Dec. 9, 1952 A. D. LA RUE 2,621,311

MECHANICAL MOVEMENT

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FIG. 1.

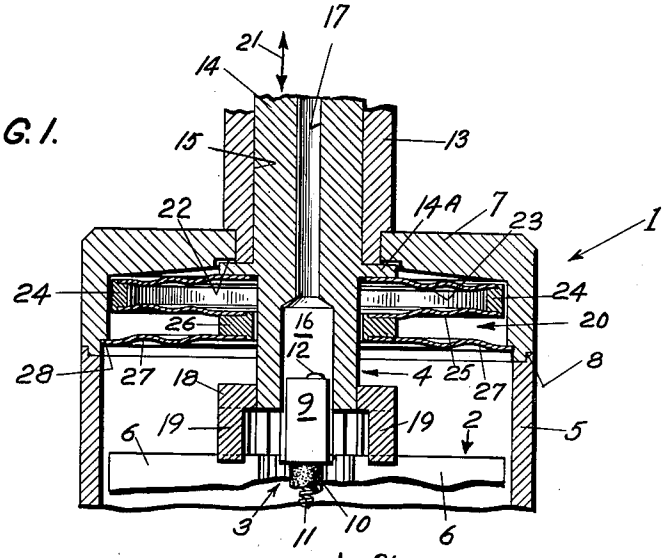


FIG. 2

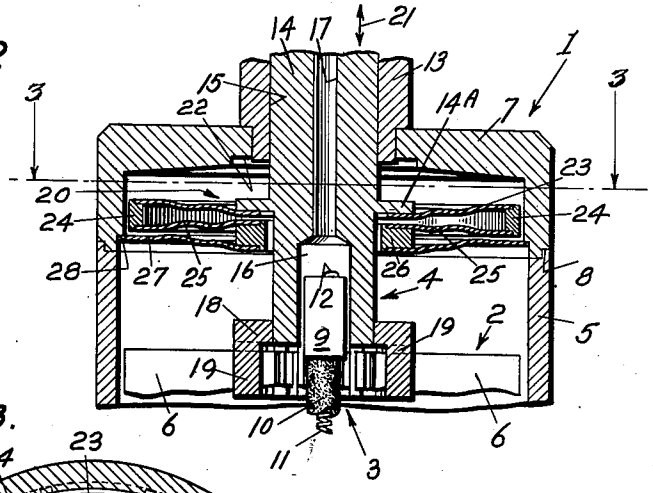
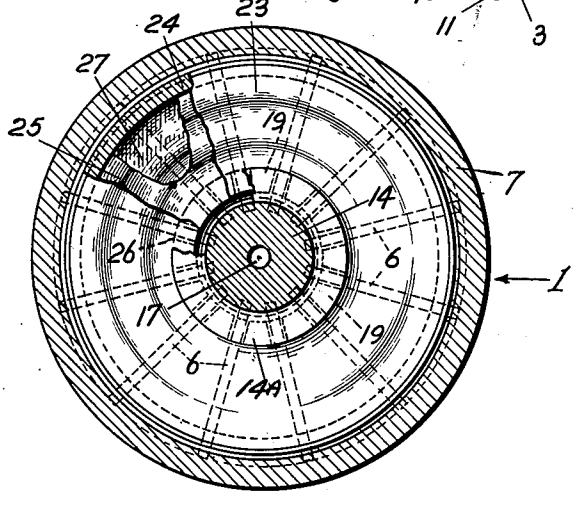


FIG. 3.



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MECHANICAL MOVEMENT

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This invention relates to mechanical movements, and more particularly to a structure for mechanical tuning of magnetrons.

It has been found desirable, for certain purposes, to be able to mechanically tune or change the output frequency of electron discharge devices of the magnetron type, while such devices are in operation. Structures have previously been devised for the accomplishment of such result, examples of such structures being disclosed in the P. L. Spencer Patent No. 2,408,237, dated September 24, 1946, and in the copending application of E. N. Kather, Ser. No. 668,847, filed May 10, 1946,, now Patent No. 2,529,950 dated November 14, 1950. In such structures, a tuning member is mechanically movable, with respect to the resonant cavities of the magnetron inside the hermetically sealed envelope thereof, from outside the envelope. In order to maintain a hermetic seal inside the envelope and at the same time permit movement or adjustment of the tuning member, a single flexible annular diaphragm is provided, this diaphragm being hermetically sealed to the inner wall of the envelope and also sealed around the movable tuning member itself. If the magnetrons are to be mechanically tuned through a rather wide range, the tuning member must be moved through a substantial range of movement, on the order of .2 inch, for example. The stresses in the diaphragm are varied with each movement thereof corresponding to a movement of the tuning member, and, if the magnetron is tuned through its range frequently enough during the life of the tube, the diaphragm may break because of fatigue before the normal tube life has expired. For uses of the magnetron wherein the tube is to be tuned frequently during operation, therefore, the fracture of the diaphragm may be the factor which limits the effective life of the tube, since such fracture breaks the hermetic seal of the envelope.

An object of this invention is to devise a diaphragm structure for the mechanical tuning of magnetrons, by means of which a longer diaphragm life may be obtained.

Another object is to accomplish the aforesaid object without limiting the total range of movement of the tuning member or tuning plunger.

The foregoing and other objects of the present 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 cross-section through a tuning structure according to the present invention, shown at one end of its range of movement;

Fig. 2 is a view similar to Fig. 1 but showing the tuning structure at the opposite end of its range of movement; and

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Fig. 3 is a horizontal cross-section taken along line 3—3 of Fig. 2.

Referring now more in detail to the aforesaid exemplification of the present invention, with particular reference to the drawing illustrating the same, the numeral 1 generally designates an electron discharge device of the so-called magnetron type, said device including an anode structure 2, a cathode structure 3, 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 4.

In the device shown, the anode structure includes a cylindrical body 5, 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 6, 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.

The anode structure 2 is closed at its upper end by a substantially inverted cup-shaped cover member 7 which is part of the tuning structure 4. The junction between the cylindrical body 5 of the anode structure and the cylindrical wall of member 7 is hermetically sealed, as at 8.

Only the upper part of the cathode structure 3, which is coaxial with the anode structure 2, is shown. Said cathode structure includes a cathode sleeve 9, conventionally made of nickel or the like, a portion of said sleeve, preferably coextensive with the height of the vanes 6, being provided with a highly electron-emissive coating 10, for example of the well-known alkaline-earth metal oxide type.

The lower end of body 5 is closed by any suitable means, for example, as disclosed in the aforesaid Kather application. The cathode sleeve 9 is preferably insulatedly supported with respect to the anode members 6 as shown in the aforesaid copending application. A cathode heating filament 11 has its lower end suitably supported in sleeve 9 and has its upper end connected, as at 12, to said sleeve.

An upper tubular pole piece 13 of ferromagnetic material is preferably, though not necessarily, hermetically sealed into the cover member 7 axially of said member.

By suitably heating the cathode, by establish-

ing an appropriate magnetic field in a direction perpendicular to the path of the electron flow between the cathode structure 3 and the anode structure 2, and by applying a proper potential difference between said cathode and the anode, the device can be made to generate electrical oscillations of a wavelength 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 resonators defined by the elements constituting the anode structure.

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 14, made of ferromagnetic material, slidably mounted in a bore 15 formed in the pole piece 13, the lower end of said plunger being recessed, as at 16, to accommodate the upper end of the cathode structure 3, the upper end of this axial recess communicating with an axial bore 17 which extends through the plunger 14 and through which the interior of the envelope may be evacuated.

The tuning member proper comprises an annulus 18 secured to the lower or inner end of plunger 14, from the under surface of which depends a plurality of spaced fingers 19, said fingers straddling the anode members 6 and thereby extending into the cavity resonators formed in the anode structure 2. Each finger 19 is more or less rectangular or plate-like and is adapted to be moved intermediate a pair of adjacent anode members 6 preferably in the high-capacitance region near the inner ends thereof. It should be noted that the lower end of plunger 14 is located somewhat below the lower end of the cylindrical wall of member 7 at all times. As a result of this construction, upward movement of the plunger 14 withdraws the capacitance-altering fingers 19 from the cavity resonators, while downward movement of said plunger introduces said fingers into the cavity resonators to vary the magnetron output frequency accordingly.

Fig. 1 shows the position of the parts in the uppermost position of the plunger 14, while Fig. 2 shows the position of the parts in the lowermost position of said plunger.

In order to maintain the interior of the envelope constituted in part by body 5 and cover member 7 hermetically sealed, while at the same time allowing for movement of tuning structure 4 with respect to the vanes 6 fixed in body 5, a flexible diaphragm structure 20 is provided. I have found, according to this invention, that longer diaphragm life may be achieved if the range of relative movement of the two ends of the diaphragm is reduced by a substantial amount. In order to so reduce the required relative movement of the ends of the diaphragm without at the same time limiting the vertical movement of the plunger 14 in the direction indicated by the arrows 21 in Figs. 1 and 2, I provide a compound diaphragm structure in which the individual diaphragm sections are so fastened together that each individual diaphragm is required to contribute only a fraction of the total movement of the plunger 14, so that the individual diaphragms each have only a fraction of the relative movement between their ends that they would have if only a single diaphragm were used.

A horizontal outwardly-extending annular flange 14A is provided on plunger 14 below the upper or disc portion of member 7. The lower disc surface of member 7 is centrally recessed as at 22 to allow for vertical movement of flange 14A therein. The lower horizontal disc surface of member 7 is beveled or countersunk toward its center to accommodate movements of diaphragm structure 20; the disc portion of said member therefore has a reduced thickness at the center thereof, as shown.

An upper annular metallic diaphragm 23, having a width somewhat less than the annular space between the outer surface of plunger 14 and the inner cylindrical wall of member 7, has its central or inner upper surface hermetically sealed, as by brazing, to the lower surface of flange 14A, to join the inner end of said diaphragm firmly to the outer surface of plunger 14. Diaphragm 23 is preferably provided with a plurality of corrugations so as to lend flexibility to said diaphragm, and is preferably made of the nickel-copper-iron alloy known as Monel metal. The outer edge of the diaphragm is spaced somewhat from the inner cylindrical wall of member 7, due to the width of said diaphragm, and the outer end of said diaphragm is hermetically sealed to the upper surface of an upper relatively thick "floating" annular spacer member 24 which is preferably also made of Monel metal. The width of member 24 is rather small, to keep the area of attachment of diaphragm 23 to said spacer member as close radially as possible to the inner cylindrical wall of member 7. The outer surface of member 24 is spaced from the inner cylindrical wall of member 7, so that member 24 is free to move with respect to member 7 and with respect to plunger 14.

A second or central annular metallic diaphragm 25, substantially similar to diaphragm 23 and also having a width somewhat less than the annular space between the outer surface of plunger 14 and the inner cylindrical wall of member 7, has its outer portion hermetically sealed to the lower surface of spacer member 24. Diaphragm 25 also has a plurality of corrugations therein to lend flexibility thereto, and is also preferably made of Monel metal. The inner edge of diaphragm 25 is spaced somewhat from the outer cylindrical surface of plunger 14, due to the width of said diaphragm, and the inner end of said diaphragm is hermetically sealed to the upper surface of a lower relatively thick "floating" annular spacer member 26 which is also made of Monel metal. The width of member 26 is such as to make the outer diameter of said member substantially equal to the outer diameter of flange 14A, to thereby keep the area of attachment of diaphragm 25 to spacer member 26 located at the same radial distance from the axis of the entire assembly as is the area of attachment of diaphragm 23 to flange 14A. The inner surface of member 26 surrounds and is spaced from the outer surface of plunger 14, so that said member is free to move with respect to plunger 14 and member 7.

A third or lower annular metallic diaphragm 27, substantially similar to diaphragms 23 and 25 and also having a width somewhat less than the annular space between the outer surface of plunger 14 and the inner cylindrical wall of member 7, has its inner portion hermetically sealed to the lower surface of spacer member 26. Diaphragm 27 is of Monel metal, and has a plurality of corrugations therein to lend flexibility to said diaphragm. The outer end of diaphragm

27 is hermetically sealed to an internal horizontal shoulder 28 provided in the cup-shaped cover member 7 close to the lower open end thereof.

It should be noted that the cover member 7, pole piece 13, plunger 14, diaphragms 23, 25 and 27, and spacer members 24 and 26, all have the same longitudinal axis. All of the diaphragms have approximately the same internal and external diameters, and, by means of the rigid spacer members 24 and 26, which have substantially the same thickness or the same height in Fig. 1, these diaphragms are joined together in spaced substantially parallel relation to form a hermetically-sealed bellows-like arrangement, thereby providing a hermetically-sealed flexible connection between the plunger 14 and the cover member 7. It will be seen that the outer end of the upper diaphragm 23 is mechanically coupled to the outer end of the central diaphragm 25, and that the inner end of the central diaphragm 25 is mechanically coupled to the inner end of the lower diaphragm 27. Thus, in order to trace out the continuity of a mechanical connection between plunger 14 and member 7, one would proceed as follows: plunger flange 14A, inner end of diaphragm 23, outer end of diaphragm 23, member 24, outer end of diaphragm 25, inner end of diaphragm 25, member 26, inner end of diaphragm 27, outer end of diaphragm 27, and cover shoulder 28. Such a mechanical coupling together of the plurality of diaphragms may be likened to the electrical connection in series of a plurality of impedance elements, so that herein such a coupling together of the diaphragms will be termed a "series" joining together.

In order to provide for manual movement of plunger 14 vertically in the direction indicated by arrows 21, a suitable manually-operable control mechanism is preferably attached to the upper end of plunger 14. An example of a suitable mechanism is disclosed in the aforesaid Kather application. Such a mechanism ordinarily includes a limiting arrangement, as shown in said copending application, for preventing excessive movement of plunger 14.

Prior to sealing of the cover member 7 to the anode body 5 to form an envelope which may be evacuated through bore 17, the entire tuning structure, consisting of cover 7, pole piece 13, plunger 14, diaphragms 23, 25 and 27, and spacer members 24 and 26, is made up as a complete cover assembly by mounting the plunger in pole piece 13 and thereafter joining the diaphragm structure 20 together as above described, with one free end of the bellows sealed to the plunger 14 and the opposite free end of the bellows sealed to the cover member 7. Thus, the entire structure above anode body 5 in the drawing is ordinarily manufactured as a mechanical tuning structure assembly.

The movable spacer members 24 and 26 are provided so that each of the diaphragms can pivot, by means of its attachment to such spacer members, about a neutral plane which is substantially the horizontal plane centrally of the height or thickness of each of the spacer members.

Fig. 1 illustrates the position of the parts of the tuning structure when the plunger is in its uppermost position. Diaphragm 23 slopes downwardly from the center to the outside thereof, diaphragm 25 slopes upwardly from the center to the outside thereof, and diaphragm 27 slopes downwardly from the center to the outside thereof. Flange 14A is adjacent the lower surface of

the disc portion of cover member 7 and the bottom ends of the fingers 19 extend only slightly below the top edges of the vanes 6.

Fig. 2 illustrates the position of the elements when the plunger is in its lowermost position. Diaphragm 23 now slopes upwardly from the center to the outside thereof, diaphragm 25 now slopes downwardly from the center to the outside thereof, and diaphragm 27 now slopes upwardly from the center to the outside thereof. Flange 14A is now a substantial distance below the lower surface of the disc portion of cover member 7 and the bottom ends of the fingers 19 extend a substantial distance below the top edges of the vanes 6.

In this position, as compared to Fig. 1, the curvatures of the diaphragms have all been reversed by pivoting about their points of attachment to the spacer members 24 and 26 with respect to a neutral plane passing horizontally through the center of thickness of the spacer members, and said spacer members have both moved bodily downward. If the spacer members were omitted and the superposed diaphragms were attached directly to each other, this reversal of curvature of the diaphragms could not take place. When Fig. 2 is compared to Fig. 1, it may be seen that, even though the curvatures of all of the diaphragms have been reversed, there have been no excessive relative movements in any diaphragm of one end of the diaphragm as compared to the opposite end of the same diaphragm, due to the fact that the spacer members, or the couplings between the separate diaphragms, are free to move with respect both to the plunger 14 and to the cover member 7. In other words, each diaphragm pivots at least in part about a movable pivot point, as contrasted to necessarily fixed pivot points if only a single diaphragm were used. Therefore, each diaphragm contributes only a fraction of the total movement of the plunger 14.

It has been found that it is the amount of relative movement between the two ends of an annular diaphragm which tends to cause proportional fatigue and fracture of said diaphragm, and not necessarily the amount of movement of said diaphragm with respect to a fixed point. In this invention, the amount of relative movement between the two ends of each diaphragm is substantially reduced as compared to the required movement if only one diaphragm were used. Therefore, a much longer diaphragm life is obtainable with this invention than with prior devices, on the order of ten times as long, for example.

It will be seen that, by the compound or multiple diaphragm bellows structure of this invention, longer diaphragm life by smaller relative diaphragm movement is obtainable without sacrifice of range of movement of the tuning plunger.

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.

What is claimed is:

1. A structure for mechanical tuning of magnetrons, comprising a cover member sealed to a body member to form an evacuated envelope, a plurality of flexible corrugated diaphragms joined together in series forming a hermetically-sealed bellows inside the space defined by said cover member and said body member, one end of said bellows being hermetically sealed to said cover member and the opposite end of said bel-

lows being hermetically sealed by tuning means attached to said bellows, and ferromagnetic means connected to said tuning means for moving said bellows to thereby move said tuning means.

2. A structure for mechanical tuning of magnetrons, comprising a cover member sealed to a body member to form an evacuated envelope, a plunger of magnetizable material slidably mounted with respect to said cover member, and a plurality of flexible corrugated diaphragms joined together in series forming a hermetically-sealed bellows inside the space defined by said cover member and said body member, one end of said bellows being hermetically sealed to said plunger and the other end of said bellows being hermetically sealed to said cover member to thereby provide a hermetically-sealed flexible connection between said plunger and said cover member.

3. A structure for mechanical tuning of magnetrons, comprising a cover member adapted to be sealed to a body member to form an evacuated envelope, a pole member of magnetizable material attached to the outside of said cover member, a plunger slidably mounted in said cover member and said pole member, a plurality of flexible corrugated diaphragms, and means joining together said diaphragms in spaced substantially parallel relation and in series forming a hermetically-sealed bellows, one end of said bellows being hermetically sealed to said plunger and the other end of said bellows being hermetically sealed to said cover member to thereby provide a hermetically-sealed flexible connection between said plunger and said cover member.

4. A structure for mechanical tuning of magnetrons, comprising a cover member adapted to be sealed to a body member to form an evacuated envelope, a plunger slidably mounted in said cover member, a plurality of flexible diaphragms, and a plurality of rigid spacer members, one of said spacer members being positioned between each pair of adjacent diaphragms and successive spacer members being positioned at opposite edges of successive pairs of adjacent diaphragms, each spacer member being hermetically sealed to its corresponding pair of diaphragms, whereby said diaphragms are joined together in spaced substantially parallel relation and in series to form a hermetically-sealed bellows, one end of said bellows being hermetically sealed to said plunger and the other end of said bellows being hermetically sealed to said cover member.

5. A structure for mechanical tuning of magnetrons, comprising a cover member adapted to be sealed to a body member to form an evacuated envelope, a plunger slidably mounted in said cover member, a plurality of flexible diaphragms, and a plurality of rigid spacer members, one of said spacer members being positioned between each pair of adjacent diaphragms and successive spacer members being positioned at opposite edges of successive pairs of adjacent diaphragms, each spacer member being hermetically sealed to its corresponding pair of diaphragms, whereby said diaphragms are joined together in spaced substantially parallel relation and in series to form a hermetically-sealed bellows, all of said spacer members being free to move with respect to said plunger and said cover member, one end of said bellows being hermetically sealed to said plunger and the other end of said bellows being hermetically sealed to said cover member.

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