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MAGNETRON INDUCTIVE TUNER EMPLOYING VARIABLY  
SPACED PARALLEL PLATE TRANSMISSION LINE  
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2,466,765

FIG. 1



FIG. 2

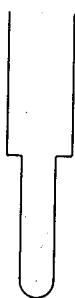


FIG. 3



FIG. 4



FIG. 5



FIG. 6

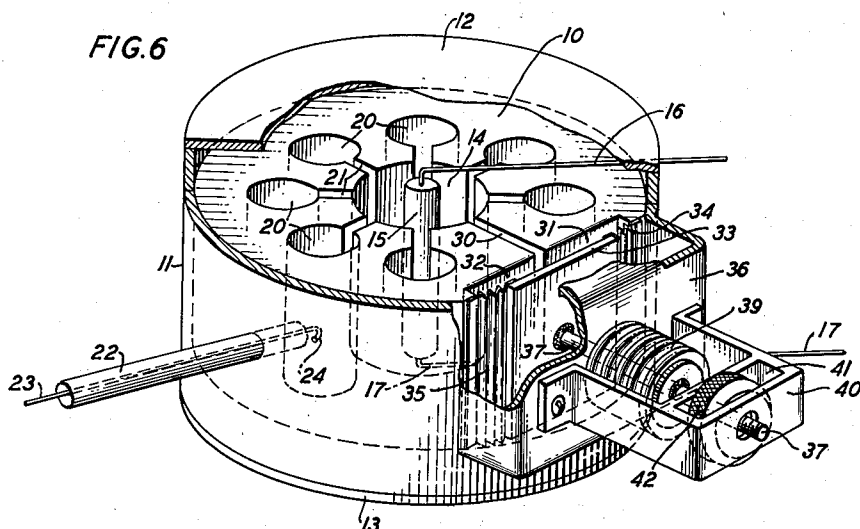


FIG. 7

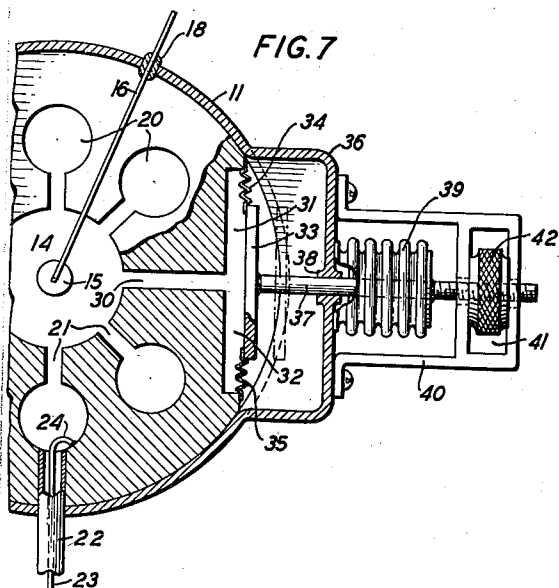
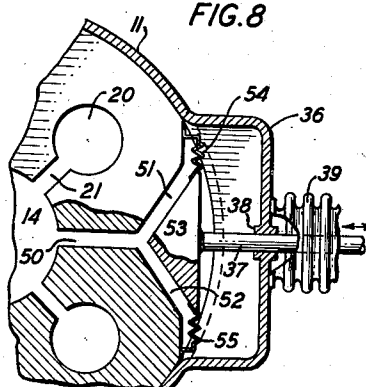


FIG. 8



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## UNITED STATES PATENT OFFICE

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## MAGNETRON INDUCTIVE TUNER EMPLOYING VARIABLY SPACED PARALLEL PLATE TRANSMISSION LINE

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5 Claims. (Cl. 315-40)

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This invention relates to a tuning arrangement for an electromagnetic resonator of the type containing a plurality of resonating cavities coupled together into a multiresonant system. The invention is particularly applicable to a type of multicavity resonator commonly employed in a magnetron oscillator.

The need for tuning a cavity resonator may arise in many situations, particularly those involving the handling of microwaves, as in the generation and transmission of such waves. It is customary where power outputs of several kilowatts are required, to generate microwaves in a magnetron oscillator which has a resonant system containing a plurality of resonating cavities that are coupled together. While the oscillating system of the magnetron may be predesigned to operate approximately at a desired frequency, it is useful to be able to adjust the operating frequency, after the oscillator has been connected to a transmission system. One reason for this is that the operating frequency of a system made up of an oscillator and a load, which system may also include an intermediate transmission medium therebetween, depends not alone upon the dimensions of the oscillator, but also upon the impedance offered to the oscillator by the load and by the transmission medium. Oscillators have in certain cases been produced in quantity, inspected and tested in a standardized transmission circuit and those oscillators operating outside a prescribed frequency band have been rejected as unsatisfactory. Of the oscillators passing such a test moreover, some operate in the test circuit at a frequency close to one edge of the band. Such marginal oscillators when placed in the system for which they are ultimately intended, which system may differ somewhat from the test circuit in its impedance characteristics, may operate at a frequency outside the band limits, and thus be unsatisfactory. An oscillator which is off frequency usually can be brought to operate within the band by effecting a small change in the resonating properties of the oscillator. Other reasons for tuning the oscillator are to permit a selection of the final operating frequency and to permit the frequency to be changed from time to time as desired. A further reason is to enable manufacturing tolerances to be relaxed while insuring a commercial product which readily can be made to operate within its prescribed frequency band.

Various mechanical means are known for altering the shape or size of a resonant cavity to change its resonant frequency. In some cases

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the known means may be limited to producing insufficiently large changes in the resonant frequency or may be unsuited electrically or mechanically for the particular application in which it is desired to have a frequency adjustment available.

The tuning arrangement of the present invention is particularly adapted, although not limited, to a currently preferred type of multianode magnetron having a perforated anode block containing a plurality of circular cylindrical cavities with their axes parallel to the axis of a central cylindrical interaction space and coupled thereto by means of slots. In accordance with the invention, one of the chambers in the anode block is replaced by a parallel plate transmission line having a lateral branch or preferably two such branches symmetrically disposed with respect to the main branch. The branch line or lines are provided with a movable plate so that the spacing of the parallel plates of the branch line may be varied. The movable plate is provided with means whereby it may be operated from outside the vacuum chamber as by means of a flexible diaphragm.

In the drawings, Figs. 1 to 5, inclusive, are diagrammatic representations of parallel plate transmission lines with various combinations of spacing between the plates.

Fig. 6 is a perspective view, partly broken away, showing a magnetron oscillator embodying the invention.

Fig. 7 is a cross-sectional view of a portion of the structure of Fig. 6, and,

Fig. 8 is a cross-sectional view of a portion of a structure similar to that shown in Fig. 6, but having an alternative form of tuning structure.

Figs. 1 to 5, inclusive, represent the shape in cross-section of a plurality of parallel plate transmission lines all of the same physical length (in the vertical direction) and all open at one end and closed at the other. The line represented by Fig. 2 has less capacitance per unit length at the open end and therefore will resonate at a shorter wavelength than that presented in Fig. 1. The line in Fig. 3, on the other hand, has more capacitance per unit length at the open end and will resonate at a longer wavelength from that of Fig. 1. Similarly, the lines of Figs. 4 and 5 will resonate at shorter and longer wavelengths, respectively, than the line of Fig. 1, because the inductance per unit length at the closed end is less in the line of Fig. 4 and greater in the line of Fig. 5. In general, the resonant frequency of a parallel plate transmission line may be varied by chang-

ing the spacing between the plates over a portion, or the whole, of the length of the line. This principle is employed in the tuning structure of the present invention.

Referring to Figs. 6 and 7, the anode block 10 of a magnetron is shown with its enclosing case comprising a cylindrical side wall portion 11 and end plates 12 and 13, respectively. The central cylindrical reaction space of the magnetron is shown at 14 and has mounted along its central axis a cathode 15 which may be suitably supported as by means of sufficiently rigid wires or rods 16 and 17 which are brought through the wall portion 11 and supported by sealing means such as a glass bead 18 (Fig. 7). A plurality of chambers 20 may be provided as in the form of cylindrical perforations of the anode block 10, the cylinders having their axes parallel to the axis of the interaction space 14. The individual chambers 20 may be connected to the interaction space 14 by means of coupling slots or channels 21 extending from end to end of the anode block 10. One of the chambers 20 may be provided with a coaxial line output fitting comprising an outer sheath 22 and an inner conductor 23, the latter terminating in a coupling loop 24 within the chamber 20 in accordance with well-known practice. The anode block 10 may be composed of conductive material but in any case the surfaces of the perforations should be highly conductive to a sufficient depth to serve as reflectors of electromagnetic waves of the generated frequency.

In accordance with the invention, one of the chambers 20 is omitted and instead the corresponding coupling slot or channel, designated 30, is extended outwardly and provided with side branches 31 and 32. The side branches may have one surface formed as by a substantially segmental cut removing a portion of the outer surface of the block 10. A movable plate for the line branches 31 and 32 may comprise the member 33 which is preferably attached at two opposite edges to the anode block as by means of a pair of corrugated metallic sheets 34 and 35. The top and bottom edges of the member 33 are unattached. The flexible members 34 and 35 are both conductively and mechanically connected between the block 10 and the element 33 although none of the members 33, 34 or 35 is necessarily required to withstand air pressure or vacuum. A housing 36 which may be an extension of the cylindrical wall 11, surrounds the members 33, 34 and 35. A rod 37 may be attached to the outer surface of the member 33 and should extend through the housing 36 as through a bearing 38 in which the rod may slide freely and at the same time be supported. Means such as a flexible metallic bellows 39 is preferably provided, the inner edge of which bellows is fastened and sealed around the edge of the bearing 38. The outer end of the bellows is fastened and sealed to the rod 37. On the outside of the housing 36 there may be mounted a frame 40 with a slot 41 in which may be fitted a captive nut 42 threaded upon the rod 37, the rod passing through suitable holes in the frame 40. It is evident that by turning the nut 42, the rod 37 may be moved radially with respect to the central axis of the magnetron, thereby adjusting the position of the member 33 and the spacing between the surfaces comprising the branch lines 31 and 32. The effect of changing the spacing in the branch lines is comparable with changing the line of Fig. 1 into the form shown in either Fig. 4 or Fig. 5. The tuning adjustment directly affects the resonant properties

of the transmission line 30, 31, 32 and due to coupling present between the various portions of the resonator, the resonant frequency of the system as a whole may be varied by adjusting the position of the member 33.

In another form of the invention, shown in Fig. 8, the branch lines, instead of being perpendicular to the slots 30, may be divergent as shown by the side branches 51 and 52 communicating with the coupling slot 50. The element 33 may then be replaced by a prismatic element 53. The adjusting mechanism may be the same as in the arrangement of Figs. 6 and 7. Corrugated sheets 54 and 55 may be used in the same manner as the elements 34 and 35. Radial motion of the member 53 with respect to the central axis of the magnetron produces a variation in the spacing of the plates in the branch lines 51 and 52 with a similar effect upon the tuning of the system as a whole as is obtainable with the system of Figs. 6 and 7.

What is claimed is:

1. A tunable electromagnetic resonator comprising an anode block having an outer surface an extended portion of which is parallel with a given linear axis, said block having a perforation therethrough parallel to the said linear axis, said perforation opening into a slot extending outwardly to and constituting an aperture in said parallel outer surface portion of the block, the adjacent portions of the block along said slot constituting a main transmission line, and a conductive plate mounted opposite said parallel outer surface portion of the block in a region including the said aperture, the said conductive plate and the adjacent parallel outer surface portions of the block on either side of said aperture constituting a pair of branch transmission lines opening out from said main transmission line, and means coupled to said plate to vary the spacing between the said plate and the said outer surface of the block.

2. A tunable electromagnetic resonator comprising an anode block having a perforation therethrough, means forming first and second parallel plate transmission lines opening into each other, the space between the plates of said first line opening out from said perforation and the plates of said second transmission line being conductively short-circuited at the end of said line remote from said perforation, and means coupled between the plates of said second transmission line for varying the separation of the plates of said second transmission line.

3. A tunable electromagnetic resonator comprising an anode block having a perforation therethrough, means including a portion of the walls of said perforation forming a first parallel plate transmission line, the space between the plates of said first line opening into the main part of said perforation, means forming a second parallel plate transmission line opening out from said first parallel plate transmission line, conductive means short-circuiting the said second parallel plate transmission line at the end thereof remote from the main part of said perforation, and means coupled between the plates of said second transmission line for varying the spacing between the plates of said second transmission line.

4. A tunable electromagnetic resonator comprising an anode block having an outer surface an extended portion of which is parallel with a given linear axis, said block having a perforation therethrough parallel to the said linear axis,

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said perforation opening into a slot extending outwardly to and constituting an aperture in said parallel outer surface portion of the block, the adjacent portions of the block along said slot constituting a main transmission line, a conductive plate mounted opposite said parallel outer surface portion of the block in a region adjacent to the said aperture, the said conductive plate and the adjacent parallel outer surface portion of the block constituting a second transmission line opening out from said main transmission line, and means coupled to said plate to vary the spacing between the said plate and the said outer surface of the block.

5. Apparatus in accordance with claim 4 with the addition of flexible conductive means connecting opposite ends of said conductive plate to said anode block at each end of said second

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transmission line on opposite sides of said aperture.

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