Sept. 14, 1948. P. L. SPENCER 2,449,090

TEMPERATURE COMPENSATED MAGNETRON

Filed March 11, 1943 2 Sheets-Sheet 1

FIG. 1.

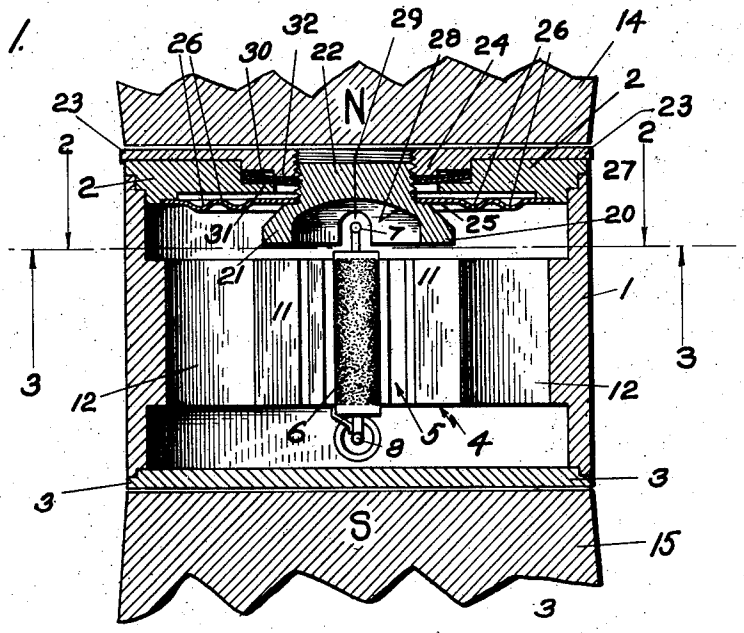
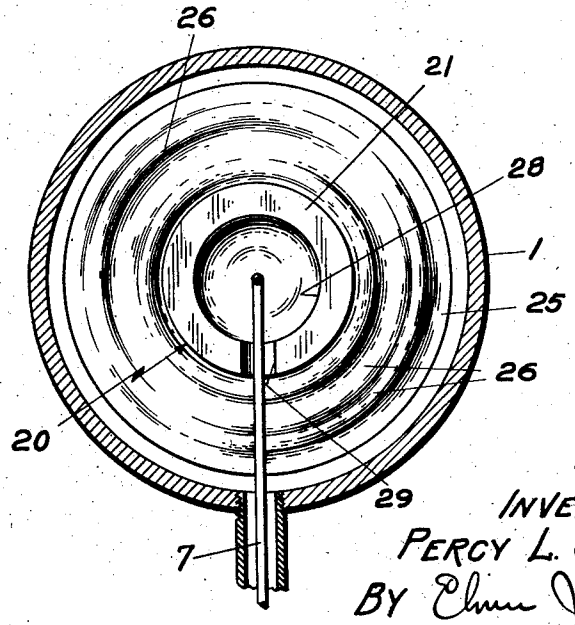


FIG. 3.



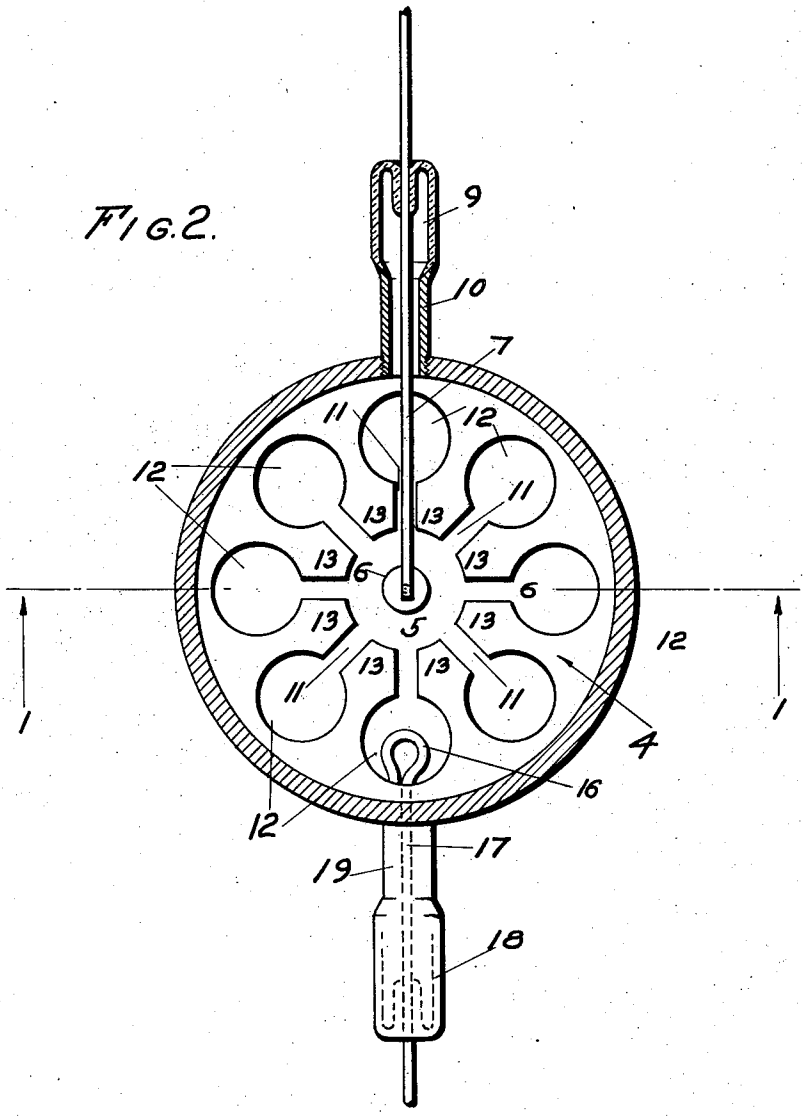
INVENTOR.
PERCY L. SPENCER,
BY Elmer J. Gorn
ATTY.

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FIG. 2.



INVENTOR.
PERCY L. SPENCER,
BY Elmer J. Gorn
ATTY.

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2,449,090

TEMPERATURE COMPENSATED MAGNETRON

Percy L. Spencer, West Newton, Mass., assignor to Raytheon Manufacturing Company, Newton, Mass., a corporation of Delaware

Application February 11, 1943, Serial No. 475,562

8 Claims. (Cl. 250—27.5)

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This invention relates to a magnetron, and more particularly to one in which the dimensions of the internal structure determine the frequency of the oscillations produced.

In many devices of this kind, temperature variations which occur during the operation of the device have produced changes in the frequency at which the device tended to oscillate, probably due to small changes in the dimensions of the internal structure. This has introduced the necessity of tuning either the magnetron itself or the external circuit supplied thereby in order to compensate for these variations.

An object of this invention is to devise a magnetron of the foregoing kind in which the tendency to change the frequency of oscillation, due to temperature variations, is substantially eliminated by an automatic compensating device.

Another object is to devise such an arrangement in which the frequency at which the compensating device tends to maintain the tube may be adjusted even while the tube is in operation and in position between the poles of its associated magnet.

The foregoing and other objects of this invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein:

Fig. 1 is a vertical section through a magnetron incorporating my invention, taken along line 1—1 of Fig. 2;

Fig. 2 is a cross-section taken approximately along line 2—2 of Fig. 1; and

Fig. 3 is a cross-section taken approximately along line 3—3 of Fig. 1.

The magnetron illustrated in the drawings comprises an envelope 1 which is preferably made of a block of conducting material, such as copper. This block forms the anode of the magnetron. It likewise has hollow end sections which are covered by caps 2 and 3 likewise of conducting material, such as copper. Between the hollow end sections of the block 1 is located a central bridging portion 4 provided with a central bore 5 within which is supported centrally thereof a cathode 6 which may be of the indirectly-heated oxide-coated thermionic type. The cathode is supported by a pair of lead-in conductors 7 and 8. The conductor 7 is sealed through a glass seal 9 mounted at the outer end of a pipe 10 hermetically fastened within the wall of the block 1 adjacent the upper hollow end section. The lead-in conductor 8 is likewise sealed through a similar glass seal and

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pipe, not illustrated, adjacent the lower hollow end section. A plurality of slots 11 extend radially from the central bore 5, and each of said slots terminates in a circular opening 12 extending through the bridging portion 4. In this way the anode structure is provided with a plurality of wedge-shaped arms 13, the faces of which cooperate as anode sections with the cathode 6.

When such a magnetron is placed between suitable magnetic poles 14 and 15 to create a longitudinal magnetic field and the device is energized, oscillations are set up. These oscillations may be led out from the tube by means of a coupling loop 16 extending into one of the cylindrical openings 12, and having one end thereof fastened to the inner wall of said opening. The other end of the coupling loop 16 is connected to the lead wire 17 which passes through a glass seal 18 mounted at the outer end of a pipe 19 likewise hermetically fastened through the wall of the envelope 1. An additional conducting pipe, not shown, may be electrically connected to the pipe 19 and form with the wire 17 a concentric line through which the high frequency oscillations generated by the magnetron may be connected to a suitable utilization circuit.

A capacity exists between the cathode 6 and the face of each anode section 13. Also capacitances exist between the side walls of each of the slots 11. The inner walls of the openings 12 constitute inductances. The anode, therefore, is so designed and spaced relative to the cathode that the inductances and capacitances described constitute circuits which are tuned. It is desired that these circuits shall be resonant at a definite predetermined frequency at which the device is to be operated. The device is intended to operate so that each bore 12 and its adjacent arms form a circuit tuned to the frequency at which each of the other bores 12 and its adjacent arms oscillate.

Heretofore, during the operation of tubes of this kind, the temperature of the tube increased, and as already indicated produced variations in the frequency at which the anode structure tended to oscillate. However, means may be provided whereby the normal frequency of such a magnetron can be adjusted over a fairly wide range even after the magnetron has been completed. For example, I have described and claimed such a tuning arrangement in my copending application, Serial No. 433,649, filed March 6, 1942, and now Patent No. 2,408,237,

granted September 24, 1946. In accordance with my present invention, this type of tuning is utilized with the addition of a temperature-responsive device which varies the position of tuning member in accordance with changes in temperature.

In order to produce the desired tuning effect, a tuning member 20 is disposed with a lower annular conducting face 21 held in juxtaposed position adjacent the anode arms 13 at one side of the structure. The member 20 is provided with an upper threaded extension 22 which receives a central threaded portion of a plate 23. Surrounding the central threaded portion of the plate 23 is a depending cylindrical projection 24 which fits rotatably into a corresponding central opening extending through the cap 2. In order to maintain an hermetical seal and at the same time permit adjustment of the tuning member 20, a diaphragm 25 is provided. The diaphragm 25 has a central opening which fits over the threaded portion 22 so that said diaphragm may be hermetically sealed onto a shoulder formed on the tuning member 20 at the base of said extension 22'. The outer edge of the diaphragm 25 is likewise hermetically sealed onto a shoulder formed adjacent the outer edges of the cap 2. The diaphragm 25 is preferably provided with a plurality of corrugations 26 so as to lend flexibility to said diaphragm, thus permitting a considerable motion of the central portion thereof which carries the tuning member 20. The cap 2 is cut away at 27 to permit such movement of the diaphragm. The tuning member 20 is likewise cut away at 28 to permit the upper end of the cathode 6 to extend therein. The member 20 is also provided with a slot 29 which allows for the passage of the lead-in conductor 7. Interposed between the cap 2 and the plate 23 is a temperature-responsive means, preferably in the form of a bimetallic dish-shaped disk 30 having an opening through which the extension 22 passes. The lower side of the disk 30 bears against and is supported by a shoulder 31 formed within the central opening of the cap 2. The upper surface of the disk 30 bears against a shoulder 32 formed on the cylindrical projection 24 of the plate 23. The outer edge of the plate 23 preferably extends slightly beyond the sides of the adjacent pole piece 14 and carries knurling which permits the plate 23 to be readily turned in order that the position of the tuning member 20 with respect to the plate 23 may be adjusted. Of course it is to be understood that the magnetron is completed in the usual manner, and is completely evacuated. Therefore, a pressure will be exerted on the plate 23 and the extension 22 of the member 20 which will tend to press said tunable structure inwardly against the body of the magnetron. This provides a biasing force which maintains the tunable structure firmly in whatever position is determined by the degree of turning of the plate 23 and the position of the thermostatic disk 30.

When the magnetron has been completed, it is placed between the magnetic poles 14 and 15 and connected into a suitable oscillating circuit, whereupon the system starts to generate oscillations. The position of the disk 30, as shown in Fig. 1, represents substantially the cold position thereof. As the magnetron warms up during operation, the temperature of the disk 30 is increased, and said disk tends to flatten out and eventually reverse its curvature. This action, therefore, moves the conducting face 21 farther away from the anode arms 13. An increase in temperature of the magnetron tends to increase the size of the cavities 11—12 and thus tends to decrease the frequency, whereas the moving of the tuning member 20 away from the anode arms 13 tends to increase the frequency. By proper design, the motion which is introduced by the thermostatic disk 30 can be made substantially to compensate for the variations in frequency introduced by temperature changes.

As discussed in my copending application, Serial No. 433,649, it is often desirable to provide for adjustments of the frequency at which a magnetron oscillates, so that if it is found that the wave length generated by a particular magnetron deviates from the exact values desired as, for example, that fixed by the constants of the associated circuit, the magnetron may be tuned to that desired frequency. The arrangement as herein described affords such an adjustment merely by turning of the plate 23. The threaded relationship between this plate and the member 20 causes said member to be raised or lowered depending upon the direction of rotation of the plate 23. Thus the exact frequency at which the magnetron is to oscillate may be fixed exactly by the member 23, and this frequency is maintained exactly despite temperature variations by the compensation introduced by the thermostatic disk 30.

In accordance with my present understanding of the operation of this invention, varying the position of the conducting face 21 will vary the capacitances of the anode structure as described above without affecting the inductances thereof to the same degree. Therefore, varying said capacitances will tune the natural frequency of the magnetron in the manner desired.

Of course it is to be understood that this invention is not limited to the particular details as described above as many equivalents will suggest themselves to those skilled in the art. For example, the conducting surfaces moved adjacent elements of the anode structure might be disposed adjacent other portions of said anode structure. Likewise elements which vary the inductance of the oscillating portions of the anode structure might be adjusted in accordance with the principles of my invention. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention.

What is claimed is:

1. An electron-discharge device comprising: a cathode; an anode structure spaced from said cathode and including a cavity resonator; a conducting member supported within said anode structure in spaced relationship to said cavity resonator, and forming therewith a capacitor; and a thermally-responsive element, disposed intermediate said anode structure and said conducting member, for controlling the spacing between said conducting member and said cavity resonator to tune said device as a function of the temperature thereof.

2. An electron-discharge device comprising: a cathode; an anode structure spaced from said cathode and provided with a plurality of anode members; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, constituting a cavity resonator; a conducting member supported within said anode structure in spaced relationship to said anode members, and forming therewith a capacitor; and a thermally-responsive

element, disposed intermediate said anode structure and said conducting member, for controlling the spacing between said conducting member and said anode members to tune said device as a function of the temperature thereof.

3. An electron-discharge device comprising: an evacuated electrode structure including a plurality of cavity resonators; a conducting member supported, in the interior of said electrode structure, in spaced relationship to said cavity resonators, and forming therewith a capacitor; the difference in pressure between the exterior and interior of said electrode structure exerting a force upon said conducting member to urge the same toward said cavity resonators; and a thermally-responsive element, disposed intermediate said electrode structure and said conducting member, and exerting a force in opposition to that created by said difference in pressure, for controlling the spacing between said conducting member and said cavity resonators to tune said device as a function of the temperature thereof.

4. An electron-discharge device comprising: an evacuated anode structure provided with a plurality of anode members; each pair of adjacent anode members, together with that portion of said anode structure lying therebetween, constituting a cavity resonator; a conducting member supported, in the interior of said anode structure, in spaced relationship to said anode members, and forming therewith a capacitor; the difference in pressure between the exterior and interior of said anode structure exerting a force upon said conducting member to urge the same toward said anode members; and a thermally-responsive element, disposed intermediate said anode structure and said conducting member, and exerting a force in opposition to that created by said difference in pressure, for controlling the spacing between said conducting member and said anode members to tune said device as a function of the temperature thereof.

5. An electron-discharge device comprising: a cathode; an anode structure spaced from said cathode and including a plurality of cavity resonators; means, supported within said anode structure, and movable with respect to said cavity resonators, for altering the natural resonant frequency of said cavity resonators; and a thermally-responsive element disposed intermediate said anode structure and said frequency-altering means, for moving the latter to tune said device as a function of the temperature thereof.

6. An electron-discharge device comprising: an evacuated electrode structure including a plurality of cavity resonators; means, supported within said electrode structure, and movable with respect to said cavity resonators, for altering the natural resonant frequency of said cavity resonators; means, located exteriorly of said electrode structure and coupled with said frequency-altering means, for moving the latter to initially adjust the resonant frequency of said cavity resonators; and a thermally-responsive element, disposed intermediate said electrode structure and said frequency-altering means, for moving the latter to tune said device as a function of the temperature thereof.

7. An electron-discharging device comprising: a cathode; an anode structure spaced from said cathode and including a cavity resonator; a conducting member supported in spaced relationship to said cavity resonator, and forming therewith a capacitor; said anode structure and said conducting member being provided, respectively, with bearing surfaces; and a thermally-responsive element, abutting said bearing surfaces, for altering the space between said conducting member and said cavity resonator to tune said device as a function of the temperature thereof.

8. An electron-discharge device comprising: a cylindrical electrode structure including a plurality of cavity resonators; an annular, conducting member; an annular, flexible diaphragm, sealed at its outer edge to said electrode structure and sealed at its inner edge to said conducting member, supporting said conducting member in spaced relationship to said electrode structure; said electrode structure being provided, externally thereof, with a bearing surface, and said conducting member having a portion thereof extending through said flexible diaphragm and, likewise, being provided with a bearing surface; and a thermally-responsive element, engaging with said bearing surfaces, for moving said conducting member with respect to said cavity resonators, whereby said device is tuned as a function of the temperature thereof.

PERCY L. SPENCER.

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