March 21, 1950 C. W. BECKER 2,501,152

TUNABLE MAGNETRON

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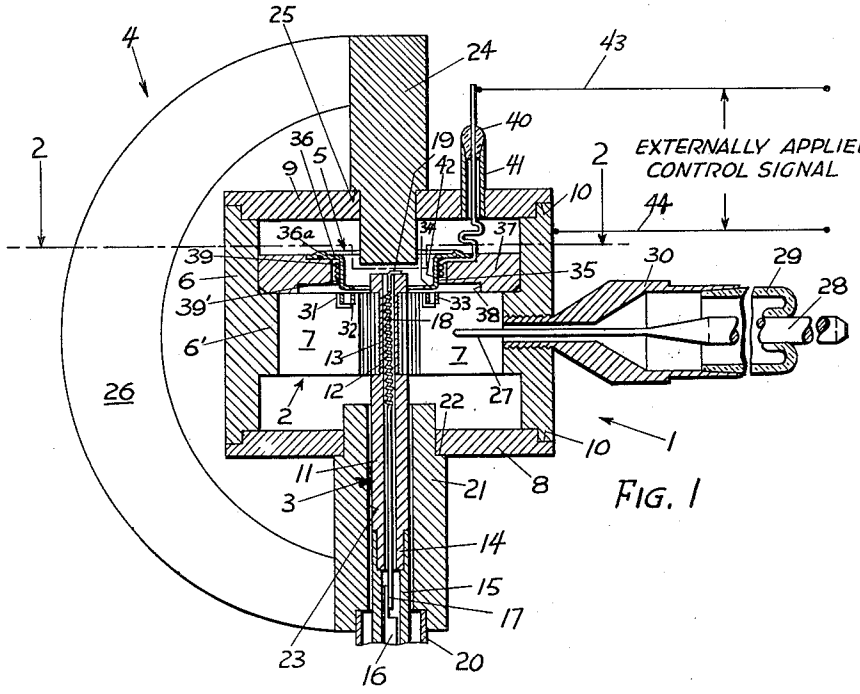


FIG. 1

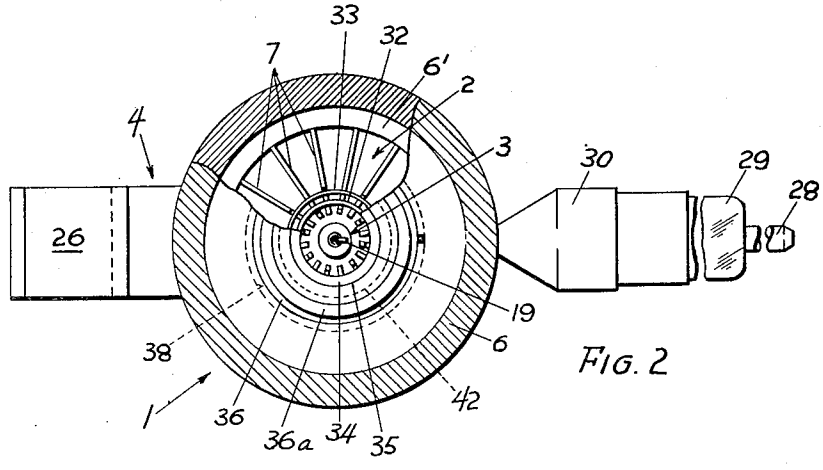


FIG. 2

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TUNABLE MAGNETRON

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6 Claims. (Cl. 315—40)

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This invention relates to electron-discharge devices, and more particularly to tunable electron-discharge devices.

While not limited thereto, the present invention is especially suitable for tunable electron-discharge devices of the so-called magnetron type.

This invention constitutes an improvement over that described in my copending application, Ser. No. 586,969, filed April 6, 1945. In said copending application, a remotely-controlled means for tuning a device of the magnetron type is disclosed, this means comprising a core or reed mounted for movement with respect to the anode of said magnetron, said core or reed having mounted thereon a coil which is located in the leakage magnetic field of said device and is adapted to be supplied with a signal or control voltage to move said core or reed.

An object of this invention is to provide means for concentrating the leakage magnetic flux of the magnetron in the region thereof in which the said coil is located, whereby the magnetic field strength in said region is increased, resulting in a greater displacement or movement of said tuning means for a given control voltage.

Another object is to increase the effective sensitivity of a voltage-controlled magnetron tuning device.

The foregoing and other objects of the invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein:

Fig. 1 is a longitudinal sectional view taken substantially through the center of a tunable magnetron made in accordance with the principles of the present invention; and

Fig. 2 is a transverse sectional view, partly broken away to show details, taken along line 2—2 of Fig. 1.

Referring now more in detail to an illustrative embodiment of the present invention, with particular reference to the drawing showing the same, the numeral 1 generally designates an electron-discharge device of the so-called magnetron type. Said device comprises an anode structure 2, a cathode structure 3, magnetic means 4 for establishing a magnetic field in a direction perpendicular to the path of the electron-flow between said cathode and anode structures, and tuning means 5.

In the device shown, the anode structure 2 includes a cylindrical body 6 made of highly conductive material, such as copper, said body being provided with an interior, annular boss 6', in turn provided with a multiplicity of radially-disposed, interiorly-extending anode members in the form of vanes 7, each adjacent pair of said vanes, together with that portion of said cylindrical body lying therebetween, constituting a resonant line, preferably, a quarter-wave line whose output end is shorted, and whose natural resonant frequency is, as is well-known in the art to which this invention relates, a function of the geometry of the physical elements making up the same. I shall further describe the anode members 7 when referring, in a later portion of this specification, to the details of the tuning means 5.

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The anode structure 2 is closed at its ends, for example, by end plates 8 and 9, with the junctions between the cylindrical body 6 of said structure, and said plates 8 and 9, hermetically sealed, as at 10.

The cathode structure 3, which is coaxial with the anode structure 2, includes a cathode sleeve 11, conventionally made of nickel, or the like, provided with a reduced portion 12 whose length, preferably, is coextensive with the width of the anode members 7, said reduced portion 12 being provided with a highly electron-emissive coating 13, for example, of the well-known alkaline-earth metal oxide type.

Cathode sleeve 11 may be reduced, as at 14, to fit into an elongated, electrically-conductive tubular member 15. A glass seal (not shown) at the outer end of member 15, together with one or more glass beads (not shown) disposed within the tubular member 15, supports a lead-in conductor 16 which passes through said member 15 and has its upper end connected, as at 17, to one terminal of a cathode heating filament 18. The other end of said filament may be connected, as at 19, to the cathode sleeve 11.

In order to convey current to the filament 18, the lead-in conductor 16 is connected by a conductor (not shown) to one terminal of a suitable source of E. M. F. (not shown), the other terminal of said source of E. M. F. being connected by a conductor (not shown) to the lower end of the tubular member 15.

The cathode 3 may be properly supported, and insulated from the anode structure 2, by any suitable supporting and insulating means, for example as shown in my aforesaid copending application. This supporting and insulating means may include a tubular bushing 20 secured to a tubular pole piece 21, constituting one of the components of the magnetic means 4.

Said pole piece 21 may be hermetically sealed, as at 22, into the end plate 8, and be provided with a central bore 23 whereby the cathode structure 3 may enter the device.

Another tubular pole piece 24 may be hermetically sealed, as at 25, into the end plate 9, said pole piece and the pole piece 21 being fixed, for example, to the opposite ends of a horseshoe magnet 26 (only partially shown), whereby an appropriate magnetic field may be established, as

previously indicated, in a direction perpendicular to the path of the electron-flow between the cathode structure 3 and the anode structure 2.

Now, by suitably heating the cathode, and applying a proper potential difference between said cathode and the anode, the device can be made to generate electrical oscillations of a wavelength determined, primarily, by the capacitance and inductance built into said device as a function of the geometry thereof, and, more especially, of the dimensions of the above referred to resonant lines defined by the anode structure.

In order to extract power from the device I may, for example, introduce a loop 27 into any one of the spaces defined by any two adjacent anode members 7, said loop coupling with the magnetic component of the above-mentioned electrical oscillations. Said loop may, in turn, be connected to a conductor 28 supported in a glass seal 29 fused into an outlet pipe 30, said pipe being threaded and hermetically sealed into the cylindrical body 6 of the anode structure 2.

Each anode member is provided with a slot 31 adapted to receive concentric conducting straps 32 and 33 which are, in turn, adapted alternately to contact successive anode members. Said straps present a capacitance therebetween which enters into the determination of a natural resonant frequency of the device, and when the anode members are thus inter-connected, spurious oscillations which might exist in the device become suppressed.

It has been found that, by moving another conducting member with respect to the anode members 7, or with respect to the straps 32 and 33 thereof, the distributed capacitance or, with appropriate modifications, the distributed inductance, of the device, or both, may be altered whereby said device may be tuned to frequencies other than the natural resonant frequency thereof, and to this end, I proceed as follows:

I provide said additional conducting member, for example, in the form of an annular flange 34 formed at the lower end of a hollow, cylindrical core or reed 35. Said core or reed depends from a diaphragm 36 which is secured, at its periphery, in a recess formed in the upper surface of a supporting ring member 37. Diaphragm 36 has formed therein, between its periphery and the cylindrical reed 35, a corrugation 36*a*, in order to make diaphragm 36 more flexible.

Ring member 37 is made of ferromagnetic material, for example iron, is of substantial thickness, and is mounted within the body 6 upon the ledge presented by the boss 6' thereof. Said ring member has a recess 38 cut in the lower surface thereof.

Wound upon the core and firmly secured thereto is a coil 39 of insulated wire, one end, 39', of said coil being electrically connected to the core, and the other end thereof passing through a suitable opening in member 37, beyond the periphery of diaphragm 36, and out of the device, through a glass seal 40 fused into a pipe 41 which is hermetically sealed into the end plate 9. Member 37 has a central aperture 42 extending entirely therethrough, this aperture being of sufficient size to allow free movement therein of core 35 and coil 39.

Core or reed 35, coil 39 carried thereby, and ring 37 should be so disposed with respect to the pole piece 24 that said coil and said ring are within the leakage field existing between said pole piece 24 and the pole piece 21. Hence, upon application of an external signal between conductors 43 and 44, respectively connected to the coil 39 and body 6, the current flowing in said coil, and the leakage field above referred to, interact to move said core, and the flange 34 carried thereby, with respect to the anode members 11. The result of this movement is, as previously indicated, an alteration of the distributed capacitance of the device, and a consequent tuning thereof.

Ferromagnetic or iron ring member 37, being in the leakage magnetic field existing between pole pieces 21 and 24, acts to concentrate the magnetic flux in the region defined by the cylindrical face of aperture 42, thus increasing the field strength in this region. This occurs because of the low reluctance of the flux path through member 37, as compared to the reluctance of the path through the surrounding air, so that the flux density in member 37 becomes quite high, giving a high field strength or magnetic intensity in the space between member 37 and the cylindrical face of upper pole piece 24. In a typical case, it was found that the field strength in the gap adjacent pole piece 24 was of the order of 5,000 gauss without the iron ring 37; with an iron ring the field strength was of the order of 8,000 gauss.

Coil 39 is located in the air gap between member 37 and pole piece 24, so that it is in this magnetic field of said high field strength. Therefore, since the force on a current-carrying conductor in a magnetic field is directly proportional to the field strength or magnetic intensity H, the force on coil 39 will be increased, for the same excitation, by the addition of flux concentrating means 37 due to the increase of H by said means. As a result, a high displacement-voltage sensitivity for coil 39 is obtained in accordance with the teaching of this invention.

If desired, damping means may be provided on core or reed 35 to damp out the natural resonant vibratory frequency of said reed. in accordance with the teachings of my copending application, Ser. No. 694,056, filed August 30, 1946.

This completes the description of an embodiment of the invention. It will be noted from all of the foregoing that I have devised flux-concentrating means, for an electromagnetically-operated magnetron tuning means, which is relatively simple in construction yet highly effective to provide a high sensitivity for the said tuning means.

Of course, it is to be understood that this invention is not limited to the particular details as described above, 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 this invention within the art.

What is claimed is:

1. The combination with an electron discharge device which incorporates a cathode, an anode spaced from said cathode, and means for establishing a magnetic field in a direction substantially perpendicular to the path of the electron flow between said cathode and said anode, said device producing oscillations having a natural resonant frequency determined by the configuration of said device: of means, supported within said device and movable with respect to said anode, for tuning said device to a frequency other than said natural resonant frequency; means, supported by said movable means within the magnetic lines of force of said magnetic field and receptive of an external signal, for establishing a signal-responsive magnetic

field cooperable with said lines of force for controlling the operation of said tuning means; and means, supported within said device near said controlling means and within said magnetic lines of force, for increasing the flux density of said magnetic field in the vicinity of said controlling means.

2. The combination with an electron discharge device which incorporates a cathode, an anode spaced from said cathode, and a pair of oppositely-disposed means for establishing a magnetic field between said anode and said cathode in a direction substantially perpendicular to the path of the electron flow between said cathode and said anode, said device producing oscillations having a natural resonant frequency determined by the configuration of said device: of means, supported within said device and movable with respect to said anode, for tuning said device to a frequency other than said natural resonant frequency; means, supported by said movable means near one of said magnetic means, within the magnetic lines of force of said pair of magnetic means and receptive of an external signal, for establishing a signal-responsive magnetic field cooperable with said lines of force for controlling the operation of said tuning means; and means, supported within said device near said controlling means and within said magnetic lines of force, for increasing the flux density of said magnetic field in the vicinity of said controlling means and of said one magnetic means.

3. An electron discharge device, comprising a cathode, an anode spaced from said cathode, a pair of oppositely-disposed means for establishing a magnetic field between said anode and said cathode in a direction substantially perpendicular to the path of the electron flow between said cathode and said anode, said device producing oscillations having a natural resonant frequency determined by the configuration of said device, means supported within said device for tuning said device to a frequency other than said natural resonant frequency, means surrounding but spaced from one of said magnetic means and within the magnetic lines of force of said pair of magnetic means, said last-named means being receptive of an external signal for establishing a signal-responsive magnetic field cooperable with said lines of force to control the operation of said tuning means, and means, surrounding said controlling means and within said magnetic lines of force, for increasing the flux density of said magnetic field between said controlling means and said one magnetic means.

4. An electron discharge device, comprising a cathode, an anode spaced from said cathode, a pair of oppositely-disposed cylindrical pole pieces for establishing a magnetic field between said anode and said cathode in a direction substantially perpendicular to the path of the electron flow between said cathode and said anode, said device producing oscillations having a natural resonant frequency determined by the configuration of said device, means supported within said device for tuning said device to a frequency other than said natural resonant frequency, means surrounding but spaced from one of said pole pieces and within the magnetic lines of force of said pair of pole pieces, said last-named means being receptive of an external signal for establishing a signal-responsive magnetic field cooperable with said lines of force to control the operation of said tuning means, and means, surrounding said controlling means and within said magnetic lines of force, for increasing the flux density of said magnetic field between said controlling means and said one pole piece.

5. An electron discharge device, comprising a cathode, an anode spaced from said cathode, a pair of oppositely-disposed cylindrical pole pieces for establishing a magnetic field between said anode and said cathode in a direction substantially perpendicular to the path of the electron flow between said cathode and said anode, said device producing oscillations having a natural resonant frequency determined by the configuration of said device, means supported within said device for tuning said device to a frequency other than said natural resonant frequency, means surrounding but spaced from one of said pole pieces and within the magnetic lines of force of said pair of pole pieces, said last-named means being receptive of an external signal for establishing a signal-responsive magnetic field cooperable with said lines of force to control the operation of said tuning means, and means, surrounding but spaced from said controlling means and within said magnetic lines of force, for increasing the flux density of said magnetic field between said controlling means and said one pole piece, and between said flux-density-increasing means and said controlling means.

6. An electron discharge device, comprising a cathode, an anode spaced from said cathode, a pair of oppositely-disposed cylindrical pole pieces for establishing a magnetic field between said anode and said cathode in a direction substantially perpendicular to the path of the electron flow between said cathode and said anode, said device producing oscillations having a natural resonant frequency determined by the configuration of said device, means supported within said device for tuning said device to a frequency other than said natural resonant frequency, means surrounding but spaced from one of said pole pieces and within the magnetic lines of force of said pair of pole pieces, said last-named means being receptive of an external signal for establishing a signal-responsive magnetic field cooperable with said lines of force to control the operation of said tuning means, and a ferromagnetic member, surrounding but spaced from said controlling means and within said magnetic lines of force, for increasing the flux density of said magnetic field between said controlling means and said one pole piece, and between said flux-density-increasing means and said controlling means.

CARL W. BECKER.

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