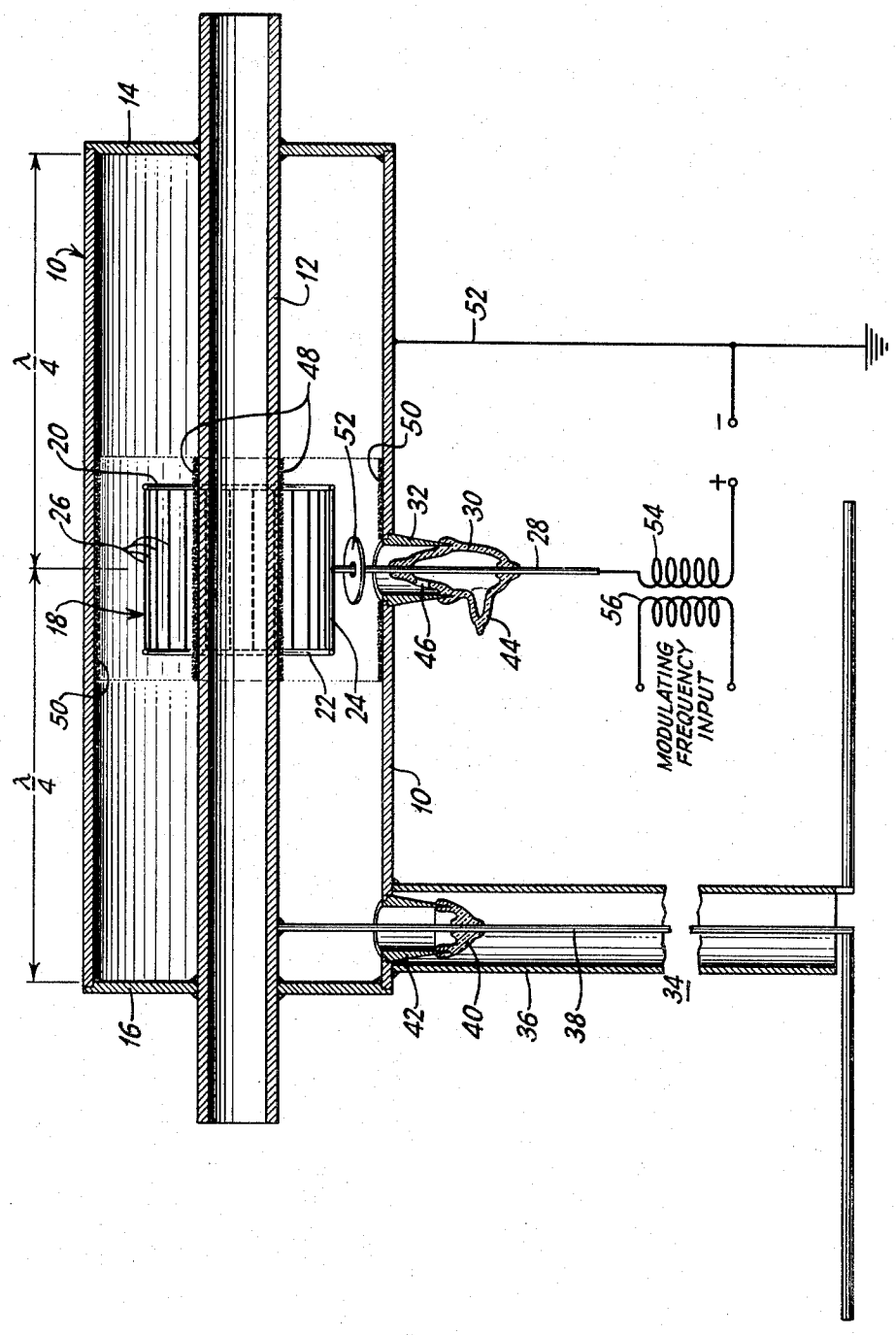
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OSCILLATOR

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OSCILLATOR

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This invention relates to an improvement in oscillators and in particular oscillators used for ultra high frequency work.

Heretofore ultra high frequency oscillators of various designs have been used but such oscillators have had the disadvantage of being unstable under operating conditions and have been limited in power output. Furthermore, previously used ultra high frequency oscillators have not been self-contained and have been so constructed that cooling of such oscillators other than by natural radiation and conduction of heat is impractical or impossible. Also, in previously used oscillators, the frequency of oscillation is controlled by the parameters of external circuits which may so vary as to cause a fluctuation of the frequencies delivered by the oscillator due to changes in the parameters by reason of changes in ambient temperatures, etc.

It is therefore one purpose of this invention to provide an ultra high frequency oscillator which is stable in operation and which will supply a fixed fundamental frequency as determined by the physical measurement of the oscillator.

Another purpose of the present invention resides in the provision of means whereby the oscillator may supply considerable power and the further provision of means whereby various agencies may be used to prevent the oscillator from becoming over-heated while in use.

Another advantage of the present invention resides in the provision of means whereby the oscillator may be cooled through the circulation of some cooling medium such as water; the cooling medium being applied both internally and externally of the tube proper.

A further advantage of the present invention resides in the fact that, by reason of the construction of the ultra high frequency oscillator, the envelope may be metallic and furthermore may be maintained at ground potential.

Still another advantage of the present invention resides in the fact that the oscillator constructed in accordance with this invention may be used to develop frequencies of the order from 3×10^8 to at least the order of 3×10^9 cycles per second. These frequencies correspond to wave lengths of from 1 meter to 10 centimeters, respectively.

Still another advantage of the present invention will become more apparent to those skilled in the art from a reading of the specification and claims, particularly when considered with the drawing herein.

The figure represents a preferred form of the present invention.

Referring now to the drawing, the ultra high frequency oscillator comprises a pair of tubular members 10 and 12 of different diameters; the one having the smaller diameter being positioned within and coaxial with respect to, the one having the larger diameter. These two cylinders are hermetically sealed with respect to each other by annular end members 14 and 16. The tubular member 12 may exceed the length of the tubular member 10 and accordingly extend beyond the planes of the end members 14 and 16 for a purpose which will be explained later. Within the envelope and within the region between the two tubular members is positioned a collector anode 18 which comprises a pair of spaced ring members 20 and 22. These two ring members are positioned in parallel planes and are preferably spaced equi-distant from the geometric center of the tube.

For mechanical strength and for electrical connection to the collector member 18 a bar member 24 is attached to and extends between the ring members. A plurality of grid wires 26 connect the two ring members at various points as indicated in the drawing. The external electrical connection to the collector anode or grid structure is by way of conductor 28 which extends outside the envelope; this connector being passed through a glass or ceramic seal 30 in order that the interior of the tube may be hermetically sealed with respect to the outside. The glass or ceramic member is fused to a metallic collar 32, the end portion of which is reduced in thickness in order to afford sufficient flexibility to compensate for the different coefficients of expansion between the metallic collar and the ceramic seal. The collar 32 is attached to the tubular member 10 in any appropriate manner such as by welding.

The ultra high frequency oscillations as produced by the oscillator are applied to a transmission line which may be used to feed an antenna such as a di-pole, or any other apparatus where ultra high frequencies are desired, a portion of the transmission line being shown at 34. As indicated in the drawing, the transmission line may be in the form of a concentric cable which includes a tubular external member 36 and an axially positioned conductor 38. The tubular member 36 is electrically connected to the tubular member 10 while the conductor 38 extends through a ceramic seal 40 and connects to the inner tubular member 12 at a point determined by the desired impedance which is necessary in

the output of the oscillator tube for matching purposes. The location of this point may be determined experimentally and the amount of impedance usually necessary in the circuit will be explained later. The ceramic seal 40 is similar to the seal 30 and a metallic collar 42 is used in order that the pressure within the oscillator may be reduced to a very low degree.

The space between the two cylinders 10 and 12 is exhausted during the making of the oscillator, the seal-off tip being indicated at 44, a small port 46 being provided in the ceramic seal 30 in order that the inner chamber of the seal may be brought into communication with the space between the two cylinders 10 and 12. The ceramic seal is preferably fused to the conductor 28 at two places to afford additional mechanical strength and to minimize the possibility of accidentally breaking the seal.

Inasmuch as the operation of this oscillator depends upon the phenomenon of secondary emission, secondary emissive surfaces are provided within the tube. One of these surfaces is indicated at 48 on the outside (major diameter) surface of the small cylinder or tubular member 12 while the other surface is indicated at 50 and is located on the inner surface of the larger cylinder 10. Since the connection to the collector anode extends through the wall of the larger cylinder 10 at a point approximately midway between the ends thereof, and since the point of entry for the conductor 28 is within the region of the secondary emission coating 50, a small annular shield member 52 is placed around conductor 28 within the tube in order to prevent the electrons which originate at surface or coating 48 from being projected against the seal 30. This construction may be obviated, however, by inserting the conductor 28 through the wall of the tubular member 10 at a point off center and just beyond the region occupied by the secondary emissive layer 50. When such construction is used, the layer 50 is continuous over the inner surface of the tubular member 10 in a region approximately near the central portion thereof as indicated in the drawing.

In the operation of the device, a source of potential is connected between the outer cylinder 10 and collector anode 18. The collector anode or grid structure must be maintained positive with respect to the metallic envelope and, as indicated in the drawing, the negative terminal of the direct current potential may be grounded as well as the metallic envelope of the tube.

The frequency supplied by the oscillator is determined by the internal dimensions of the oscillator; the wave length of the oscillation being equal to twice the distance between the inside surfaces of the end members 14 and 16. In other words, the distance from the center of the tube to the inner surface of either end wall is equivalent to one-quarter the wave length of the oscillations produced by the tube. When the tube is in operation, a standing wave is present on the inner surface of the tube extending in each direction from one secondary emissive coating to the end of the tube and back to the other secondary emissive coating.

When a high potential is applied to the conductor 28 and the envelope of the oscillator, primary electrons, for the purpose of illustration and explanation, will be removed from the coating 48 and will be accelerated towards the collector anode 18. Due to the high potential field which exists between these electrodes, the acceleration of the electrons is so great that the electrons pass through the collector anode grid structure 18 and are caused to strike the secondary emissive surface 50. When these electrons strike the secondary emissive surface 50, secondary electrons are produced which, by reason of the potential between the surface 50 and the collector anode or grid structure 18, are caused to impinge upon the secondary emissive surface 48. This oscillation of electrons between surfaces 48 and 50, together with the accompanying production of secondary electrons at each bombardment, produce an oscillation, and, at the same time, a standing wave on the surfaces of cylinders 10 and 12 and the end members 14 and 16. Due to the production of secondary electrons at the emissive surfaces which produce the oscillations and the standing wave in the envelope, an electric current will of course flow in opposite directions on the surface of the metal constituting the tube envelope; for instance, the current flows from the surface 50, along the inner surface of the cylinder or tubular member 10, radially along the inner surface of the end members 14 and 16, and inwardly from each end along the surface of the cylinder 12 to the secondary emissive coating 48. This direction of current flow reverses at each one-half oscillation and, although the length of this path is in excess of the electronic path, the transit time of the electrons between the surfaces 48 and 50 should for best operation and efficiency be exactly identical with the length of time necessary for the current to complete one direction of travel in the oscillating circuit, including the tube envelope as traced above.

Inasmuch as the current constituting the standing wave in the envelope of the tube is of ultra high frequency, this current, by reason of skin effect is confined entirely to the inner surface of the tube envelope so that the external surface of the tube envelope to which a cooling medium may be applied remains constantly at ground potential.

For best operation of the tube, and since the frequency of the oscillations produced thereby is determined by the physical measurements of the tube, an optimum value of potential which is applied between the tube envelope and the collector anode or grid structure should be used in order that the transit time of electronic path may just equal the length of time for the standing wave current to complete one-half cycle on the inner surface of the tube envelope. The value of this potential may be calculated, or may be determined by experimentation. The frequency produced by the tube is, however, not variable with respect to this potential since the frequency produced by the tube is substantially entirely controlled by its physical dimensions. However, values of potential other than the optimum value will reduce the available power output of the tube, i. e., the amplitude of the high frequency oscillations.

In the above example of operation of the device, it was assumed that, upon the application of a potential to the collector anode, one or more electrons will leave the surface 48. Whether the original primary electrons originating at the one emissive surface or the other depnds upon the alignment of the anode 18 with respect to these surfaces and/or upon transient conditions which exist in the tube at the instant that the operating potential is applied thereto. Furthermore, in view of the high Q of the tube, no means are normally required for initially establishing oscilla-

tions since the transient conditions and disturbances which accompany the initial energization of the tube are ordinarily entirely sufficient to establish initial oscillation. If, however, such disturbance are not sufficient, the surface 48 could well be subjected to the effect of a light beam which could be projected through the transparent or translucent ceramic seal 30, or such a light beam could be projected through an adequately provided window in the side of the tube. Furthermore, as an alternate means for establishing similar oscillation of the tube, a hot cathode could be provided which could be momentarily energized in order to supply the electrons necessary for the operation of the tube.

The Q of the ultra high frequency oscillator tube constructed in accordance with this invention is quite large and is of the order of several thousand. This is by reason of the fact that the inductance of the tube and the frequencies generated thereby are large as compared to the resistances and losses thereof since

$$Q=\frac{\omega L}{R}=\frac{2\pi fL}{R}$$

From such an equation, it may be seen that if the frequency is of the order of that indicated earlier in this specification, and since the inductance of the oscillator tube times the frequency is high, the Q will be quite large since the resistance and losses are relatively small.

Inasmuch as the surfaces of the tube which are exposed to atmospheric pressure may be constantly maintained at zero or ground potential, it is possible to immerse the tube in water or other liquid cooling bath; and furthermore it is entirely possible to circulate water through the bore of the inner cylinder member 12 by connecting a hose or other conduit to each end thereof.

As stated above, the wave length of the frequency supplied by the oscillator is determined entirely by the length of the oscillator as measured between the inner surfaces of the two end walls. The dimension of the two end walls is not effective in determining the frequency of the oscillator and the two tubular members 10 and 12 may be spaced apart various amounts as determined by the end wall dimensions. There is, however, a more or less optimum value for the diameter of the end wall members and this value may be determined either experimentally or through calculation. If the radius of the end wall members, that is, the spacing of the two tubular members 10 and 12, is increased, then obviously greater energizing potentials must be applied between the grid or collector anode 18 and the envelope of the oscillator. Such increase in potential must be applied for two reasons: First, because higher potentials are necessary in view of the increased spacing, and secondly, because higher potentials must be used in order that the transit time of the electrons from the one secondary emissive coating to the other should, for best operation, remain the same for a fixed length of tube construction.

The thickness of the tubular members 10 and 12 as well as of the end members 14 and 16 is not vital since, as stated above, the skin effect which is present under such ultra high frequency oscillations, as well as the attraction of the charges on the inside surface of the tube are sufficient to cause the current of the standing wave to be confined entirely to the inner surface of the tube envelope. The thickness of the envelope is therefore determined by the size of the oscillator and the amount of mechanical strength necessary to withstand atmospheric pressure to which the tube is subjected when exhausted.

The length of the anode member 18 as well as the length of the two secondary emissive coatings 48 and 50 is not particularly vital but should not be excessive since secondary electrons emerging from the end portions of an excessively long coating may not actually be effective in the operation of the device. However, if the length of the anode and of the coatings is too reduced the available power output of the oscillator may also be correspondingly reduced.

The oscillator may be used merely as a source of ultra high frequency oscillations alone or if the oscillator is used to supply a carrier frequency to a transmitting antenna by way of a transmission line, then it might become desirable to modulate the ultra high frequency by some lower frequency such as by the video frequencies which originate at a television transmitting station. Such modulating frequencies may vary from zero to some 4 or 5 megacycles per second. The modulation of the ultra high frequency produced by the oscillator may be accomplished in various manners. One method of so doing is to vary the effective potential applied to the collector anode of the oscillator. This may be accomplished by means of a pair of mutually inductive members or cores 54 and 56, the former of which is connected in series with conductor 28 to which the positive terminal of the high potential source is connected, the modulating frequency input being applied to the terminals of the other inductive member. When such a connection is used, the effective voltage on the collector anode 18 is varied above and below the potential of the source of high voltage so as to affect the output of the oscillator resulting in an amplitude modulation of the frequencies produced thereby in accordance with the frequencies applied to the inductive winding 56. It is to be understood that to produce linear modulation the oscillator must be operated at a potential slightly above or below the optimum value so that the variation in anode potential as caused by the modulating voltage will cause the tube to operate on the increasing or decreasing linear portion of the characteristic curve of amplitude output vs. collector anode potential. This method of modulation is somewhat desirable inasmuch as the presence of an inductive member between the positive terminal of the source of potential and the collector anode 18 is sometimes desirable to enhance the operation of the device.

Inasmuch as the impedance of a di-pole antenna is normally less than 100 ohms and generally of the order of 72 ohms (which impedance is somewhat independent of wave length at which the antenna is operated), proper impedance matching between the transmission line 34 and the antenna is necessary and desirable, so that the impedance of the transmission line 34 should be substantially equivalent to the impedance of the antenna di-pole. Furthermore, for complete impedance matching the connection of the conductor 38 of the transmission line should be connected to a point along the tubular member 12 so that the impedance at the point of connection will also be equivalent to the impedance of the transmission line (coaxial cable) and to the di-pole antenna. Such a connection will obviously be relatively adjacent to the end of the oscillator tube since the impedance of the oscillator tube

at the plane of the end wall thereof is zero, the impedance increasing to infinity at a point midway between the ends of the oscillator. The exact location of this connection may be determined by mathematical calculation, by experimentation or graphically.

Since the efficiency of the device and the energy dissipated by the antenna depends upon impedance matching of the transmission line 34, a second method of modulation is possible by varying the impedance of the transmission line. If this impedance is increased or decreased above or below the optimum value, then the amount of energy available at the antenna is increased or decreased above or below a predetermined maximum so that amplitude modulation may be produced by varying the impedance of the transmission line 34 in accordance with the modulating frequency potentials with the result that the frequency transmitted by the antenna will be amplitude modulated in accordance with such voltage variations. In this instance the impedance of the transmission line must be chosen at a value other than the optimum value in order to produce linear modulation for reasons analogous to those above in regard to modulation by varying collector anode potential.

From the above, it may be seen that a new and improved ultra high frequency oscillator has been developed which is inherently stable in operation since the frequency delivered by the oscillator is entirely a function of the internal length of the oscillator which is, of course, fixed and constant. The oscillator includes no external circuits and all of the elements necessary to produce oscillation except for the source of potential are included within the tube envelope. Furthermore, even though the oscillator is capable of generating high frequency oscillations of the order referred to above, the oscillator is still of such physical dimensions as to permit it to supply considerable power and as to permit it to be conveniently constructed without the exercise of an excessive degree of technical skill. The principle portion of the apparatus to which attention must be directed in the process of construction is the internal length of the tube, which, as stated above, determines the frequency at which the device will oscillate.

Also, it may be seen that the device is capable of being constructed to produce a wide range of frequencies of a very high order since an oscillator tube having an internal length of 5 cm. will produce an oscillation of the order of 3×10^9 cycles per second. Such a frequency is, of course, not necessarily the upper limit of a device constructed in accordance with this invention since it is feasible to construct a tube having an internal length of less than 5 cm. The low frequency extreme to which such a device may operate is determined solely by the practical physical length which may be used.

In view of the construction of the oscillator as described above, very large quantities of power may be derived therefrom, it being entirely possible to increase the amount of power by cooling the tube through the use of some fluid medium. The use of a cooling fluid at ground potential is permissible in view of the fact that the external surface of the oscillator may always be maintained at ground potential. The fact that a cooling fluid may be placed in intimate contact with the tube envelope is advantageous since, by controlling the temperature of the cooling medium the length of the tube may be controlled within very close limits to compensate for small errors in the length of the tube due to construction in order that the tube may be made to operate at exactly the desired frequency, the length of the tube varying slightly as a function of temperature by reason of the thermal coefficient of expansion of the metal (preferably copper) of which the tube envelope is made.

Moreover, in view of this construction, the oscillator is completely shielded so that no additional means need be provided for shielding the oscillator. Accordingly, no apparatus which is situated near the oscillator will be affected due to extraneous fields of potential inasmuch as no such fields could exist by reason of the complete shielding. Also, by reason of the construction a transmission line may be very closely coupled to the oscillator so that losses by reason of such coupling may be reduced to a minimum.

Although the device as described and shown is more or less specific in form it is obvious that various alterations and modifications may be made therein without departing from the scope thereof and it is desired that any and all such modifications be considered within the purview of the present invention except as limited by the hereinafter appended claims.

It is claimed:

1. An ultra high frequency oscillator comprising a pair of tubular members of different diameters, a pair of annular end members for maintaining the tubular members coaxially and concentrically spaced to produce an hermetically sealed space between the members, a cylindrical grid-like anode electrode, means for positioning said electrode coaxially between the tubular members and substantially equi-distant between the end members, a coating of secondary electron emissive material on the opposed surfaces of the tubular members and at least along the central portions thereof, means for applying a high direct current potential between the tubular members and the anode electrode, an output circuit including a coaxial cable comprising an internal and an external conductor, means for connecting the external conductor to the tubular member having the larger diameter, and means for connecting the internal conductor to the other tubular member at a point near one end thereof.

2. An ultra high frequency oscillator comprising a pair of tubular members of different diamters, a pair of annular end members for maintaining the tubular members coaxially and concentrically spaced, a cylindrical grid-like anode electrode, means for positioning said electrode coaxially with respect to the tubular members and substantially equi-distant between the end members, a coating of secondary electron emissive material on the opposed surfaces of the tubular members, means for applying a direct current potential between the tubular members and the anode electrode, a coaxial cable comprising an internal and an external conductor, means for connecting the external conductor to one of the tubular members, and means for connecting the internal conductor to the other tubular member.

3. An ultra high frequency oscillator comprising a pair of tubular members of different diameters, a pair of end members for maintaining the tubular members coaxially and concentrically spaced and to provide an hermetically sealed space between the members, a cylindrical grid-like electrode, means for positioning said electrode between the tubular members, a coating of

secondary electron emissive material on the opposed surfaces of the tubular members along the central portions thereof, means including a source of high potential for maintaining a potential difference between the tubular members and said electrode, an output circuit including a coaxial cable comprising an internal and an external conductor, means for connecting the external conductor to one of the tubular members, means for connecting the internal conductor to the other tubular member, and means to modulate the potential.

4. An ultra high frequency oscillator comprising a pair of tubular members of different diameters, a pair of annular end members for maintaining the tubular members coaxially and concentrically spaced with respect to each other to provide an hermetically sealed space between the members, a cylindrical grid-like anode electrode, means for positioning said electrode coaxially between the tubular members and substantially midway between the end members, a layer of secondary electron emissive material on the opposed surfaces of the tubular members and along the central portions thereof, means for applying a source of high voltage direct current potential between the tubular members and the anode electrode, and an output circuit connected to the tubular members.

5. An ultra high frequency oscillator comprising a pair of tubular members, a pair of end members for maintaining the tubular members coaxially and concentrically spaced with respect to each other to provide an hermetically sealed envelope, a cylindrical anode electrode, means for positioning said electrode between the tubular members and the end members, a layer of secondary electron emissive material on the inner surfaces of the envelope and at least along the central portion thereof, means for impressing a direct current potential source between the tubular members and said anode electrode, and an output circuit connected to the tubular members.

6. An ultra high frequency oscillator comprising a pair of tubular members, a pair of end members for maintaining the tubular members coaxially and concentrically spaced with respect to each other, a cylindrical grid-like electrode, means for positioning said electrode between the tubular members, a layer of secondary electron emissive material on the surfaces of the tubular members, means for impressing a direct current potential source between the tubular members and said electrode, means to modulate the potential, and an output circuit connected to the tubular members.

7. An ultra high frequency oscillator comprising a pair of tubular members, a pair of end members adapted to maintain the tubular members coaxially and concentrically spaced in order to provide an hermetically sealed space between the members, an electron pervious cylindrical electron accelerating electrode, means for positioning said electrode between the tubular members and substantially equi-distant between the end members, a layer of electron emissive material positioned on the surfaces of the cylindrical members opposite the said electrode, means for maintaining said electrode at a high positive potential with respect to said tubular members, means to modulate said potential, and an output circuit connected to said tubular members.

8. An ultra high frequency oscillator comprising a pair of tubular members, a pair of end members adapted to maintain the tubular members coaxially and concentrically spaced, an electron pervious cylindrical electrode, means for positioning said electrode between the tubular members, a layer of electron emissive material on the surfaces of the cylindrical members, means for maintaining said electrode positive with respect to said tubular members, and an output circuit connected to said tubular members.

9. An ultra high frequency oscillator comprising a pair of tubular members, a pair of end members adapted to maintain the tubular members coaxially and concentrically spaced in order to provide an hermetically sealed envelope, an electron pervious electron accelerating electrode, means for positioning said electrode between the tubular members and the end members, a layer of electron emissive material positioned on the inner surfaces of the envelope opposite the said accelerating electrode, and means for maintaining said electrode positive with respect to said envelope.

10. An ultra high frequency oscillator comprising a casing having an inner and an outer tubular wall member, end members for providing a hermetically sealed space between the tubular members, an electron pervious accelerating electrode positioned between the wall members, a secondary electron emissive coating on the opposed surfaces of the wall members in the region of the accelerating electrode, means for maintaining said electrode positive with respect to said wall members, and an output circuit connected to said tubular wall members.

11. An ultra high frequency oscillator comprising a casing having an inner and an outer wall and end members for providing a hermetically sealed envelope, an electron pervious accelerating electrode positioned in the envelope, a secondary electron emissive coating on the inner surfaces of the envelope in the region of the accelerating electrode, means for maintaining said electrode positive with respect to said envelope, and an output circuit connected to said envelope.

12. An ultra high frequency oscillator comprising a casing having an inner and an outer wall member, together with end members for providing a hermetically sealed space between the members, an electron pervious electrode positioned between the members, a secondary electron emissive coating on the opposed surfaces of the wall, and means for maintaining said electrode positive with respect to said wall.

13. An ultra high frequency oscillator comprising a casing including a pair of coaxially and concentrically spaced tubular members and an end wall adapted to electrically connect at least one end of each of the tubular members, means whereby a high vacuum may be maintained between the tubular members, an electron pervious electron accelerating electrode positioned between the tubular members, a secondary electron emissive coating positioned on the opposed surfaces of the tubular members in the region of the accelerating electrode, means for maintaining a high potential difference between the accelerating electrode and the tubular members, and an output circuit connected to said tubular members.

14. An ultra high frequency oscillator comprising a casing including a pair of coaxially and concentrically spaced members and an end wall adapted to electrically connect at least one end of each of the tubular members, means whereby a vacuum may be maintained between the members, an electron pervious anode electrode posi-

tioned between the members, an electron emissive coating positioned on the opposed surfaces of the members in the region of the anode electrode, means for maintaining a potential difference between said anode electrode and the members, and a load circuit connected to said members.

15. An ultra high frequency oscillator comprising a casing including a pair of coaxially and concentrically spaced members and an end wall adapted to electrically connect one end of each of the tubular members, means whereby a vacuum may be maintained between the members, an electron accelerating electrode positioned between the members, an electron emissive coating positioned on the opposed surfaces of the members in the region of the electron accelerating electrode, and means for maintaining a potential difference between the accelerating electrode and the members.

16. An ultra high frequency oscillator comprising a pair of electrodes at least one of which forms the side wall of a casing, closure means associated with said electrodes for providing a hermetically sealed space between the electrodes, an additional electron pervious electrode positioned between the first named electrodes, a secondary electron emissive coating on the opposed surfaces of said first named electrodes, and means for maintaining a high potential difference between said first named electrodes and said additional electrode.

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