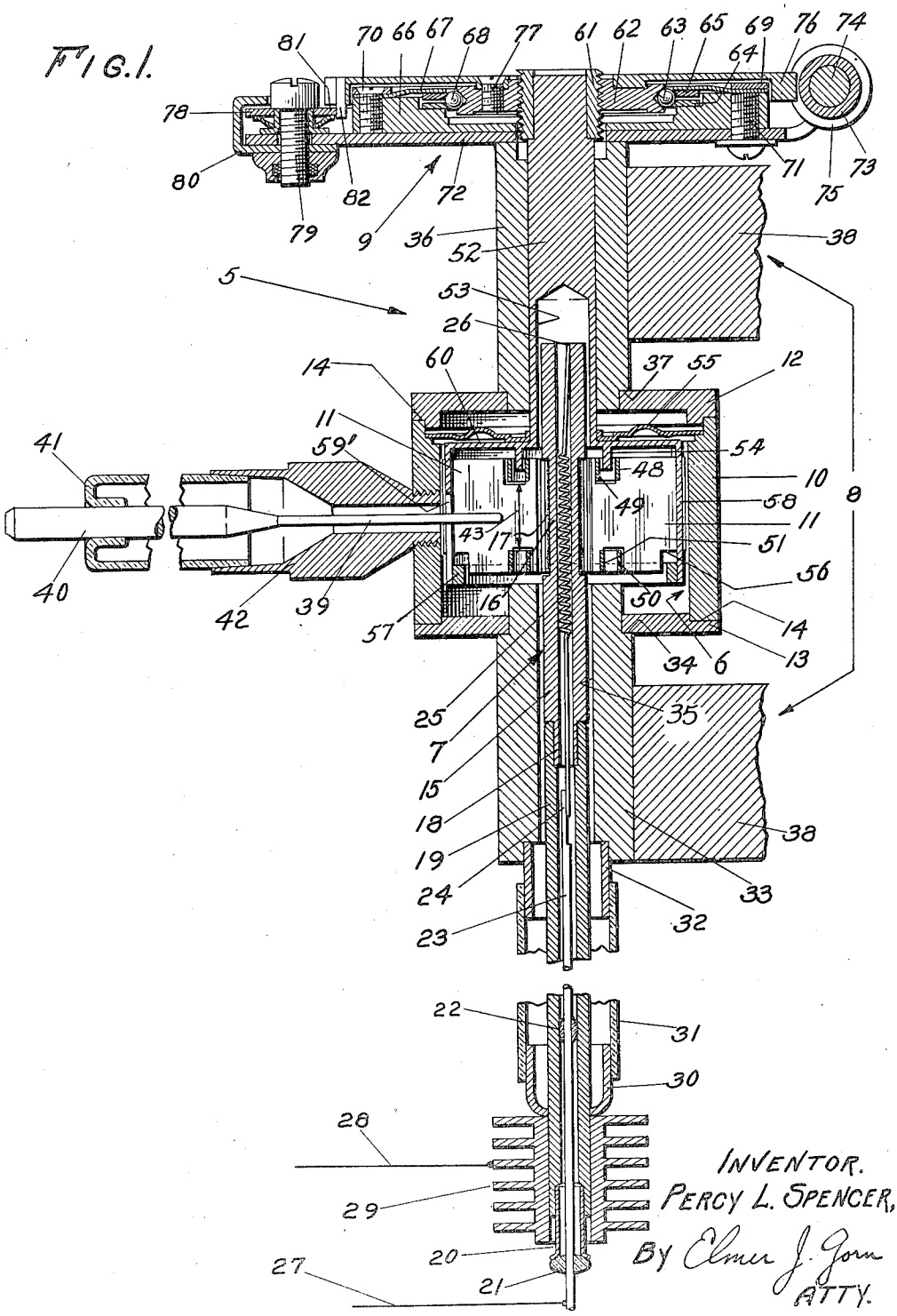
Sept. 6, 1949. P. L. SPENCER 2,481,171

ELECTRON DISCHARGE DEVICE

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FIG. 1.



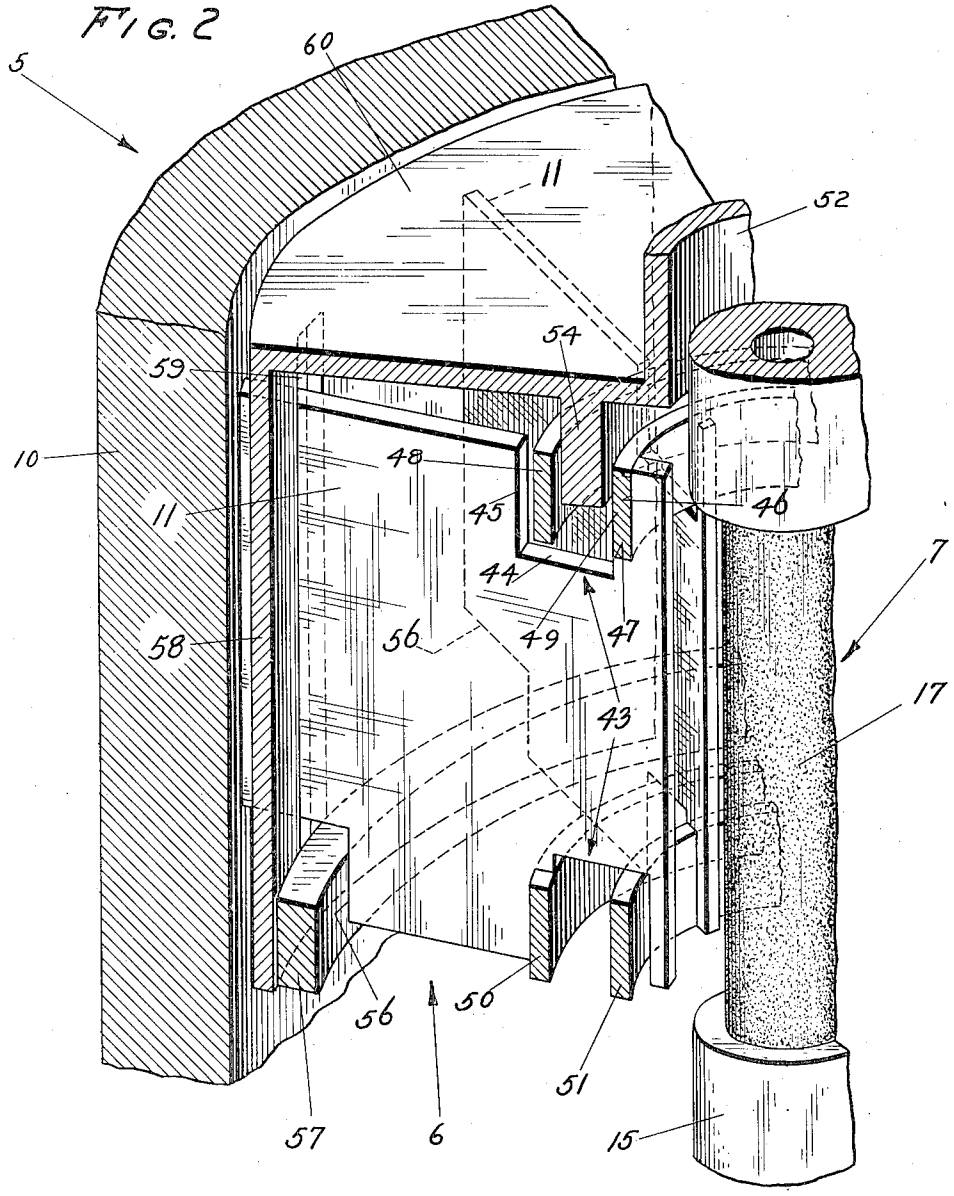
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FIG. 2



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2,481,171

ELECTRON DISCHARGE DEVICE

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7 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 electron-discharge devices of the so-called magnetron type.

The main object of my present invention is to provide means for tuning an electron-discharge device through a much greater frequency range than has heretofore been possible, and to this end I so construct the device that both the capacitance and inductance thereof are simultaneously varied, each to a considerable degree, and in the same direction.

This, 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 particularly well adapted to the tuning of electron-discharge devices of the magnetron type. I prefer that said device include at least one electrode, for example, the anode thereof, in the form of a cylindrical structure, made of highly conductive material, such as copper, and provided with a plurality of interiorly-extended, radially-disposed anode members, each adjacent pair of said anode members, together with that portion of said anode structure lying therebetween, constituting walls defining a cavity resonator.

I provide at least some of said defining walls, preferably, those comprised of said anode members, with at least one gap therein, said gap serving to increase the distributed inductance of each anode member provided therewith over what it would be in the absence of such a gap. By moving a conducting member in and out of each such gap, I am able to vary said distributed inductance, said distributed inductance being maximum when said conducting member is entirely withdrawn from said gaps. Preferably, said conducting member is so formed that it also is movable in and out of the space comprising one or more of said cavity resonators, thereby providing additional control over the inductance, generally, of the device. As a matter of fact, either of the above-described inductance-controlling expedients may be utilized alone, although, as stated, it is preferred that they be used together.

I further provide said anode members with at least one pair of conducting straps which alternately contact successive anode members, the straps of each pair being so disposed with respect to each other so as to present a capacitance therebetween. By introducing a conducting member

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into the space between one of the pairs of said conducting straps, I am able to alter the inter-strap capacitance, said inter-strap capacitance being minimum when said conducting member is entirely withdrawn from between said straps.

Thus, by moving both of the above referred to conducting members with respect to said gaps and cavity resonator spaces, and said straps, I am able to alter the distributed inductance and the distributed capacitance built into the device as a function of the geometry thereof, and so tune said device to a frequency other than its natural resonant frequency.

Preferably, both of said conducting members are moyable as a unit, one of said conducting members being withdrawn from the gaps and cavity resonator spaces as the other conducting member is introduced between the straps, thereby altering both the inductance and capacitance at the same time, in the same direction, and enabling the attainment of an appreciable frequency deviation, which is continuous, and substantially linear.

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 a tunable magnetron made in accordance with the principles of my present invention; and

Fig. 2 is an enlarged, perspective view of a portion of said magnetron, more clearly showing the relationships between the components of the above referred to tuning means.

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 generaly designates an electron-discharge device of the so-called magnetron type. Said device comprises an anode structure 6, a cathode structure 7, magnetic means 8 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 9.

In the device shown, the anode structure 6 includes a cylindical body 10 made of highly con-

ductive material, such as copper, said body being provided with a multiplicity of radially-disposed, interiorly-extending anode members in the form of vanes 11, each adjacent pair of said vanes, together with that portion of said cylindrical body lying therebetween, defining the walls of a cavity resonator whose natural resonant frequency is, as is well known in the art to which my present invention relates, a function of the geometry of the physical elements making up the same. I shall further describe the anode members 11 when referring, in a later portion of this specification, to the details of the tuning means 9.

The anode structure is closed at its ends, for example, by end plates 12 and 13, with the junctions between the cylindrical body 10 of said structure, and said plates 12 and 13, hermetically sealed, as at 14.

The cathode structure 7, which is coaxial with the anode structure 6, includes a cathode sleeve 15, conventionally made of nickel, or the like, provided with a reduced portion 16 whose length, preferably, is coextensive with the width of the anode members 11, said reduced portion 16 being provided with a highly electron-emissive coating 17, for example, of the well-known alkaline-earth metal oxide type.

In order properly to support the cathode sleeve 15 with respect to the anode members 11, said sleeve may be reduced, as at 18, to fit into an elongated, electrically-conductive tubular member 19 having, at its outer end, a ferrule 20 closed by a glass seal 21. Said seal, together with one or more glass beads 22 disposed within the tubular member 19, support a lead-in conductor 23 which passes through said member 19 and has its upper end connected, as at 24, to one terminal of a cathode heating filament 25. The other terminal of said filament may be connected, as at 26, to the cathode sleeve 15.

In order to convey current to the filament 25, the lead-in conductor 23 is connected by a conductor 27 to one terminal of a suitable source of voltage (not shown), the other terminal of said source of voltage being connected by a conductor 28 to a heat-dissipating member 29 fixed upon the lower end of the tubular member 19.

In order properly to support the cathode 7, and insulate the same from the anode structure 6, the tubular member 19 may have fixed thereto a cup-like bushing 30 sealed into one end of a glass tube 31, the other end of said glass tube having sealed therein a tubular bushing 32, in turn, secured to a tubular pole piece 33, constituting one of the components of the magnetic means 8.

Said pole piece 33 may be hermetically sealed, as at 34, into the end plate 13, and be provided with a central bore 35 whereby the cathode structure 7 may enter the device.

Another tubular pole piece 36 may be hermetically sealed, as at 37, into the end plate 12, said pole piece and the pole piece 33 being fixed, for example, to the opposite ends of a horseshoe magnet 38 (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 7 and anode structure 6.

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 wave length 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 cavity resonators defined by the anode structure.

In order to extract power from the device I may, for example, introduce a loop 39 into one of said cavity resonators, said loop coupling with the magnetic component of the above-mentioned electrical oscillations. Said loop may, in turn, be connected to a conductor 40 supported in a glass seal 41 fused into an outlet pipe 42, said pipe being threaded and hermetically sealed into the cylindrical body 10 of the anode structure 6.

In the device thus far described, there is no external control over the frequency of the generated oscillations, and in order to overcome this deficiency, I proceed as follows:

Each anode member 11 is provided, preferably, in both its upper and lower edges, adjacent its inner end, with cutaway portions or slots 43, each slot being defined by a straight bottom edge 44, a straight side edge 45, and a shouldered side edge 46, the shoulder being designated by the reference character 47. Said upper and lower slots are laterally reversed with respect to each other, whereby the straight side edge 45 of one of said slots, say, the upper slot in the particular anode member 11 being described, is in substantial alignment with the shouldered side edge 46 of the lower slot in said anode member, and the shouldered side edge 46 of said upper slot is in substantial alignment with the straight side edge 45 of said lower slot. By so forming each anode member 11, and inverting adjacent members with respect to each other, a single type of element can be utilized for all of said anode members.

I now provide an annular member or strap 48, which seats upon all of the shoulders 47 of the side edges 46 of the upper slots 43 in alternate anode members 11, said strap clearing the straight side edges 45 in the adjacent, inverted anode members. I also provide a similar, but smaller-diameter strap 49, which seats upon the shoulders 47 of the side edges 46 of the upper slots in said adjacent, inverted anode members, said strap 49 clearing the straight side edges 45 in said first-mentioned alternate anode members.

The straps 48 and 49 are thus concentrically disposed with respect to each other, and present a capacitance therebetween which enters into the determination of the natural resonant frequency of the device.

The lower slots 43 in the anode members 11 may, if desired, also be provided with concentrically disposed straps 50 and 51, and if such straps are provided, they, too, enter into the determination of the natural resonant frequency of the device.

It has been found that when alternate anode members are electrically inter-connected as just described by the straps 48 to 51 inclusive, spurious oscillations become suppressed.

Now, it has also been found that inasmuch as the straps of each pair thereof have a capacitance therebetween, and they may be considered the plates of a capacitor, by varying said capacitance, and introducing additional capacitance in parallel therewith, the device can be tuned, and to this end, I proceed as follows:

A plunger 52, made of highly conductive material, such as copper, is slidably mounted in the bore of the tubular pole piece 36, the inner end of said plunger being recessed, as at 53, to accommodate the upper end of the cathode structure

6, and the extremity thereof being cupped to provide a conducting annulus 54, which, when moved, for example, intermediate the straps 48 and 49, constitutes, together with said straps, a variable capacitor. In order to maintain the device air-tight, I provide an apertured, flexible diaphragm 55, hermetically sealed, at its periphery, to the cylindrical body 10 of the anode structure 6, and similarly sealed, at its central aperture, to said plunger 52.

The introduction of the annulus 54 into the space between the straps 48 and 49 does two things. First, it reduces the effective area of the surfaces of said straps between which the above-mentioned capacitance exists, but inasmuch as this capacitance is small to begin with, the overall effect on the frequency of the device is, likewise, small. Second, it forms, together with said straps, two capacitors, connected in series, which did not, before, exist. Inasmuch as the gaps between said annulus and said straps are small, the total capacitance of the newly formed capacitors is relatively large, and this capacitance, added in parallel with what remains of the original capacitance, has a considerable effect upon the frequency of the device.

I shall now describe my means for varying the inductance of the device.

I provide at least some, and preferably, all of the anode members or vanes 11, at the lower, outer corner thereof, with gaps 56. A conducting ring 57 is adapted to be moved in and out of said gaps 56, thereby altering the distributed inductance of each vane 11 provided with such a gap. Now, the ring 57 being, preferably, continuous, its movement with respect to the gaps 56 results in its movement in and out of the space of each cavity resonator. This provides additional control over the inductance of the device.

The ring 57 may be secured at the lower end of a cylindrical shell 58 nested within, but spaced from, the cylindrical body 10, said shell being provided with slots 59 and 59' to accommodate, respectively, the vanes 11 and the loop 39. The upper end of the shell 58 may be provided with a horizontal disc 60, with which the annulus 54 may, if desired, be integrally formed.

There remains to be described the control mechanism of the tuning means 9, by means of which there may be brought about the hereinbefore described relative movement between the annulus 54 and straps 48 and 49, and the ring 57 and gaps 56.

While not limited thereto, I prefer to construct such tuning control means as follows:

Secured on the upper end of the plunger 52 is a threaded bushing 61 engageable in a disc 62 whose periphery may be provided with a V-cut 63, constituting a ball-bearing race. Surrounding said race is another race comprised of two cooperating bevelled rings 64 and 65, the ring 64 being carried by a disc 66, and the ring 65 being pressed into cooperation with said ring 64 by an annular spring 67. The races are receptive therebetween of bearing balls 68, and the spring 67 is affixed to the disc 66 by a flat, retaining ring 69 and bolts 70.

The disc 66 is maintained against rotation by being bolted, as at 71, to a plate 72 fixed, at its center, to the pole piece 36, the plate 72 being provided with bearings 73 in which is journalled a shaft 74. Mounted upon the shaft 74 is a worm gear 75 engageable with a worm wheel 76 secured to the disc 62 by means of bolts 77. The shaft 74 is provided, at one end, with a pinion (not shown), or any other means whereby the same may be manually or otherwise rotated, slidably to move the plunger 52 with respect to the pole piece 36, and thus vary the capacitances between the straps 48 and 49, the inductances of the vanes 11 provided with the gaps 56, and the inductance, generally, of each cavity resonator.

In order to protect the device against damage which might be caused by excessive movement of the plunger 52, I provide means for limiting the rotation of the worm wheel 76. Such means may comprise a cam 78 pivotally mounted upon a bolt 79 which is fixed in a bracket 80 carried by the plate 72, said cam having a tooth 81 cooperable with a pin 82 carried by the worm wheel 76. The arrangement is such that the first time the pin 82 approaches the cam 78, it engages the tooth 81 thereof and trips the same, whereby the next time the pin 82 comes around, it abuts the surface of the cam and cannot pass the same. Rotation of the worm wheel in the opposite direction causes a reversed disposition of the cam, thereby limiting said rotation to two revolutions in each direction.

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 relatively simple means for tuning an electron-discharge device, particularly, a magnetron, through an appreciable frequency range, the tuning means of my present invention enabling simultaneous alteration, in the same direction, of both the inductance and capacitance of the device. It will also be noted that the frequency deviation thereby obtained is continuous and linear.

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: an electrode structure provided with electrode members; each pair of adjacent electrode members, together with that portion of said electrode structure lying therebetween, constituting walls defining a cavity resonator; the defining walls of at least one of said cavity resonators being provided with a gap therein forming part of the distributed inductance thereof; spaced means, cooperable with the defining walls of at least one of said cavity resonators, presenting, in parallel with the distributed capacitance thereof, an additional distributed capacitance; and means, carried by said device and movable into and out of each of said gaps and intermediate said spaced means, for simultaneously altering, in the same direction, said distributed inductance and said last-named distributed capacitance.

2. A tunable electron-discharge device comprising: a cathode structure; a cylindrical anode structure surrounding said cathode structure, and provided with a plurality of inwardly-directed, radially-disposed anode members; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, constituting walls defining a cavity resonator; the defining walls of one of said cavity resonators being provided with a gap therein forming part of the distributed inductance thereof; means, cooperable with the defining walls of said one of said cavity resonators, presenting, in parallel with the distributed capacitance thereof, an additional distributed capacitance; a shell, movably mounted in said device,

and having slots in one of the walls thereof for straddling said anode members; and means, carried by said shell and movable thereby with respect to each of said gaps and said last-named means, for simultaneously altering, in the same direction, said distributed inductance and said last-named distributed capacitance.

3. A tunable electron-discharge device comprising: an electrode structure provided with electrode members; each pair of adjacent electrode members, together with that portion of said electrode structure lying therebetween, constituting walls defining a cavity resonator; the defining walls of at least one of said cavity resonators being provided with a gap therein forming part of the distributed inductance thereof; a pair of conductors alternately contacting said electrode members; said conductors presenting a distributed capacitance therebetween; and means, carried by said device and movable into and out of each of said gaps and intermediate said conductors, for simultaneously altering, in the same direction, said distributed inductance and said inter-conductor distributed capacitance.

4. A tunable electron-discharge device comprising: a cathode structure; a cylindrical anode structure surrounding said cathode structure, and provided with a plurality of inwardly-directed, radially-disposed anode members; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, constituting walls defining a cavity resonator; the defining walls of one of said cavity resonators being provided with a gap therein forming part of the distributed inductance thereof; a pair of conductors alternately contacting said anode members; said conductors presenting a distributed capacitance therebetween; a shell, movably mounted in said device and having slots in one of the walls thereof straddling said anode members; and means, carried by said shell and movable thereby with respect to each of said gaps and said conductors, for simultaneously altering, in the same direction, said distributed inductance and said inter-conductor distributed capacitance.

5. A tunable electron-discharge device comprising: an electrode structure provided with electrode members; each pair of adjacent electrode members, together with that portion of said electrode structure lying therebetween, constituting walls defining a cavity resonator; the defining walls of one of said cavity resonators being provided with a gap therein forming part of the distributed inductance thereof; a pair of conductors alternately contacting said electrode members; said conductors presenting a distributed capacitance therebetween; means, carried by said device and movable with respect to each such gap, for altering said distributed inductance; a third conductor, movable intermediate said first-named conductors, for altering said inter-conductor distributed capacitance; and adjustable means, carried by said device, for moving said last-named means and said third conductor as a unit, whereby the alterations in said distributed inductance and in said distributed capacitance are simultaneous, and in the same direction.

6. A tunable electron-discharge device comprising: an electrode structure provided with electrode members; each pair of adjacent electrode members, together with that portion of said electrode structure lying therebetween, constituting walls defining a cavity resonator; the defining walls of one of said cavity resonators being provided with a gap therein forming part of the distributed inductance thereof; spaced means, cooperable with the defining walls of said one of said cavity resonators, presenting, in parallel with the distributed capacitance thereof, an additional distributed capacitance; a conducting ring, movable into and out of each of said gaps, for altering said distributed inductance; means, carried by said device and movable intermediate said spaced means, for altering said last-named distributed capacitance; and means, connecting said conducting ring and said last-named means, for moving said conducting ring and said last-named means as a unit, whereby the alterations in said distributed inductance and in said last-named distributed capacitance are simultaneous, and in the same direction.

7. A tunable electron-discharge device comprising: a cathode structure; a cylindrical anode structure surrounding said cathode structure, and provided with a plurality of inwardly-directed, radially-disposed anode members; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, constituting walls defining a cavity resonator; each of said anode members being provided with a gap therein forming part of the distributed inductance thereof; a pair of conductors alternately contacting said anode members; said conductors presenting a distributed capacitance therebetween; a shell, movably mounted in said device, and having slots in one of the walls thereof straddling said anode members; a conducting ring, carried by said shell and movable thereby with respect to each of said gaps, for altering said distributed inductance; a third conductor, carried by said shell and movable thereby intermediate said first-named conductors, for altering said inter-conductor distributed capacitance; and means carried by said device for moving said shell, whereby the alterations in said distributed inductance and in said distributed capacitance are simultaneous, and in the same direction.

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