

May 2, 1967

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MAGNETRON ASSEMBLY HAVING DIELECTRIC MEANS, EXTERNAL TO
ENVELOPE, FOR SETTING THE CENTER OPERATING FREQUENCY
Filed Jan. 7, 1963

3,317,785

FIG. 1.

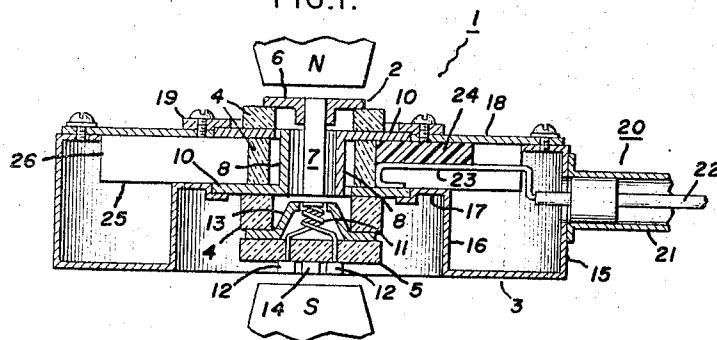


FIG. 2.

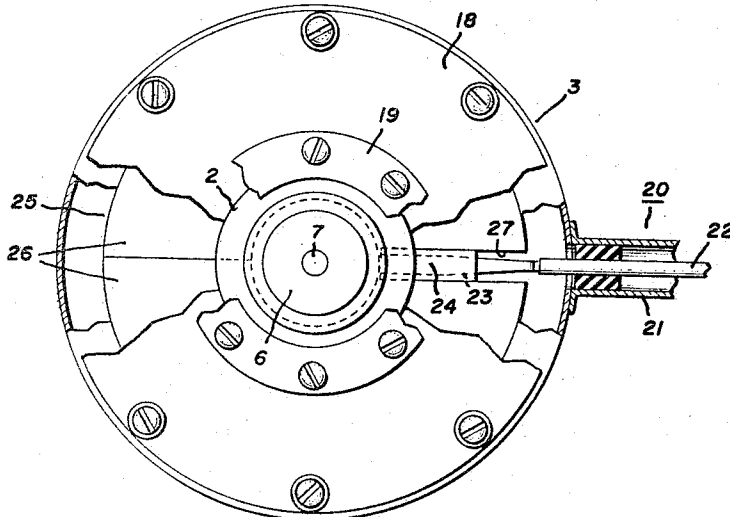
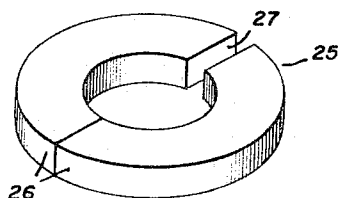


FIG. 3.



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MAGNETRON ASSEMBLY HAVING DIELECTRIC MEANS, EXTERNAL TO ENVELOPE, FOR SETTING THE CENTER OPERATING FREQUENCY
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Filed Jan. 7, 1963, Ser. No. 249,721
5 Claims. (Cl. 315—39.77)

This invention relates to radio frequency apparatus and pertains more particularly to a new and improved voltage-tunable magnetron package and new and improved means for predeterminedly varying the center operating frequency of such packages.

Voltage-tunable magnetron packages generally comprise a voltage-tunable magnetron tube, radio frequency or R.F. circuit having the tube mounted therein, and a magnet structure for providing an operating magnetic field extending generally coaxially through the tube. The magnetron tube is often of the interdigital type such, for example, as those disclosed and claimed in U.S. Patent No. 2,810,096 of P. H. Peters, Jr., et al. and U.S. Patent No. 2,930,933 of G. J. Griffin et al., both assigned to the same assignee as the present invention. Briefly, these tubes include an envelope having sealed in the wall thereof a longitudinally spaced pair of anode terminals each of which supports internally of the envelope a set of anode segments interdigitally arranged with respect to the segments of the set supported by the other. The anode segments define a central space in which is axially mounted a non-emissive cathode which cooperates with the anode segments to define an annular interaction space. Longitudinally spaced from the non-emissive cathode are an emissive cathode and control means for directing electrons longitudinally into the interaction space. The interdigital anode structure of the tube provides the required capacitance for an oscillatory circuit, and the necessary inductance is afforded by an R.F. circuit which can be of the form of either a resonant cavity or a line-over-ground plane transmission line. Such a package is by its construction and dimensions inherently adapted for operating at a certain center operating frequency; and in order to vary the center operating frequency of such a package it is ordinarily necessary either to vary the design dimensions of the tube or R.F. circuit, to modify the internal tube construction, to provide specific electrical tuning circuitry external of the package, or to provide adjustable mechanical tuning mechanism for altering the effective internal dimensions of the R.F. circuit.

The present invention obviates the need for the above discussed types of tuning means and contemplates means effective for providing center operating frequency tuning of a voltage tunable magnetron package simply through the provision of a dielectric element of predetermined dielectric constant, dimensions and location in the package with respect to the voltage-tunable magnetron tube therein. Additionally, the present invention contemplates improved means for introducing capacitance in a voltage tunable magnetron R.F. circuit for thereby enabling the effective employment of overall circuits of reduced sizes for given center operating frequencies.

Accordingly, a primary object of the present invention is to provide a new and improved voltage tunable magnetron package including new and improved means for varying the center operating frequency thereof.

Another object of the present invention is to provide new and improved means for varying the center operating frequency of a voltage tunable magnetron package without altering the construction or dimensions of any of the elements therein.

Another object of the present invention is to provide

new and improved means which enable the provision of a family of voltage tunable magnetron packages which are adapted for operating at different center operating frequencies but which can be basically identical structurally except for the dielectric tuning means incorporated therein.

Another object of the present invention is to provide new and improved means effective for reducing the sizes of voltage tunable magnetron circuits.

Still another object of the present invention is to provide new and improved means which simply and inexpensively enables voltage tunable magnetron packages of essentially the same structure to be adapted for predetermined different center operating frequencies.

Further objects and advantages of the present invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of this invention there is provided a voltage tunable magnetron package comprising an R.F. circuit having an interdigital voltage-tunable magnetron tube mounted therein. The tube comprises an envelope including a pair of axially-spaced annular terminals separated by an insulative wall section of the envelope and supporting an interdigital anode circuit in the envelope. The R.F. circuit comprises a pair of spaced parallel conductive elements apertured for receiving opposite ends of the tube and for serving as coaxial electrical contacts for the anode terminals. Extending laterally from one side of the R.F. circuit is a coaxial output coupler including an inductive loop extending preferably between the anode terminals for effecting R.F. coupling to energy propagated through the insulative section between the anode terminals. Positioned peripherally about the magnetron between the anode terminals is a solid dielectric element effective for varying the center operating frequency of the package. Predetermined variations of the center operating frequency are obtainable by employing dielectric elements of predetermined different dielectric constants and quantities of dielectric material and by predeterminedly dimensioning the dielectric element to control the closeness of fit thereof above the insulative section of the tube between the anode terminals.

For a better understanding of the invention reference may be had to the accompanying drawing in which:

FIGURE 1 is an enlarged sectionalized side elevation view of R.F. apparatus incorporating an embodiment of the invention;

FIGURE 2 is a fragmentary plan view of the structure in FIGURE 1; and

FIGURE 3 is an enlarged perspective view of the dielectric tuning element employed in the apparatus of FIGURES 1 and 2.

Referring to FIGURE 1, there is illustrated a voltage tunable magnetron package generally designated 1 and including a voltage tunable magnetron tube 2 mounted centrally in an R.F. circuit subassembly 3. The package 1 also includes a magnet subassembly including opposed pole pieces designated N and S in FIGURE 1 and adapted for providing an operating magnetic field extending coaxially through the tube 2. The magnet subassembly can, if desired, be secured to the R.F. circuit 3 in any suitable manner to provide a unitary package or assembly.

The magnetron 2 can be of the type disclosed and claimed in the above-mentioned U.S. Patent No. 2,930,933. Briefly, the magnetron 2 is constructed to include stacked alternate ceramic and metal elements. These ceramic elements generally include a plurality of cylindrical ceramic wall sections 4 and an apertured disk-like

ceramic end cap 5. The metal members are suitably brazed to or between opposed surfaces of the ceramic elements to complete a hermetically-sealed envelope and include a metal end cap 6 supporting a cylindrical non-emissive cathode 7 extending centrally in a cylindrical space defined by a plurality of anode segments generally designated 8. The anode segments 8 are arranged in a pair of sets of interdigital segments, with each set being carried by a washer-like anode terminal 10. The anode terminals 10 are each sealed between a pair of the ceramic cylinders 4 and are thus mutually insulated. Additionally, the terminals are separated by an interposed one of the ceramics which serves as an R.F. energy transparent window for propagation therethrough of R.F. energy appearing on the anode circuit defined by the interdigital sets of anode segments. An emitter 11 is suitably mounted on the ceramic end cap 5 with leads sealed therethrough and connected to a pair of button-like contact members 12 bonded to the outer surface of the ceramic end cap. A control electrode 13 is sealed between one of the ceramic insulators 4 and the ceramic end cap 5 and is positioned about the emitter 13. By means of a lead (not shown) which extends also in a sealed manner through the ceramic end cap, an electrical connection is made between the control electrode 13 and a third button-like contact member 14 bonded to the outer surface of the ceramic end cap.

The magnetron 2 is adapted for operating while axially aligned with the magnetic field provided by the pole pieces N and S. Additionally, the magnetron is adapted for operating with suitable direct current potentials on the various electrodes supplied through the metal end cap 6 and the contact buttons 12 and 14 in a manner not shown.

The radio frequency circuit of the apparatus package includes the above-mentioned R.F. circuit subassembly 3, the anode segments 8 and the anode terminals 10. The subassembly 3 can advantageously comprise a reentrant resonator cavity which, as seen in FIGURE 2, can be circular and can comprise a cup-like body having a cylindrical outer side wall 15, a reentrant bottom which includes a cylindrical inner wall 16 and a transverse end wall 17. Additionally, the cavity includes a washer-like cover 18 held in place by a plurality of machine screws, for example.

The end wall 17 is centrally apertured for receiving one end of the magnetron 2 and for affording a coaxial contact surface adapted for making circumferential electrical contact with one of the anode terminals 10. The cap 18 receives the opposite end of the magnetron and carries a metallic annular retaining member 19 suitably secured to the inner rim of the cap 18 in a manner to engage the other anode terminal and hold the magnetron tightly in place in the cavity.

During operation of the magnetron strong magnetic fields are propagated from the interdigital section of the anode circuit through the insulator between the anode terminals and thus are established between the anode terminals 10 in the cavity 3; and provided for transmitting this energy out of the cavity is a coaxial R.F. coupler 20. The coupler 20 includes a tubular outer conductor 21 suitably mounted conductively in the side wall 15 of the cavity and extending radially outwardly therefrom. An inner conductor 22 of the coupler 20 includes an end portion extending radially inwardly and shaped to define a substantially J-shaped inductive loop 23 adapted for coupling R.F. energy from the cavity into the coaxial line. The inductive loop 23 extends sufficiently inwardly to dispose the looped end portion between the anode terminals 10. An insulative member 24 can be employed for holding the loop securely in place.

In order to vary the center operating frequency of the disclosed package, and in accordance with the present invention, there is provided in the circuit subassembly 3 a solid dielectric tuning element generally designated 25.

As seen in FIGURES 2 and 3, the tuning element 25 is constructed of two generally semi-circular segments 26 adapted for enabling the element 25 to be positioned about the magnetron tube 2 between the anode terminals 10. The segments 26 extend peripherally and externally for at least about 180° around the envelope or tube 2 and are each less than a complete semicircle in order to define a gap, or space, 27 to accommodate the coupling loop 23 when the element 25 is in position.

The presence of the element 25 in the circuit subassembly between the anode terminals serves to increase the capacitance of the oscillatory circuit provided by the co-operation of the magnetron tube and the circuit subassembly. Thusly, the element 25 serves to adapt the package for a center operating frequency different from that at which the package would resonate without the provision of the element 25. By predeterminedly selecting the dielectric constant of the element 25, the quantity of dielectric material employed in forming the element 25 and the spacing of the element 25 relative to the ceramic insulator 4 disposed between the anode terminals, the package can be adapted for a predetermined center operating frequency. More specifically, the center operating frequency can be predeterminedly lowered by forming the element 25 of a higher dielectric constant material, by utilizing greater quantities of material in forming the element 25 or by forming the element of a smaller inner diameter to locate it closer to the anode insulator. Additionally, the frequency variation can be obtained by combining any two or more of these approaches toward varying the frequency. Specifically, and by way of example, a lesser amount of a dielectric material can be employed in forming the element 25, provided the dielectric constant is sufficiently high to obtain the desired reduction in operating frequency; and a lesser amount of dielectric material can be employed, provided the element is dimensioned to approach closely the anode insulator.

Additionally, the presence of the element 25 in the circuit subassembly makes possible the use of a smaller overall circuit than would be obtainable without it. That is, the capacitance introduced by the element 25 enables the use of a smaller R.F. circuit for a given center operating frequency. This feature of the invention is highly advantageous when space is at a premium. It is especially advantageous when working with a magnet structure of a given gap dimension and the R.F. circuit would, without the present invention, be larger than the gap space. Also, by means of the present invention magnet structures of standard gap dimensions can be adapted for use with circuit subassemblies designed for different center operating frequencies.

Thus, it will be seen that with the present invention it is possible to utilize a given basic voltage tunable magnetron package comprising a voltage tunable magnetron tube and a resonant circuit and to adapt same for various predetermined different operating frequencies simply by utilizing different dielectric elements 26 each adapted for introducing a predetermined different capacitance value between the anode terminals. This avoids the necessity for providing differently constructed or dimensioned tubes and R.F. circuits and serves to reduce considerably the effort and cost of providing a family of voltage tunable magnetron packages wherein each member of the family is adapted for a different predetermined center operating frequency. Also, the present invention enables the use of R.F. circuits of smaller sizes for given center operating frequencies.

Additionally, if desired, the element 25 can be formed of thermally-conductive dielectric material and thus adapted for transferring heat to the external environment of the package. The disposition of a thermally-conductive insulative member about a voltage tunable magnetron tube for heat-transferring purposes is disclosed and claimed in copending U.S. application S.N. 190,548 of

G. A. Krug, Jr., filed April 27, 1962, now U.S. Patent 3,225,249 and assigned to the same assignee as the present invention.

While a specific embodiment of the present invention has been shown and described, it is not desired that the invention be limited to the particular form shown and described, and it is intended by the appended claims to cover all modifications within the spirit and scope of the present invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In combination, an interdigital structure magnetron, said magnetron including an evacuated envelope having a longitudinally spaced pair of anode terminals sealed through the wall of said envelope and separated by an insulative section of said wall, said anode terminals being connected to said interdigital structure, a radio frequency circuit comprising a pair of spaced, parallel conductors each electrically contacting one of said anode terminals and means for controlling the center operating frequency of said circuit comprising a dielectric element disposed externally of and about said magnetron envelope between said anode terminals, said dielectric element extending peripherally about said evacuated envelope for at least about 180°.

2. The combination according to claim 1, wherein the quantity of dielectric material constituting said element, the dielectric constant of said material and the proximity of said element to said insulative section between said anode terminals are predeterminedly selected for predeterminedly affecting the center operating frequency of said combination.

3. The combination according to claim 1, wherein said dielectric element comprises a plurality of cooperating arcuate segments enabling disposition of said dielectric element about said magnetron between said anode terminal.

4. In combination, an interdigital structure voltage tunable magnetron, said magnetron including an evacuated envelope having a longitudinally spaced pair of anode terminals sealed through the wall of said envelope and separated by an insulative section of said wall, said anode terminals being connected to said interdigital structure, a radio frequency circuit comprising a pair of spaced, parallel conductors each electrically contacting one of

said anode terminals, a coaxial coupler supported by said circuit and including an inductive loop extending radially inwardly between said anode terminals, and means for controlling the center operating frequency of said circuit comprising a dielectric element disposed between said anode terminals and extending externally of and completely about said magnetron envelope except for a section wherein said inductive loop is accommodated.

5. In combination, an interdigital structure voltage tunable magnetron, said magnetron including an evacuated envelope having a longitudinally spaced pair of anode terminals sealed through the wall of said envelope and separated by an insulative section of said wall, a resonant cavity circuit having a pair of parallel spaced conductive walls, said walls each defining an aperture adapted to receive an end of said magnetron therein, each of said walls making circumferential electrical contact with one of said anode terminals, a coaxial radio frequency output having the outer conductor conductively coupled to said walls of said resonant cavity circuit and an inner conductor supporting an inductive loop extending reentrantly in said circuit and disposed between said anode terminals, and a generally annular dielectric element extending externally of and completely about said magnetron envelope between and engaging said anode terminals except for a section wherein said inductive loop is accommodated, the quantity of dielectric material constituting said element, the dielectric constant of said material and the inner diameter of said element being predeterminedly selected for predeterminedly affecting the center operating frequency and dimensions of said circuit by increasing the capacitance of the oscillatory circuit provided by the cooperation of the magnetron tube and the circuit assembly.

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