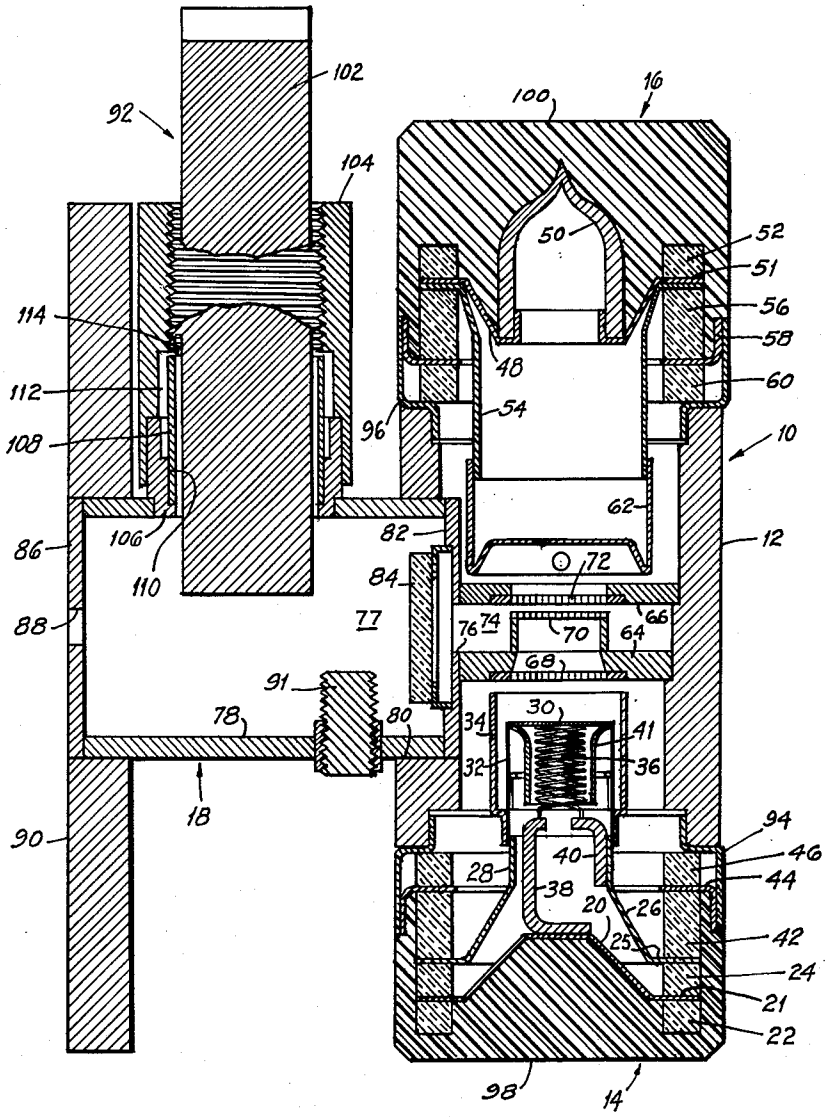
July 17, 1962 R. W. HAEGELE ETAL 3,045,146

TUNABLE RESONANT CAVITY

Filed March 18, 1959



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United States Patent Office 3,045,146 Patented July 17, 1962

3,045,146

TUNABLE RESONANT CAVITY

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Filed Mar. 18, 1959, Ser. No. 800,326
10 Claims. (Cl. 315—5.21)

This invention relates to a tunable resonant cavity, and, more particularly, to a tunable resonant cavity in relation with an electron tube.

One particular type of electron tube which has a tunable cavity is a reflex klystron. A reflex klystron comprises an electron gun, a tunable resonant cavity and a reflector electrode. The electron gun generates a beam of electrons which is projected across an interaction gap and through the resonant cavity toward the reflector electrode. In crossing the interaction gap, electromagnetic oscillation in the resonant cavity which surrounds the gap will tend to accelerate certain electrons of the beam and decelerate others. The electrons will proceed on toward the reflector electrode where they will be reflected back through the gap and during the course of which the fast electrons will tend to catch up with the slow electrons to form bunches. The bunches of electrons will tend to increase the electromagnetic oscillations in the resonant cavity when they recross the interaction gap. Thus, the electromagnetic oscillations will be maintained and power may be coupled from the resonant cavity.

There are many methods for tuning the cavity, and one practical method is to adjustably insert a metallic plunger or post into the cavity through a wall of the cavity by means of engaging screw threads on the plungers and cavity wall. However, whenever metal-to-metal contact is present in a cavity such as occurs between the post and cavity wall threads, relative movement of the metal parts will cause noise or static in the output of the tube. The relative movement of the metal parts will vary the electrical resistance at the interface therebetween, and since the current across the interface is high, the power (I^2R) losses across the interface will also vary. The noise or static thus produced will upset the proper operation of an electronic system which uses the output of the klystron, particularly during tuning of the klystron.

According to this invention, the problem of noise and static during tuning is eliminated through the use of a non-contacting tuner. In the non-contacting tuner according to this invention, there is no mechanical contact between the tuning plunger and the cavity wall, but an adequate high frequency (hereinafter referred to as H.F.) short is provided at the usual contact point by means of a shorted half-wavelength line, and the metal-to-metal contact between the threads of the tuning post and cavity wall is placed along such line at a point where the electrical current is approximately zero.

It is an object of this invention to provide a tunable resonant cavity in which tuning noises and static are reduced.

It is another object of the present invention to provide a tunable resonant cavity with non-contacting H.F. short between the cavity wall surface and the tuning plunger.

It is a further object of the present invention to provide a tunable resonant cavity with the sliding metal-to-metal contact of the tuning control means of the tunable cavity where the electrical current is approximately zero.

It is yet another object of this invention to provide a reflex klystron in which tuning noise and static are reduced.

These and other objects of the invention will become more clearly apparent from the following description when read in conjunction with the accompanying single figure drawing which is a sectional view of a reflex klystron taken through the klystron axis, and through the tuning cavity.

Referring now to the drawing, there is shown a reflex klystron 10 with a tubular body 12, a cathode assembly 14, a repeller assembly 16, and a tuning assembly 18.

The cathode assembly 14 is composed of a series of stacked ceramic rings with metallic rings disposed interstitially between the ceramic rings. A dish-shaped disk 20 forms a vacuum wall of the klystron tube at the cathode end. The disk 20 has an outwardly protruding flange 21, which is brazed between two ceramic cylinders 22 and 24. The ceramic ring 24 forms a part of the vacuum envelope, and the ceramic ring 22 is a backing ring which reinforces the metal-to-ceramic braze. On the other end of the ceramic ring 24 is brazed an outwardly protruding flange 25 formed on the large end of a truncated cathode support cone 26. The smaller end of the truncated cone is formed into a cylinder 28, which supports a disk cathode 30 with the aid of a thin cylindrical heat shield 32. A stepped-sided cylindrical focusing electrode 34 is fixed by its smaller diameter end also to cylinder 28. A helical filament 36, disposed within the cathode 30 and heat shield 32, heats the cathode. Two leads 38 and 40 fixed to the disk 20 support cone 26, respectively, conduct electricity to the filament 36. A heat conducting cylinder 41, disposed around the filament, is welded by an outward protruding flange to the underside of cathode 30 to transfer heat from the filament 36 to the cathode 30.

The cathode assembly is completed by brazing a ceramic ring 42, which forms a part of the vacuum envelope, to flange 25 on the truncated cone 26. A vacuum sealing ring 44 is brazed to the other end of ceramic ring 42, and the ceramic backing ring 46 completes the ceramic-to-metal braze.

The repeller assembly is also made of a series of stacked ceramic disks with metallic rings disposed interstitially between them. The end vacuum wall of the repeller assembly is an inwardly disposed truncated cone 48 which supports an exhaust tubulation 50. The cone 48 has an outwardly extending flange 51 on its larger end onto which is brazed a ceramic backing ring 52. On the other end of the flange 51 is brazed an outwardly extending flange of repeller support cylinder 54, and to the flange of the support cylinder 54 is brazed ceramic ring 56, which is a part of the vacuum envelope. A sealing ring 58 is brazed to the opposite end of ceramic ring 56. A ceramic backing ring 60 is brazed to the opposite side of the sealing ring 58, reinforcing the metal-to-ceramic braze. A repeller 62 is brazed on the free end of the repeller support cylinder 54.

The body 12 of the reflex klystron is in a tubular form. Within the body 12 are located a drift tube anode 64 and an annular metal plate 66 which form part of the resonant cavity of the klystron. At the end of the drift tube anode 64 adjacent the cathode is disposed an anode accelerating grid 68, and on the other end of the drift tube is disposed a gap grid 70. A second gap grid 72 is disposed in the opening of the annular plate 66. The drift tube anode 64, together with the annular plate 66, grids 70 and 72, form a primary cavity 74 which is disposed internally of the vacuum envelope of the reflex klystron. The primary cavity 74 has an aperture 76 which leads into an external secondary cavity 77 which is disposed externally of the vacuum envelope. Cavities 74 and 77 are electrically coupled by apertures 76 so that the tuning of the secondary cavity 77 will control

the frequency of the primary cavity 74 and have characteristics of a single cavity.

The secondary cavity 77 is formed by rectangular metal tube 78, which is brazed into a rectangular port 80 in the side of the body 12. The tube 78 is disposed perpendicularly to the axis of the body 12. The internal end of the rectangular tube 78 is closed with a metal plate 82, into which the aperture 76 is formed. A ceramic window 84 brazed over the opening 76 makes a vacuum-tight seal. The other end of the rectangular tube 78 is closed by metal end plate 86, which has an output aperture 88, and a waveguide connecting flange 90 is welded externally of the rectangular tube 78 for coupling waveguides to the cavity. A matching plug 91 is placed in the secondary cavity wall to control the coupling between the primary cavity 74 and the secondary cavity 77, and maintain a proper level of coupling over the tunable range of the klystron.

Through one wall of the rectangular tube 78 and parallel to the axis of the klystron is disposed a tuning plunger assembly 92.

The repeller assembly 16 and the cathode 14 are mounted to opposite ends of body 12 with the aid of sealing rings 94 and 96 brazed to the ends of the body 12. The vacuum seal is made by arc-welding the mating ends of a sealing ring 94 to the sealing ring 58. The tube is evacuated through a tubulation 50 which is pinched off to seal the tube. The backing rings 60 and 46 prevent the repeller and cathode from squeezing into the body 12 and misaligning the electrodes and also allow for uneven thermal expansion between the metallic body and the ceramic insulators. The cathode assembly and repeller assembly are coated externally with an insulating plastic 98 and 100.

In operation, electrons are emitted from the heated cathode 30 focused by the focusing electrode 34 towards the klystron axis, and accelerated by the anode grid 68. The electrons pass across the interaction gap formed by grids 70 and 72. On passing across the gap, some electrons are accelerated and other electrons are decelerated, forcing the electrons to bunch axially. The repeller reflects the electrons back across the gap. The relative voltage and space between the cathode, anode and repeller are so that the electrons are effectively bunched as they recross the gap and add power to the high frequency oscillations in the resonant cavity.

The operating frequency of the reflex klystron is controlled by the tuning plunger assembly 92. The frequency decreases when a metal tuning plunger 102 is screwed into the secondary cavity 77. The tuning plunger 102 is disposed parallel to the tube axis. The plunger 102 is threaded into internal threads of a tubular tuning plunger support 104, which in turn is held at one end by a short bushing 106 that is brazed into a bore formed in the rectangular tube 78. The internal threads of the plunger support 104 which engage the plunger are confined to its free end. The end of support 104 adjacent the cavity has a larger internal diameter than the other end. A sleeve 108 is brazed internally of the bushing 106 and a braze 110, which is located at the ends of sleeve 108 and bushing 106 adjacent the cavity. The outer diameter of sleeve 108 is smaller than the inner diameter of support 104 and the bore of bushing 106 into which the bore of the sleeve is disposed, forming a cylindrical void 112. The free end of sleeve 108 is spaced from the internal threads on support 104 so as to provide a radial void 114 which communicates with void 112 and also communicates with the space between the plunger 102 and sleeve 108. Voids 112 and 114 are one-quarter wavelength long at the average operating frequency of the tube. The distance from the cavity surface to void 114 is also a quarter-wavelength long at the operating frequency. Together they form a shorted half-wavelength line.

As is well known in the art, the folded void formed by voids 112 and 114 forms a shorted quarter-wavelength choke. Accordingly, since the folded void is shorted at one end, the voltage at that end is zero and the current is at its highest value. Therefore, at a point one-quarter wavelength from the short the voltage is at its highest and the current is zero. Since the current at this point is zero, the thread contacts between the post 104 and support 106 was placed as close to this point as practical. As stated previously, the tuning noise is caused by the varying resistance across the sliding thread contact and therefore causing a varying power loss. The electrical resistance across the sliding thread contacts cannot be controlled, but the power losses can be controlled by providing a quarter-wavelength choke. The power loss is computed by the well-known formula $P=I^2R$. Therefore, if the I (current) is zero, the power loss is always zero independent of the value of R (resistance).

Since the distance from the cavity surface to the void 114 is also one-quarter wavelength, an H.F. short (zero voltage) appears at the cavity surface. The same properties of a high frequency alternating current are reproduced every half-wavelength. The H.F. path from the shorted end of void 112 to the cavity is a half-wavelength, thereby reflecting the short to that point. In keeping with the spirit of the invention, the metal-to-metal contact can be placed at any odd multiples of quarter-wavelength from the short, and the cavity surface can be placed on multiples of half-wavelength from the short.

According to an alternative embodiment, the folded quarter-wavelength choke may be placed in the tuning plunger 102. The circular opening of the choke will still be adjacent the threads on the post so that the metallic sliding contact will be in a region of low current. According to this embodiment the choke will also communicate with the cavity through the space between the plunger 102 and sleeve 108, thus providing a H.F. short at the point where the plunger enters the cavity.

We claim:

1. An electron tube comprising a vacuum envelope, a plurality of electrodes within said envelope, a tunable resonant cavity comprising a conductive wall means forming said cavity, and an interaction gap for producing electromagnetic oscillation therein, said wall means having a bore therethrough communicating with said cavity, a tuning means for said cavity comprising a conductive tuning plunger extending through said bore in spaced relation to the wall thereof, means including said wall means and said plunger forming a shorted half-wavelength coaxial transmission line electrically terminating in said cavity, friction means for retaining said plunger in fixed relation with said cavity and electrically connected to said wall means making sliding conductive contact with said plunger near the quarter-wave point of said coaxial line.

2. An electron tube comprising a vacuum envelope, a plurality of electrodes within said envelope, a tunable resonant cavity comprising a conductive wall means forming said cavity, and an interaction gap for producing electromagnetic oscillation therein, said wall means having a bore therethrough communicating with said cavity, a tuning means for said cavity comprising a conductive tuning plunger extending through said bore in spaced relation to the said wall means, means including said wall means and said plunger forming a shorted half-wavelength coaxial transmission line electrically terminating in said cavity, friction means for retaining said plunger in fixed relation with said cavity and electrically connected to said wall means making sliding conductive contact with said plunger at the quarter-wave point of said coaxial line whereby said sliding contact is disposed in a region of minimum current.

3. An electron tube comprising a vacuum envelope, a plurality of electrodes within said envelope, a tunable resonant cavity comprising a conductive wall means forming said cavity, and an interaction gap for producing electromagnetic oscillation therein, said wall means having a

bore therethrough communicating with said cavity, a tuning means for said cavity comprising a conductive tuning plunger extending through said bore in spaced relation to the wall thereof, means including said wall means and said plunger forming a folded shorted half-wavelength coaxial transmission line electrically terminating in said cavity, said fold of said shorted half-wavelength coaxial transmission line disposed near the center thereof, said plunger having external threads and engaging internal threads in said bore near said fold and outside the coaxial transmission line whereby said contact between said threads is disposed at the region of lower current and higher voltage.

4. An electron tube as set forth in claim 3 wherein said shorted transmission line has its shorted end folded into said wall means, and said internal threads of said bore extend to said fold in said closed-ended half-wavelength H.F. short.

5. An electron tube as set forth in claim 3 wherein said shorted transmission line has its shorted end folded radially into said bore's cylindrical surface, and said internal threads of said bore extend to said fold in said closed-ended half-wavelength H.F. short.

6. A reflex klystron tube comprising a vacuum envelope; a cathode, an anode, and a repeller electrode disposed coaxially within said envelope, a tunable resonant cavity having a portion disposed interiorly of said envelope and a portion disposed exteriorly of said envelope, said envelope having a high frequency aperture communicating between the interior and exterior portions of said tunable resonant cavity, a ceramic window covering said aperture and vacuum sealed to the periphery of said aperture, said tunable resonant cavity comprising a conductive wall means forming said cavity, said wall means having a bore therethrough communicating with said cavity, a tuning means for said cavity comprising a conductive tuning plunger extending through said bore in spaced relation to the wall thereof, means including said wall means and said plunger forming a shorted half-wavelength coaxial transmission line electrically terminating in said cavity, friction means for retaining said plunger in fixed relation with said cavity and electrically connected to said wall means making sliding conductive contact with said plunger near the quarter-wave point of said coaxial line.

7. A reflex klystron tube comprising a vacuum envelope; a cathode, an anode, and a repeller electrode disposed coaxially within said envelope, a tunable resonant cavity having a portion disposed interiorly of said envelope and a portion disposed exteriorly of said envelope, said envelope having a high frequency aperture communicating between the interior and exterior portions of said tunable resonant cavity, a ceramic window covering said aperture and vacuum sealed to the periphery of said aperture, said tunable resonant cavity comprising a conductive wall means forming said cavity, said wall means having a bore therethrough communicating with said

cavity, a tuning means for said cavity comprising a conductve tuning plunger extending through said bore in spaced relation to the wall thereof, means including said wall means and said plunger forming a shorted half-wavelength coaxial transmission line electrically terminating in said cavity, friction means for retaining said plunger in fixed relation with said cavity and electrically connected to said wall means making sliding conductive contact with said plunger at the quarter-wave point of said coaxial line whereby said sliding contact is disposed in a region of minimum current.

8. A reflex klystron tube comprising a vacuum envelope; a cathode, an anode, and a repeller electrode disposed coaxially within said envelope, a tunable resonant cavity having a portion disposed interiorly of said envelope and a portion disposed exteriorly of said envelope, said envelope having a high frequency aperture communicating between said interior and exterior portions of said tunable resonant cavity, a ceramic window covering said aperture and vacuum sealed to the periphery of said aperture, said tunable resonant cavity comprising a conductive wall means forming said cavity, said wall means having a bore therethrough communicating with said cavity, a tuning means for said cavity comprising a conductive tuning plunger extending through said bore in spaced relation to the wall thereof, means including said wall means and said plunger forming a folded shorted half-wavelength coaxial transmission line electrically terminating in said cavity, said fold of said shorted half-wavelength coaxial transmission line disposed near the center thereof, said plunger having external threads and engaging internal threads in said bore near said fold and outside the coaxial transmission line whereby said contact between said threads is disposed at the region of lower current and higher voltage.

9. A reflex klystron as set forth in claim 8 wherein said shorted transmission line has its shorted end folded into said wall means, and said internal threads of said bore extend to said fold in said closed-ended half-wavelength H.F. short.

10. A reflex klystron as set forth in claim 8 wherein said shorted transmission line has its shorted closed end folded radially into said bore's cylindrical surface and said internal threads of said bore extend to said fold in said closed-ended half-wavelength H.F. short.

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