Nov. 20, 1945. I. E. MOUROMTSEFF ET AL 2,389,271

TANK CIRCUIT

Filed June 20, 1941

Fig. 1.

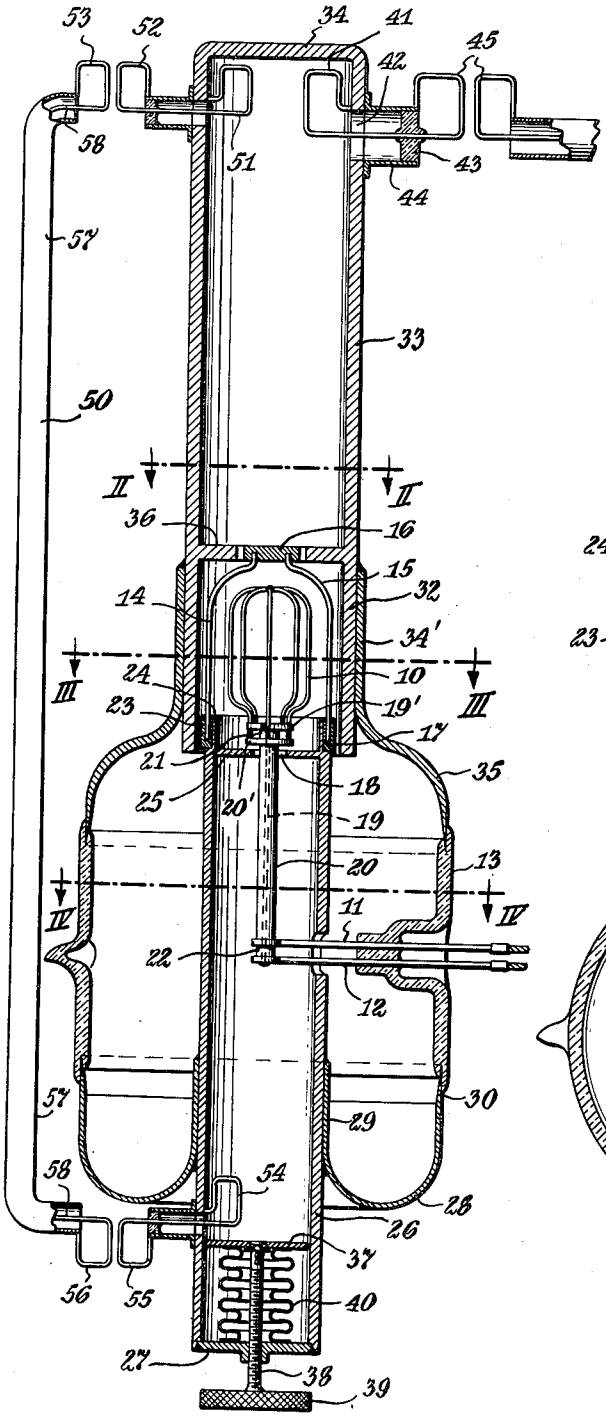


Fig. 2.

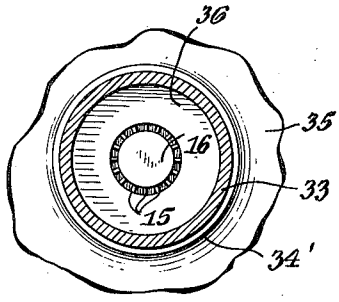


Fig. 3.

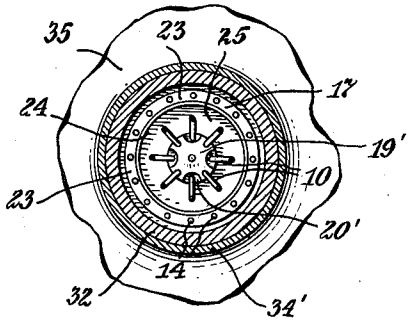
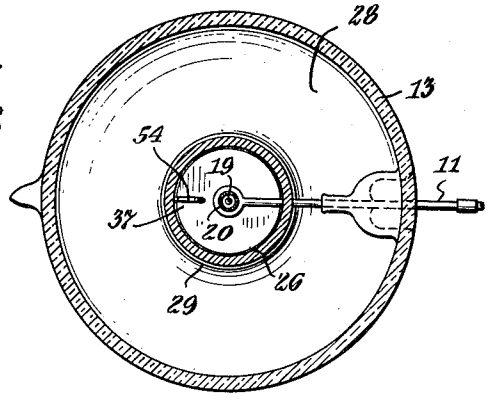


Fig. 4.



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TANK CIRCUIT

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Application June 20, 1941, Serial No. 398,910

13 Claims. (Cl. 250—27.5)

Our invention relates to an ultra high frequency oscillator and especially to such an oscillator utilizing a hollow body resonator.

One of the difficulties with ultra high frequency oscillators is that as the frequency is increased there is difficulty in forming a necessary tank circuit with means for properly adjusting this circuit and also there is difficulty in the satisfactory adjustment of the grid circuit. Another limitation on the use of increased high frequency is the limitation caused by the finite transit time of the electrons.

We have solved these difficulties by utilizing the properties of hollow body resonators and combining these properties with the three-element vacuum tube oscillator design and as a result have accomplished an ultra high frequency oscillator having adjustable output tank and grid circuits incorporated in suitable hollow body resonators. Other advantages will be apparent from the following description and drawing in which:

Fig. 1 is a view of the main cross section of a preferred embodiment of our invention. Figs. 2, 3 and 4 are views, respectively, of lines II—II, III—III and IV—IV of Fig. 1.

The cathode 10 of our device is preferably formed of a cage of wires more particularly described in our Patent 2,238,596, issued April 15, 1941, for "Ultra high frequency tube." This cathode 10 has two leads 11 and 12 sealed through an insulating cylindrical portion 13 preferably of borosilicate glass. As described in our patent the cathode has, as connections, a rod 19 and a surrounding tube 20 extending to the leads 11 and 12 and separated by the insulator button 22. The upper portion of the cathode rod terminates in a disk 19' and tube in a disk 20' perforated for the passage of the rod 19 therethrough. An insulator button 21, also perforated for the rod 19, separates the two disks. The wires of the cage are connected at each end to a different disk, the disk 19' being cut away for the passage of the wires from the disk 20'. The cage of wires forming the cathode 10 is surrounded in turn by a grid structure 14 which is composed of a plurality of grid wires 15 secured at the top to a disc or plate 16 and supported by these wires 15 in a plane perpendicular to the axis of the cathode and grid wires 10 and 15. The lower end of these wires is secured in the rim of a metal cup-shaped member 17 surrounding the base proper of the cathode and having an opening 18 sufficiently large for the passage of the cathode connections therethrough.

The cup-shaped member 17 is preferably composed of two members, one of which forms the portion 23 to receive the wires and this is bound about the periphery of the inner member 24 having the lower base portion 25 containing the opening 18. The member 24 has preferably a long tubular extension 26 integral therewith and extending for a considerable distance below the grid structure and having a bottom plate 27 welded thereto. A re-entrant annular member has its inner periphery 29 fastened to the outer wall of the tubular grid extension 26 and its outer periphery 30 sealed vacuum tight to the adjacent edge of the insulation 13.

Surrounding the active cathode and grid wires is a cylindrical anode 32 having an extended tubular extension or cavity 33 with a closed end 34. Secured vacuum tight to the exterior wall of the anode 32 is a metal member 34' having a flared out portion 35 sealed into the insulation 13. The tubular portion formed by the anode 32 and its extension 33 has an annular partition 36 preferably extending inwardly and closely surrounding the disc 16 at the top of the grid wires. The distance between the annular partition 36 and the closed end 34 of the anode extension is half a wave length of the desired standing waves to be produced in the hollow body resonator formed by the enclosed portion of the anode extension 33.

The lower grid extension 26 from the lower base 25 to the closed end 27 is in excess of the half wave length dimension of the anode 33. In order that this grid extension may form a hollow body resonator tunable to the anode extension we preferably place a metal disk 37 in the lower portion of the grid extension and support it on a screw-threaded shaft 38 extending through the closed end 27 to an adjusting head 39. A metal bellows 40 is secured to the back of the metal disk and the inner base of the closed end 27 to maintain a vacuum inside the grid resonator and yet permit the adjustment.

The oscillations of the two cavities formed by 26 and 33 are coupled to each other by a feed back transmission line 50. An interior loop 51 in cavity 33 terminates in an exterior loop 52 adjacent the loop 53 at one end of the transmission line 50. An interior loop 54 in the cavity 26 terminates in an exterior loop 55 adjacent a loop 56 at the other end of the transmission line 50. The transmission line 50 preferably comprises a cylindrical conductive sheath 57 surrounding an axial conductor 58. The phase of the two oscillations may be adjusted for maximum efficiency by the length of the transmission line and the angular position of the two pairs of loops 52, 53 and 55, 56. This exterior feed-back arrangement is a coupling between the

two resonators in addition to that provided by the internal electrode capacitance. This particular feed-back arrangement is illustrative as other types may be utilized such as a direct concentric transmission line with one or several tunable lateral lines to regulate the feed-back as to its amplitude and phase.

The output circuit preferably comprises a loop 41 attached to the upper portion of the inner wall of the anode extension and having the other end pass through an opening 42 in the wall and an insulating plug 43 supported by an eyelet 44 on the side of the anode extension 33. A similar loop 45 may be formed on the exterior of the device for coupling to this type of transmission line.

The casing portions of resonators are preferably copper, silver soldered together where necessary. The cathode is preferably thoriated tungsten and the cathode leads molybdenum. The grid wires are preferably tantalum and the grid disc 16 molybdenum.

If desired, the anode portion and its hollow resonator extension 33 may conveniently be air- or water-cooled. The potential difference between the cathode and anode may be any desired value and preferably from 1,000 to 10,000 volts. The cathode grid potential difference may be a suitable value and preferably approximately 100 volts difference. These high voltages can be more safely operated by having the anode at ground potential and the cathode at —1000 to —10,000. The grid will be correspondingly less negative. Inasmuch as the higher negative cathode leads 11 and 12 extend through the casing at only one section illustrated in the drawing the negative high voltage at this particular portion can be effectively protected and there will be no danger to the operator from the ground potential of the anode extension 33.

The operation of the device is that of the familiar 3-electrode oscillators formed by the cathode 10, grid 15 and anode 32 and feed-back arrangement. The oscillations of the grid will be reinforced by the tunable resonating hollow body extension 26 and these oscillations will be applied to the grid disc 16. The oscillatory voltage develops also between the disc 16 and the adjacent portion 36 of the anode resonator 33 thus producing oscillations in the cavity resonator 33.

The resonant properties of the grid and anode extensions will operate to provide an efficient and stable output from the device.

We have accordingly devised the high frequency oscillator which is capable of efficiently utilizing very high frequencies. The entire tube elements are contained in a vacuum tight envelope and there is no external radiation. The device has an area to permit rapid and effective cooling of the anode and also a careful and accurate adjustment of the grid and anode. When this adjustment is set the frequency of the output is very stable.

Although we have described a preferred embodiment it is apparent that many modifications may be made therein and accordingly we desire only such limitations to be imposed upon our invention as are necessitated by the spirit and scope of the following claims:

We claim:

1. A discharge device comprising a cathode, a grid and an anode, said grid having a disc secured thereto, said anode having an extension forming a closed-end hollow body resonator, said disc located in an opening in a wall of said hollow body resonator.

2. A discharge device comprising a cathode, a grid and an anode, said grid having a disc secured thereto, said anode having an extension with an outer closed end thereby forming a hollow body resonator, said disc located in an opening in a wall of said hollow body resonator and an extension of said grid with an outer closed end thereby forming a second hollow body resonator.

3. A discharge device comprising a cathode, a grid surrounding said cathode, and an anode surrounding said grid and cathode, a hollow body resonator forming an extension of said grid in one direction and having an outer closed end, and a hollow body resonator forming an extension of said anode in another direction and an exterior feed-back transmission line between said resonators entering the same next said outer closed ends.

4. A discharge device comprising a cathode, a grid and an anode, said grid having a disc secured thereto, said anode having an extension with an outer closed end, thereby forming a hollow body resonator, said disc located in an opening in a wall of said hollow body resonator and an extension of said grid with an outer closed end thereby forming a second hollow body resonator, and an exterior feed-back transmission line between said resonators entering the same next said outer closed ends.

5. A discharge device having electrodes comprising a cathode, grid and anode forming a discharge space, two of said electrodes having structure forming a closed-end hollow body resonator separate from said discharge space and one of said electrodes having an extension forming a second closed-end hollow body resonator separate from said discharge space, one of said resonators having means at its closed end to make its resonating length equivalent to that of the other resonator.

6. A discharge device having electrodes comprising a cathode, grid and anode forming a discharge space, two of said electrodes having structure forming a closed-end hollow body resonator separate from said discharge space and one of said electrodes having an extension forming a second closed-end hollow body resonator separate from said discharge space and an external feed-back from one hollow body resonator to the other hollow body resonator.

7. A discharge device comprising a cathode, a grid surrounding said cathode, and a cylindrical anode surrounding said grid and cathode and forming a discharge space therein, a disc at one end of said grid, an annular extension from said anode closely surrounding said disc, said anode having a further extension with its outer end closed, thereby forming a hollow body resonator with said annular extension and grid disc and on the opposite side thereof from said discharge space.

8. A discharge device comprising a cathode, a grid surrounding said cathode, and a cylindrical anode surrounding said grid and cathode and forming a discharge space therein, a disc at one end of said grid, an annular extension from said anode closely surrounding said disc, said anode having a further extension with its outer end closed, thereby forming a hollow body resonator with said annular extension and grid disc and on the opposite side thereof from said discharge space, said grid having an extension with its outer end closed, thereby forming a second hollow body resonator.

9. A discharge device comprising a cathode, a grid surrounding said cathode, and a cylindrical anode surrounding said grid and cathode and forming a discharge space therein, a disc at one end of said grid, an annular extension from said anode closely surrounding said disc, said anode having a further extension with its outer end closed, thereby forming a hollow body resonator with said annular extension and grid disc and on the opposite side thereof from said discharge space, said grid having an extension with its outer end closed, thereby forming a second hollow body resonator and a feed back transmission line between said resonators.

10. A discharge device comprising an evacuated envelope, a cathode within the evacuated envelope, a control grid surrounding said cathode, an anode surrounding said control grid and cathode, a closed-end hollow body resonator forming an extension of said control grid in one direction and constituting a part of said evacuated envelope, a closed-end hollow body resonator forming an extension of said anode in another direction and also constituting a part of said evacuated envelope, one of said resonators having means within the evacuated space thereof movable therein for adjusting the resonating length thereof.

11. A discharge device having an evacuated space and having electrodes comprising a cathode, control grid and anode forming a discharge space, two of said electrodes having structure forming a closed-end hollow body resonator separate from said discharge space but forming part of said evacuated space, and one of said electrodes having an extension forming a second closed-end hollow body resonator separate from said discharge space and also forming part of said evacuated space.

12. A discharge device comprising a cathode, control grid and anode forming a discharge space, said control grid having an extension forming a closed-end hollow body resonator, said hollow body resonator being completely partitioned off electrically from said discharge space, said anode having an extension forming a second closed-end hollow body resonator, said resonators and discharge space being evacuated.

13. A discharge device comprising a cathode, control grid and anode forming a discharge space, said control grid having an extension forming a closed-end hollow body resonator, said hollow body resonator being completely partitioned off electrically from said discharge space, said anode having an extension forming a second closed-end hollow body resonator, said grid having a portion in an opening in said second resonator, said resonators and discharge space being intercommunicating.

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