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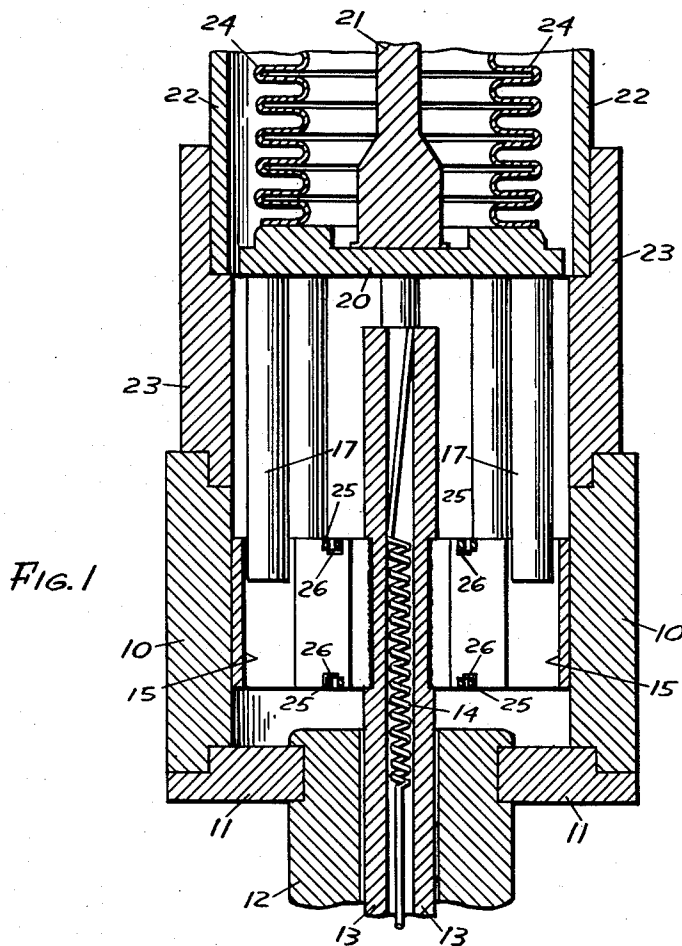
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2,801,368

WIDE RANGE TUNABLE MAGNETRONS

Filed May 24, 1955

3 Sheets-Sheet 1



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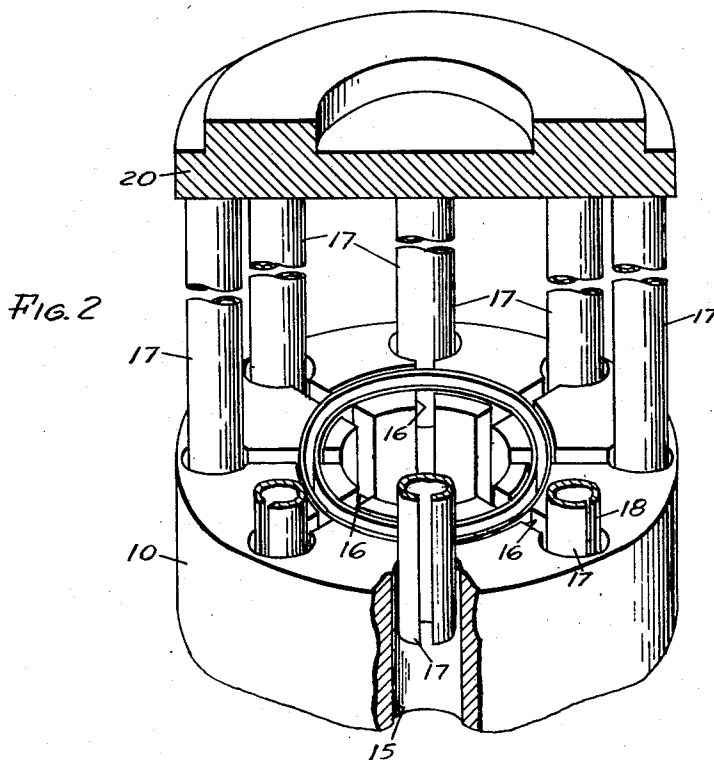
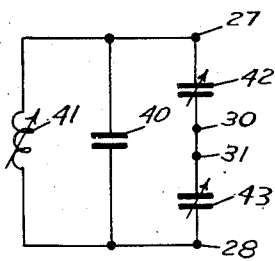
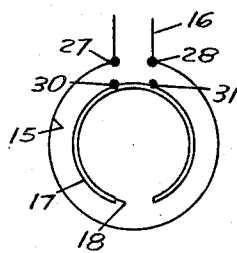
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WIDE RANGE TUNABLE MAGNETRONS

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FIG. 6

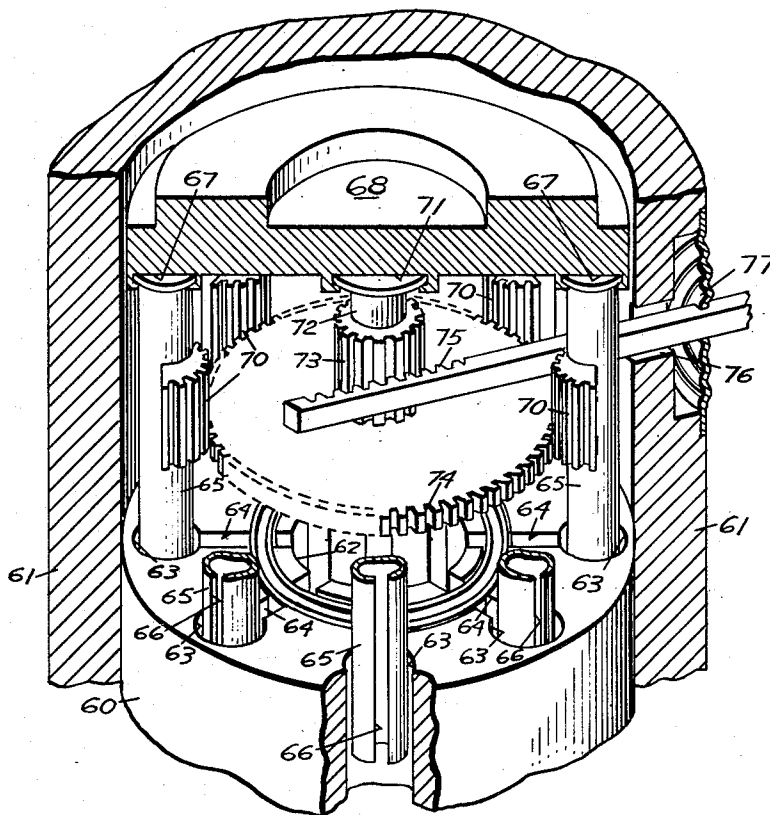
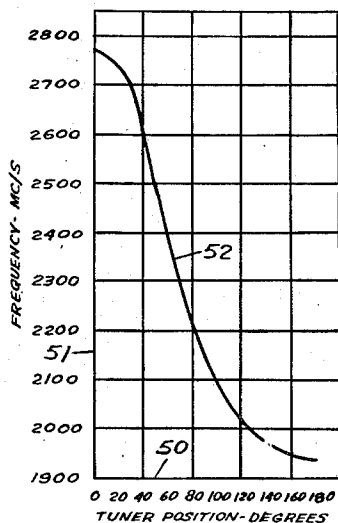


FIG. 5

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2,801,368

WIDE RANGE TUNABLE MAGNETRONS

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8 Claims. (Cl. 315—39.61)

This invention relates to magnetrons that may be tuned over a wide range of frequencies and more particularly to tuning devices for such magnetrons in which a slotted tube is concentrically mounted for either or both axial and rotary movement within the inductive portion of at least one cavity of the anode to vary both the capacity and inductance of the cavity simultaneously.

This structure for the tuning of a magnetron provides means for tuning the magnetron over a wider frequency range than tuning structures of the prior art without interference with extraneous tuner resonances inherent in prior tunable magnetrons and for achieving a faster tuning rate than is realized with ordinary inductive tuners.

Another feature of the invention is the introduction of capacitive tuning in a portion of the cavity resonators where radio frequency voltage is relatively low, thereby permitting satisfactory operation of this type of structure in high power tubes of the pulse type. Finally, the tuning structure is so positioned within the cavity resonators that mechanical interference between the tuner and the straps on the anode structure is avoided. As is well known in the magnetron art, a magnetron anode structure consists of several more or less radially disposed anode segments extending from a generally cylindrical wall portion. Each pair of adjacent anode segments, and its portion of the anode structure lying between, form a cavity resonator whose resonant frequency is determined by the geometry of the elements bounding the cavity. Each cavity resonator has a distributed capacity and inductance, but, for practical purposes, the portion of each cavity adjacent the cathode on the front part of the cavity is predominantly capacitive, while the inductance is more or less concentrated in that portion of the cavity furthest removed from the cathode in the rear part of the cavity. With a hole-and-slot type of anode the capacitive region is considered to exist almost entirely within the slot between the parallel disposed portions of adjacent anode segments, while the inductive region is concentrated largely within the hole or cylindrically shaped part of the resonator remote from the cathode. The electric field is greater in the capacitive or forward portion of each resonator, while the magnetic field is greater in the inductive or rear portion, making the latter part a high current region. This is generally true of other types of anode structure.

The standard inductive magnetron tuning system of the prior art comprises a plurality of tuning fingers of conductive material, each of which extends into the rear or inductive portion of the corresponding resonator. When such tuning fingers are inserted within a cavity resonator, the surface-to-volume ratio in the high current region of the oscillating resonator is altered and the current flowing about the periphery of the resonator induces a current in the tuning finger which is largely concentrated near the surface of the finger. Thus the inductance of the magnetron radio frequency circuit is decreased as the fingers penetrate further into each resonator, consequently increasing the frequency of oscillation of the magnetron.

In the present invention a slotted sleeve of conductive material is concentrically mounted within the back portion of at least one cavity with the slot in the sleeve to the rear of the cavity and supported for either axial mo-

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tion in and out of the cavity or for rotary motion to present the slot to different portions of the cavity. Both types of motion can be used together. In accordance with well-known principles of magnetron tuning, the insertion of the conductive sleeve in the rear of the cavity adds inductance. With the tube completely inserted and the slot of the tube facing the slot of the cavity, less capacity is added than in other positions with the maximum capacity being added when the slot of the sleeve is facing the rear of the cavity. Thus rotary motion of the sleeve results in a rapid change in the operating frequency of the magnetron as the sleeve's position is changed. This change is considerably more rapid than that obtained by purely inductive tuning.

The foregoing and other advantages, objects and features of the invention will be better understood from the following description taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a vertical section of a magnetron incorporating this invention;

Fig. 2 is an enlarged view partly in section of the tuner and anode block of the magnetron shown in Fig. 1;

Fig. 3 is a diagrammatic horizontal section through a portion of the anode structure with a tuner element inserted in one cavity;

Fig. 4 is a schematic diagram of the equivalent circuit of the arrangement of Fig. 3;

Fig. 5 is a graph showing how the resonant frequency of a representative magnetron varied when the device of the invention was used in only one anode cavity; and

Fig. 6 is an isometric view of a magnetron incorporating this invention with provision for both rotary and axial movement of the tuning sleeves.

In Figs. 1 and 2 the reference numeral 10 designates the cylindrical anode having a lower cover plate 11. A pole piece 12 associated with a magnet (not shown) is inserted in an opening in the plate 11. A cathode sleeve 13 is inserted through an opening in the pole piece 12 and sealed in one of the well-known ways. This cathode sleeve encloses a heater filament 14. The anode 10 is formed with a plurality of cylindrical openings 15, each connected to the anode-cathode space by a slot 16. A sleeve 17 having an axial slot 18 formed on the side facing the rear of the cavity 15. The sleeves 17 are attached to a support 20 fitted with a rod 21 by which it is moved up and down to move sleeves 17 into and out of the cavities 15. The support 20 and the rod 21 are preferably made of magnetic material so as to form part of the magnetic circuit and concentrate the magnetic field within the interaction space. The ring 22 is in turn supported by a ring 23 attached to the anode block 10. The plate 20 is attached to the ring 22 through a bellows 24 to permit vertical movement of the sleeves 17 while preserving the vacuum within the anode cavity. While the invention is most readily applied to magnetrons having keyhole shaped cavities in the anode block, it may be applied to magnetrons having any shape of cavity provided these cavities have a definite inductive region. Straps 25 may be added in notches 26 in the anode block 10 without interfering with the motion of the sleeves 17.

The operation of the device can best be understood by reference to Figs. 3 and 4. In Fig. 3 the cavity is seen with the movable sleeves 17 fully inserted within the cavity 15. It can be seen from this diagram that in addition to the parallel combination of the capacity across the slot 16 represented by the capacitor 40 in Fig. 4 between the terminals 27 and 28, and the inductance of the cylindrical part of the resonant cavity represented by the coil 41, there are a pair of variable capacitors 42 and 43 between the terminals 27 and 30 and 28 and 31, respectively, connected in series across the capacitor 40 and inductor 41. The inductance 41 is shown as

variable as it varies as the sleeve 17 is inserted and retracted from the cavity 15 or rotated about its axis within the cavity in a manner to be described.

The degree of the change in the resonant frequency of the cavity and the linearity of this change is indicated by the graph of Fig. 6 in which the variation in frequency is accomplished by rotating the sleeve 17 and the degrees of rotation are plotted horizontally along the line 50, and the resonant frequency is plotted vertically along the line 51 to give the graph 52. The useful portion of this graph can be seen to extend from 1,950 to 2,750 megacycles and this range of frequency is covered by a rotation of 140 degrees from a position close to that shown in Fig. 3 to a position with the slot 18 almost at the opening to the slot 16. A similar range of frequencies can be covered in a relatively small axial displacement of the sleeve with respect to the anode cavity. In many applications such a wide range of frequencies will not be required, and a diaphragm rather than a bellows can be used to accommodate the desired motion and thus reduce the cost of the tube.

How both the annular and axial displacements of the sleeve with respect to the cavity are achieved without disturbing the vacuum is best seen in Fig. 6 where the reference numeral 60 designates the cylindrical anode block mounted in an outer cylinder 61 closed in any suitable manner, such as that shown in Fig. 1, to form a vacuum tight envelope. The anode block 60 is formed with an opening 62 to receive a suitable cathode structure (not shown) which may be like that shown in Fig. 1. The anode block 60 is formed with a plurality of cylindrical openings 63, each connected to the opening 62 by a slot 64. A sleeve 65 having an axial slot 66 formed on the side normally facing the back of the cavity 63 is supported in a bearing 67 formed in a plate 68 preferably of magnetic material so that it can also form part of the magnetic circuit. A gear 70 is formed on each shaft 65a. The plate 68 also supports, in a bearing 71, a shaft 72 formed with a pinion 73 and carrying a large gear 74 adapted to engage each of the gears 70. The pinion 73 is driven by a rack 75 that passes through an opening 76 in the wall 61 and is supported by a diaphragm 77 to permit longitudinal motion of the rack 75 without disturbing the vacuum within the wall 61. The plate 68 can be mounted in any convenient manner, such as that shown in Figs. 1 and 2 to permit its movement along the axis of the magnetron without disturbing the vacuum. Movement of the rack 75 causes the sleeve 65 to rotate within the cavity 63, while lifting and lowering the plate 68 causes the sleeve 65 to move axially in the cavity 63 again without interfering with the vacuum or with their rotary motion. This dual motion is made possible by forming the gear 73 with at least the axial length of the desired axial motion of the sleeves 65. Either the construction for axial movement or the gears and rack and pinion construction for rotary motion can be used alone. For rotary motion only the upper bellows would be eliminated and the upper plate fixed in position. For axial motion the gears, pinion and ratchet could be eliminated together with the diaphragm 77. Provision for both movements gives a broader range of operating frequencies with less of either type of displacement. Other mechanisms for obtaining these movements of the sleeves can be used with this method of tuning.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. An electron discharge device comprising a cathode, an anode structure spaced from said cathode, said anode structure defining a multiplicity of cavity resonators each having an outer predominantly inductive section and a

tuning structure including an axially extending tubular electrically conductive member formed with an opening on one side and mounted for movement within the outer portion of at least one of said cavity resonators.

2. An electron discharge device comprising a cathode, an anode structure spaced from said cathode, said anode structure defining a multiplicity of cavity resonators each having an outer predominantly inductive section and a tuning structure including an axially extending tubular electrically conductive member formed with an opening on one side and mounted for axial movement within the outer portion of at least one of said cavity resonators.

3. An electron discharge device comprising a cathode, an anode structure spaced from said cathode, said anode structure defining a multiplicity of cavity resonators and a tuning structure including an axially extending tubular electrically conductive member formed with an opening on one side and mounted for rotational movement within at least one of said cavity resonators.

4. An electron discharge device comprising a cathode, an anode structure formed with a central opening to receive said cathode, said anode structure defining a multiplicity of cavity resonators each formed as a cylindrical opening in said anode structure connected to said central opening by an axial slot and a tuning structure including an axially extending tubular electrically conductive member formed with an opening on one side and mounted for movement within the cylindrical portion of at least one of said cavity resonators.

5. An electron discharge device comprising a cathode, an anode structure formed with a central opening to receive said cathode, said anode structure defining a multiplicity of cavity resonators each formed as a cylindrical opening in said anode structure connected to said central opening by an axial slot and a tuning structure including an axially extending tubular electrically conductive member formed with an opening on the side opposite the slot of said anode cavity and mounted for movement within the cylindrical portion of at least one of said cavity resonators.

6. An electron discharge device comprising a cathode, an anode structure formed with a central opening to receive said cathode, said anode structure defining a multiplicity of cavity resonators each formed as a cylindrical opening in said anode structure connected to said central opening by an axial slot and a tuning structure including an axially extending tubular electrically conductive member formed with an opening on the side opposite the slot of said anode cavity and mounted for axial movement within the cylindrical portion of at least one of said cavity resonators.

7. An electron discharge device comprising a cathode, an anode structure formed with a central opening to receive said cathode, said anode structure defining a multiplicity of cavity resonators each formed as a cylindrical opening in said anode structure connected to said central opening by an axial slot and a tuning structure including an axially extending tubular electrically conductive member formed with an opening on one side and mounted for axial movement within the cylindrical portion of at least one of said cavity resonators.

8. An electron discharge device comprising a cathode, an anode structure formed with a central opening to receive said cathode, said anode structure defining a multiplicity of cavity resonators each formed as a cylindrical opening in said anode structure connected to said central opening by an axial slot and a tuning structure including an axially extending tubular electrically conductive member formed with an opening on one side and mounted for rotational movement within the cylindrical portion of at least one of said cavity resonators.

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