Nov. 15, 1955 B. C. GARDNER 2,724,072

REFLEX KLYSTRON

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FIG. 1

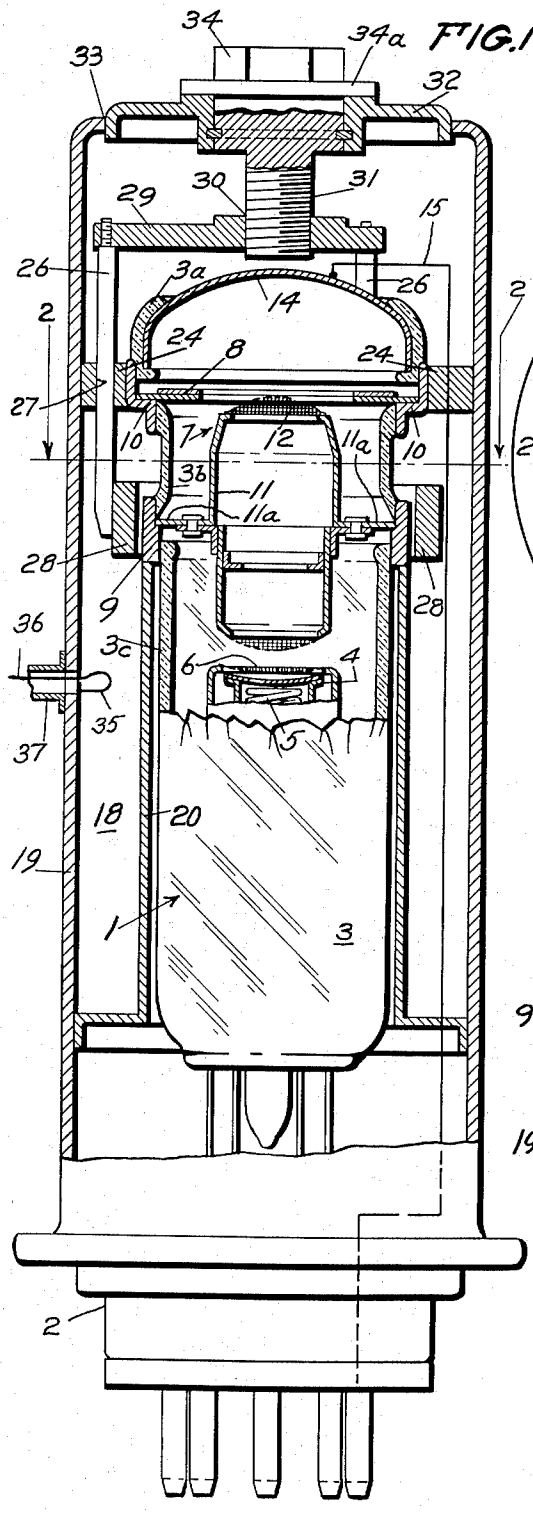


FIG. 2

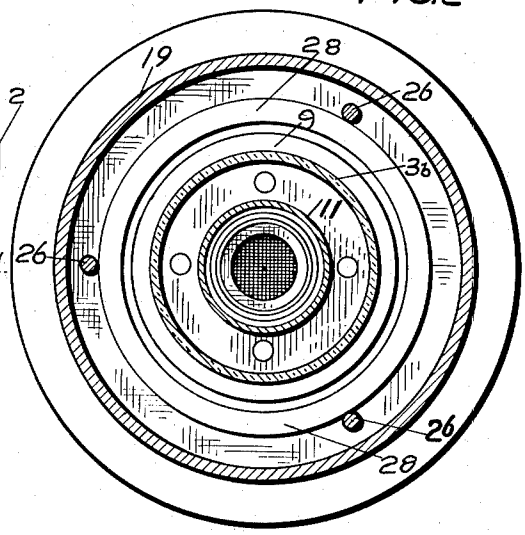
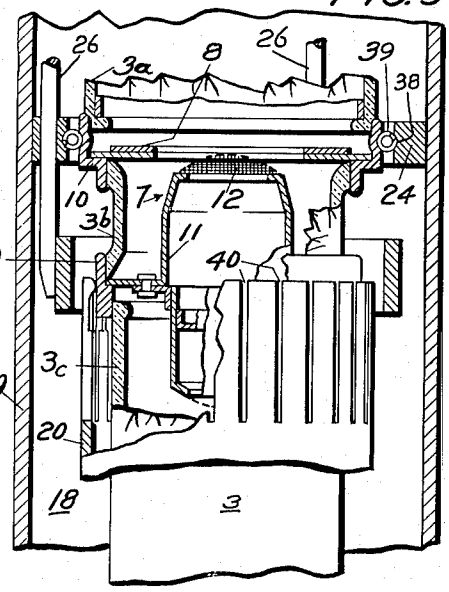


FIG. 3



INVENTOR
BERNARD C. GARDNER
BY Elmer J. Gross
ATTORNEY

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2,724,072

REFLEX KLYSTRON

Bernard C. Gardner, Redwood City, Calif., assignor to Raytheon Manufacturing Company, Newton, Mass., a corporation of Delaware

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10 Claims. (Cl. 315—5)

This invention relates to cavity resonators for electron-discharge devices of velocity-modulated types such as the klystron and the reflex klystron.

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 such tubes into different frequency ranges or bands.

The broad idea of doing this by capacitive means was disclosed in the copending patent application, Serial No. 696,796, filed September 13, 1946, now Patent No. 2,587,136, dated February 26, 1952. The present invention is an improved means for applying this principle to coaxial cavity resonators used with the type of velocity-modulated tubes having the interaction space grids terminated outside the envelope in conductive surfaces. These and other purposes of the present invention which will become more apparent as the detailed description thereof progresses are attained, briefly, in the following manner:

The coaxial cavity is formed of two concentric tubes joined at one end. A cylindrical ring is fastened to the inside of the open end of the outer tube and punched to receive rods of conductive material. The rods are passed through the cylindrical ring and the lower ends attached to a cylindrical ring mounted concentric with the inner tube and the cylindrical termination of the lower interaction space grid that is attached and electrically connected to the inside surface of the inner conductive tube. The cylindrical termination of the upper interaction space grid is attached and electrically connected to the ring carrying the rods so that the collar attached to these rods forms a variable capacitor between the two interaction space grids to increase the total effective capacitance between said grid, thereby varying the frequency of the klystron output.

These and other features and advantages of the invention will become more apparent from the following description taken in connection with the accompanying drawings illustrating the invention, wherein:

Fig. 1 is a longitudinal cross-section through a microwave cavity resonator and velocity-modulated tube embodying the invention;

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

Fig. 3 is a longitudinal cross-section of a portion of a modification of the device shown in Fig. 1.

Referring now more in detail to one of the aforesaid illustrated 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 high electron-emissive cathode 4 adapted to be heated by a filament 5 to a temperature suitable to bring about copious emission. 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 with a lead-in ring or external portion 9 which is hermetically sealed between the portions 3*b* and 3*c* of the side wall of the envelope 3. The exterior portion of the upper grid 8 is formed into a contact surface 10 about the tube envelope 3 and hermetically sealed between the portions 3*a* and 3*b* of the side wall of the envelope 3. The grid 7 is approximately cylindrical in shape with the side walls 11 supporting at its upper end a perforated conducting member 12. The perforated member 12 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 lower end of the wall 11 is formed into a flange 11*a* welded to the contact surface 9.

Spaced from said grids 7 and 8 is a repeller electrode 14 sealed into an opening in the glass envelope 3 and having a conductor 15 connected to it.

A coaxial cavity resonator 18 is formed of two concentric tubes 19 and 20 of highly conductive material, such as copper, joined at their lower ends to form a shorted coaxial transmission line. Such a coaxial cavity resonator may be considered or termed a tuned or resonant circuit.

This resonant circuit is coupled to the velocity-modulated tube by means of the conducting surfaces 9 and 10 associated with interaction space grids 7 and 8, respectively.

The inner tube of the coaxial cavity is welded to the contact surface 9 associated with grid 7. Both the outer tube 20 of the coaxial cavity and contact surface 10 associated with grid 8 are welded to a ring 24 to connect the upper grid to the outer conductor of the cavity. Rods 26 of conductive material pass through holes 27 in the ring 24. These rods 26 are attached at their lower ends to a ring 28 of conductive material. The rods 26 are attached at their upper ends to a plate 29 having a threaded hole 30 into which a screw 31 is inserted. This screw 31 passes through a bushing 32 in a hole 33 in the outer conductor 19 of the cavity 18. The head 34 of this screw has a flanged portion 34*a* resting on the bushing 32 so that, as the screw head 34 is turned clockwise, the screw 31 raises the plate 29, and, through the rods 26, the ring 28. As the screw head 34 is turned counterclockwise, the plate 29 is lowered, and, with it, the ring 28.

The oscillations which are produced by the device may be picked up by a coupling loop 35 placed within the chamber member 18, and led off by a conductor 36 which conveniently may be surrounded by a pipe 37 fastened into the chamber 18 so as to form a concentric or coaxial line with the conductor 36.

It will be recalled that the ring 24 is in electrical contact with both the outer wall 19 of the cavity 18 and the grid 8. As the rod 26 and the ring 28 are of conducting material, the ring 28 is at the same potential as the grid 8. It will be seen that the ring 28 is positioned in spaced relation to the contact surface 9 associated with the grid 7. This construction thus adds a capacity across

the grids 7 and 8. The screw 31, plate 29, rods 26 and ring 24 permit this capacity to be varied by changing the area of overlap of the ring 28 and the contact area 9, thus changing the effective area of the capacitor.

This capacity is inserted at the otherwise open end of the coaxial resonator. The effect of this capacity is to lower the resonant frequency of the cavity 18 by an amount dependent upon the position of ring 28 relative to the contact surface 9. Thus, by the addition of the cylindrical ring, 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 and permits the ready variation of the frequency to which the cavity is resonant.

This construction permits capacitive tuning of this type oscillator without the usual interaction gap change, either in dimensions or in voltage, with the consequent avoidance of the adverse electron transit time variation caused by such interaction gap changes.

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 14 back through the pair of control grids 7 and 8. As is well known, the initial passage of the beam through control grids 7 and 8 produces a bunching action, and, upon reflection and repassage of the beam through these control electrodes, a debunching action results which feeds ultra-high-frequency energy to the resonant circuit formed by the coaxial resonator 18, thus setting up ultra-high-frequency oscillations which may be led off along the coaxial line 22.

Fig. 3 shows a modification of the above structure in which the ring 24 is formed with a groove 36 in its inner surface shaped to receive a toroidal spring 38 to provide a tight but sliding contact with the external portion 10 of the grid 8. The inner tube 20 of the coaxial resonator is formed with slots 40 to make removably sliding contact with the external portion 9 of the grid 7. This modification in the construction of the cavity permits the ready insertion and removal of the tube 1 from the cavity.

This invention is not limited to the particular details of construction, material and processes described, 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 the 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 coaxial cavity resonator the inner and outer conductors of which are connected, respectively, to said grids; said cavity resonator including said capacitance; and a metallic member mounted outside the envelope and in electrical contact with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

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 coaxial cavity resonator the inner and outer conductors of which are connected, respectively, to said grids; said cavity resonator including said capacitance; and a cylindrical metallic member mounted outside the envelope and in electrical contact with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

3. 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; the external portions of said grids terminating in a cylindrical surface concentric with the axis of the electron-discharge device, a resonant circuit the terminals of which are connected, respectively, to said grids; said resonant circuit including said capacitance; and a metallic member mounted outside the envelope and in electrical contact with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

4. 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; the external portions of said grids terminating in a cylindrical surface concentric with the axis of the electron-discharge device, a resonant circuit the terminals of which are connected, respectively, to said grids; said resonant circuit including said capacitance; and a cylindrical metallic member mounted outside the envelope and in electrical contact with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

5. 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; the external portions of said grids terminating in a cylindrical surface concentric with the axis of the electron-discharge device, a coaxial cavity resonator the inner and outer conductors of which are connected, respectively, to said grids; said cavity resonator including said capacitance; and a metallic member mounted outside the envelope and in electrical contact with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

6. 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; the external portions of said grids terminating in a cylindrical surface concentric with the axis of the electron-discharge device, a coaxial cavity resonator the inner and outer conductors of which are connected, respectively, to said grids; said resonant circuit including said capacitance; and a cylindrical metallic member mounted outside the envelope and in electrical contact with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

7. 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 coaxial cavity resonator the walls of which are connected, respectively, to said grids; said coaxial cavity resonator including said capacitance; and a metallic member mounted outside the envelope and in electrical contact with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

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 grid being sealed through the walls of said envelope and having an inherent capacitance therebetween; a coaxial cavity resonator the walls of which are connected, respectively, to said grids; said coaxial cavity resonator including said capacitance; and a cylindrical metallic member mounted outside the envelope and in electrical contact with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

9. 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; the external portions of said grids terminating in a cylindrical surface concentric with the axis of the electron-discharge device, a coaxial cavity resonator the walls of which are connected, respectively, to said grids; said coaxial cavity resonator including said capacitance; and a metallic member mounted outside the envelope and in electrical contact

with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

10. 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; the external portions of said grids terminating in a cylindrical surface concentric with the axis of the electron-discharge device, a coaxial cavity resonator the walls of which are connected, respectively, to said grids; said coaxial cavity resonator including said capacitance; and a cylindrical metallic member mounted outside the envelope and in electrical contact with one of the said grids and forming a capacity with the other of said grids, said member being adapted for movement parallel to the main axis of the device for modifying the value of the total capacity between said grids.

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