April 18, 1950 P. P. DERBY 2,504,187

ELECTRON DISCHARGE DEVICE

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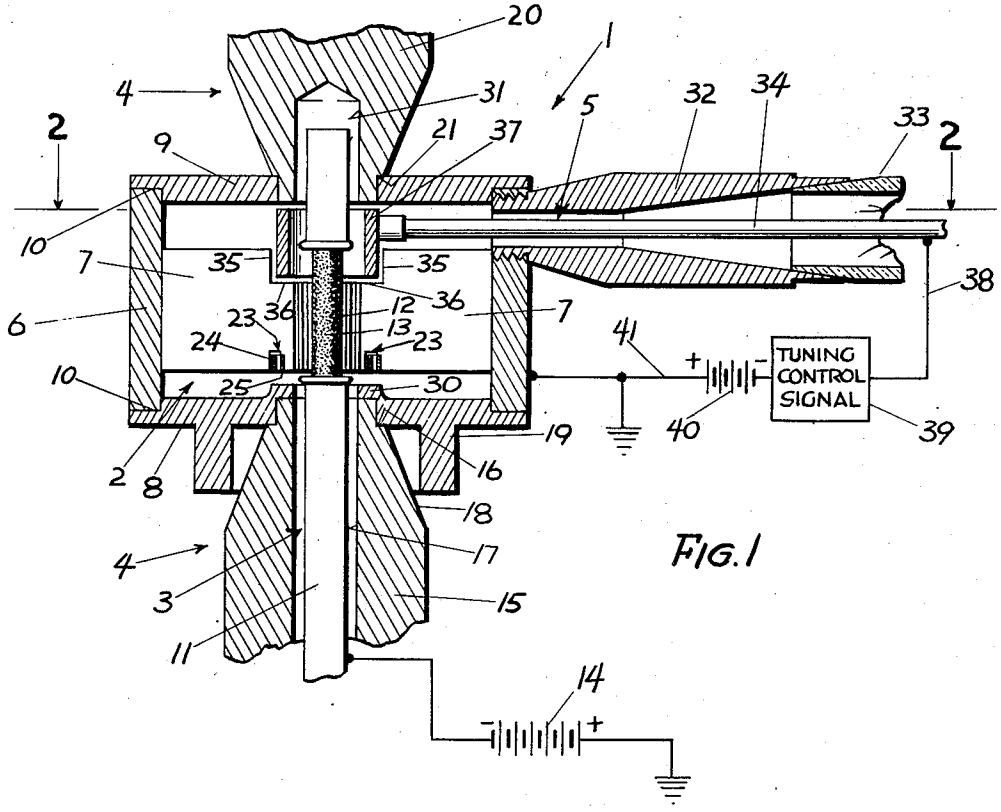


FIG. 1

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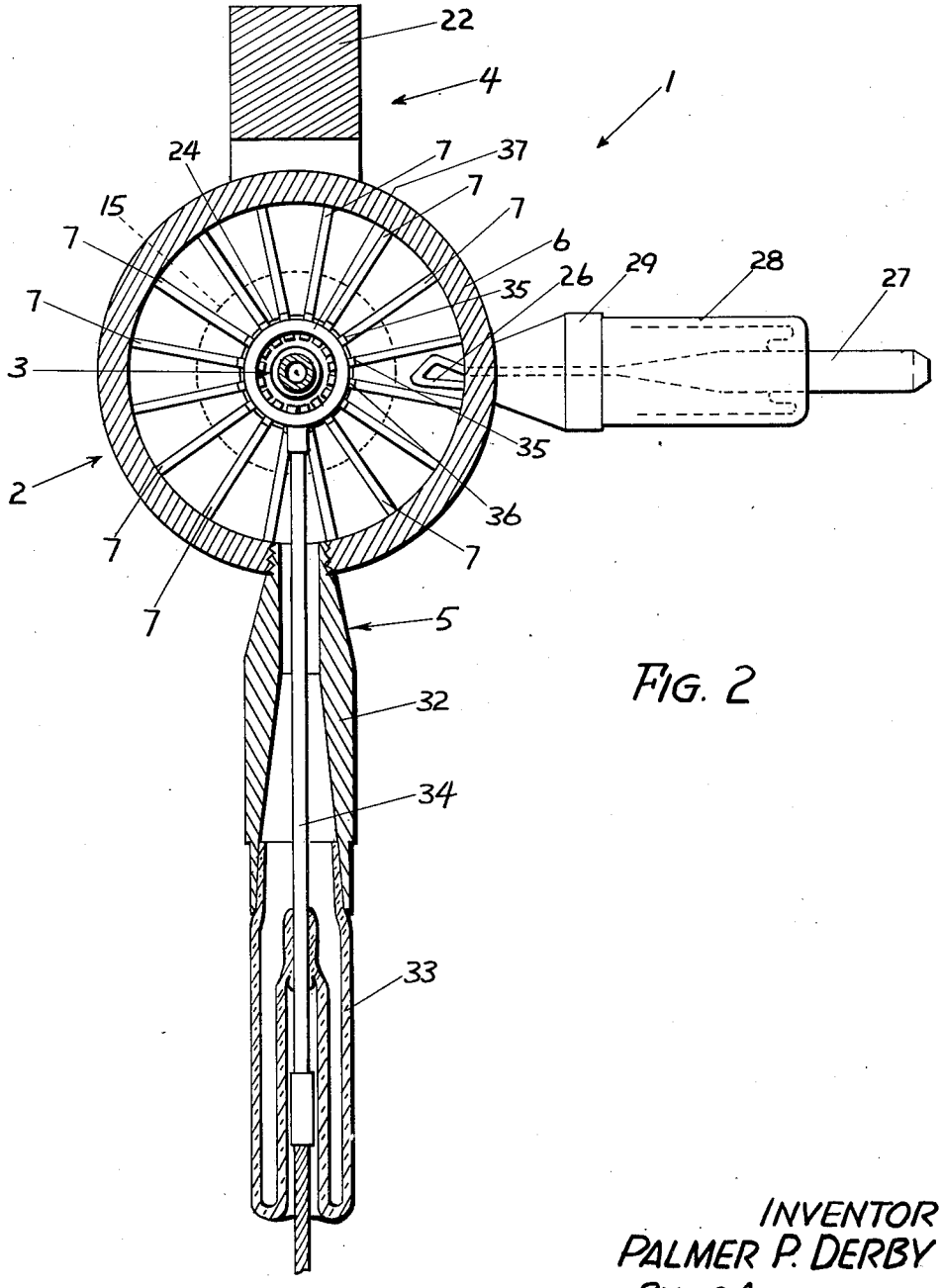


FIG. 2

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Patented Apr. 18, 1950 2,504,187

UNITED STATES PATENT OFFICE

2,504,187

ELECTRON DISCHARGE DEVICE

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Application May 2, 1946, Serial No. 666,587

4 Claims. (Cl. 250—27.5)

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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 tuning or modulating electron-discharge devices adapted to generate electrical oscillations having a wavelength 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 the 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.

Another object of the present invention is to accomplish such tuning or modulating with the expenditure of very little power.

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

As above stated, the 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 at a wavelength 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, it has been found that by placing a conducting member, having a potential negative with respect to the anode structure, in a position contiguous to the cathode and anode structures, and by varying the potential of said member, considerable deviation from the natural resonant frequency of the device may be obtained.

While I do not wish to be limited to any particular theory as to why this occurs, I believe that electrons emitted from the cathode strike this conducting member, causing secondary electron emission therefrom, the secondary electrons being attracted toward the anode structure because of its positive potential. These electrons, because of the magnetic field in the device, are caused to take orbital rather than straight-line paths in the cavity resonators. It is thought 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. By varying the potential applied to the conducting member, different numbers of primary electrons are caused to strike it, so that the rate of secondary electron emission and, therefore, also, the capacitance of the cavity resonators are correspondingly varied.

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In any event, by providing an electrode or conducting member adjacent the anode and cathode structures, and applying a variable potential to said electrode, it is possible to tune or frequency-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 will be described, and in the annexed drawings will be shown, an illustrative embodiment of the electron-discharge devices of the present invention. It is, however, to be clearly understood that the invention is not to be limited to the details herein shown and described, which are 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 the 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 the present invention, and with particular reference to the drawings illustrating the same, the numeral 1 generally designates an electron discharge device of the magnetron type.

As herein shown, said device includes an anode structure 2, a cathode structure 3, magnetic

means 4 for establishing a magnetic field in a direction perpendicular to the electron path between said cathode and anode structures, and tuning means 5.

The anode structure 2 preferably comprises a cylindrical body 6, 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 7.

The cylindrical body 6 is closed at its end by plates 8 and 9, the junctions between said body and said plates being hermetically sealed, as at 10.

The cylindrical body 6 is of such diameter, and the number, size and relative spacing of the vanes 7 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 3, which is coaxial with the anode structure 2, preferably comprises an elongated sleeve 11, made of nickel, or the like, and having a reduced portion 12 which is substantially coextensive with the vertical dimension of the vanes 7, and which is provided with a highly electron-emissive coating 13, for example, of the well known alkaline-earth oxide type.

The cathode sleeve 11 is supported with respect to the anode members 7 by any suitable supporting means, not shown. The supporting means should be made of insulating material, so as to electrically insulate the cathode structure 3 from the anode structure 2. The cathode is brought to the temperature of thermionic emission by any suitable heating means, not shown.

The positive terminal of the source 14 of potential may be grounded, as shown, as may be the cylindrical body 6, while the negative terminal of said source is connected to sleeve 11, whereby a potential difference is established between the cathode structure 3 and the anode structure 2.

A tubular pole piece 15 is hermetically sealed, as at 16, into the end plate 8, and is provided with a bore 17 through which the cathode structure 3 may enter the device. The upper end of pole piece 15 may be tapered, as at 18, and a downwardly-extending collar 19 may be provided on lower plate 8, said collar surrounding the tapered portion 18 but being spaced therefrom.

A cooperating tubular pole piece 20 is hermetically sealed, as at 21, into the end plate 9, said pole piece, together with the pole piece 15, being fixed, for example, at the ends of a horseshoe magnet 22, only partially shown in Fig. 2, and constituting the above referred to magnetic means 4 for establishing a magnetic field transversely of the electron-path between the cathode and anode structures of the device. The upper end of cathode sleeve 11 projects above the upper surface of upper plate 9, an aperture 31 being provided in pole piece 20 to allow for this projection.

While not essential, it is preferred that the vanes 7 be provided, in the lower edges thereof, adjacent their inner ends, with slots 23 receptive of a pair of concentric conducting straps 24 and 25, the straps of said pair alternately contacting successive vanes 7. 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 order to extract power from the device, a loop 26, which may be introduced into any one of the cavity resonators defined by the anode structure 2, is provided, said loop being connected to a conductor 27 embedded in a glass seal 28 which is fused into a pipe 29, in turn, threaded and hermetically sealed into the cylindrical body 6.

An upstanding boss 30 is provided on the upper or inner surface of lower plate 8.

In the device as thus far described, there is no means for controlling the frequency thereof, and in order to provide such means the device is modified as follows:

A pipe 32 is threaded and hermetically sealed in the cylindrical body 6 at a point above vanes 7, said pipe having a reentrant glass seal 33 fused into its outer end, and said glass seal having embedded therein a rather stiff lead-in conductor 34. Conductor 34 extends through the hole in pipe 32 into the interior of device 1.

Vanes 7 are provided, at their inner ends and in the upper edges thereof, with rectangular recesses or cut-away portions which are defined by vertical walls 35 and horizontal walls 36. Fixedly mounted in these recesses and surrounding the cathode, but spaced from both the cathode sleeve 11 and the vanes 7, is a hollow cylindrical electrode 37 of conducting material, for example of copper. Said electrode is held fixed in position by stiff lead 34, to which it is rigidly attached, as by soldering or welding. Electrode 37, due to the provision of the recesses in vanes 7, surrounds the coating 13 of the cathode for a portion of the length of said electrode 37. Also, due to said recesses in the vanes, electrode 37 is contiguous to the anode structure 2 and to the cavity resonators defined by vanes 7 and the portions of cylindrical body 6 therebetween.

Conductor 34 is connected, through a conductor 38 and any suitable source 39 of tuning control signal, to the negative terminal of a source 40 of potential, the positive terminal of which is grounded by means of conductor 41, so that a voltage negative with respect to the anode is supplied to electrode 37.

When the invention is to be used for purposes of frequency-modulated communication, the source 39 may be the modulating voltage or signal to be transmitted. If a stabilized output frequency of the magnetron is desired, so that the magnetron may be amplitude-modulated without any frequency modulation, source 39 may provide a control signal for stabilizing said output frequency. This tuning scheme may be used to supplement mechanical tuning, for producing relatively small frequency changes—that is, relatively small with respect to the rest or mid-frequency of the magnetron—for modulating purposes.

It is thought that an electron-emissive coating of alkaline-earth metal oxide is formed on the inner surface of the electrode 37 during activation of the cathode. During operation of device 1, it is believed that some of the electrons emitted from cathode 3 find their way to electrode 37, and cause secondary electrons to be emitted from said electrode. These secondary electrons, due to their negative charges, are attracted toward the anode vanes 7 because of the positive potential of said vanes with respect to electrode 37. The magnetic field produced by magnetic means 4 causes the electrons to follow orbital paths, enabling the building up of a space charge which effectively alters the dielectric constant of the space within the cavity resonators, altering therefore the capacitance thereof and therefore also the output frequency of the magnetron. By varying the

voltage applied to electrode 37, the magnetron may be tuned or frequency-modulated.

It has been found that, with this invention, rather large frequency changes may be effected with the expenditure of very little power from the local source. For example, in one practical embodiment of the invention, a frequency shift of three megacycles was obtained with only 0.08 watt input to electrode 37. It has been found that the frequency change effected varies with the strength of the magnetic field produced by magnetic means 4 and is, moreover, peaked, so that a maximum frequency change is produced, at a particular value of voltage applied to electrode 37, for a certain optimum value of magnetic field strength.

This completes the description of the aforesaid illustrative embodiment of the present invention. It will be noted from all of the foregoing that tuning means has been provided 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.

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.

What is claimed is:

1. A tunable electron discharge device comprising: an electron-emissive cathode; an anode structure adjacent said cathode, but spaced therefrom, and including a plurality of anode members; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, defining a cavity resonator; each of said anode members having a recessed portion contiguous to said cathode; means adjacent said cathode for establishing a magnetic field in a direction perpendicular to the electron path between said cathode and said anode structure and through at least one of said cavity resonators; an electrode adjacent said cathode, but spaced therefrom, and located in the recessed portions of said anode members; and means electrically connected to said electrode for connecting the same to a voltage source.

2. A tunable electron discharge device comprising: an electron-emissive cathode; an anode structure adjacent said cathode, but spaced therefrom, and including a plurality of anode members; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, defining a cavity resonator; each of said anode members having a recessed portion contiguous to said cathode; means adjacent said cathode for establishing a magnetic field in a direction perpendicular to the electron path between said cathode and said anode structure and through at least one of said cavity resonators; a signal-receptive electrode adjacent said cathode, but spaced therefrom, and located in the recessed portions of said anode members; and means electrically connected to said electrode for connecting the same to a source of signals.

3. A tunable electron discharge device comprising: a cylindrical electron-emissive cathode; an anode structure surrounding said cathode, but spaced therefrom, and including a cavity resonator; said anode structure having a recessed portion contiguous to said cathode; means adjacent said cathode for establishing a magnetic field in a direction perpendicular to the electron path between said cathode and said anode structure and through said cavity resonator; a hollow cylindrical electrode surrounding said cathode, but spaced therefrom, and located in the recessed portion of said anode structure; and means electrically connected to said electrode for connecting the same to a source of signals.

4. A tunable electron discharge device comprising: a cylindrical electron-emissive cathode; an anode structure surrounding said cathode, but spaced therefrom, and including a plurality of anode members, each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, defining a cavity resonator; each of said anode members having a recessed portion contiguous to said cathode; means adjacent said cathode for establishing a magnetic field in a direction perpendicular to the electron path between said cathode and said anode structure and through at least one of said cavity resonators; a hollow cylindrical electrode surrounding said cathode, but spaced therefrom, and located in the recessed portions of said anode members; and means electrically connected to said electrode for connecting the same to a source of signals.

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