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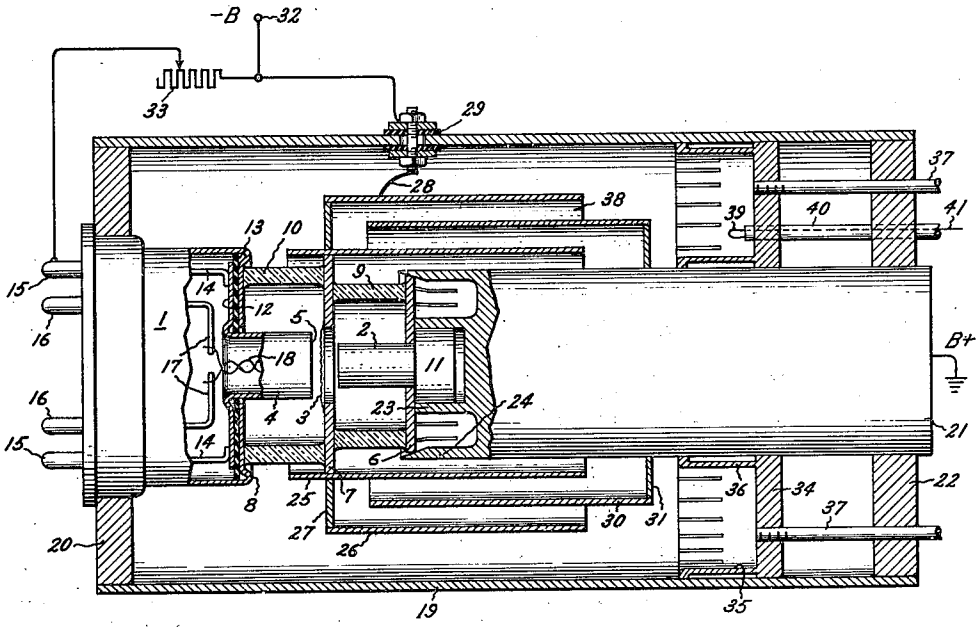
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ULTRA HIGH FREQUENCY OSCILLATOR DEVICE

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ULTRA HIGH FREQUENCY OSCILLATOR DEVICE

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8 Claims. (Cl. 315—39)

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The present invention relates to high frequency apparatus and is primarily concerned with the provision of an improved oscillator of the type which employs a discharge device or tube, such as a vacuum triode, as an exciting element.

In my copending application, Serial No. 471,973, filed January 11, 1943, now U. S. Patent No. 2,443,-907, granted June 22, 1948, and assigned to the assignee of the present application, there is disclosed an oscillator in which a vacuum triode arranged within a cavity-forming structure has connected with the grid of the triode a conductive member which is adapted to form a continuous wave-guiding path between the grid-anode gap of the triode and its grid-cathode gap. When this path is given appropriate length and proportions, the feedback effects attributable to it are readily fixed at the proper phase and amplitude to assure the efficient generation of self-sustained oscillations. It is an object of the present invention to provide a new and improved oscillator of the above type for producing longer wave lengths while retaining a small size of the oscillator structure.

It is another object of the present invention to provide a new and improved ultra high frequency oscillator operable at a plurality of discrete frequencies.

It is a still further object of the present invention to provide a new and improved feedback circuit for a re-entrant ultra high frequency oscillator.

Briefly, the invention makes use of a multiply folded coaxial transmission line arrangement providing a plurality of concentric transmission line sections connected in series between the anode-grip gap and the grid-cathode gap of a triode used in a re-entrant type oscillator. In order to obtain oscillations at predetermined frequencies, the lengths of the sections of the coaxial transmission line are properly adjusted to act either as a single resonator corresponding to the length of the sections in series or as a resonator corresponding to the length of any one or more of the sections.

The features of the invention desired to be protected herein are pointed out in the appended claims. The invention itself, together with its further objects and advantages, may best be understood by reference to the following description taken in connection with the accompanying drawing in which the single figure is a longitudinal sectional view of a high frequency oscillator embodying the invention.

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Referring to the drawing, there is shown an ultra high frequency oscillator having a three-electrode discharge device 1 as its central element. This tube comprises a cylindrical anode 2, a grid 3 and a cylindrical cathode 4 having its emissive part in the form of a flat disk surface 5 which faces the grid 3. The envelope within which these electrodes are enclosed comprises a series of three circular metal parts 6, 7, 8 which are supported in mutually spaced relation by glass cylinders 9, 10 sealed between them. The part 7 provides a terminal for the grid 3. A terminal for the anode is provided by a cylindrical enlargement 11 which is welded or soldered against the upper surface of the disk 6. The cathode 4 is provided at its lower extremity with a flange 12 which parallels the under surface of the part 8, but which is separated from that part by an insulating spacer 13 which may be, for example, a mica washer. With this arrangement, the part 8 has a high frequency connection with the cathode through the capacity existing between this part and the flange 12, but is effectively insulated from the cathode so far as direct current is concerned. Separate direct current connections are made to the cathode by means of lead-in wires 14, secured to the under surface of the part 12 and terminally connected to prongs 15 which depend from the base of the discharge tube. Additional prongs 16 and lead-in wires 17 are provided for the purpose of supplying heating current to the coiled filament 18 arranged within the cathode cylinder 4 so that the emissive part of the filament can be maintained at an elevated temperature by this means.

The oscillating system in which the tube 1 is incorporated comprises a cavity-forming structure having, as a principal component, an elongated conductive (e. g. copper or brass) preferably silver-plated cylinder 19. This surrounds the tube 1 and is symmetrical with respect to the axis of alignment of the electrodes of the tube. A conductive wall part 20 extends across one end of the cylinder 19 and provides a mount for the base of the cylinder 2. In addition, the wall part 20 bears upon the exposed surface of the lower portion of the part 8 and is thus effectively connected with the cathode 4 so far as high frequency currents are concerned by capacity coupling through the insulating spacer 13. A corresponding connection to the anode is made by a solid longitudinal cylindrical conductor 21 which is supported within the cylinder 19 by means of a transverse wall part 22 and which is provided at its inner extremity with contact

fingers 23 and 24 arranged to engage the anode end of the tube 10 both at the terminal tap 11 and at the periphery of the disk 6.

The grid terminal 7 is peripherally connected to a tubular conductor 25 which extends longitudinally of and concentric with the cylinder 19. Mounted concentric with the tubular conductor 25 is a conductive cylinder 26 having a transverse end wall 27 connected to the outer surface of the conductor 25 for supporting the cylinder 26 in concentric alignment with the conductor 25. A terminal wire 28, which extends through an insulating washer 29 provided in a wall of the cylinder 19, is connected to the outer surface of the conductor 26 to provide an external connection with the grid terminal 7 for supplying control potentials thereto. Mounted concentrically between the parallel tubular conductors 25, 26 is a tubular conductor 30 which is supported from the cylindrical conductor 21 by means of a transverse wall portion 31.

The connections for unidirectional potential for the triode 1 may be made in various ways. In the arrangement illustrated, the anode is assumed to be at ground potential (i. e., at the potential of the conductive structure as a whole), while the cathode is insulated (in a D. C. sense) from the main conductive structure by the spacer 13 and is made negative with respect to the anode by an appropriate connection to the contact prongs 15. The grid connection is made through the conductor 28 and, if a cathode bias arrangement is to be employed, the connection should be made to the terminal 32 and resistor 33 adjusted to give the bias which is required for most effective operation.

Like any confined space bounded by a conductive medium, the chamber enclosed by the cylinder 19 provides a system which may be made to resonate electrically at a particular frequency determined by the dimensions and configuration of the chamber and of the elements enclosed by it. This means that, under appropriate conditions, electro-magnetic waves may be caused to exist within the chamber in a space distribution fixed by the nature and location of the exciting source and by the boundary conditions set by the form of the conductive structure.

The effective electrical impedance and inductance loss ratio of a space-resonant structure of the type under consideration are high enough so that a structure of this kind can be made to serve as a tank circuit of an oscillator having an intended operating frequency which is the same as, or is harmonically related to, the resonant frequency of the space enclosed by the structure. Since resonant frequency is a direct function of the resonators in question, it may be varied within reasonable limits by appropriate adjustment of these dimensions. To permit such adjustment in connection with the structure illustrated in the drawing, there is provided a plunger 34 having two sets of contact fingers 35, 36 which, respectively, bear upon the opposed surfaces of the parts 19 and 21. This plunger may be moved back and forth by any externally accessible actuating rods 37 and, by this means, the size of the cavity resonator may be adjusted as desired.

In the oscillator illustrated, the triode 1 comprises a means for exciting the resonant system provided by the cylinder 19. If voltage variations can be caused to occur between the grid and anode of the tube 1 at the resonant frequency of cylindrical structure 19 (as modified by the presence of the tubular conductors 25, 26, 30, the solid cylinder 21, and the tube itself), electromagnetic waves of the frequency in question will be established in a cavity-forming space. Such waves may be considered as being initiated in the vicinity of the grid-anode gap and as being propagated from this point throughout the remainder of the cavity. Their path of propagation is governed in the first instance by the presence of the conductive tubes 25, 26, 30 and transverse walls, 31, 27 which necessarily tend to confine or guide the waves along the multiply folded path between the cylindrical conductors. At the extremity of the tube 26, however, the waves are free to pass through the gap indicated at 38. Viewing the mechanism of wave propagation as being a condition of energy flow, it is seen that wave energy issuing from the gap 38 can flow in the reverse direction along the outside of the conductor 26 toward the vicinity of the cathode to grid gap of the triode 1. At this point, a variable electric field can be established in accordance with the properties of waves of the type under consideration.

The feedback path between the anode-grid gap and the cathode-grid gap of the device 1, as previously stated, consists of three sections of concentric transmission line connected in series and formed, respectively, between tubular conductor 25 and the cylindrical conductor 21, the outer surface of the conductor 25 and the inner surface of tubular conductor 30, and finally the outer surface of conductor 21 and the inner surface of the conductor 26. If all three sections are properly adjusted in length, they will act as a single resonator corresponding in length to the three sections in series. This single resonator functions as an anode tank circuit for the device 1 and the cavity resonator constituted by the member 19 may be tuned by adjustment of plunger 34 to the frequency of this tank circuit.

The gap 38, as well as the transverse walls 27, 31 in the feedback path between the grid-anode gap and cathode-grid gap, represent discontinuities in the path of propagation of waves originating at the former gap. In accordance with principles well understood in the electronics are, some reflection of the wave energy will occur at each of these discontinuities. Depending upon matching conditions of impedances of the discontinuities, a single section of the folded feedback path, for instance the section comprising the inner surface of the tubular conductor 25 and the outer surface of the cylindrical conductor 21, may be made to act as the anode tank circuit of the tube 1. Likewise, this particular concentric line section, in series with the concentric line section constituted by the tubular conductors 25, 30, may be used as the anode tank circuit of the tube 1. It is apparent, therefore, that the multiply folded concentric transmission line sections may be used as tank circuits for at least three different frequencies. At each particular frequency, exact tuning of the cavity resonator constituted by the member 19 is obtained by adjustment of the plunger 34.

In order that high frequency energy may be taken from the oscillator for utilization in an external circuit, there is provided a coupling loop 39 which extends into the cavity and which is supported from a hollow tubular conductor 40 extending outwardly through the plunger 34 and the end wall 22. A conductor 41, which connects with one extremity of the coupling loop 39, is arranged within the tubular conductor 40 and forms with it a coaxial transmission line.

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An important advantage of the oscillator structure described lies in the fact that the multiply folded resonator permits the construction of an oscillator operable over a plurality of different wave lengths, the longest wave length being several times the length of the shortest wave, but which still retains the small over-all dimensions of a re-entrant type oscillator. By proper matching of impedances throughout the length of the folded transmission line sections, it has been found that an oscillator of this type may be operated at frequencies having wave lengths of 10 centimeters, 15 centimeters, and 30 centimeters. At each of these frequencies, satisfactory tuning of the cavity resonator structure is obtained by a small adjustment of the position of the plunger 34.

While the invention has been described by reference to a particular embodiment thereof, it will be understood that numerous modifications may be made by those skilled in the art without departing from the invention. For example, more than three sections of folded transmission line may be employed to provide a greater number of predetermined frequencies of oscillation. I, therefore, aim in the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A high frequency oscillator comprising a cavity resonator defined by a hollow conductive structure, an electric discharge device within said resonator comprising a plurality of electrodes including a cathode, an anode and a grid defining anode-grid and grid-cathode gaps, coupling means between said anode-grid and grid-cathode gaps of said discharge device comprising a plurality of sections of concentric transmission line concentrically arranged and connected in series, said line being coupled at one end to the anode-grid gap of said device and at its other end to said resonator, said conductive structure comprising an adjustable end wall for controlling the resonant frequency of said resonator.

2. An ultra high frequency oscillator for operation at a plurality of predetermined frequencies comprising a cavity resonator defined by a conductive cylinder, an electric discharge device in said cylinder comprising a plurality of electrodes including an anode, a cathode and a grid defining anode-grid and grid-cathode gaps, means connecting said cathode and said anode to spaced points on said resonator, and coupling means defining a waveguiding path between the anode-grid gap and grid-cathode gap of said discharge device comprising a plurality of successively telescoped coaxial conductors connected to provide a plurality of concentrically arranged concentric transmission line sections connected in series, said resonator including an adjustable end wall for controlling the resonant frequency thereof.

3. An ultra high frequency oscillator comprising a cavity resonator defined by a conductive cylinder, an electric discharge device within said resonator including a plurality of electrodes comprising a anode, a cathode and a grid defining anode-grid and grid-cathode gaps, means connecting said cathode to said cylinder, a longitudinal cylindrical conductor connected to said anode and coupling means defining a waveguiding path between the anode-grid and grid-cathode gaps of said discharge device comprising a pair of concentrical cylindrical members of different diameters connected to said grid, the inner of said cylinders extending an appreciable distance along said longitudinal conductor but spaced therefrom and the outer of said cylinders being supported from said inner cylinder by a transverse metallic wall, and a conductive cylinder concentric to said longitudinal conductor and supported therefrom extending an appreciable distance between said pair of concentric cylindrical members to define therewith a plurality of concentrically arranged concentric transmission line sections connected in series.

4. An ultra high frequency oscillator comprising a conductive member defining a cavity resonator, an electronic tube within said resonator including an anode, a cathode and a grid defining anode-grid and grid-cathode gaps, a cylindrical conductor connected to said anode, coupling means providing a waveguiding path between the anode-grid and grid-cathode gaps of said tube comprising a pair of longitudinal cylinders connected to said grid and an intermediate longitudinal cylinder connected to said conductor, said cylinders defining a plurality of concentrically arranged concentric transmission line sections connected in series.

5. A high frequency oscillator comprising, a conductive structure defining a resonator, an electric discharge device including an anode, a cathode and a grid supported in mutually spaced and insulated relation within said structure and defining a grid-anode gap and a grid-cathode gap, said anode and cathode having respectively high frequency electrical connections with spaced points of said structure, a plurality of concentric cylinders of progressively increasing diameters, alternate ones of said cylinders being connected with said grid and said anode and with the free ends thereof extending in oppositely directed and overlapping relation to provide a plurality of concentrically arranged transmission line sections defining a waveguiding path from the grid-anode gap of said device to the grid-cathode gap of said device, which is folded back on itself.

6. A high frequency oscillator comprising, a cavity resonator defined by a conductive cylinder, an electric discharge device within said resonator including an anode, a cathode and a grid supported in mutually spaced and insulated relation to define grid-anode and grid-cathode gaps, a cylindrical conductor connected with said anode and to said conductive cylinder, means connecting said cathode with said conductive cylinder, a plurality of concentric cylinders of progressively increasing diameters, alternate ones of said concentric cylinders being connected respectively with said grid and said cylindrical conductor to define therebetween a waveguiding path which is folded back on itself for guiding electromagnetic waves from the grid-anode gap to the grid-cathode gap of said device and thereby sustain regenerative oscillations.

7. High frequency apparatus comprising a cavity resonator, an electric discharge device within said resonator having a plurality of electrodes including a cathode, a grid, and an anode defining cathode-grid and anode-grid gaps, a structure comprising at least two concentric cylinders having a common closed end at one end thereof and at least one cylinder having a closed end and concentrically intermeshing with said cylinders, one of said closed ends being connected to said grid whereby said resonator is divided into a cathode-grid region and an anode-grid region, and the other of said closed ends being connected to said anode whereby said struc-

ture defines a multiply folded feedback path for guiding waves from said anode-grid gap to said cathode-grid gap in proper phase and magnitude to sustain oscillations in said resonator, said cathode and anode having high frequency connections to spaced points on said resonator.

8. High frequency apparatus comprising a cylindrical cavity resonator, an electric discharge device within said resonator having a plurality of electrodes including a cathode, a grid, and an anode defining cathode-grid and anode-grid gaps, said cathode and anode having high frequency connections to the ends of said resonator, a conductive structure comprising at least two cylinders having a common closed end at one end thereof and positioned concentrically within said resonator, and at least one cylinder having a closed end and concentrically intermeshing with said cylinders, one of said closed ends being connected to said grid whereby said resonator is divided into a cathode-grid region and an anode-grid region,

and the other of said closed ends being connected to said anode whereby said structure defines a multiply folded feedback path for guiding waves from said anode-grid gap to said cathode-grid gap in proper phase and magnitude to sustain oscillations in said resonator.

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