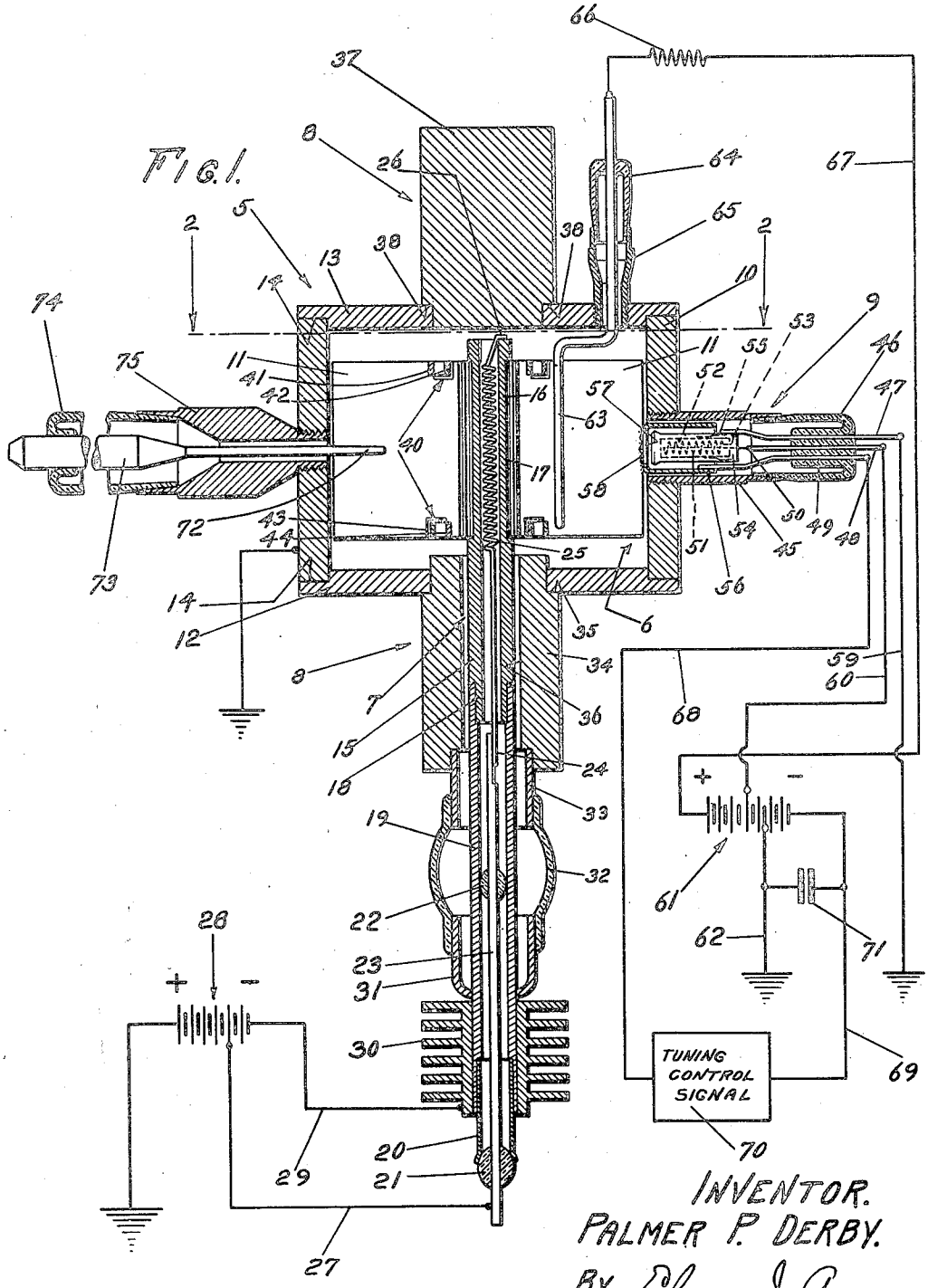
Aug. 22, 1950 P. P. DERBY 2,519,826

ELECTRON DISCHARGE DEVICE

Filed April 30, 1945 2 Sheets-Sheet 1

FIG. 1.



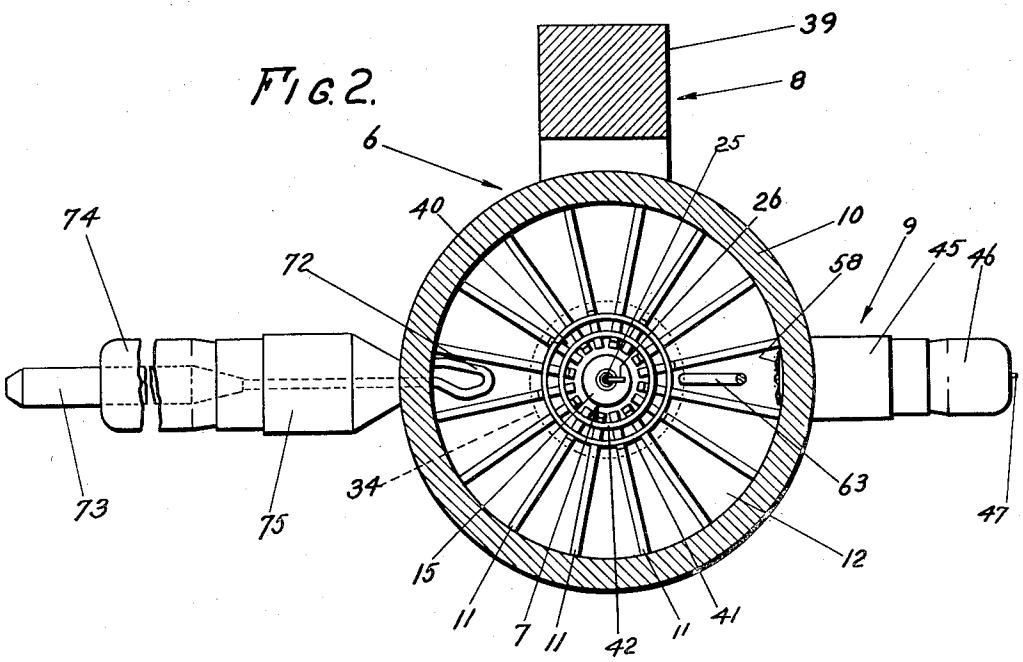
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FIG. 2.



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2,519,826

ELECTRON DISCHARGE DEVICE

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4 Claims. (Cl. 250—27.5)

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

While not limited thereto, my present invention is especially suitable for tuning or modulating electron-discharge devices adapted to generate electrical oscillations having a wave length of the order of a few centimeters or less, for example, devices of the so-called magnetron type.

Such devices have heretofore been tuned mechanically, but the mechanisms employed, possessing considerable inertia, were restricted to use at relatively low frequencies.

It is, therefore, the main object of my present invention to overcome the foregoing limitation by providing electronic tuning means, having practically no inertia, and, hence, permitting use at any frequency, including, for example, video frequencies.

It is a further object of my present invention to accomplish such tuning or modulating with the expenditure of very little power.

These, and other objects of my present invention, which will become more apparent as the detailed description thereof progresses, are attained, briefly, in the following manner:

As above stated, my present invention is especially suitable for tuning or modulating electron-discharge devices of the magnetron type. Such a device may include a cathode structure, an anode structure, spaced from said cathode structure, and incorporating one or more cavity resonators, and means for establishing a magnetic field in a direction perpendicular to the electron-path between said cathode and anode structures.

When a proper voltage is applied between the cathode and anode structures of such a device, and the magnetic field thereof is adjusted to an appropriate value with respect to the electric field created by said voltage, electrical oscillations are generated of a wave length determined by the inductance and capacitance built into the device, primarily, as a function of the geometry of the physical elements making up the aforementioned cavity resonators.

Now, I have found that by introducing a stream of electrons into one or more of said cavity resonators, and, through the use of coacting magnetic and electric fields, causing said electrons to take orbital rather than straight-line paths therein, I am able to obtain considerable deviation from the natural resonant frequency of the device.

While I do not wish to be limited to any particular theory as to why this occurs, I believe

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that the distortion of the paths, which the electrons would ordinarily follow in the absence of a magnetic field, enables the building up of a space charge of appreciable density, and this alters the dielectric constant of the space within said cavity resonators and, therefore, the capacitance thereof.

In any event, by providing an electrode adjacent the source of the electron-stream, and applying a variable potential between said electrode and said source, I am able to tune or modulate the device, and inasmuch as the electrons have, for all practical purposes, no inertia, there is no limitation on the frequency which may be employed.

In the accompanying specification I shall describe, and in the annexed drawings show, an illustrative embodiment of the electron-discharge devices of my present invention. It is, however, to be clearly understood that I do not wish to be limited to the details herein shown and described for purposes of illustration only, inasmuch as changes therein may be made without the exercise of invention and within the true spirit and scope of the claims hereto appended.

In said drawings,

Fig. 1 is a longitudinal sectional view taken substantially through the center of an electron-discharge device made in accordance with the principles of my present invention; and

Fig. 2 is a transverse sectional view taken along line 2—2 of Fig. 1.

Referring now more in detail to the aforesaid illustrative embodiment of my present invention, and with particular reference to the drawings illustrating the same, the numeral 5 generally designates an electron-discharge device of the magnetron type.

As herein shown, said device includes an anode structure 6, a cathode structure 7, magnetic means 8 for establishing a magnetic field in a direction perpendicular to the electron-path between said cathode and anode structures, and tuning means 9.

The anode structure 6 preferably comprises a cylindrical body 10, made of highly conductive material, such as copper, and provided with a plurality, here shown as sixteen, of anode members in the form of interiorly-extending, radially-disposed vanes 11.

The cylindrical body 10 is closed at its ends by plates 12 and 13, the junctions between said body and said plates being hermetically sealed, as at 14.

The cylindrical body 10 is of such diameter, and the number, size and relative spacing of the

vanes 11 are so chosen that each pair of adjacent vanes, together with that portion of said cylindrical body lying therebetween, defines a cavity resonator at the frequency desired of the output of the device.

The cathode structure 7, which is coaxial with the anode structure 6, preferably comprises an elongated sleeve 15, conventionally made of nickel, or the like, and having a reduced portion 16 which is substantially coextensive with the vertical dimension of the vanes 11, and provided with a highly electron-emissive coating 17, for example, of the well known alkaline-earth metal oxide type.

In order to support the cathode sleeve 15 with respect to the anode members 11, said sleeve may be reduced at its lower end 18 to fit into a tubular conducting member 19, the latter having at its lower end a ferrule 20 closed by a glass seal 21 which, together with one or more glass beads 22 disposed within said tubular member 19, supports a lead-in conductor 23.

The inner end of said lead-in conductor 23 is connected, as at 24, to a heating filament 25 which is substantially coextensive with the cathode coating 17, and has its opposite end electrically connected to the cathode sleeve 15, as at 26.

Current may be conveyed to the filament 25 by connecting the lower end of the lead-in conductor 23, through a conductor 27, to a positive tap on a suitable source 28 of electromotive force, the negative terminal of said source being connected, through a conductor 29, to a heat-dissipating member 30 carried by the tubular member 19.

The positive terminal of the source 28 of electromotive force may be grounded, as shown, as may be the cylindrical body 10, whereby a potential difference is established between the cathode structure 7 and the anode structure 6.

In order to insulate the cathode structure 7 from the anode structure 6, I provide the tubular member 19 with a cup-like bushing 31 which is fused into one end of a glass insulating member 32, the other end of said insulating member having a tubular bushing 33 fused therein which, in turn, is secured in a recess formed in the lower end of a tubular pole piece 34.

The pole piece 34 is hermetically sealed, as at 35, into the end plate 12, and is provided with a bore 36 through which the cathode structure 7 may enter the device.

A cooperating tubular pole piece 37 is hermetically sealed, as at 38, into the end plate 13, said pole piece, together with the pole piece 34, being fixed, for example, at the ends of a horseshoe magnet 39 (only partially shown in Fig. 2) and constituting the above referred to magnetic means 8 for establishing a magnetic field transversely of the electron-path between the cathode and anode structures of the device.

While not essential, I prefer that the vanes 11 be provided, in both the upper and lower edges thereof, adjacent their inner ends, with slots 40 receptive of two pairs of concentric conducting straps 41 and 42, and 43 and 44, the straps of each pair thereof alternately contacting successive vanes 11. It has been found that when alternate vanes are electrically connected, as by the straps just described, the tendency of the device to generate spurious oscillations, which would reduce its efficiency, is eliminated.

In the device as thus far described, there is no means for controlling the frequency thereof,

and in order to provide such means, I proceed as follows:

A pipe 45 is threaded and hermetically sealed in the cylindrical body 10 at a point midway between any two of the vanes 11, said pipe having a glass seal 46 fused into its outer end, and said glass seal having imbedded therein three lead-in conductors 47, 48 and 49. The lead-in 48 is connected, as at 50, to one end of a heating filament 51 which is disposed within a highly electron-emissive cathode 52, the other end of said filament being connected, as at 53, to a shield 54, to which said cathode is also connected, as at 55. The shield 54 is connected to and supported by the lead-in 47. Surrounding the shield 54 is a thimble 56 provided, in its front end, with an aperture 57 which may be covered by a screen mesh 58.

In order to convey current to the filament 51, the lead-in 47 may be connected, through a conductor 59, to ground, and the lead-in 48 may be connected, through a conductor 60, to a positive tap on a source 61 of electromotive force, the circuit being completed by grounding a negative tap on said source 61, through a conductor 62.

By means of the gun just described, a stream of electrons is introduced into one of the cavity resonators defined by the anode structure 6 and, if desired, additional guns may be incorporated into the device to introduce electron streams into additional cavity resonators.

It is preferable that the electrons so introduced be captured before they can fall onto the vanes 11, and for this purpose I provide a collecting electrode 63 which enters the device through a glass seal 64, the latter being fused into a pipe 65 threaded and hermetically sealed into the end plate 13, said electrode extending into the cavity resonator and being located closely adjacent the outer straps 41 and 43. The electrode 63 is connected, through a current-limiting resistor 66 and a conductor 67, to the positive terminal of the source 61 of electromotive force, the potential to which said electrode is thereby raised being higher than that of the anode structure 6.

The electron-path between the gun and the collecting electrode is, it will be noted, transverse of the magnetic field, more particularly, the leakage field, between the pole pieces 34 and 37, so that, by properly adjusting the relative intensities of said magnetic field and the electric field between said gun and said collecting electrode, the electrons emitted by the cathode 52 can be made to take orbital rather than straight-line paths. This permits the use of such voltages between said gun and said collecting electrode that a space charge of appreciable density can be built up in the cavity resonator, which space charge, as I have indicated to be my belief, affects the dielectric constant of the cavity.

Now, by connecting the thimble 56, through conductors 68 and 69 and any suitable source 70 of tuning control signal, to the negative terminal of the source 61 of electromotive force, the space charge density can be varied so as to tune or modulate the device.

It is preferable that alternating current be kept out of the direct-currect source 61, and for this purpose a by-pass capacitor 71 may be connected between ground and the negative terminal of said direct-current source.

In order to extract power from the device, I provide a loop 72 which may be introduced into any one of the cavity resonators defined by the anode structure 6, said loop being connected to

a conductor 73 imbedded in a glass seal 74 which is fused into a pipe 75, in turn, threaded and hermetically sealed into the cylindrical body 10.

This completes the description of the aforesaid illustrative embodiment of my present invention. It will be noted from all of the foregoing that I have provided tuning means for an electron-discharge device adapted to generate exceedingly short wave oscillations, more especially, a magnetron, which tuning means, being electronic, has for all practical purposes no inertia, and is, therefore, well suited to use at very high frequencies. It will further be noted that, by reason of the nature of the control over the operation of said tuning means, modulation may be effected with the expenditure of very little power from the local source.

Other objects and advantages of my present invention will readily occur to those skilled in the art to which the same relates.

What is claimed is:

1. A tunable electron-discharge device comprising: a cathode; an anode structure, spaced from said cathode, and including a cavity resonator; means, adjacent said anode structure, for establishing a unidirectional magnetic field through said cavity resonator; means, disposed in said cavity resonator and cooperable with said magnetic field, for producing a space charge within said cavity resonator; said last-named means including a source of electrons; and electrostatic means, disposed in said cavity resonator, for directing said electrons along paths substantially transverse to said magnetic field; and means, disposed adjacent said last-named means, for altering the density of said space charge.

2. A tunable electron-discharge device comprising a cathode; an anode structure, spaced from said cathode, and including a cavity resonator; means, adjacent said anode structure, for establishing a unidirectional magnetic field through said cavity resonator; means, disposed in said cavity resonator and cooperable with said magnetic field, for producing a space charge within said cavity resonator; said last-named means including a source of electrons; and a collecting-electrode, disposed in said cavity resonator and adapted to have an electrostatic field established between itself and said source of electrons, for directing said electrons along paths substantially transverse to said magnetic field; and means, disposed adjacent said last-named means, for altering the density of said space charge.

3. A tunable electron-discharge device comprising: a cathode; an anode structure, spaced from said cathode, and including a cavity resonator; means, adjacent said anode structure, for establishing a unidirectional magnetic field through said cavity resonator; means, disposed in said cavity resonator and cooperable with said magnetic field, for producing a space charge within said cavity resonator; said last-named means including a source of electrons; and electrostatic means, disposed in said cavity resonator, for directing said electrons along paths substantially transverse to said magnetic field; and a signal-receptive electrode, disposed adjacent said last-named means, for altering the density of said space charge as a function of the instantaneous intensity of said signal.

4. A tunable electron-discharge device comprising: a cathode; an anode structure, spaced from said cathode, and including a cavity resonator; means, adjacent said anode structure, for establishing a unidirectional magnetic field through said cavity resonator; means, disposed in said cavity resonator and cooperable with said magnetic field, for producing a space charge within said cavity resonator; said last-named means including a source of electrons; and a collecting-electrode, disposed in said cavity resonator and adapted to have an electrostatic field established between itself and said source of electrons, for directing said electrons along paths substantially transverse to said magnetic field; and a signal-receptive electrode, disposed adjacent said last-named means, for altering the density of said space charge as a function of the instantaneous intensity of said signal.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,167,201	Dallenbach	July 25, 1939
2,241,976	Blewett et al.	May 13, 1941
2,338,237	Fremlin	Jan. 4, 1944
2,409,038	Hansell	Oct. 8, 1946
2,412,372	Usselman	Dec. 10, 1946
2,413,385	Schmidt	Dec. 31, 1946
2,416,168	Fiske	Feb. 18, 1947
2,416,963	Fiske et al.	Jan. 7, 1947
2,422,465	Bondley	June 17, 1947
2,466,531	Derby	Aug. 10, 1948
2,468,243	Spencer	Apr. 26, 1949

FOREIGN PATENTS

Number	Country	Date
114,102	Australia	Oct. 22, 1941