, and (2) the predominantly electrical effect of the progressive variation in capacitance as the copper jackets 22 shift axially of the fixed anode vanes 2, the resulting frequency change being a function of the product obtained by multiplication of these inductance and capacitance changes.

Although not illustrated in the particular views presented in the drawings, the magnetron will of course be provided with the usual loop-ended conductor leading from the space defined by any two of the anode vanes 2, for the purpose of extracting power from the device. Such output conductor may be supported in the usual manner (not shown) to maintain hermetic sealing between such conductor and the body 7.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. An electron discharge device comprising a body of highly conductive material, a plurality of vanes each of which is attached at one end to said body, the other end of each of said vanes being in spaced relation to the next adjacent of said vanes, means for emitting a stream of electrons past the spaced ends of said vanes, a tuning assembly including material of high magnetic permeability adapted to be interposed in the space between adjacent vanes, a sheath of conducting material extending substantially around a portion of said magnetically permeable material, and means for producing displacement of said magnetically permeable material in said space, to adjust the operating frequency of said device.

2. An electron discharge device comprising a body of highly conductive material, a plurality of vanes each of which is attached at one end to said body, the other end of each of said vanes being in spaced relation to the next adjacent of said vanes, means for emitting a stream of electrons past the spaced ends of said vanes, a tuning assembly including material of high magnetic permeability adapted to be interposed in the space between adjacent vanes, a sheath of conducting material extending substantially around a portion of said magnetically permeable material, and means for producing displacement of said magnetically permeable material in said space, to adjust the operating frequency of said device, said means comprising a magnetic pole piece forming part of a magnetic assembly, and means secured to said pole piece for supporting said permeable material.

3. An electron discharge device comprising a cathode element, a plurality of anode elements disposed radially of said cathode element to define resonant cavities, a corresponding plurality of ferromagnetic segments inter-digitated with said anode elements, a jacket of conductive material extending substantially around the perimeter of each of said segments, and means for shifting said ferromagnetic segments to vary the depth of penetration thereof into said cavities.

4. An electron discharge device comprising a body of highly conductive material, a plurality of vanes each of which is attached at one end to said body, the other end of each of said vanes being in spaced relation to the next adjacent of said vanes, means for emitting a stream of electrons past the spaced ends of said vanes, a corresponding plurality of ceramic segments of high magnetic permeability interdigitated with said vanes, said segments having a solid metal jacket extending substantially around the perimeter thereof, and means for effecting relative axial movement as between said segments and said vanes to vary the frequency of oscillation of the electromagnetic field generated in said device in response to application of energizing current to said emitting means.

5. In an electron discharge device of the magnetron type having a plurality of radially disposed anode elements surrounding a centrally disposed cathode element to define resonant cavities, means for tuning said magnetron including ceramic segments interposed between successive anode elements, and capacitance controlling means carried by said ceramic segments, said capacitance controlling means being of a peripheral length slightly less than the peripheral dimension of said ceramic segments to provide a current conducting discontinuity preventing current diversion by way of said capacitance controlling means.

6. An electron discharge device comprising a body of highly conductive material, a plurality of vanes each of which is attached at one end to said body, the other end of each of said vanes being in spaced relation to the next adjacent of said vanes, means for emitting a stream of electrons past the spaced ends of said vanes, a tuning assembly including ferrite segments interposed in the space between said vanes, a metallic jacket extending substantially around the perimeter of said segments, and means for producing displacement of said ferrite material in said space to adjust the operating frequency of said device.

7. An electron discharge device comprising a body of highly conductive material, a plurality of vanes each of which is attached at one end to said body, the other end of each of said vanes being in spaced relation to the next adjacent of said vanes, means for emitting a stream of electrons past the spaced ends of said vanes, a tuning assembly including a high magnetic permeability ferromagnetic material interposed in the space between said vanes, a magnetic strip extending around a portion of

said ferromagnetic material and having a gap between the ends of said strip, and means for producing displacement of said material in said space to adjust the operating frequency of said device.

8. An electron discharge device according to claim 7 in which said ferromagnetic material at least substantially occupies the space between each of said vanes which is closest to said highly conductive body.



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