Aug. 26, 1952 W. C. BROWN 2,608,673

ELECTRON DISCHARGE DEVICE

Filed Oct. 25, 1949 2 SHEETS—SHEET 1

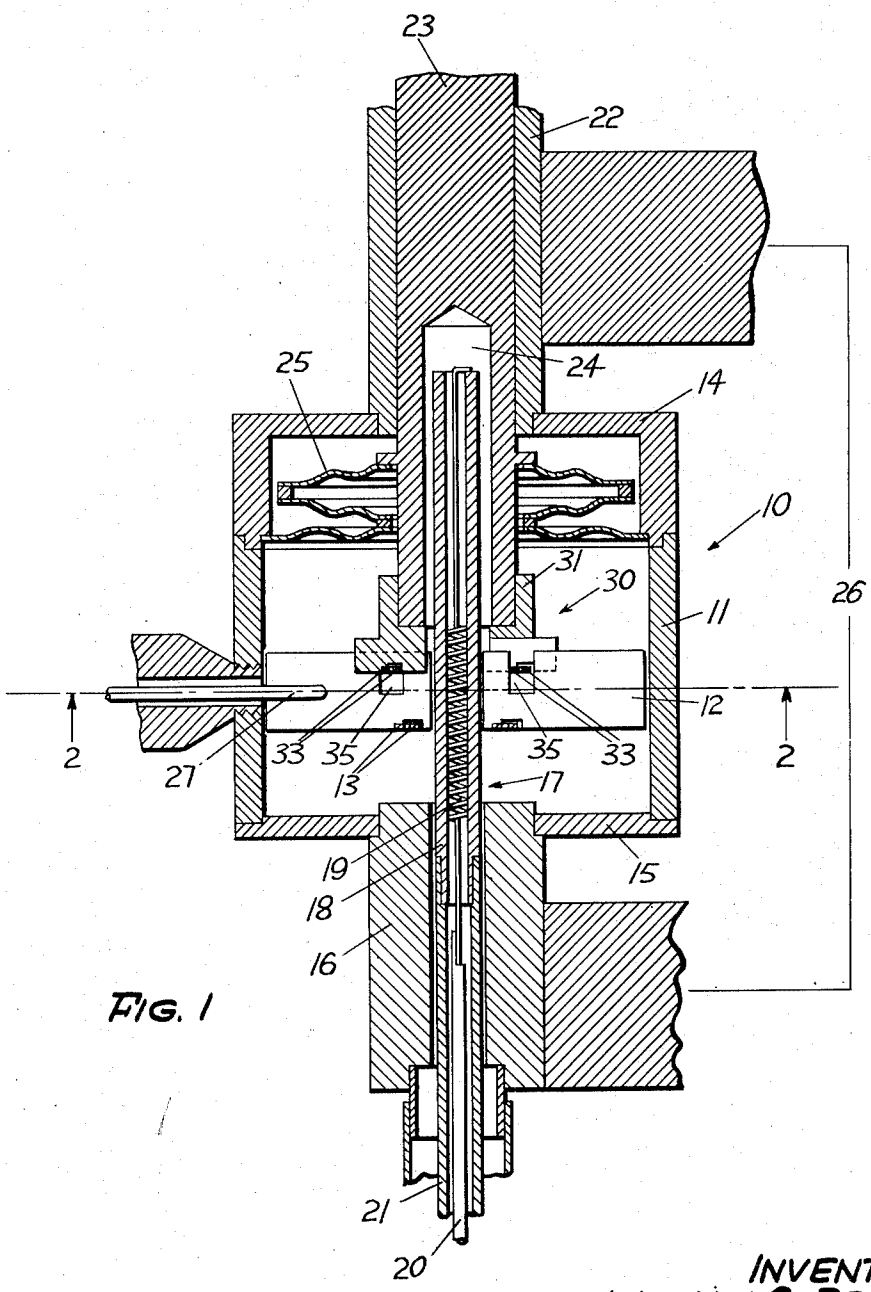


FIG. 1

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FIG. 2

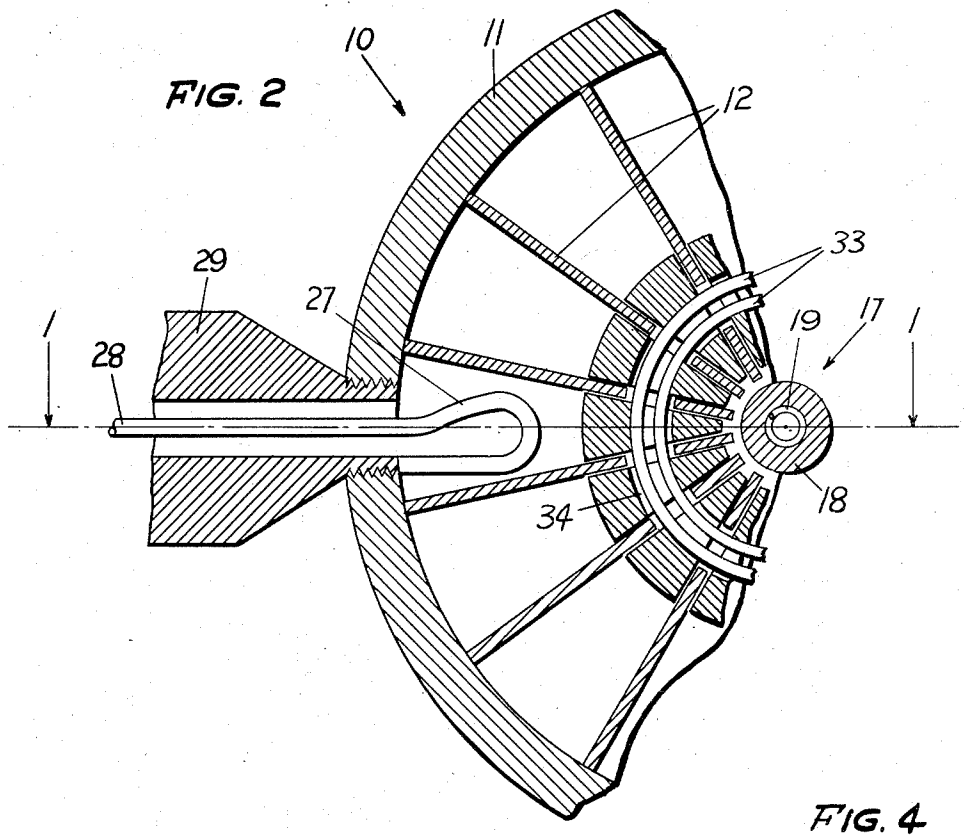


FIG. 4

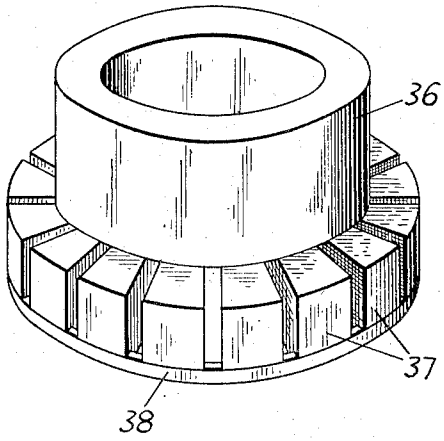
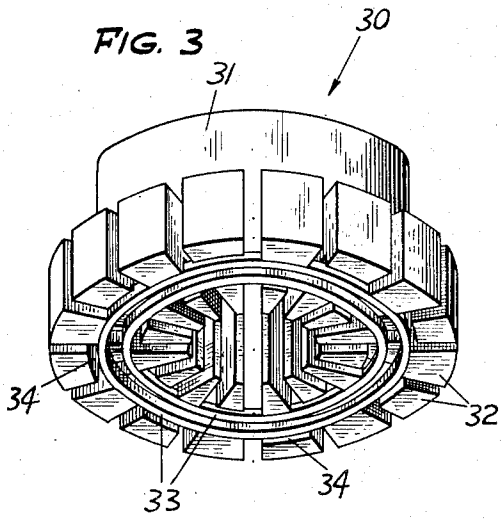


FIG. 3



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ELECTRON DISCHARGE DEVICE

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9 Claims. (Cl. 315—39)

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This application relates to electron discharge devices and more particularly to magnetrons of the tunable type.

In tunable magnetrons of the cavity type which are tuned by the insertion of tuning elements into the cavities, it has been discovered that the tuning elements themselves resonate, thereby sapping power from the cavities and lowering the efficiency of the device. More specifically, as the magnetron frequency is varied, the resonant frequencies of the tuning structure vary so that they will coincide with the frequency of the magnetron at several points over the frequency range of operation of the magnetron. At these points of coincidence the power sapped by the tuner from the cavities is so great that operation of the magnetron as a microwave power generator is unsatisfactory, if, indeed, operation is at all possible.

Applicant has discovered that by strapping the lower ends of the tuner elements which extend into the cavities, interference between the resonances of the tuner and the operation frequency of the magnetron may be eliminated.

Applicant also provides herein a mechanism particularly adaptable to operation of this tuning structure whereby the magnetic field across the magnetron is varied synchronously with variations in the tuning of the device.

Further objects and advantages of this invention will become apparent as the description progresses, reference being had to the accompanying drawings wherein:

Fig. 1 illustrates a longtudinal cross-sectional view of a magnetron utilizing applicant's invention taken along line 1—1 of Fig. 2;

Fig. 2 illustrates a partially broken-away transverse cross-sectional view of the device shown in Fig. 1 taken along line 2—2 of Fig. 1;

Fig. 3 illustrates a perspective view of the tuning structure used in Figs. 1 and 2 showing the details of the tuner strapping; and

Fig. 4 illustrates a modification of the tuning structure shown in Fig. 3 which may be used in place of the tuning structure shown in Fig. 3.

Referring now to Figs. 1 and 2, there is shown a magnetron comprising an anode structure 10 consisting of an anode cylinder 11 which may be of any desired material, such as copper. Extending radially inwardly from the inner surface of anode cylinder 11 are a plurality of planar anode members 12 whose planar surfaces are parallel to the axis of cylinder 11. Anode members 12 may be connected alternately at their lower edges adjacent their inner ends by a pair

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of straps 13 to prevent spurious oscillations in the anode structure.

The ends of anode cylinder 11 are closed by upper and lower end plates 14 and 15, respectively. Lower end plate 15 has therein a hole concentric with the axis of cylinder 11 in which is positioned a magnetic pole piece 16. Pole piece 16 has therein a hole concentric with the axis of cylinder 11 and through which extends a cathode assembly 17. Cathode assembly 17 comprises a metallic cylinder 18 which extends upwardly into cylinder 11 past the inner ends of anode members 12, and which is coated with electron-emissive material on its outer surface over the area adjacent the inner ends of anode members 12.

Cathode cylinder 18, which is hollow, contains therein a heater coil 19, the upper end of which is connected to cylinder 18, and the lower end of which is connected to a lead-in member 20. Heater coil 19 and lead-in member 20 are insulated from cylinder 18 by being coated by any desired insulating material, such as, for example, Alundum. The lower end of cathode cylinder 18 is attached to a supporting cylinder 21 surrounding lead-in member 20. Lead-in member 20 is insulatedly supported with respect to supporting cylinder 21 by any desired means, such as an insulating seal, not shown. Similarly, supporting cylinder 21 may be insulatedly supported with respect to magnetic pole piece by an insulating seal, not shown.

Upper end plate 14 has therein a hole concentric with the axis of cylinder 11 and through which extends a magnetic pole piece 22. Inside magnetic pole piece 22, and concentric therewith, is a movable pole piece 23 which slidably engages the inner surface of pole piece 22. The lower end of movable pole piece 23 has therein a recess 24 to accommodate the upper end of cathode cylinder 18. A vacuum seal is maintained in anode cylinder 11 by means of a diaphragm structure 25 attached to movable pole piece 23 and upper end plate 14. A magnetic field is produced between the adjacent ends of pole pieces 16 and 23 by any desired means, such as a permanent magnet connecting pole pieces 16 and 23 through an external magnetic path 26.

In order to remove microwave energy from the cavities there is provided an output coupling comprising a loop 27 extending into one of the cavities formed by a pair of anode members 12. One end of loop 27 is connected to a lead-in member 28 which extends through the wall of anode cylinder 11. Concentric with lead-in

member 28 is a sealing member 29 comprising a cylinder threaded into the wall of anode cylinder 11 and extending outwardly concentric with lead-in member 28 to an insulating seal, not shown. The other end of loop 27 is connected to the inner end of the cylinder 29.

Attached to the lower end of movable pole piece 23 is a tuning structure 30 comprising a metallic ring 31 surrounding the lower end of pole piece 23. Extending downwardly from ring 31, and integral therewith, are a plurality of tuning elements 32. Each tuning element comprises a prism having a substantially trapezoidal cross-section which conforms to the cross-section of the inner ends of the cavities formed by anode members 12.

Alternate tuning elements 32 are connected at their lower ends by a pair of straps 33. As shown here, the straps 33 set into notches 34 in the tuning elements. This form of notching is similar to the form of notching used for connecting alternate anode members 12 by the straps 13. However, the straps may be positioned below the tuning elements and connected to the tuning elements by small extensions on the lower ends of the tuning elements. The upper edges of anode members 12 have notches 35 therein which allow the passage of straps 33 downwardly as the tuning elements 32 are inserted into the cavities formed by anode members 12, said notches being large enough to prevent contact between straps 33 and the anode members 12.

One explanation of the operation of straps 33 is as follows. The tuning structure 30 behaves as a resonant cavity at a frequency where the electrical distance from the lower end of one tuning element up to ring 31 and back to the lower end of the next adjacent tuning element is equal to a half wave length of said frequency. This may be termed the π mode resonance of the tuner. Thus it may be seen that adjacent tuner elements form resonant cavities in a manner substantially similar to the manner in which adjacent anode members 12 form resonant cavities. These cavities may be thought of as a tank circuit having lumped parameters comprising inductance and capacitance. Due to close coupling between adjacent cavities, they may be considered as a plurality of sections of a transmission line which are connected in series. An analysis of these circuit parameters, which include the inductance and capacitance of the tuner elements and the capacitance between the tuner elements and the anode members, discloses that, in the absence of straps in the lower ends of the tuning elements, each pair of adjacent tuner elements which comprises a transmission line section behaves as a low-pass filter whose upper cutoff frequency is the π mode of the tuner. Thus it may be seen that even though the dimensions of the tuning be shortened to raise the π mode of the tuner 30 well above the operating frequency of the magnetron, lower frequencies will exist in the tuner structure which represents modes of resonance whereat a wave travelling along the transmission line made up of the cavities of the tuner structure will shift in phase by a multiple of two π radians during one complete journey around the tuning structure, thereby returning to the starting point in phase to reinforce the initial wave.

However, when the tuning structure is strapped, an analysis of the tuning structure discloses each cavity thereof, together with the segments of straps, becomes a high-pass filter whose lower cutoff frequency is the π mode of the tuner. Therefore, frequencies below the π mode of the tuner will not travel along the transmission line made up by the tuner cavities, and hence no resonances below the π mode of the tuner will occur therein. Since the π mode frequency of the tuner is made considerably higher than the operating frequency of the magnetron and since the strapped tuner will not resonate at frequencies below the π mode of the tuner, interference due to coincident resonance of the tuner with the operating frequency of the magnetron is completely eliminated.

Referring now to Fig. 4, there is shown another modification of a strapped tuning structure. This comprises a ring 36 similar to ring 31 for attachment to the lower end of pole piece 23. Extending downwardly from ring 36 are tuner elements 37 similar to tuner elements 32 of the tuner 30. The lower ends of the tuner elements 37 are all connected together by a single circular strap set in notches in the lower, outer corners of the tuner elements 37.

It may be seen that the lowest frequency at which the tuner elements 37 will resonate will be governed by the greatest distance between points where adjacent tuner elements 37 are shorted and points where adjacent elements 37 are open, for example, the distance between the straps 38 and the lower inner corners of the elements 37. This distance equals an electrical quarter wave length of the lowest possible resonant frequency of the tuner. Since this distance is made considerably less than a quarter wave length of the operating frequency of the magnetron, the resonances of the tuning structure are well above the operating frequency of the magnetron.

By connecting the tuning structure 30 to the movable magnetic pole piece 23, applicant is able to vary the magnetic field across the interaction space between the cathode 17 and the anode members 12 synchronously with variations in the operating frequency of the device. Either the magnetic field or the anode-cathode voltage of a magnetron must be varied with variations in frequency to produce optimum operating conditions for the magnetron, and applicant, by varying the magnetic field, is able to utilize a constant anode voltage for the device over the range of frequencies. Since a magnetron uses extremely high voltages which involve large insulators, the use of a constant voltage power supply rather than a variable one produces a cheaper and more reliable device.

This completes the description of the particular species of the invention illustrated herein. However, many modifications thereof will be apparent to persons skilled in the art. For example, the straps 33 and 38 may be placed at other positions on the tuning structure and other configurations of tuning elements may be used. Furthermore, the anode members 12 need not necessarily be strapped, and may be of a different shape from that used herein. Therefore, applicant does not wish to be limited to the specific details of the embodiment of the invention disclosed herein except as defined by the appended claims.

What is claimed is:

1. An electron discharge device comprising an anode structure defining a cavity resonator having a plurality of cavities, a cathode adjacent said anode structure, and a tuning structure having a

plurality of tuning elements extending into said cavity resonator, elements of said tuning structure being connected by conductive strapping at the ends thereof extending into said cavity resonator, said strapping being rigidly attached to said tuning structure and movable therewith.

2. An electron discharge device comprising an anode structure defining a cavity resonator having a plurality of cavities, a cathode adjacent said anode structure, and a tuning structure having a plurality of tuning elements extending into said cavity resonator, alternate elements only of said tuning structure being connected by conductive strapping.

3. An electron discharge device comprising an anode structure defining a cavity resonator having a plurality of cavities, a cathode adjacent said anode structure, and a tuning structure having a plurality of tuning elements, an element of said tuning structure extending into each cavity of said resonator, and elements of said tuning structure being connected by conductive strapping at the ends thereof which extend into said cavity resonator, said strapping being rigidly attached to said tuning structure and movable therewith.

4. An electron discharge device comprising an anode structure defining a cavity resonator having a plurality of cavities, a cathode adjacent said anode structure, and a tuning structure having a plurality of tuning elements, an element of said tuning structure extending into each cavity of said resonator, and alternate elements only of said tuning structure being connected by conductive strapping.

5. An electron discharge device comprising an anode structure defining a cavity resonator having a plurality of cavities, a cathode adjacent said anode structure, and a tuning structure having a plurality of tuning elements extending into said cavity resonator, said tuning elements being connected at one end to said tuning structure and at the other end to conductive means which connect together only alternate elements.

6. An electron discharge device comprising an anode structure defining a cavity resonator having a plurality of cavities, a cathode adjacent said anode structure, and a tuning structure having a plurality of tuning elements, an element of said tuning structure extending into each cavity of said resonator, said tuning elements being connected at one end to said tuning structure and at the other end to conductive means which connect together only alternate elements.

7. An electron discharge device comprising an anode structure defining a cavity resonator having a plurality of cavities, a cathode adjacent said anode structure, a tuning structure having a plurality of tuning elements extending into said cavity resonator, elements of said tuning structure being connected by conductive strapping, means adjacent said cavity resonator for producing a magnetic field across the space between said anode and cathode, and means coupled to said tuning structure for varying the strength of said magnetic field in response to variations in the frequency of said device.

8. An electron discharge device comprising an anode structure defining a cavity resonator having a plurality of cavities, a cathode adjacent said anode structure, a tuning structure having a plurality of tuning elements extending into said cavity resonator, elements of said tuning structure being connected by conductive strapping, and means adjacent said cavity resonator for producing a magnetic field across the space between said anode and cathode comprising a movable magnetic pole piece attached to said tuning structure.

9. An electron discharge device comprising an anode structure defining a cavity resonator having a plurality of cavities, a cathode adjacent said anode structure, a tuning structure having a plurality of tuning elements extending into said cavity resonator, alternate elements of said tuning structure being connected by conductive strapping, means adjacent said cavity resonator for producing a magnetic field across the space between said anode and cathode, and means coupled to said tuning structure for varying the strength of said magnetic field in response to variations in the frequency of said device.

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