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2,587,136

REFLEX KLYSTRON ELECTRON-DISCHARGE DEVICE

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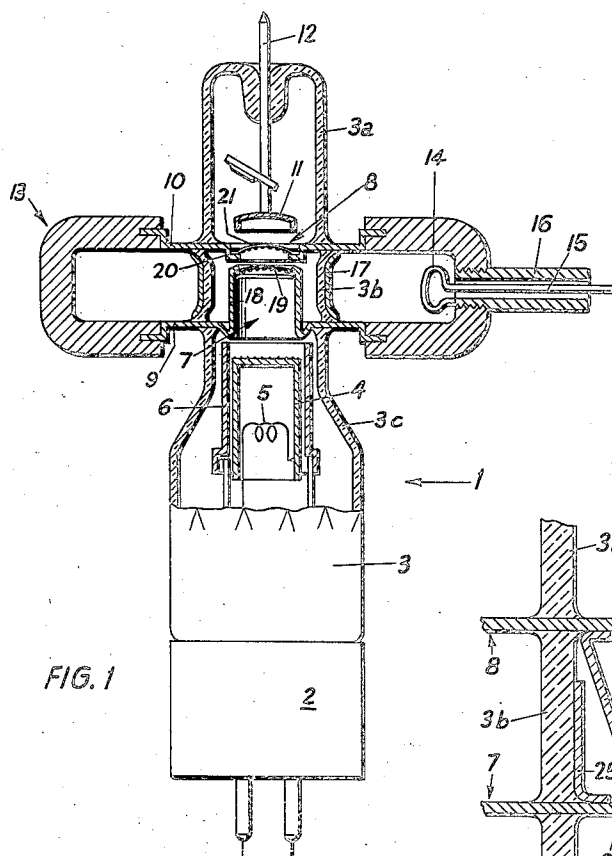


FIG. 1

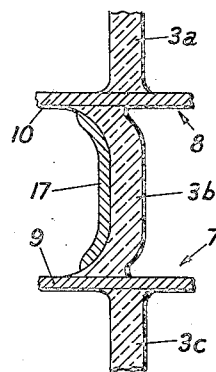


FIG. 2

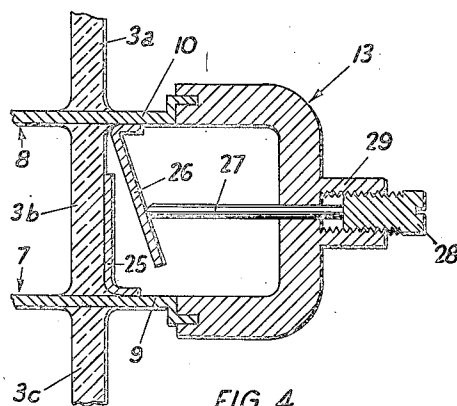


FIG. 4

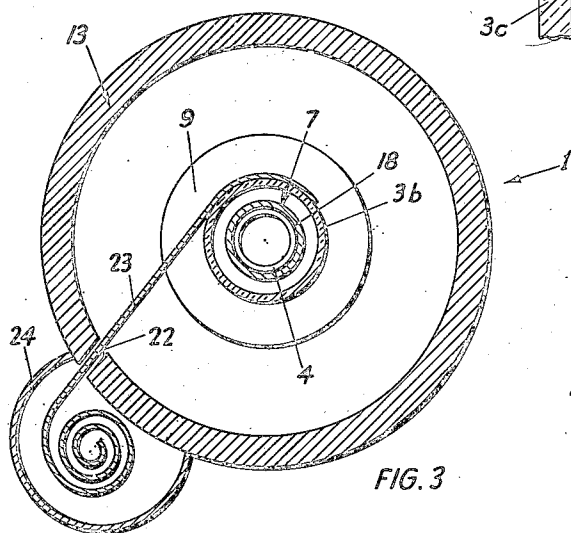


FIG. 3

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REFLEX KLYSTRON ELECTRON-
DISCHARGE DEVICE

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8 Claims. (Cl. 315-5)

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This invention relates to electron-discharge devices, and more particularly to electron-discharge devices of the velocity-modulated types known as klystrons and reflex klystrons.

In certain instances, cavity resonators, with which tubes of this character are commonly associated, are variable in volume in order to vary the frequency, and therefore also the wavelength, of the output of such tubes over a small range, for example, over a range of the order of one centimeter in wavelength. Generally, for economy in production, it is desirable to produce cavity resonators of uniform size and tubes of uniform dimensions and configuration, while at the same time it is desirable to be able to shift the output frequency of said tube into different frequency ranges or bands.

It is, therefore, an object of this invention to devise means for readily shifting the output frequency band of an electron-discharge device of the klystron or reflex klystron type.

Another object is to provide a novel means for continuously varying the tuning of a reflex klystron.

A further object is to provide a plurality of different means, adapted to be interchangeably applied during the life of the klystron, for shifting the klystron output frequency into a plurality of different bands.

A still further object is to devise means whereby, with a given klystron and with a given cavity resonator, the output frequency of said klystron may be easily shifted into a different band.

These, and other objects of the present invention, which will become more apparent as the detailed description thereof progresses, are attained, briefly, in the following manner:

An evacuated, dielectric envelope is provided to enclose an electron gun, a pair of grids spaced from said gun, and a repeller electrode spaced from said grids. Said grids are sealed through the walls of said envelope and are connected, respectively, to the terminals of a tuned circuit. Said tuned circuit consists of a cavity resonator which is external of the said envelope. A metallic conducting member or band is adapted to be placed, externally of said envelope, between said grids, but not short-circuiting the same, to increase the capacitance between said grids, thereby to lower the frequency or increase the wavelength of the klystron output.

In the accompanying specification there is described, and in the annexed drawing shown, some illustrative embodiments of the electron-discharge device of the present invention. It is, however, to be clearly understood that the pres-

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ent invention is not to be limited to the details herein shown and described for purposes of illustration, only inasmuch as changes therein may be made without the exercise of invention, and within the true spirit and scope of the claims hereto appended.

In said drawing, Fig. 1 is a longitudinal cross-section through an ultra-high-frequency velocity-modulated tube embodying the invention;

Fig. 2 is a portion of Fig. 1, on an enlarged scale;

Fig. 3 is a transverse cross-section of a modification of Fig. 1, taken on a horizontal plane substantially through the center of the cavity resonator; and

Fig. 4 is an enlarged view, similar to Fig. 2 but showing another modification.

Referring now more in detail to one of the aforesaid illustrative embodiments of the present invention, with particular reference to Figs. 1 and 2 illustrating the same, the numeral 1 generally designates a velocity-modulated electron-discharge device of the type known as a reflex klystron.

Said device 1 includes a base 2 supporting an evacuated glass envelope 3. The envelope 3 may be provided with a reentrant press (not shown) supporting a highly electron-emissive cathode 4 adapted to be heated to a temperature suitable to bring about copious emission by a filament 5. Said cathode may be surrounded by a hollow accelerating electrode 6.

The electron gun structure described above produces a compact beam of electrons which emerges through the end of electrode 6 with the requisite velocity. This electron beam is subjected to the action of a pair of control grid structures 7 and 8. The structure of the lower control grid 7 is formed by a lead-in ring or external portion 9 which is sealed through the side walls of the envelope 3. The internal edges of the ring 9 are turned upwardly and form a relatively elongated cylindrical member 18 which has an opening at its upper end across which a perforated conducting member 19 is supported. The perforated member 19 is made of fine conducting wires so as to interpose a minimum of grid surface for intercepting the electrons contained in the electron beam. The second (upper) control grid structure 8 is formed of a conducting ring or external portion 10 sealed through the side walls of the envelope 3. The inner ends of the ring are turned downwardly so as to form a relatively short cylindrical member 20 having an opening at the lower end thereof across which

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is supported a perforated member 21 likewise formed of fine conducting wires.

Spaced from said grids 7 and 8 is a repeller electrode 11 which may be supported, for example, at the end of a lead-in conductor 12 sealed through the envelope 3 at the end thereof opposite the base 2.

A hollow resonant chamber member 13, which may conveniently be a toroidal cavity resonator open along its inner edge, mates at its upper and lower edges respectively with portions 10 and 9 of the grid structures. The resonant chamber member 13 is preferably formed of a highly conductive material, such as copper. Said cavity resonator may be considered or termed a tuned or resonant circuit. The oscillations which are produced by the device may be picked up by a coupling loop 14, placed within the chamber member 13, and led off by a conductor 15 which conveniently may be surrounded by a pipe 16 fastened into the chamber 13 so as to form a concentric or coaxial line with the conductor 15.

The chamber or cavity resonator 13 may have its edges permanently secured to the external portions 3 and 10 of the grids 7 and 8 if desired, but said chamber is preferably adapted to be removably attached to said external portions of the grids in a manner well known to those skilled in the art to which this invention relates. The cavity resonator 13 is adapted to be tuned in any well known manner, for example as disclosed in my copending application, Ser. No. 625,732, filed October 31, 1945, now Patent No. 2,488,906, issued Nov. 22, 1949.

The envelope 3 is formed of a plurality of sections 3a, 3b, and 3c, the section 3a extending from lead-in conductor 12 at the top of the device to external portion 10 of upper grid structure 8, the section 3b extending between grid structures 8 and 7, and the section 3c extending between external portion 9 of lower grid structure 7 and the base 2. Section 3b is preferably of outwardly concave shape as shown.

Mounted on the external surface of said section 3b is a capacity band 17 made of a high-conductivity metal. Band 17 extends entirely around section 3b between the external portions 9 and 10 of grid structures 7 and 8 and may touch neither of said external portions or either one, but not both, of said external portions; in the drawing it is shown as touching neither. Band 17 may be a removable clamp band or a coating, for example, although it is shown in the drawing as a metallic coating; if the clamp-band contains an iron alloy for purposes of strength, it should be plated with a high-conductivity (low-resistivity) metal.

In a parallel-plate condenser, such as that provided between the external portions 9 and 10 of the grid structures, it is well known that the capacitance thereof has a certain value depending upon, among other things, the distance between the plates. If a conducting band is added between the "parallel plates" 9 and 10, the effect is to place a pair of capacitances (those between the band 17 and the respective plates 9 and 10) in parallel with the inherent capacitance between plates 9 and 10, and since parallel capacitances are added to get the resultant capacitance, the resultant capacitance of the parallel-plate condenser is increased. If band 17 touches one of the "parallel plates" 9 or 10, the resultant capacitance of the parallel-plate condenser may be looked upon as being increased due to the decrease in distance between the plates, since the capacitance of a parallel-plate con-

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denser is inversely proportional to the distance between the plates.

As will be seen from the drawing, the capacitance between external portions 9 and 10 of the grid structures is effectively in parallel with that between grid members 19 and 21 themselves, so that, if the capacitance between the external portions 9 and 10 is increased, the total or overall capacitance of the resonant circuit provided by the inductance and capacitance of the cavity resonator 13 is increased. Since the frequency of oscillation of a klystron is inversely proportional to the capacitance of the resonant circuit thereof, addition of capacitance by the band 17 will decrease the frequency, or increase the wavelength of the oscillations thereof with a given outer cavity. Thus, by the addition of the capacity band, the range of frequencies, over which the klystron may be tuned, by variation in the volume of the cavity resonator, may be shifted to a lower frequency band in the electromagnetic spectrum.

Also, since ordinarily the cavity must be enlarged to lower the frequency, and since with this invention the frequency may be lowered without enlarging the cavity, this invention permits the use of a smaller cavity for a given frequency.

If a removable clamp band is utilized for capacity band 17, as suggested above, it is possible to provide removable clamp bands of different widths, whereby different capacity changes, and thereby also different bands of frequencies, may be readily obtained by selectively using each of the plurality of clamp bands with the some klystron and with the same cavity resonator.

When the tube 1 is energized with the proper potentials, a beam of electrons coming from the cathode 4 will be accelerated by the accelerating electrode 6, and pass through the grid structures 7 and 8. As the beam emerges from the grid structure 8, it is reflected by the repeller electrode 11 back through the pair of control grids 7 and 8. As is well known, the initial passage of the beam through the control grids 7 and 8 produces a bunching action, and upon reflection and re-passage of the beam through these control electrodes, a debunching action results which feeds ultra-high frequency energy to the resonant circuit formed by the hollow resonant chamber 13, thus setting up ultra-high-frequency oscillations which may be led off from the coaxial line 15, 16.

Now referring to Fig. 3, which represents a modification, a means for continuously varying the tuning of a reflex klystron is shown. In this figure, parts which are the same as those of Fig. 1 are denoted by the same reference numerals. This figure is a transverse cross-section of a reflex klystron, taken on a horizontal plane substantially through the center of the cavity resonator, and looking downwardly. Extending through an aperture 22 in the side wall of cavity resonator 13, into the interior thereof, is one end of a coiled spring-like metallic member 23. Member 23 is a relatively flat coiled spring-like member similar to those often found in clocks, and is of sufficient length, and is adapted, to extend from the exterior of cavity resonator 13, transversely through said resonator, to and entirely around the exterior of section 3b of the envelope. This member is of such height that it will pass between the external portions of the two grid structures without contacting simultaneously both of said portions; said member is made of a

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low-resistivity material or is plated with such a material. The portion of member 23 which is outside the cavity resonator 13 at any particular time is coiled up in, and enclosed by, a suitable casing 24 which is mounted on the outside of cavity resonator 13 adjacent aperture 22. Member 23 is adapted to be fed, in a continuous and reversible manner, by any suitable means (not shown), from casing 24, through slot 22 and cavity resonator 13, to and around section 3b of the envelope, between the external portions of the grid structures. Member 23, because of its inherent curvature, tends to follow closely the exterior surface of section 3b of the envelope, when it is fed toward said exterior surface.

The member 23 acts as a capacity band to vary the tuning of the klystron in the same manner as band 17 of Fig. 1, except that the capacity variation caused by member 23 is continuous, between limits, due to the structure of said member. Due to the construction, the variation of capacitance with movement of member 23 is linear. It is obvious that the capacitance of the "parallel-plate" condenser continuously increases as member 23 is fed between the plates thereof, due to the effective decrease of the distance between the plates, over more and more of the area of the plates. As the capacitance of the condenser is increased, the klystron is tuned to a lower frequency, with a given outer cavity. The tuning of the klystron is continuously variable, because of the continuous nature of the selective movement of member 23 between the "parallel-plates" of the grid structures.

Of course, as member 23 is removed from between the plates 9 and 10, the capacitance of the condenser is decreased, thereby increasing the frequency to which the klystron is tuned.

Referring now to Fig. 4, which is an enlarged partial view of another modification, the sections of envelope 3 are shown at 3a, 3b, and 3c. A thin metallic plate 25, of relatively limited area, is secured to external portion or ring 9 of grid structure 7 and extends, adjacent the exterior surface of section 3b of the envelope, toward external portion 10 of the grid structure 8, but falls short thereof. A spring member 25, made, as is plate 25, of a metal of low resistivity, and having an area comparable to that of plate 25, is secured to external portion 10 of the grid structure 8, extending toward ring 9 in such a position that it overlies, but is spaced from, plate 25. Spring member 26 has a free end which overlies plate 25 and is adapted to be moved with respect thereto.

In order to control the relative position of members 25 and 26 in a continuous and reversible manner from the exterior of the cavity resonator 13, I provide an elongated small-diameter shank 27, one end of which bears against the outer surface of spring member 26, said shank passing freely through an aperture in the outer wall of said resonator and the other end of said shank being fastened securely to a stud 28 exteriorly of said resonator. Said stud is in threaded engagement with a bushing 29 mounted on the exterior surface of said resonator and is adapted to be manually rotated to positively move member 25 toward member 26, or to allow member 26 to move away from member 25 due to its resiliency.

Since members 25 and 26 are both conducting and since member 25 is attached to ring 9 and member 26 to ring 10, it is apparent that, when members 26 and 25 are moved closer to each other, the effective distance between rings 9 and 10 is reduced, so that the capacitance of parallel-

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plate condenser 9-10 is increased; when members 26 and 25 are moved further apart, the capacitance of said condenser is decreased. When the capacitance of the parallel-plate condenser 9-10 is increased, as in Fig. 1, the frequency to which the klystron is tuned is lowered or decreased. When the capacitance of condenser 9-10 is decreased, the frequency to which the klystron is tuned is raised or increased. Since the spacing between members 25 and 26 may be continuously varied, between limits, in either direction, it is obvious that means for continuously varying the tuning of the klystron has been devised or provided.

If desired, a plurality of springs and cooperating metal bands, such as 25 and 26, may be provided around the circumference of section 3b, with the plurality of spring members being arranged to be moved by a common operating means. Adjacent metal bands should be spaced from each other, although this is not essential.

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. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of this invention within the art.

What is claimed is:

1. In an electron-discharge device: a dielectric envelope; an electron gun, a pair of grids, and a repeller electrode enclosed in said envelope; said grids being sealed through the walls of said envelope and having an inherent capacitance therebetween; a resonant circuit the terminals of which are connected, respectively, to said grids; said resonant circuit including said capacitance; and a metallic member externally mounted on said envelope between the lead-in portions of said grids, for modifying the value of said capacitance.

2. In an electron-discharge device: a dielectric envelope; an electron gun, a pair of grids, and a repeller electrode enclosed in said envelope; said grids being sealed through the walls of said envelope and having an inherent capacitance therebetween; a cavity resonator the terminals of which are connected, respectively, to said grids; said cavity resonator including said capacitance; and a metallic member attached directly to the external surface of said envelope between the lead-in portions of said grids, for modifying the value of said capacitance.

3. In an electron-discharge device: a dielectric envelope; a plurality of electrodes enclosed in said envelope; at least two of said electrodes being sealed through the walls of said envelope and having an inherent capacitance therebetween; and a metallic band externally mounted on and tightly encircling said envelope between the lead-in portions of said two electrodes, for modifying the value of said capacitance.

4. In an electron-discharge device: a dielectric envelope; a plurality of electrodes enclosed in said envelope; at least two of said electrodes being sealed through the walls of said envelope and having an inherent capacitance therebetween; a resonant circuit the terminals of which are connected, respectively, to said two electrodes; said resonant circuit including said capacitance; and a metallic band externally mounted on and tightly encircling said envelope between the lead-in portions of said two electrodes, for modifying the value of said capacitance.

5. In an electron-discharge device: a dielectric envelope; an electron gun, a pair of grids,

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and a repeller electrode enclosed in said envelope; said grids being sealed through the walls of said envelope and having an inherent capacitance therebetween; a cavity resonator the terminals of which are connected, respectively, to said grids; said cavity resonator including said capacitance; and a metallic band externally mounted on and closely encircling said envelope between the lead-in portions of said grids, for modifying the value of said capacitance.

6. In an electron-discharge device: a dielectric envelope; a plurality of electrodes enclosed in said envelope; at least two of said electrodes being sealed through the walls of said envelope and having an inherent capacitance therebetween; a pair of overlying but radially-spaced metallic plate members external of said envelope and between the lead-in portions of said two electrodes; each one of said pair of members being attached to a different one of said two electrodes and the outer one of said pair of members being resilient; and means operable to vary the spacing between said members to thereby modify the value of said capacitance.

7. In an electron-discharge device: a dielectric envelope; a plurality of electrodes enclosed in said envelope; at least two of said electrodes being sealed through the walls of said envelope and having an inherent capacitance therebetween; a resonant circuit the terminals of which are connected, respectively, to said two electrodes; said resonant circuit including said capacitance; a pair of overlying but radially-spaced metallic plate members external of said envelope and between the lead-in portions of said two electrodes; each one of said pair of members being attached to a different one of said two electrodes and the outer one of said pair of members being resilient;

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and means operable to vary the spacing between said members to thereby modify the value of said capacitance.

8. In an electron-discharge device: a dielectric envelope; an electron gun, a pair of grids, and a repeller electrode enclosed in said envelope; said grids being sealed through the walls of said envelope and having an inherent capacitance therebetween; a cavity resonator the terminals of which are connected, respectively, to said grids; said cavity resonator including said capacitance; a pair of overlying but radially-spaced metallic plate members external of said envelope but within said cavity resonator and between the lead-in portions of said grids; each one of said pair of members being attached to a different one of said grids and the outer one of said pair of members being resilient; and means operable externally of said cavity resonator to vary the spacing between said members to thereby modify the value of said capacitance.

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