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Nov. 4, 1952 C. M. RUSSELL 2,617,038

ULTRAHIGH-FREQUENCY DEVICE

Filed June 23, 1943 3 Sheets-Sheet 1

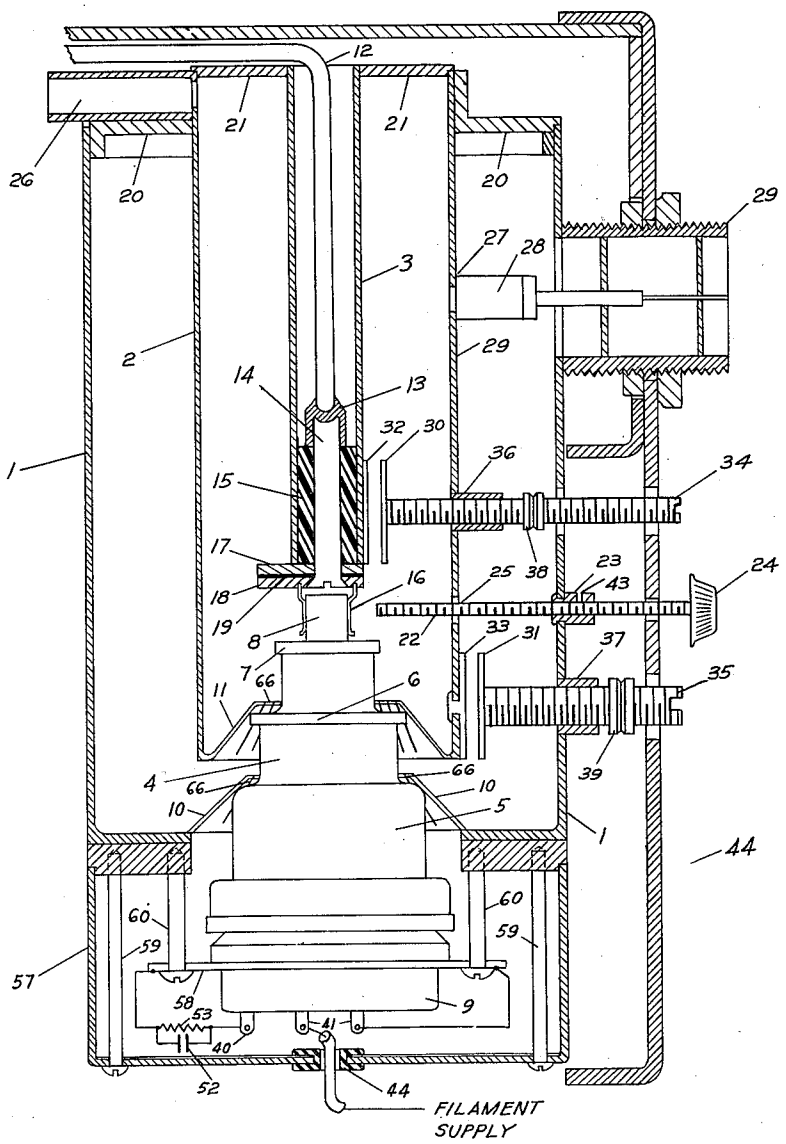


FIG. 1

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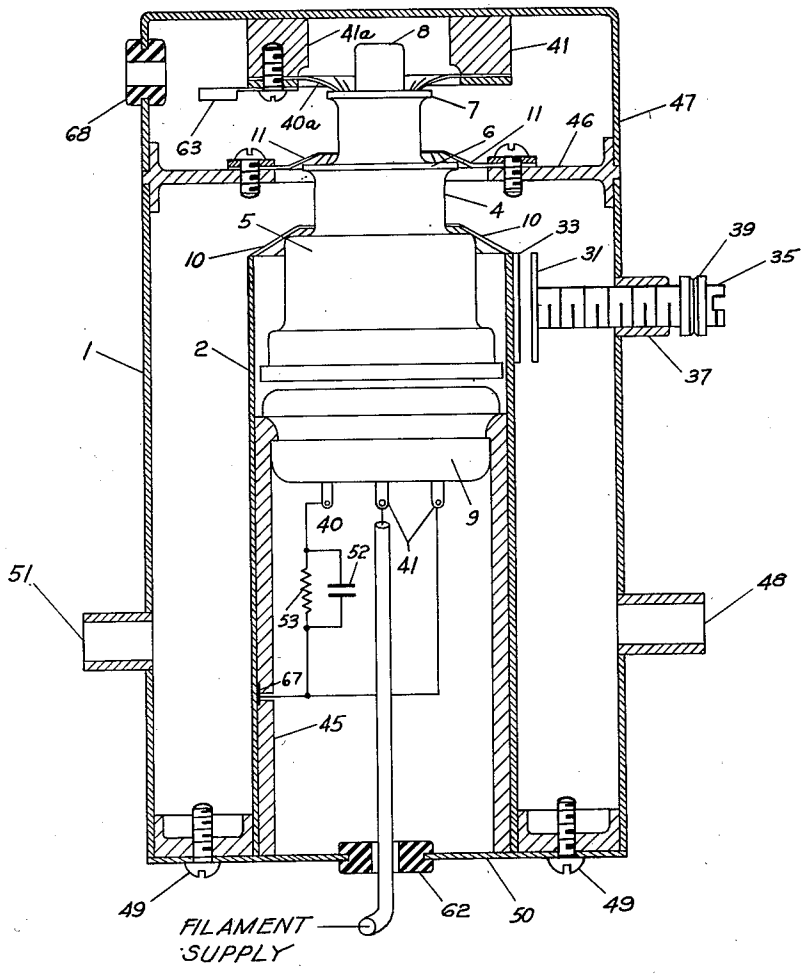
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ULTRAHIGH-FREQUENCY DEVICE

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Fig. 2



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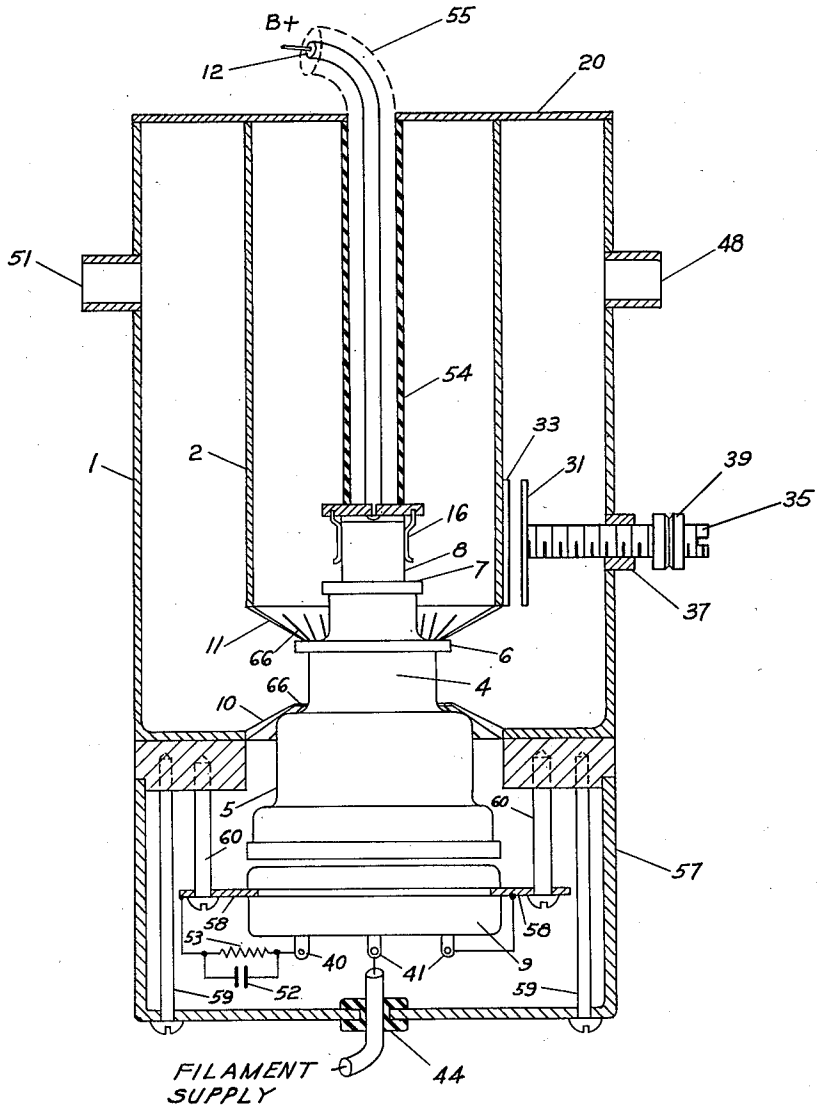
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ULTRAHIGH-FREQUENCY DEVICE

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FIG. 3



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Patented Nov. 4, 1952

2,617,038

UNITED STATES PATENT OFFICE

2,617,038

ULTRAHIGH-FREQUENCY DEVICE

Carl M. Russell, Washington, D. C.

Application June 23, 1943, Serial No. 491,923

1 Claim. (Cl. 250—36)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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My invention relates to ultra-high frequency apparatus and more particularly to such apparatus incorporating a hollow conductor resonator.

Because of their inherently low loss factor and excellent shielding ability cavity resonators of the coxial and cylindrical type are readily lending themselves to use in ultra-high frequency apparatus. As is well known to those skilled in the art, the operating frequency of this type of resonator is a function of the physical dimensions of the resonator itself. Thus, cavity resonators provided by the prior art are generally fitted with means for changing their physical dimensions in accordance with the frequency at which they are selected to operate.

In the present invention I contemplate to control the frequency of a hollow conductor resonator by varying the capacity between the adjacent walls of the coaxial tubular elements. More particularly, a tuning vane is inserted in the space between the adjacent walls of the concentric cylinders which usually comprises the hollow tube resonator. The tuning vane is moved in a radial direction by an appropriate tuning knob or set screw which is projected from the front panel of any suitable cabinet, housing ultra-high frequency apparatus of this character.

It is an object of this invention to provide a means for accurately tuning a hollow conductor resonator.

It is another object of this invention to provide a means for accurately tuning a hollow conductor resonator without changing its original external dimensions.

Other objects and features of the present invention will become apparent upon a careful consideration of the following description when taken together with the accompanying drawings, the figures of which are to be used for purposes of illustration only and not as a definition of the limits of the invention. Reference for the latter purpose is to be had to the appended claim.

Fig. 1 is an elevational view partly in block and partly in cross-section of one embodiment of the present invention,

Fig. 2 is an elevational view partly in block and partly in cross-section of a second embodiment of the present invention.

Fig. 3 is an elevational view partly in block and partly in cross-section of one modification of the present invention.

Reference is had more particularly to Fig. 1 wherein there is shown one embodiment of the present invention comprising three cylindrical

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members 1, 2 and 3 all of different diameters and concentrically disposed one within the other in a manner to form what I prefer to call "a hollow conductor resonator." There is inserted at one end of the cylinders an exciting means, comprising a step-wise tube 4, which is now known to the art and often referred to as a "lighthouse tube," while the opposite ends of cylinders 1 and 2 are closed by the metallic plate members 20 and 21 conveniently brazed or soldered to their respective cylinders. Tube 4 is a triode and contains an electron emissive cathode, a grid and an anode, each of which are provided with ring terminals projected diametrically from the tube envelope as members 5, 6 and 7 respectively. The cathode ring terminal 5 is generally capacitatively coupled to the cathode itself by virtue of a built-in capacitance, not shown here, while a direct connection to the cathode, for bias purposes, is also provided through a suitable base pin, not shown here. Cathode bias for tube 4 may be produced, for example, by way of a self biasing circuit comprising parallel resistance 53 and capacitance 52 tied to the cathode prong 40 of any suitable tube socket 9 which is adapted to engage the base pins of tube 4, while the filament connection may be made by way of prongs 41.

Tube socket 9 is supported in place by the annular member 58, hereinafter referred to as the "socket plate," and bolts 60 and is shielded by the cup-shaped member 57 coaxially arranged with cylinder 1 and held in place by bolts 59. The cathode and grid ring terminals, 5 and 6 respectively, are connected to the cylinders 1 and 2 by way of the respective inwardly extending flange members 10 and 11 conveniently brazed or soldered to their corresponding cylindrical members. Flanges 10 and 11 are constructed of any convenient resilient conducting material such as brass or copper provided with a plurality of flexible contact fingers 66. The anode of this tube is also projected axially from the tube envelope as rod 8 which is connected to a source of positive potential by way of conductor 12, conducting lug 13, screw 14 and the cup-shaped member 16 which also contains a plurality of contact fingers, not shown here. The screw 14 which is a connecting link between the positive potential and the anode is insulated from cylinder 3 by way of a suitable insulating block 15. Metallic plates 17 and 18 secured at the anode end of cylinder 3 are separated by a piece of suitable dielectric material 19 to form a coupling condenser for coupling the radio frequency output from anode 8 to the cylinder 3.

From the foregoing description, it will be noted that two independent resonant cavities exist; viz, the grid-plate cavity comprising the space between cylinders 2 and 3 and the grid-cathode cavity comprising the space between cylinders 1 and 2. Each of the aforementioned cavities are one-half wave in length and comprise, for example in the case of the grid-plate cavity, the perimeter extending around the outside wall of the innermost cylinder 3 and the inside wall of the second cylinder 2. It, therefore, becomes apparent that the maximum over-all length of the resonator itself would normally be one-quarter wave. The actual over-all length, however, is less than a quarter wave by virtue of the reentrant flanges 10 and 11. Thus it becomes obvious that by carefully selecting the length of the re-entrant flanges 10 and 11 a considerable reduction in over-all resonator length can be realized. It should also be noted that cylinder 2 is positioned between cylinders 1 and 3 thereby providing a common member between the grid-plate cavity and the grid-cathode cavity to constitute a more compact resonator unit than any provided by the prior art. The folding back of cylinder 2 is made possible since there is sufficient skin effect at the operating frequency of this apparatus to prevent any undesirable coupling between the two cavities. In order to generate oscillations feedback from one cavity to the other is essential. Therefore, coupling member 22 which is capacitatively coupled to the plate 8 is inserted in aperture 25 and projected out through the front panel 44 to knob 24 where the feed-back may be conveniently regulated. The coupling member 22 may be supported, for example, by flange 23 suitably secured to the outer cylinder 1 and having a recess 43 cut therein for receiving a spring, not shown here, adapted to contact the threads of member 22. Thus, when it becomes desirable to vary the amount of feed-back from one cavity to the other, knob 24 may be rotated to vary the portion encompassed by each cavity and consequently the amount of feed-back. The radio frequency output of this embodiment is generally taken from the innermost cylinder 3 by any suitable conductor tapped at the proper impedance point on the cylinder and fed out through a convenient outlet such as 26. The tuning of this embodiment will be described in the succeeding paragraph.

The embodiment shown in Fig. 1 may be readily employed as a radio frequency amplifier by simply removing the feed-back means mentioned in the foregoing paragraph and thereby isolate each cavity from the other to prevent oscillations from taking place. The input to this arrangement is then tapped to the grid cylinder 2 at the desired impedance point, for instance point 27, by a suitable conductor 28 which may be brazed or soldered to the cylinder and housed in the adapter socket 29 which may also be brazed or soldered to the outer cylinder 1.

The grid-plate cavity and the grid-cathode cavity are each tuned by vanes 30 and 31 respectively which are varied in proximity to the stator plates 32 and 33 by the set screws 34 and 35 which project from the front panel 44 of any suitable cabinet housing this apparatus. The stators 32 and 33 of the trimming condensers are generally brazed or soldered at one end of their respective cylinders 3 and 2 as shown in the figure. The outwardly extending flange members 36 and 37 are provided with a plurality of fingers, not shown here, so that they may grip the set screws 34 and 35 and prevent undesirable coupling from taking place between the two cavities which might be caused by the set screws passing through the cavities. A pair of nuts 38 and 39 are adjusted on the respective set screws 34 and 35 in order to prevent the tuning vanes from shorting on the stator plates during the tuning operation.

It will be noted that the present system of cavity tuning is not only easily accessible from the front panel of a suitable housing cabinet, but also functions to reduce the overall length of the resonator over that heretofore obtainable by tuning systems of the prior art.

Another embodiment of this invention is shown in Fig. 2 comprising two cylinders 1 and 2 of different diameters and concentrically disposed one within the other in such a manner as to form a coaxial resonator. One end of the resonator is closed by an exciting means, comprising a stepwise tube 4, while the opposite end is closed by a metallic plate member 50. In this arrangement the grid of tube 4 is grounded by way of ring terminal 6, flexible flange 11 and partition 46, while the cathode is coupled to the inner cylinder 2 by virtue of the built-in capacitance, ring terminal 5 and flexible flange 10. The position of tube 4 with respect to the cylinders 1 and 2 forms a grid-cathode cavity one-half wave length in the perimeter extending around the adjacent walls of the two cylinders or a total of one-quarter wave length in over-all dimensions. The plate and grid are protected from stray magnetic fields by the cup-shaped shielding member 47 coaxially fitted to cylinder 1 and provided with stand-off insulators 41*a* suitably fixed to the top of the shield to support the flexible flange 40*a* in contact with the plate terminal 7. A cylindrical member 45 made of any suitable material of either insulating or conducting qualities, is adapted to support socket 9 and consequently the ring terminals 5, 6 and 7 of tube 4 in the proper contact pressure against their respective flexible flange contactors 10, 11 and 40*a*. Thus in order to remove tube 4 from the resonator, screws 49 and plate 50 are removed which consequently allows cylinder 45, associated tube socket and tube to be removed as a unit. In general the self biasing circuit comprising resistance 53 and capacitance 52 is connected to the cathode prong 40 and grounded directly to 45 if metal be used for the cylinder or to solder lug 67 which is held in sliding contact with cylinder 2 if insulation be used for cylinder 45, while the filament lead is again taken from the prongs 41 of the socket 9 and brought out any convenient aperture such as 62. The apparatus shown in Fig. 2 is generally used as a converter or mixer by injecting, for example, a signal from the antenna or radio frequency amplifier through opening 48 and tapped to cylinder 2 at the proper impedance point, while the signal from the local oscillator can be injected through opening 51 and also tapped to the proper impedance point of cylinder 2 thereby producing the mixing action at the grid. The heterodyne output, (intermediate frequency), will then be present in the plate circuit thereby enabling the plate to be connected to the desired positive voltage by way of the primary winding of an intermediate frequency transformer, aperture 68 and conducting lug 63. The remaining features and characteristics of this embodiment are identical to that of Fig. 1, therefore further explanation thereof is believed to be unnecessary.

Still another embodiment of the present invention is shown in Fig. 3. Many of the com-

ponent parts of this embodiment, such as, for instance, the cup-shaped member 57, trimming capacitor 31, cylinders 1 and 2 have been described in connection with Figs. 1 and 2, therefore further explanation thereof is believed to be unnecessary. The present arrangement like that of Fig. 2 can be used as a mixer or a converter, but differs from Fig. 2 in that the signal is injected at the grid and not the cathode. The plate connection is again made to the B supply through the primary winding of an intermediate transformer, for instance, not shown here, conductor 12 and the cup-shaped member 16. The cup-shaped member 16 is supported in contact to the anode terminal 8 by a cylindrical piece of insulating material 54. The lead 12 which is connected to the intermediate transformer may be shielded as shown at 55 and consequently serve as a means for by-passing radio frequencies above intermediate frequency to ground.

Although I have shown and described only certain and specific embodiments of the present invention, I am fully aware of the many modifications possible thereof, such as for instance, the changing of all signal input and output taps to coupling loops. Therefore, this invention is not to be restricted except insofar as is necessitated by the prior art and the spirit of the appended claim.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

An ultra-high frequency device including a hollow conductor resonator assembly comprising three cylindrical members each of different diameter coaxially disposed one within the other and each of such a length as to form a pair of quarter wave resonant line sections, means conductively shorting the adjacent ends of said cylindrical members at one end of the assembly, a vacuum tube having anode and cathode terminals at opposite ends and a grid terminal positioned intermediate the other terminals, said cathode, grid and anode terminals comprising conductive, ring-shaped sections of progressively decreasing diameter with a cylindrical conductive metal cap attached to the anode ring-shaped section, said cylindrical metal cap and said conductive ring-shaped sections being coaxially disposed, means coupling the anode to the innermost cylinder including a pair of metallic plates separated by dielectric means, one of said metallic plates being secured to said innermost cylinder and the other to said conductive metal cap of said anode terminal, and means coupling the space between the innermost cylinder and the middle cylinder to an output circuit, separate reentrant flexible contact rings attached to the ends opposite said one end connecting the middle and outer cylinders respectively to the grid and cathode electrodes of said tube, means for tuning said resonator comprising first and second flat condenser stator plates electrically connected to the outer wall of the innermost cylindrical member and the intermediate cylindrical member respectively at the ends thereof which receive said vacuum tube, a first flat condenser rotor plate disposed in spaced parallel relation to the stator plate connected to the innermost cylindrical member and electrically connected to the intermediate cylindrical member, a similar condenser rotor disposed in spaced parallel relation to the stator plate connected to the intermediate cylindrical member and electrically connected to the outer cylindrical member, and separate means operable to adjust the spacing between the rotor plates and their associated stator plates to tune the high frequency device, feedback adjusting means including a threaded conductive rod supported by said outer cylinder, projecting through and insulated from said middle cylinder, and radially movable with respect to the anode terminal of said vacuum tube.

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