

Sept. 19, 1967

NILS-ERIK BACKMARK
TUNABLE ELECTRONIC TUBE

3,343,031

Filed Dec. 26, 1963

3 Sheets-Sheet 1

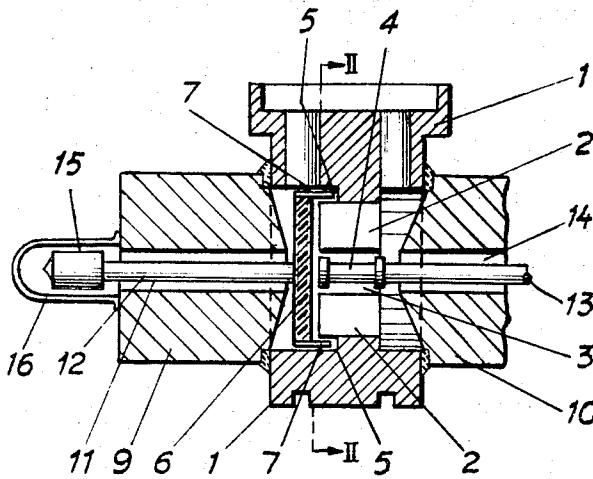


Fig. 1

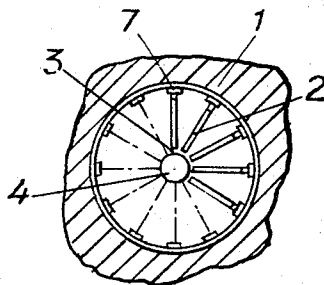


Fig. 2

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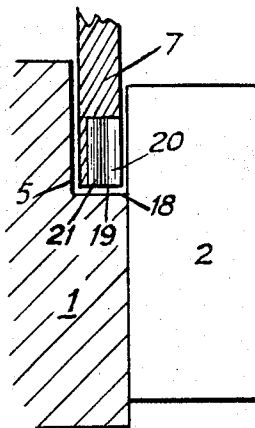
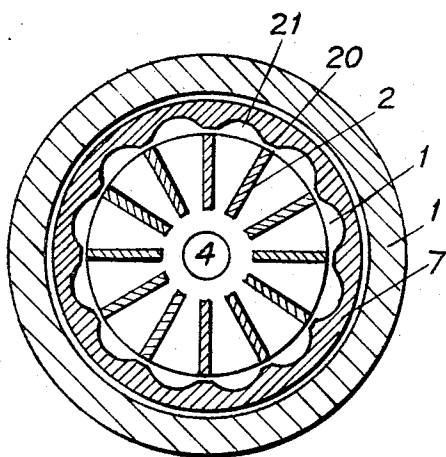
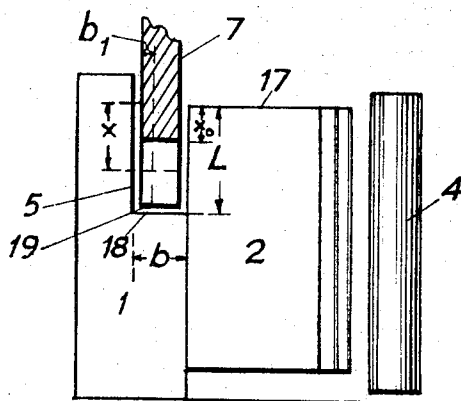
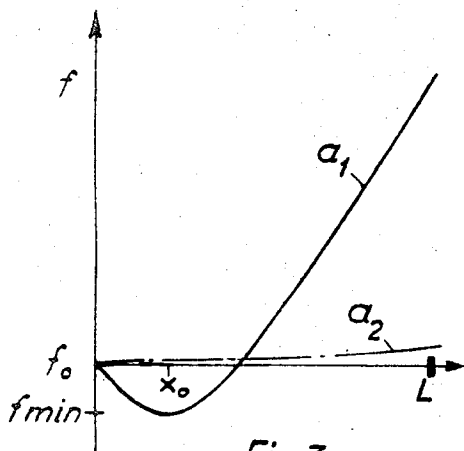
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3 Sheets-Sheet 2



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TUNABLE ELECTRONIC TUBE

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3 Sheets-Sheet 3

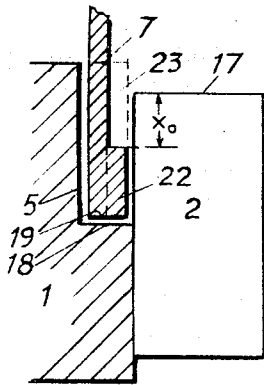


Fig 7

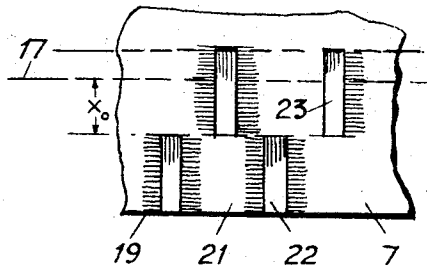


Fig 8

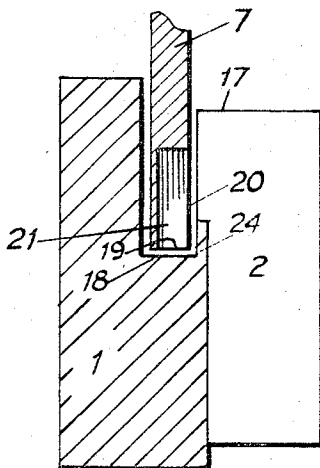


Fig 9

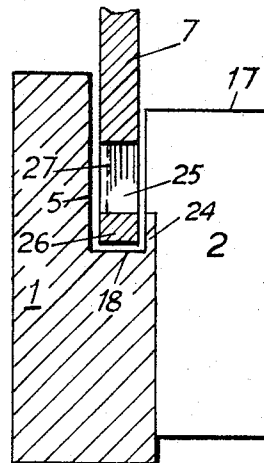


Fig 10

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TUNABLE ELECTRONIC TUBE

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6 Claims. (Cl. 315—39.55)

ABSTRACT OF THE DISCLOSURE

A tunable magnetron provided with a member having a variable cross-section rotatable in a peripheral slot in the anode vanes.

The present invention relates to a tunable electron discharge tube. More particularly, the invention relates to a tube having at least two cavities which determine the frequency of an oscillation generated by the tube and between which there are apertures extending from an end surface of the cavities. A tuning member consisting of an electric conducting body is movable in those apertures for varying, especially periodically, the resonance frequency of the tube. In particular the invention relates to arrangements of this kind in which the movable portions in the apertures between the cavities are arranged to be periodically moved into and out of the apertures for periodically changing the resonance frequency of the device.

The device according to the present invention has for its object increasing the frequency range, within which the cavities are tunable by the movement of said body or bodies in the apertures between the cavities. Devices according to the invention are particularly important in magnetrons having cavities annularly disposed around a discharge chamber and having apertures between the cavities so arranged that they lie on a circle substantially concentric with the discharge chamber. One or more conducting bodies extend into these apertures or are arranged along a corresponding circle, supported by a rotating carrier and caused to pass into and out of the apertures between the cavities upon rotation of the carrier. These conducting bodies thereby give rise to a change, especially periodically, of the resonance frequency of the tube (it is of no importance for the invention whether the "cold frequency" or the operating frequency is considered).

The invention is therefore described below in connection with an embodiment having cavities disposed annularly in an anode block, in which the apertures between the cavities are formed by recesses in the walls forming the cavities. These recesses are arranged along a circle line substantially concentric with the discharge chamber, and have electrically conducting parts along a corresponding circle line arranged on a rotatable carrier. The electrically conducting parts pass through the apertures upon rotation of the carrier and thereby effect a change of the filling in the apertures with conducting material. The apertures between the cavities may suitably be formed by a circular groove extending from one end surface of the anode block into the material of the anode block and are so disposed that apertures occur between the cavities.

According to the present invention the metal parts of the tuning member arranged on a carrier and movable through the apertures by rotation of the carrier are made in the shape of a metal body. This metal body is dimensioned with regard to the dimensions of the apertures and provided with recesses, the dimension of which in a direction normal to that end surface of the anode body from which the aperture extends, that is in the direction of the depth of the groove, is less than the depth of the aper-

tures. The recesses are situated entirely inside the end surface of the cavity.

Thus it is achieved that the outer portion adjacent to the end surface of the anode body may have a maximum or nearly maximum filling of conducting material as determined by the radial dimensions of the movable body. The inner portions of the aperture, as seen from the end surface, are filled more or less when the body is moved through the aperture. The result thus obtained which causes a substantial increase of the frequency separation between the highest and the lowest resonance frequency of the electron discharge tube when the body is moved in the apertures between the cavities will be more clearly explained below.

An additional increase in this frequency separation may be obtained if the conducting material of the movable conducting body exists at the bottom of the aperture in the wall between cavities also at places where the body is provided with a recess. For this purpose the recesses affecting the frequency change of the device have such an extension over a portion of the depth of the aperture, that is the groove, that the filling in the groove with conducting material at the recesses is reduced by them only over a portion of the height. This portion does not extend to the portion of the body located deeply in the aperture and not right to the outer edge of the aperture. The recesses in the body may then suitably consist of holes in a movable ring lying in the aperture or the groove in the cavities respectively. These holes may then pass entirely through the conducting material of the ring or be covered by conducting material on the outside of the ring as seen from the center of the tube.

A device according to the invention will be described in connection with the accompanying drawing, in which FIG. 1 is an elevational view of a magnetron tube, in which the invention is applied to a ring movable in the aperture between the cavities, and FIG. 2 is a view in section of the same device normal to the axis along lines II—II in FIG. 1. FIG. 3 shows curves for illustrating the effect obtained by the invention and FIG. 4 shows a detail of an aperture between cavities described in connection with FIG. 3. FIGS. 1 and 2 are intended to give a general view of an arrangement according to the invention. Those details, which are especially connected with the invention appears in different embodiments from FIGS. 5—10.

The magnetron shown in FIGS. 1 and 2 consists of anode-block 1 provided with radially disposed plates 2 arranged in a cylindrical recess and forming together with the surfaces of the cylindrical recess resonance cavities arranged around a discharge chamber outside the centrally situated cathode 4. On each side of the sector-shaped cavities formed by the plates 2 there are magnet poles 9 and 10. Through a hole 14 in one of these a carrier 13 for the cathode 4 is arranged, and through a hole 11 in the other one passes a rotating shaft 12 of a driving device 15 situated in a vacuum tight cap 16. On the shaft 12 a carrier 6 for an electrically conducting ring 7 is arranged. This ring 7 extends into a groove 5 cut out from the end surface of the anode block 1. This groove is so situated that apertures are obtained between neighboring sector-shaped cavities formed by the plates 2. If the ring 7 has varying dimensions in a peripheral direction of the portions extending in the groove 5 a change of the resonance frequency of the magnetron is obtained when the ring 7 is rotated about its shaft.

The invention has regard to a special arrangement of the metal portions, which extend into the apertures formed by the groove 5 between neighboring cavities of the tube upon rotation of the carrier 6, whereby the change of resonance frequency of the magnetron is effected by rotation of the carrier. This change of the resonance fre-

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quency of the magnetron is materially increased in relation to the frequency change obtained if the metal portions passing through the apertures on the rotation consist of teeth substantially entirely filling the apertures with intermediate portions, in which the recesses do not contain any metal portions movable with the carrier or such metal portions have the same width over the entire depth of the apertures.

The principle of the invention is illustrated by the curves in FIG. 3 in connection with the detail of a groove in the anode body between two cavities shown in FIG. 4 and an electrically conducting portion movable in the same, by which a resonance frequency variation is effected.

In FIG. 4 a part of the real anode body is designated 1 and a wall attached to it and bounding two neighboring cavities is designated 2. An aperture between these cavities (which also holds good for other cavities situated around the cathode 4) is obtained by the groove 5 in the anode block extending to a depth L from the edge of the cavity bounding plate 2. In principle a frequency variation is obtained with different fillings in the recess formed by the groove 5 between the cavities due to the fact that the field lines running at the edges of the cavities are more or less influenced by a greater or less filling of the aperture between the cavities.

Basic to the invention is the insight about the behavior of the resonance frequency with a change of the filling of the aperture between the cavities with conducting material. Thus in FIG. 3 the frequency change is illustrated which is obtained by inserting a metal portion substantially entirely filling the width of the aperture from the edge 17 of the aperture and towards its bottom 18. Starting from the position where the edge 19 of the metal portion 7 is on the same level as the edge 17 of the cavity wall 2 at the end surface of the magnetron curve a_1 , FIG. 3 shows the frequency change obtained when the metal portion is displaced from the edge of the bottom of the aperture 5. The distance between the said edges at the displacement is designated X and the total depth of the recess is designated L. In FIG. 3 the distance is the abscissa and the frequency is the ordinate. At first on the insertion of the metal portion into the recess a frequency decrease from resonance frequency f_0 of the magnetron without filling in the groove is obtained up to a point x_0 , where the frequency passes a minimum f_{min} , after which the frequency again increases and passes through f_0 up to a maximum when the metal portion has been inserted to the bottom of the groove, that is the distance L at which point the magnetron has its maximum frequency.

If instead the conducting portion 7 does not have substantially the same width b as the recess 5 but is materially narrower, which has been indicated in the figure at b_1 , and is inserted in the same way from the edge towards the bottom of the aperture 5 a frequency characteristic according curve a_2 in FIG. 3 is obtained.

These frequency characteristics valid for frequencies corresponding to metal portions arranged at different places in the recesses may according to the invention be utilized for improving the frequency variation obtainable according to the invention with a device of the type illustrated.

A first embodiment of a tuning device according to the invention is shown in a section normal to the axis of the magnetron in FIG. 5 and a detail of an axial section through the same device is shown in FIG. 6. In this embodiment the body movable in the groove 5 consists of a ring 7 provided with teeth 20, the teeth being formed by recesses 21 in the ring 7 and having such a height, that substantially maximum frequency reduction corresponding to the point X_1 , f_{min} in FIG. 3 is obtained between the teeth and maximum frequency increase is obtained when the teeth are situated in the recesses between the cavities.

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A further improvement of the obtainable frequency change may be achieved by providing the ring 7 with teeth in the manner illustrated in FIGS. 7 and 8. In these figures a tooth wheel similar to the one shown in FIG. 5 is illustrated, in which however the teeth 22 have a smaller height than that corresponding to the depth of the recess and only reach a point at the distance x_0 from the edge corresponding the lowest frequency at the frequency minimum according to FIG. 3. By this expedient the effect of material present above this point to reduce the frequency is eliminated, which implies an increased frequency variation corresponding to the change between the lowest frequency at this minimum and the highest frequency. If in addition a further toothed wheel is arranged having teeth 23, which are displaced in the direction of rotation in relation to the first mentioned teeth 22 and extending at least from the outer edge 17 of the recess and up to the point at the depth x_0 , where there is a frequency minimum according to FIG. 3, a further increase of the frequency variation range is obtained.

A further increase of the tuning range may be obtained in accordance with the invention with a device according to FIGS. 9 and 10, in which the teeth extend into a groove in the anode block which then inside the teeth as seen from the axis of the tube forms a wall 24 in the anode block, which wall projects over a portion of the openings between the cavities. With this arrangement the formation of stray fields for obtaining maximum frequency variation is obviated. In such a device a further improvement may be obtained if the ring 7, as appears from FIG. 10, substantially fills the entire width of the groove at the bottom of it at 26 along the height corresponding to the height of the portion 24 of the material of the anode cavity covering the inner side of the ring as seen from the anode axis. In this embodiment the teeth of the ring 7 are formed by recesses 25 which substantially extend from the edge of the portion 24 of the anode material covering the ring and suitably up to a point on the level x_0 which according to FIG. 3 gives the lowest frequency. An improvement of the frequency variation may however also be obtained if the recess 25 reaches or passes over the edge 17. This recess may pass entirely or only partially (as has been indicated with the dotted line 27) through the material of the ring 7. It may for instance consist of a number of holes punched into the ring 7 with a pitch corresponding to the number of anode cavities.

With the same magnetron type and the same play between the tuning member and the apertures in the cavities walls with a magnetron frequency of 9000 mc. the frequency variation has been increased from 150 mc. between maximum and minimum frequency with the aid of single teeth completely filling the apertures and leaving this entirely open respectively to 600 mc. by the use of recesses in a metal ring extending only to a distance x_0 from the edge of the cavity. With a construction according to FIG. 10 having an inner wall 24 in the anode block as well as a filling 26 of the space in the apertures inside the edge of the anode block the frequency variation has been increased to 800 mc., that is an increase at a ratio of about 1 to 4 and 1 to 5 respectively.

What is claimed is:

1. A tunable magnetron comprising a substantially cylindrical anode block of electrically conductive material enclosing a plurality of sectors constituting cavity resonators, the sectors being interconnected by apertures forming part of an annular groove on and penetrating a depth into an end face of the anode block, electrically conductive parts comprising first and second portions secured to a common support rotatable about an axis concentric with the groove, said parts being displaceably arranged in said apertures, a first portion of said conductive part completely filling each of the apertures from the end surface to an intermediate depth less than the depth of the groove, said second portion of the conductive part having an outer cylindrical surface and an inner profiled

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cylindrical surface whereby the filling of the aperture by the second portion of the conductive part varies as the support is rotated relative to the anode block.

2. A tunable magnetron as claimed in claim 1, wherein the conductive parts have recesses in the second portion which pass at least partially through the second portion in a radial direction.

3. A turnable magnetron as claimed in claim 1, wherein the conductive parts have apertures in the second portion which extend radially through the second portion.

4. A tunable magnetron comprising a substantially hollow cylindrical anode block of electrically conductive material, a conductive annular wall spaced from and connected with the anode block forming therewith a groove, a plurality of vanes secured to said wall and to said anode block and extending inwardly therefrom defining a plurality of sectors constituting cavity resonators, the sectors being interconnected by apertures forming part of said annular groove, electrically conductive parts comprising first and second portions secured to a common support rotatable about an axis concentric with the groove, said parts being displaceably arranged in said apertures, a first portion of said conductive part completely filling each of the apertures from the end surface to an intermediate depth less than the depth of the groove, said second portion having a profile such that the filling of the aperture

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by the second portion of the conductive part varies as the support is rotated relative to the anode block.

5. A tunable magnetron as claimed in claim 4, wherein the second portion is provided with a recess extending partially through said second portion in a radial direction, the edge of the recess remote from the anode end surface lying in the same plane normal to the axis as the free end of the annular wall extending from the anode block.

10 6. A tunable magnetron as claimed in claim 4, wherein the second portion is provided with apertures extending therein, the edge of the aperture remote from the anode and surface lying in the same plane normal to the axis as the free end of the annular wall extending from the anode block.

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