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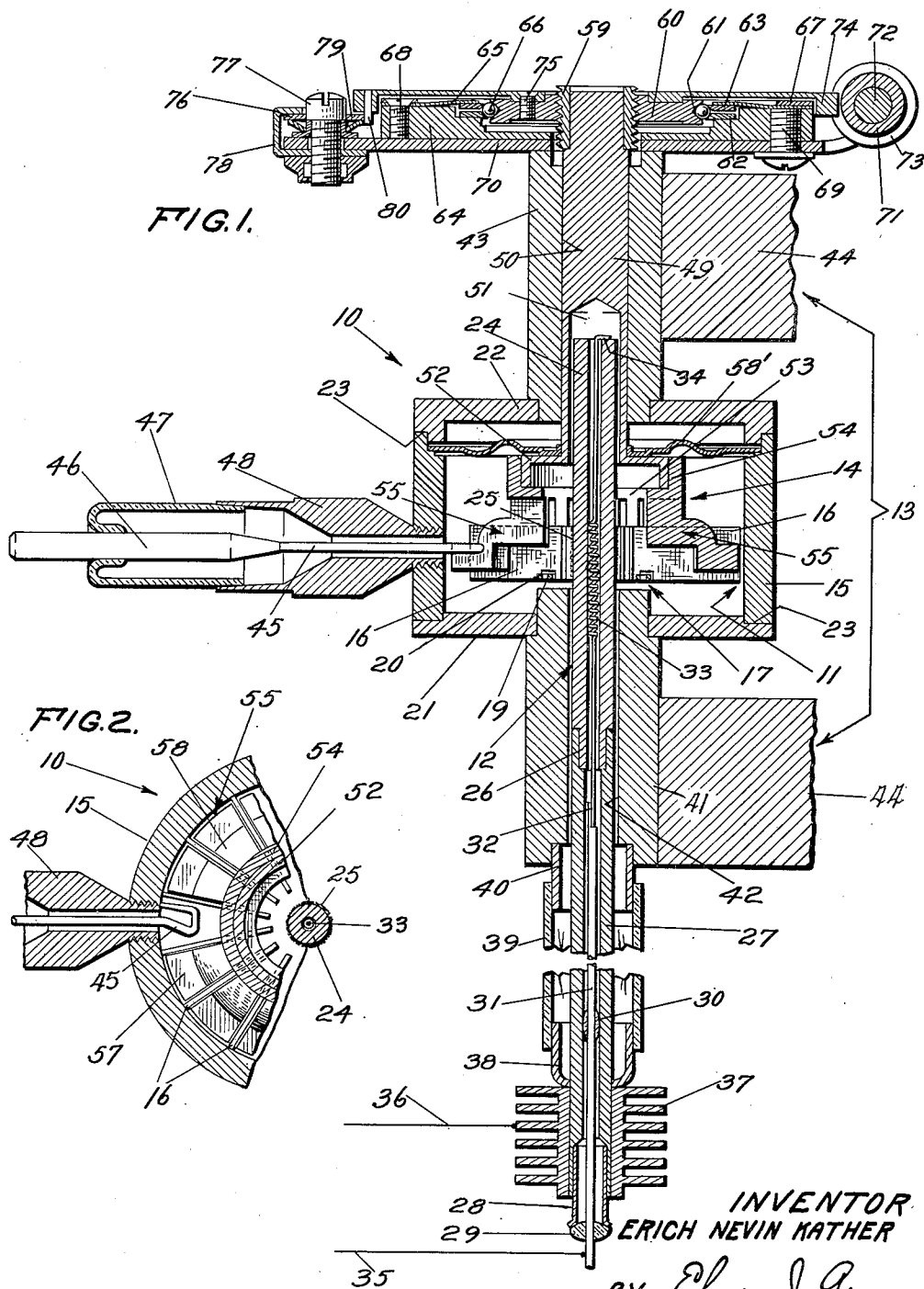
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TUNABLE ELECTRON DISCHARGE DEVICE

Filed May 10, 1946

2 Sheets-Sheet 1



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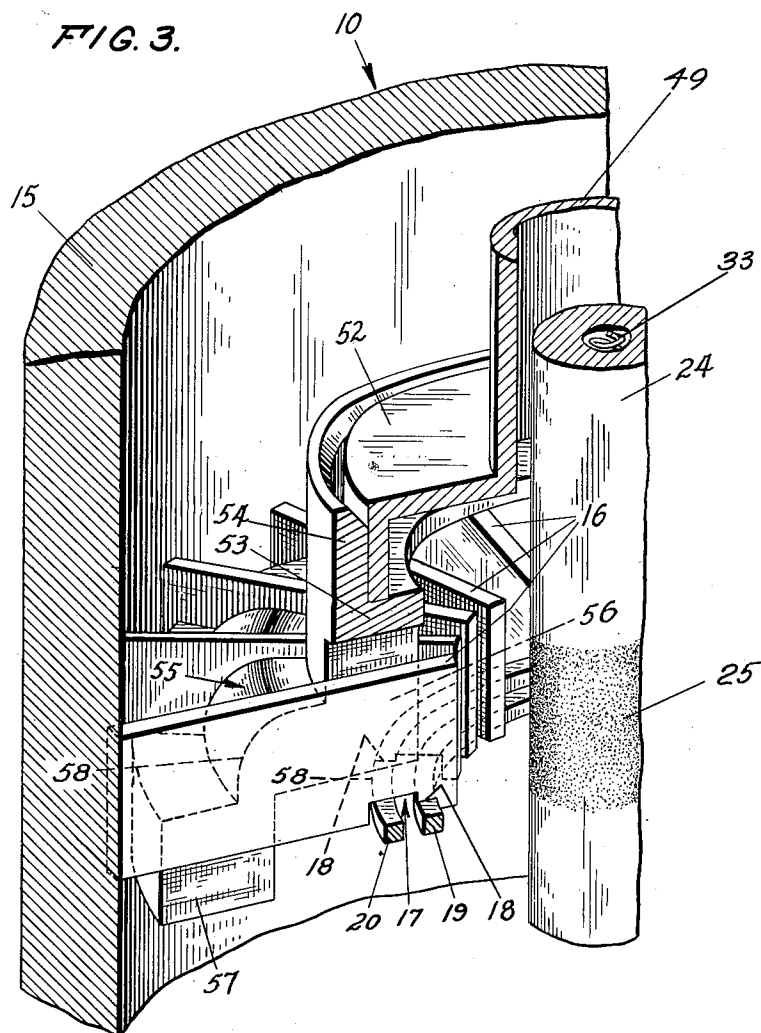
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TUNABLE ELECTRON DISCHARGE DEVICE

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2 Sheets-Sheet 2



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TUNABLE ELECTRON DISCHARGE DEVICE

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7 Claims. (Cl. 250—27.5)

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This invention relates to electron-discharge devices, and more particularly to tunable electron-discharge devices of the so-called magnetron type.

The main object of the 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, the device is so constructed that both the capacitance and inductance thereof may simultaneously be varied, each to a considerable degree, and in the same direction.

This, 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 particularly well adapted to the tuning of electron-discharge devices of the magnetron type. It is preferred that said devices 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-extending, radially-disposed anode members, each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, defining a cavity resonator.

While not absolutely necessary, it has been found advisable in order to suppress spurious oscillations in devices of the type to which the present invention relates, to provide the anode structure thereof with at least one pair of conducting straps alternately contacting successive anode members, said straps presenting a capacitance therebetween which, together with the distributed capacitance and inductance built into the device as a function of the geometry thereof, enters into a determination of the natural resonant frequency thereof.

Each of the anode members of the anode structure has a certain distributed inductance, and it has been found that by moving a conducting member in and out of each of the above-referred to cavity resonators, in the vicinity of each of said anode members, the aforesaid distributed inductance may be considerably altered, said inductance being maximum when said conducting members are substantially entirely withdrawn from said cavity resonators.

Between each pair of adjacent anode members capacitance exists, said capacitance being of greatest value intermediate the inner ends of said anode members, adjacent the cathode of the device. It has been found that by moving

a conducting member intermediate each pair of adjacent anode members, preferably, in the high-capacitance regions thereof, considerable additional capacitance may be added in parallel with that already existing.

Hence, by moving all of the above-referred to conducting members with respect to the cavity resonators, the distributed inductance and the distributed capacitance of the device may be greatly altered, and said device may be tuned to a frequency considerably different from its natural resonant frequency.

Preferably, said conducting members are movable as a unit, the first above-named conducting members being withdrawn from the cavity resonators as the second above-named conducting members are introduced therein, 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 there shall be described and in the annexed drawings shown an illustrative embodiment of the tunable electron-discharge device of the present invention. It is, however, to be clearly understood that the present invention is not 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 the present invention;

Fig. 2 is a fragmentary transverse sectional view taken substantially through the center of said magnetron, in a plane at right angles to the sectional plane of Fig. 1; and

Fig. 3 is an enlarged, perspective view of a portion of said magnetron, more clearly showing the relationships between the various components of the above briefly described tuning means.

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 10 generally designates an electron-discharge device of the so-called magnetron type, said device comprising an anode structure 11, a cathode structure 12, magnetic means 13 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 14.

In the device shown, the anode structure includes a cylindrical body 15, made of highly conductive material, such as copper, said body being provided with a multiplicity of radially-disposed, interiorly-extending anode members in the form of vanes 16, each pair of adjacent anode members or vanes, together with that portion of said cylindrical anode structure lying therebetween, defining a cavity resonator whose natural resonant frequency is, as is well known in the art to which the present invention relates, a function of the geometry of the physical elements making up the same.

Because of the numerous paths which the oscillating energy can take in a structure of the nature described, spurious oscillations appear which reduce the efficiency of the device, and in order to eliminate such spurious oscillations, each anode member 16 may be provided, in its lower edge, with a slot 17, the opposite side edges of the slots in adjacent anode members being provided with shoulders 18 upon which there may be seated concentrically-disposed, circular conducting straps 19 and 20, said straps alternately contacting successive anode members and thereby assuring that alternate anode members will always be at the same instantaneous potential.

The anode structure 11 is closed at its ends, for example, by end plates 21 and 22, with the junctions between the cylindrical body 15 of said structure, and said plates 21 and 22 hermetically sealed, as at 23.

The cathode structure 12, which is coaxial with the anode structure 11, includes a cathode sleeve 24, conventionally made of nickel, or the like, a portion of said sleeve, preferably, coextensive with the height of the vanes 16, being provided with a highly electron-emissive coating 25, for example, of the well known alkaline-earth metal oxide type.

In order properly to support the cathode sleeve 24 with respect to the anode members 16, said sleeve may be reduced as at 26, to fit into an elongated, electrically-conductive tubular member 27 having at its outer end a ferrule 28 closed by a glass seal 29, said seal, together with one or more glass beads 30 disposed within the tubular member 27, supporting a lead-in conductor 31 which passes through said member 27 and has its upper end connected, as at 32, to one terminal of a cathode heating filament 33. The other terminal of said filament may be connected, as at 34, to the cathode sleeve 24.

The lead-in conductor 31 may be connected by a conductor 35 to one terminal of a suitable source of voltage, not shown, the other terminal of said source of voltage being connected by a conductor 36 to a heat dissipating member 37 fixed upon the lower end of the tubular member 27. By the means just described, heating current may be conveyed to the filament 33.

In order properly to support the entire cathode structure 12, and insulate the same from the anode structure 11, the tubular member 27 may have fixed thereto a cup-like bushing 38 sealed into one end of a glass tube 39, the other end of said glass tube having sealed therein a tubular bushing 40, in turn, secured in the lower end of a tubular pole piece 41 constituting one of the components of the above-referred to magnetic means 13. The pole piece 41 may be hermetically sealed into the end plate 21, and be

provided with a central bore 42 whereby the cathode structure 12 may enter the device.

Another tubular pole piece 43 may be hermetically sealed into the end plate 22, said pole piece and the pole piece 41 being fixed, for example, to the opposite ends of a horseshoe magnet 44 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 12 and the anode structure 11.

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 distributed capacitance and inductance built into the same as a function of the geometry thereof, and more especially, of the dimensions of the above referred to cavity resonator defined by the elements constituting the anode structure.

In order to extract power from the device, a loop 45 may be introduced into the space intermediate any two anode members 16, said loop coupling with the magnetic component of the above-mentioned electrical oscillations. Said loop may, in turn, be connected to a conductor 46 supported in a glass seal 47 fused into a pipe 48, said pipe being threaded and hermetically sealed into the cylindrical body 15 of the anode structure 11.

In the device thus far described, there is no external control over the frequency of the generated oscillations, and in order to provide such control, the device may be further constructed as follows:

A plunger 49, made of highly conductive material, such as copper, is slidably mounted in a bore 50 formed in the pole piece 43, the inner end of said plunger being recessed, as at 51, to accommodate the upper end of the cathode structure 12, and being formed into a cup-shaped portion 52 adapted to support the previously mentioned tuning member generally designated by the reference character 14.

The tuning member 14, which may be substantially cup-shaped, comprises an annulus 53, from the outer edge of which rises a flange 54 secured to the cup-shaped portion 52 of the plunger 49, and from the under surface of which depends a plurality of spaced fingers 55, said fingers straddling the anode members 16 and thereby extending into the cavity resonators formed in the anode structure 11.

As most clearly seen in Fig. 3 of the drawings, each finger 55 includes a more or less rectangular plate-like portion 56 adapted to be moved intermediate a pair of adjacent anode members 16, preferably, in the high-capacitance region near the inner ends thereof, and a more or less plug-like portion 57 also adapted to be moved intermediate said pair of adjacent anode members 16, preferably, in the high-inductance region adjacent that portion of the cylindrical body 15 which connects said anode members.

Said plate-like and plug-like portions 56 and 57 are connected by an intermediate portion 58 which is so designed that the lower edge of the former may be in a line with or, and as is preferable, below the upper edge of the latter. As a result of this construction, upward movement of the tuning fingers 55 withdraws the capacitance-altering portions 56 from the cavity resonators and simultaneously introduces therein the inductance-altering portions 57. Obviously,

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downward movement of the tuning fingers 55 introduces the capacitance-altering portions 56 into the cavity resonators and simultaneously removes the inductance-altering portions 57 therefrom.

Hence, capacitance and inductance are simultaneously altered in the same direction, thereby enabling considerable frequency deviation from the natural resonant frequency of the device.

In order to maintain the device hermetically sealed, a flexible, annular diaphragm 58' is secured, at its outer edge, to the cylindrical body 15, and at its inner edge, to the plunger 49.

In order to enable the coupling loop 45 to extend into one of the cavity resonators of the device, one of the fingers 55 of the tuning member 14 is removed, as shown in Fig. 2 of the drawings.

There remains to be described the control mechanism for the tuning member 14, by means of which there may be brought about the hereinbefore described relative movement between the fingers 55 and the cavity resonators formed in the anode structure 11.

Secured on the upper end of the plunger 49 is a threaded bushing 59 engageable in a disc 60 whose periphery may be provided with a V-cut 61, constituting a ball-bearing race. Surrounding said race is another race comprised of two cooperating bevelled rings 62 and 63, and the ring 62 being carried by a disc 64, and the ring 63 being pressed into cooperation with said ring 62 by an annular spring 65. The races are receptive therebetween of bearing balls 66, and the spring 65 is affixed to the disc 64 by a flat, retaining ring 67 and bolts 68.

The disc 64 is maintained against rotation by being bolted, as at 69, to a plate 70 fixed, at its center, to the pole piece 43, the plate 70 being provided with bearings 71 in which is journaled a shaft 72. Mounted upon the shaft 72 is a worm gear 73 engageable with a worm wheel 74 secured to the disc 60 by means of bolts 75. The shaft 72 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 49 with respect to the pole piece 43, and thus vary the capacitance and inductance, generally, of each cavity resonator of the device.

In order to protect the device against damage which might be caused by excessive movement of the plunger 49, means for limiting the rotation of the worm wheel 74 are provided. Such means may comprise a cam 76 pivotally mounted upon a bolt 77 which is fixed in a bracket 78 carried by the plate 70, said cam having a tooth 79 co-operable with a pin 80 carried by the worm wheel 74. The arrangement is such that the first time the pin 80 approaches the cam 76, it engages the tooth 79 thereof and trips the same, whereby the next time the pin 80 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 the present invention. It will be noted from all of the foregoing that relatively simple means for tuning an electron-discharge device, particularly, a magnetron, through an appreciable frequency range are provided, the tuning means of the present invention enabling simultaneous alteration, in the same

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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 the 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, provided with a plurality of anode members, spaced from said cathode; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, defining a cavity resonator; and means, supported adjacent said cavity resonators and movable with respect thereto, for simultaneously altering the distributed capacitance and inductance thereof in the same direction; said last-named means including a plurality of conducting members each of which, is movable intermediate a pair of adjacent anode members to increase the capacitance existing therebetween, and a plurality of additional conducting members each of which, is movable intermediate a pair of adjacent anode members to decrease the existing inductance thereof; said first and second named conducting members lying in planes parallel to the longitudinal axes of said cavity resonators and being completely offset with respect to each other.

2. A tunable electron-discharge device comprising: a cathode; an anode structure, provided with a plurality of anode members, spaced from said cathode; each pair of adjacent members, together with that portion of said anode structure lying therebetween, defining a cavity resonator; and a pair of rigidly connected means, supported adjacent said cavity resonators and simultaneously movable in opposite directions with respect thereto, for simultaneously altering the distributed capacitance and inductance thereof in the same direction; said last-named means including, respectively, a plurality of conducting members each of which, is movable intermediate a pair of adjacent anode members to increase the capacitance existing therebetween, and a plurality of additional conducting members each of which, is movable intermediate a pair of adjacent anode members to decrease the existing inductance thereof; said first and second named conducting members lying in planes parallel to the longitudinal axes of said cavity resonators and being completely offset with respect to each other.

3. A tunable electron-discharge device comprising: a cathode; an anode structure, provided with a plurality of anode members, spaced from said cathode; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, defining a cavity resonator; and means, supported adjacent said cavity resonators and movable with respect thereto, for simultaneously altering the distributed capacitance and inductance thereof in the same direction; said last-named means including a substantially cup-shaped conducting member having a plurality of portions depending therefrom, each of which is movable intermediate a pair of adjacent anode members to increase the capacitance existing therebetween, and a plurality of additional portions depending from said first-named portions, each of which is movable intermediate a pair of adjacent anode members to decrease the existing inductance thereof; said first and second named portions lying in planes

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parallel to the longitudinal axes of said cavity resonators and being completely offset with respect to each other.

4. A tunable electron-discharge device comprising: a cathode; an anode structure, provided with a plurality of anode members, spaced from said cathode; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, defining a cavity resonator; and means, supported adjacent said cavity resonators and movable with respect thereto, for simultaneously altering the distributed capacitance and inductance thereof in the same direction; said last-named means including a substantially cup-shaped conducting member having a plurality of spaced projections depending therefrom, each of which is movable intermediate a pair of adjacent anode members to increase the capacitance existing therebetween, and a plurality of additional spaced projections, integrally formed with said first-named projections, each of which is movable intermediate a pair of adjacent anode members to decrease the existing inductance thereof; said first and second named projections lying in planes parallel to the longitudinal axes of said cavity resonators and being completely offset with respect to each other.

5. A tunable electron-discharge device comprising: a cathode; an anode structure, provided with a plurality of anode members spaced from said cathode; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, defining a cavity resonator; and a substantially cup-shaped member, supported adjacent said cavity resonators, movable with respect thereto, and having a plurality of spaced fingers integrally formed therewith which, together with said cup-shaped member, straddle said anode members.

6. A tunable electron-discharge device comprising: a cathode; an anode structure, provided with a plurality of anode members, spaced from said cathode; each pair of adjacent anode mem-

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bers, together with that portion of said anode structure lying therebetween, defining a cavity resonator; and a substantially cup-shaped member, supported adjacent said cavity resonators, movable with respect thereto, and having a plurality of spaced fingers integrally formed therewith which, together with said cup-shaped member, straddle said anode members; said fingers each including a portion movable intermediate a pair of adjacent anode members to alter the capacitance existing therebetween, and an additional portion movable intermediate a pair of adjacent anode members to alter the existing inductance thereof.

7. A tunable electron discharge device comprising: a cathode; an anode structure spaced from said cathode and incorporating a cavity resonator having a relatively high capacitance region relatively adjacent said cathode and a relatively high inductance region relatively remote from said cathode; and a tuning member supported adjacent said cavity resonator and being movable with respect thereto; said tuning member including plate and plug-like members movable, respectively, within the high capacitance and high inductance regions of said cavity resonator; said plate and plug-like members being completely offset with respect to each other in planes parallel to the longitudinal axis of said cavity resonator and being partially overlapping in planes at right angles to said longitudinal axis of said cavity resonator.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,424,496	Nelson	July 22, 1947
2,449,794	Steele, Jr.	Sept. 21, 1948
2,481,171	Spencer	Sept. 6, 1949

Disclaimer

2,529,950.—*Erich N. Kather*, South Lincoln, Mass. TUNABLE ELECTRON DISCHARGE DEVICE. Patent dated Nov. 14, 1950. Disclaimer filed Sept. 29, 1951, by the inventor; the assignee, *Raytheon Manufacturing Company*, assenting.

Hereby enters this disclaimer to claims 1 and 2 of said patent.
[*Official Gazette November 6, 1951.*]