

June 29, 1948.

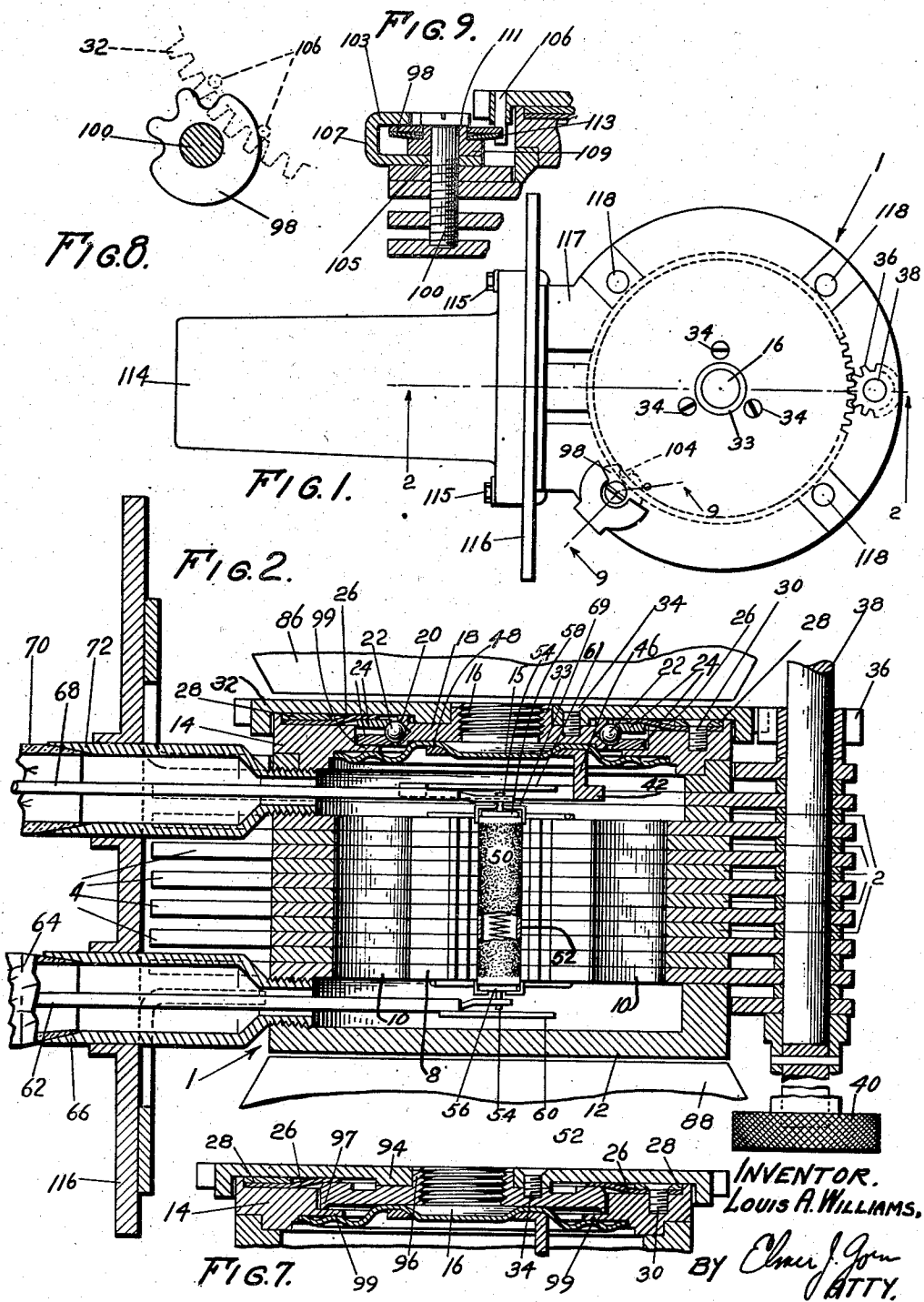
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2,444,080

ELECTRON DISCHARGE DEVICE OF THE MAGNETRON TYPE

Filed Oct. 27, 1944

2 Sheets-Sheet 1



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FIG. 4.

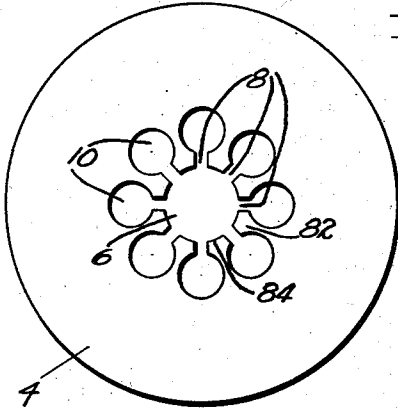
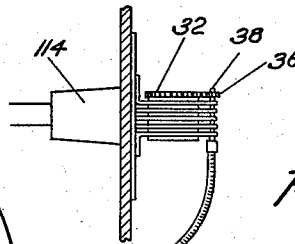


FIG. 6.

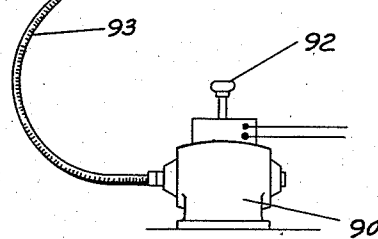


FIG. 5

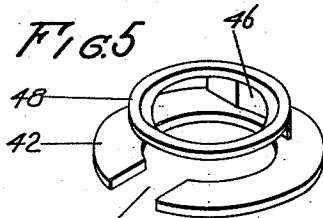
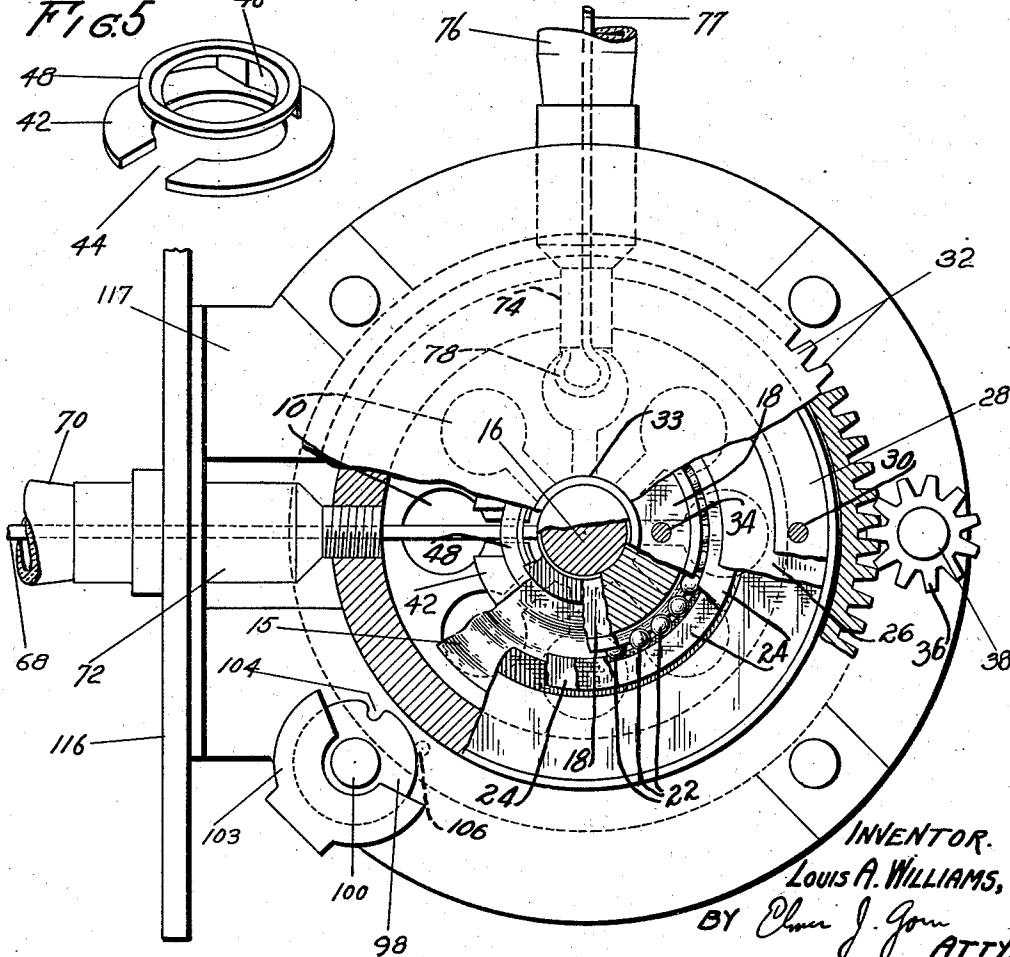


FIG. 3.



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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE OF THE
MAGNETRON TYPE

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4 Claims. (Cl. 315—39)

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This invention relates to electron discharge devices, and more particularly to those, such as magnetrons, for example, in which the frequency of the oscillations generated by the device is determined by the dimensions of the internal structure.

One of the objects of the present invention is to provide a device of the above specified type comprising improved means for adjusting the device so that it shall be resonant at any frequency desired within the range of frequencies for the generation of which the device is designed.

Another object of the present invention is to provide a device of the general type referred to comprising means for readjusting the device to restore a desired frequency, where for any cause, such as a change in dimensions of the device, for instance, due to temperature changes, for example, the frequency of the device has varied.

Another object of the present invention is to provide a device of the general type referred to comprising means for limiting the range of adjustment.

A further object of the present invention is to provide a device of the character referred to comprising remotely-controlled frequency adjusting means.

These objects of the present invention, and such others as may hereinafter appear, will be best understood from the following description, taken in connection with the accompanying drawings of embodiments of the invention herein presented for illustrative purposes.

In the drawings:

Fig. 1 is a top plan view of a device incorporating an illustrative embodiment of the invention;

Fig. 2 is a vertical section on line 2—2 of Fig. 1;

Fig. 3 is a top plan view of the device shown in Fig. 1, certain parts being broken away to show the structure underneath;

Fig. 4 is a plan view of one of the laminae;

Fig. 5 is a perspective view of the tuning member;

Fig. 6 shows illustrative means for the remote control of the invention;

Fig. 7 is a sectional detail showing a substitute device for the ball bearing;

Fig. 8 is a top plan view of a modification of the locking member for limiting the adjustment of the tuning member; and

Fig. 9 is a vertical section on line 9—9 of Fig. 1, on an enlarged scale.

In the drawings an illustrative embodiment of the invention is shown as incorporated in a mag-

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netron, said magnetron comprising an envelope structure 1 forming the anode of the magnetron. This anode structure is made up of laminae 2 and 4, each formed with a central opening 6 and a plurality of radial slots 8 (see Fig. 4) each of which terminates in a circular opening 10. The laminae 2 are of smaller diameter than the laminae 4 and said laminae 2 and 4 are stacked or superposed one upon another alternately, the laminae 4 thus projecting beyond the laminae 2, the projecting portions of the laminae 4 forming cooling fins for the magnetron. Said laminae are preferably stamped from some suitable conductive sheet material, preferably from sheet copper. The laminae are soldered to each other with the corresponding openings therein aligned, thus forming a central bore constituted by the central openings 6 for the reception of a cathode, and a plurality of other bores corresponding to the openings 10. The slots 8 are also aligned, thus forming radial passages interconnecting said central bore with the plurality of surrounding bores. Silver solder is preferably used for soldering the laminae together.

Said envelope structure is hermetically sealed at one end by a cap 12 soldered in place to the edge of said envelope structure 1. At the other end said envelope structure is hermetically sealed by an annular member 14 (see Fig. 2) soldered at its edges to the edge of said envelope structure 1 and provided centrally with a circular metal diaphragm 15 hermetically sealed at its edge in said annular member. Said diaphragm will preferably be undulated to increase the extent of its transverse yielding movement. A screw-threaded stud 16, preferably of copper, is soldered to the outer surface of said diaphragm centrally of the latter, and has screw-threaded connection with a metal disc 18 having a groove 20 in its edge to receive balls 22 of a ball bearing, of which the other ball race is formed by two thin annular plates 24 having bevelled edges to receive the balls and held in place in an annular depression provided in the outer surface of said annular member 14, by a thin flat spring annulus 26 (Figs. 2 and 3), clamped in place by a relatively thin flat metal ring 28 secured to the marginal portion of said annular member 14 by screws 30. A toothed wheel 32 is mounted upon the hub 33 of said disc 18 and is secured to the outer surface of said disc 18 by screws 34. A pinion 36, fast upon one end of a shaft 38, is in mesh with said toothed wheel 32. Said shaft 38 may be provided with a knurled disc 40 (see Fig. 2). A flat annular member 42 (see Figs. 2 and 5)

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of copper or other suitable metal and having a gap at 44 is provided at its inner edge with a rib 46 at right angles thereto and carrying a metal ring 48 soldered to the inner surface of said diaphragm 15 concentrically therewith. Said shaft 38 is herein conveniently mounted in suitable bearings provided between the cooling fins of the device (see Fig. 2). Rotation of said shaft 38 in the right direction will, through the connections above described, move said annular member 42 toward or from the anode structure as the case may be, thus to increase or decrease the frequency, as will be hereinafter more fully explained.

A cathode 50, preferably of the indirectly heated thermionic type, is provided with an outer conducting sleeve 52 of suitable conductive material, nickel for example, coated with an electron-emissive coating, such as barium and strontium oxides, and contains a heater 54. Said heater 54 is supported within said sleeve 52 by having its ends extend through insulating blocks 56, 58 mounted in the opposite ends of said sleeve 52. A lead-in conductor 62 is sealed through a glass seal 64, mounted at the outer end of a conducting pipe 66 extending through the wall of said envelope structure 1 and hermetically sealed and fastened therein adjacent the lower end thereof and is connected to the lower extended end of the heater 54. A second lead-in conductor 68 is sealed through a similar glass seal 70 mounted at the outer end of a conducting pipe 72 likewise hermetically sealed through the wall of said envelope structure 1 at the upper end thereof. The lead-in conductor 68 is connected to the upper, extended end of the heater 54 and the latter is connected to the cathode sleeve 52 by a metal band 69. The lead-in conductors 62 and 68 carry lower and upper shields 60 and 61, respectively, of tantalum, for example, to prevent electron beams from being projected outwardly to the cap 12 and diaphragm 15. Said lower shield 60 may also be connected to the cathode sleeve 52. By the above arrangement the conductors 62 and 68 may serve as the heater current leads, said lead-in conductor 68 also serving as the cathode lead. Said conductors 62 and 68 also serve to support the cathode structure.

A conductor pipe 74 (see Fig. 3) is hermetically sealed through the side of the envelope structure 1 and extends into the interior of the magnetron. The outer end of said pipe 74 carries a glass seal 76 through which is sealed a lead-in conductor 77 having its inner end connected to one end of a coupling loop 78 in one of the bores formed by the superposed openings 10. The other end of the coupling loop 78 may be connected to the outer wall of said pipe 74. Said loop is in a plane at right angles to the longitudinal axis of the bore in which it is located and thus is inductively coupled to one of the bores formed by the aligned openings 10 in the superposed laminae 2 and 4. A second conducting pipe (not shown) may be connected to said pipe 74 and surround the latter, thus forming a concentric transmission line therewith so that the oscillations generated by the device may be transmitted to the desired point.

The pipes 66, 72 and 74 are preferably soldered in place by silver solder.

It will be seen that in the completed assembly the anode structure comprises a plurality of substantially wedge-shaped arms 82 (see Figs. 2 and 4), the faces 84 of which are adjacent the cathode 50 and cooperate as anode sections with said

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cathode. A capacity exists between said cathode and each of said anode faces 84. Capacitances also exist between the side walls of each of the aligned slots 8. The inner walls of the aligned openings 10 constitute inductances. When the magnetron is energized and placed between pole pieces, such as 86 and 88 (see Fig. 2), it generates oscillations as mentioned above. The frequency of these oscillations is determined by the inductances and capacitances above mentioned. These inductances and capacitances constitute resonant circuits. It is desired that these circuits shall be resonant at definite predetermined frequencies within the range of frequencies at which the device is to operate. The device is intended to operate so that each oscillating cavity 10 shall be tuned to the frequency at which each of the other oscillating cavities 10 oscillates.

According to my present understanding of the operation of the present invention, varying the position of the annular member 42 relatively to the anode structure as above mentioned will vary the capacitances of the anode structure and consequently the frequency of the oscillations generated by the device, without affecting the inductances of said structure to the same degree. Thus I have found that movement of said flat annular member 42 toward the anode structure will increase the frequency, while movement of said annular member away from the anode structure will decrease the frequency. The present invention therefore enables the device to be adjusted to generate oscillations of any frequency within the range of frequencies that the device can generate. Furthermore, if due to changes in temperature the dimensions of the electron structure of the device should be so changed as to change the frequency from that desired, adjustment of said annular member 42 toward or from the anode structure as the case may require, according as the change in frequency is due to rise or to fall in temperature, will restore the original frequency.

Instead of the manual control of the tuning member, shown in Fig. 2, the control may be effected from a distance. Fig. 6 shows illustrative means for this purpose comprising a small reversible motor 90 of conventional construction, supplied with electrical energy from a suitable source, not shown, and controlled by a conventional reversing key 92 or other suitable means. The shaft of said motor may be operatively connected to said shaft 38, as by a flexible shaft 93 splined to the end of said shaft 38. This is particularly useful where the device is used in aircraft, as it enables the device to be located remote from the cockpit, where it will be the least exposed to harmful influences, and still be controlled from the cockpit.

Fig. 7 shows an alternative device which may be used in place of the ball bearing structure 18, 22, 24; said alternative device consisting of an anti-friction metal disc 94 having a central hub 96 interiorly screw-threaded for screw-threaded connection with said screw-threaded stud 16 and is provided upon its underside, around its edge, with a thin rib 97. This disc 94 is placed in a depression provided on the outer surface of annulus 14 and is held in place by said resilient annulus 26 and clamping ring 28 secured to the end surface of said envelope structure 1 by screws 30. The rib 97 rests upon a shoulder 99 thus reducing friction. Said disc 94 is no thicker than the ball bearing 18, 22, 24 and is provided with three holes for the above-mentioned screws 34 by

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which to fasten said disc to the underside of said toothed wheel 32.

The invention contemplates the provision of means for limiting the adjustment range of said annular member 42. Said means herein illustratively comprises a small disc 98 (see Fig. 3) rotatably mounted upon one end of a screw-threaded stud 100 screwed into the cooling fins of the device, as shown in Figs. 3 and 9. A recess 104 is provided in the periphery of said disc 98 and a pin 106 projects from the underside of said toothed wheel 32 near the edge of the latter. The arrangement is such that when the annular member 42 is at either extreme of its range of adjustment, said pin 106 will be in engagement with the edge of said disc 98 at one side or the other at said recess 104, as shown in dotted lines in Fig. 3, and said toothed wheel 32 will thus be locked against further rotation clockwise, viewing said figure. If the said toothed wheel be now rotated contraclockwise, viewing said Fig. 3, the pin 106 upon reaching said disc 98 will register with and engage said recess 104 in the edge of said disc 98 and rotate it through an angle sufficient to free said pin 106, thus permitting further rotation of said toothed wheel in the same direction. When, however, in such further rotation, the pin 106 again reaches said disc 98, said pin will engage the edge of said disc and arrest further rotation of said toothed wheel, because, by the angular movement imparted to said disc 98 by engagement of said pin 106 with said recess in the first revolution of said toothed wheel, said disc 98 was moved out of position to register with said pin. In the illustrative embodiment of the invention herein disclosed, only two consecutive revolutions of said toothed wheel in each direction are possible, that being sufficient to permit selective adjustment of said tuning member to generate oscillations of any frequencies within the range of frequencies of said illustrative embodiment. In the case of a tube possessing a greater range of frequencies, it is only necessary to increase the number of recesses, such as 104, suitably spaced to allow, as it is revolved, said pin 106 to engage each of said recesses in succession before it is arrested, thus increasing the range of adjustment. In Fig. 8, for example, three recesses 104 are shown instead of one. It will be understood that each time said pin engages a recess, it moves the disc through an angle sufficient to bring the next following recess into position to be engaged by said pin during the next revolution of said toothed wheel. In the revolution of said toothed wheel following that in which said pin engaged the last recess, however, said pin will engage the edge of said disc behind the last recess, thus arresting the adjustment.

The stop device, above described, precludes adjustment of the tuning member so close to the anode structure as to cause a short circuit.

A shield may be provided to protect said disc 98. Said shield conveniently comprises a semi-annular plate 103 partly overlying said disc and mounted upon said screw-threaded stud 100 by means of a supporting plate 105 parallel thereto and spaced therefrom by a rib 107, said screw-threaded stud 100 extending through holes in said circular plate 103 and said supporting plate 105 and being screwed in place by said screw-threaded stud 10. A spacing ring 109 is mounted upon said stud 100 between said semi-annular plate 103 and said supporting plate 105 and is provided at its top with a thin hub portion 111. A spring washer 113 surrounds said hub portion 111 so

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that when said screw-threaded stud is screwed down into place said disc 98 will be clamped between said spring washer and said plate 103 sufficiently tight to prevent accidental rotation of said disc 98, but not sufficiently tight to prevent rotating of said disc when the recess 104 therein is engaged by said rotating pin 106, as close contact of said disc 98 with said ring 109 is prevented by engagement of the head of said screw-threaded stud 100 with the upper edge of said hub 111.

It will be noted that the space for the tuning member is obtained by eliminating that part of the top laminae within the envelope structure 1. This and the compact structure of the ball bearing 18, 22, 24 keep the height of the device within normal limits.

A protective shield 114, preferably of transparent material, may be provided for the glass seals 64 and 70 secured by screws 115 to a plate 116, said plate being secured to the cooling fins by a bracket 117 and screws 118.

Whenever the expression "a plurality" occurs it is to be construed as meaning "two or more."

I am aware that the present invention can be embodied in other specific forms without departing from the spirit or essential attributes thereof, and I therefore desire that the present description be considered in all respects as illustrative and not restrictive, reference being had to the appended claims rather than to the aforesaid description to indicate the scope of the invention.

What is claimed is:

1. An electron-discharge device comprising: a cathode; an anode, including a plurality of cavity resonators, spaced from and surrounding said cathode; a flexible diaphragm secured to said anode; a tuning member supported by said flexible diaphragm in spaced relation to said cavity resonators; a pair of threadedly-engaged, relatively-rotatable members, one of which is secured to said flexible diaphragm and the other of which is rotatably mounted with respect to said anode, for adjusting the spacing between said tuning member and said cavity resonators; and a ball bearing intermediate said last-named relatively-rotatable member and said anode, said ball bearing including a race formed in said last-named relatively-rotatable member, a pair of spring-pressed, race-forming members carried by said anode, and bearing balls supported intermediate said race and race-forming members.

2. An electron-discharge device comprising: a cathode; an anode, including a plurality of cavity resonators, spaced from and surrounding said cathode; a flexible diaphragm secured to said anode; a tuning member supported by said flexible diaphragm in spaced relation to said cavity resonators; a pair of threadedly-engaged, relatively-rotatable members, one of which is secured to said flexible diaphragm and the other of which is rotatably-mounted with respect to said anode, for adjusting the spacing between said tuning member and said cavity resonators; a ball bearing intermediate said last-named relatively-rotatable member and said anode, said ball bearing including a race formed in said last-named relatively rotatable member, a pair of spring-pressed race-forming members carried by said anode, and bearing balls supported intermediate said race and race-forming members; and means, journaled in said anode and engageable with said last-named relatively-rotatable member, for rotating the latter whereby said tuning member

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is moved toward or away from said cavity resonators.

3. An electron-discharge device comprising: a cathode; an anode, including a plurality of cavity resonators, spaced from and surrounding said cathode; a flexible diaphragm secured to said anode; a tuning member supported by said flexible diaphragm in spaced relation to said cavity resonators; a pair of threadedly-engaged, relatively-rotatable members, one of which is rotatably-mounted with respect to said anode, for adjusting the spacing between said tuning member and said cavity resonators; a ball bearing intermediate said last-named relatively-rotatable member and said anode, said ball bearing including a race formed in said last-named relatively-rotatable member, a pair of spring-pressed race-forming members carried by said anode, and bearing balls supported intermediate said race and race-forming member; means, journaled in said anode and engageable with said last-named relatively-rotatable member, for rotating the latter whereby said tuning member is moved toward or away from said cavity resonators; a pin carried by said last-named relatively-rotatable member; and a cam member pivotally mounted on said anode and engageable with said pin for limiting the movement of said last-named relatively-rotatable member.

4. An electron discharge device comprising: a cathode; an anode, including a plurality of cavity

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resonators, spaced from and surrounding said cathode; a flexible member secured to said anode; a tuning member supported by said flexible member in spaced relation to said cavity resonators; means, operatively connected to said flexible member, for adjusting the spacing between said tuning member and said cavity resonators; and means, including a pin carried by said adjusting means, and a cam having peripherally-disposed teeth carried by said anode and engageable with said pin, for limiting the movement of said adjusting means.

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