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ABSORPTION OSCILLATOR

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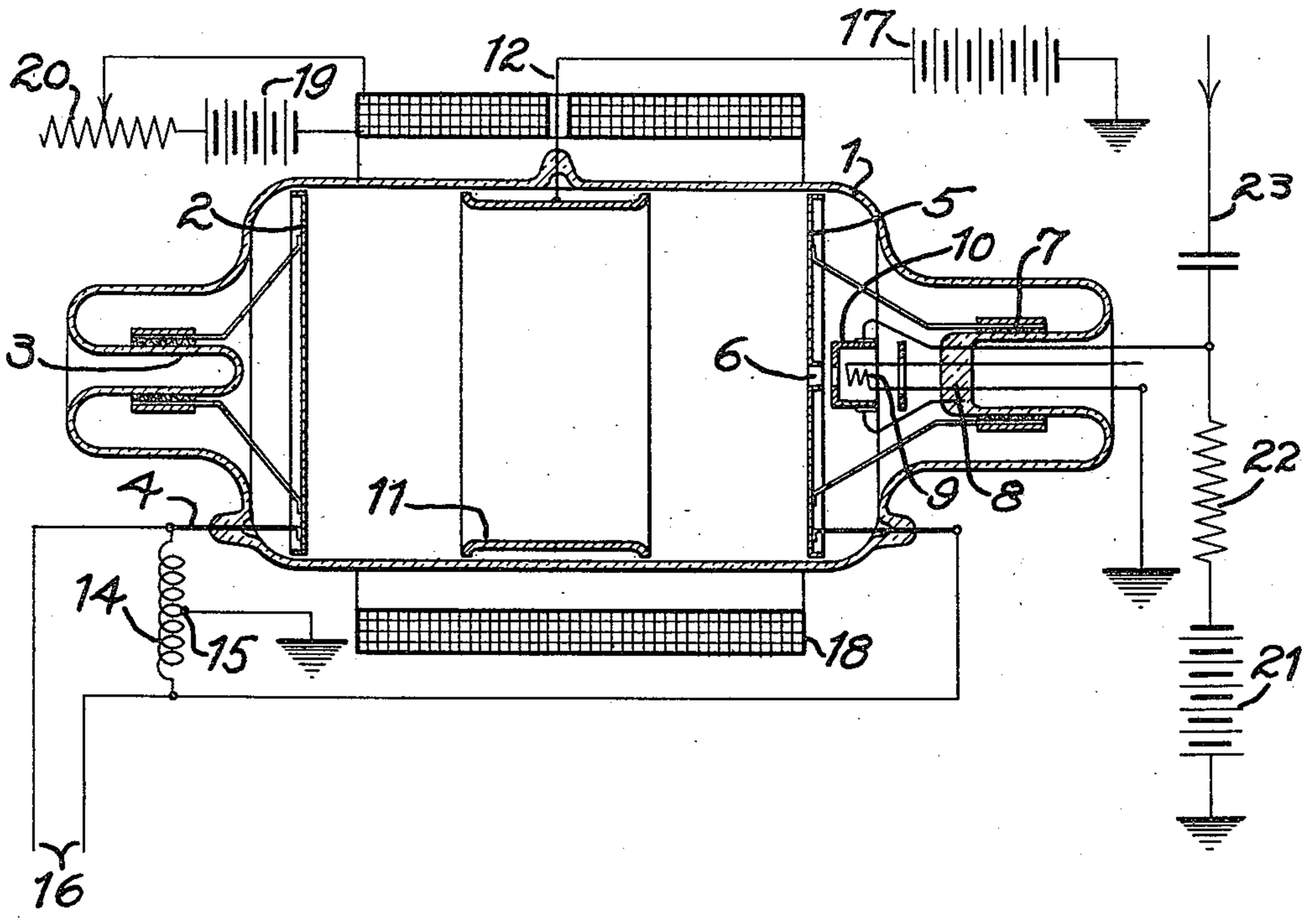

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ABSORPTION OSCILLATOR

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6 Claims. (Cl. 250—36)

My invention relates to oscillation generators and more particularly to an oscillation generator operating by absorbing the energy from an oscillating cloud of electrons.

The main object, therefore, of my invention is to convert direct current to alternating current.

Other objects of my invention are: to provide an oscillation generator of exceptionally high efficiency; to provide an oscillation generator that is easily modulated; to provide a high efficiency radio frequency amplifier; to provide an oscillation generator and amplifier which is operable over a wide range of potential; to provide a thermionic tube capable of converting direct current to alternating current with an exceptionally high efficiency; to provide an oscillation generator having minimum heat loss and to provide a means and method of generating and amplifying radio frequency currents at high efficiency.

My invention possesses numerous other objects and features, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing my novel method. It is therefore to be understood that my method is applicable to other apparatus, and that I do not limit myself, in any way, to the apparatus of the present application, as I may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

In my prior application, Serial No. 65,465, filed February 24, 1936, entitled, Multipactor oscillator and amplifier, I have described an electron multiplying device wherein electrons are multiplied by impact generated secondary electrons and the multiplied cloud passed into a power absorption structure wherein energy is absorbed from the oscillating cloud. The present invention is concerned with power absorption from a cloud of primary electrons generated by a source and maintained in oscillation by power absorbed from the cloud. The device may be used as a radio frequency amplifier, oscillator, or modulated oscillator, if desired, and does not depend on secondary emission for its operation.

The fundamental structure of my invention is simple and is shown in the figure which is a longitudinal sectional view of a preferred form of my invention together with a work circuit attached thereto.

The broad scope of my invention may best be understood by direct reference to the drawing wherein an envelope 1, is provided at one end with an absorption electrode 2, mounted on a stem 3, and having an exterior lead 4. At the other end of the tube is an opposing absorption electrode 5, differing only from electrode 2, in that it is provided with a central aperture 6. This absorption electrode is also mounted on a stem 7, the press 8, of which supports a gun cathode 9, and an apertured gun grid 10, each having their appropriate external leads. Midway between the two absorption electrodes 2 and 5 is a ring-shaped anode 11, having an external lead 12. No special treatment of the electrodes is necessary. The entire envelope is exhausted in the modern approved manner, all electrodes are thoroughly de-gassed, and the tube sealed from the pumps.

The device may then be connected in a circuit as shown for example, the two absorption electrodes 2 and 5 are connected by an exterior tuned impedance 14, the mid-point 15 of which is grounded. Wires 16, across the impedance 14, represent a transmission line or alternating current work circuit. The anode 11 is energized to a positive potential by anode source 17, the negative end of which is grounded. I also prefer to provide the tube with an axial magnetic field by the use of an external focusing coil 18 energized by a focusing source 19 under the control of a resistor 20. It should be distinctly understood, however, that an electrostatic focusing field is a full equivalent and may be obtained by proper relative shaping of the two absorption electrodes and the anode, if desired.

The gun cathode 9, and the gun grid 10, are positioned back of the absorption electrode aperture 6, in such a manner that the electrons from the gun cathode will be projected into the space between absorption electrodes 2 and 5. The gun grid 10, is preferably biased in accordance with its desired mode of operation by a biasing source 21, through a resistor 22, and modulation to the grid is supplied through input lead 23. The heating battery for the gun cathode is not shown and one leg of the cathode is grounded.

Tubes built and connected, as taught by the foregoing description, are easy oscillators irrespective of the power output; for example, the tubes may be made exceptionally small for receiving purposes and the anode potential need not exceed 30 to 60 volts, whereas, high powered tubes may operate with anode potentials between 10,000 and 150,000 volts and the general mode of operation in any case will be the same.

Let us consider the case of a high power tube for transmitting purposes and that the anode

11 is energized at a potential for example, between 10,000 and 150,000 volts with the gun cathode 9 capable of emitting an ampere of current and disregarding gun grid conditions. When the tube is energized a beam of electrons will enter the chamber between absorption electrodes 2 and 5 through aperture 6. These electrons will have all possible phase angles and will be, of course, accelerated to a high velocity by the potential on the anode 11 toward electrode 2. They will not, however, be collected by anode 11 because of the action of focusing coil 18. If then, I adjust the potential on anode 11 so that the time of flight between absorption electrodes 2 and 5 is exactly equal to the half period of the tuned impedance 14 connecting the absorption electrodes there will be, of course, no average power transferred to the external circuit. If, however, there is any oscillation induced in the tuned circuit connecting the absorption electrodes, no matter how small, this will cause some electrons to strike the absorption cathode and others to be slowed down. Such oscillation always takes place and the resulting oscillation in the external circuit will be intensified with an increase in the predominance of energy-giving electrons over energy-absorbing electrons with a result that an oscillation builds up immediately to the point where few if any of the electrons hit either electrode 2 or 5 but transfer their energy electrostatically to the absorption electrodes thus maintaining an oscillating current in the tuned impedance 14.

It will be seen that as the oscillating cloud of electrons approaches electrode 2, this electrode will become negative; whereas, electrode 5 will become positive. Thus, during all the time when the electron cloud is traveling away from electrode 5, electrode 5 will be positive and electrons will be entering the electrode space through aperture 6. When, however, the electrons turn and start to approach electrode 5, electrode 5 then becomes negative shutting off the flow of electrons through aperture 6. Thus, electrons from the gun cathode 9 enter the space between absorption electrodes 2 and 5 only when electrode 5 is positive thereby renewing the electron cloud in synchronism with the oscillations of the cloud.

As the electrons oscillate between the absorption electrodes 2 and 5, they are slowed down rapidly in giving up their energy to the electrodes. If, for example, the radio frequency voltage across the electrodes is 1,000 volts the electrons will lose 65% of their velocity at each trip so that they only need to make ten trips between the electrodes, that is, five radio frequency cycles, before they have given up their entire energy to the field. At this point they are collected by the anode 11, and as they have, at this time, practically no velocity, very little heat is generated in the anode by collection.

If, during the grouping of the electrons entering the space, by the action of the potential around aperture 6, gun grid 10 is provided with a modulating potential, it will be seen that the output of the device may be modulated, as the gun grid 10 will control the amount of electrons entering during each cycle. Inasmuch as the electrons are moving at a relatively low velocity in the neighborhood of the gun grid 10, only a very small amount of power is needed to modulate the large power output of the tube.

If it is desired to utilize the device as a class "C" amplifier, or separately excited oscillator, the grid-exciting voltage may be supplied to gun grid 10 through input line 23 from a master oscillator, for example, and the gun biased below cut-off. In this case, the input should, of course, have the same frequency as that determined by the tuned impedance 14, and the anode potential. In the case of class "C" operation, it will be seen that the gun grid 10 and anode 5 will vary in potential synchronously and it may be advantageous in case of the higher powers to utilize the device in this latter manner. It should also be pointed out that it is perfectly practical to make the structure symmetrical and to aperture electrode 2 similarly to electrode 5 and provide, back of the aperture, an electron supply identical with gun cathode 9 and grid 10. In this case, the structure may be connected for push-pull operation, each absorption electrode admitting electrons to the space between absorption electrodes 2 and 5 in synchronism with the oscillating cloud.

While the device will operate as an oscillator with various field distributions, I prefer to design the electrodes 2, 11, and 6, so that the electrostatic distribution is such that the gradient increases parabolically as the absorption electrode is approached from the center of the anode. This results in the electral oscillation being sinusoidal so that its frequency is independent of the amplitude of its oscillation. It should be noticed that in the embodiment shown the field distribution will be approximately parabolical for a large portion of the space near the center of the absorption electrodes.

One great advantage of the type of tube above described is that it is not necessarily a voltage amplifier but it will transfer all of the anode source energy into radio frequency current no matter what the impedance connecting the absorption electrodes may be. The device merely becomes more sluggish as the impedance is lowered. When the tube is used as a class "C" radio frequency amplifier, and modulated oscillator, the input need not be neutralized because there may be an actual voltage loss instead of a voltage amplification. The power amplification produced is enormous and tubes can be built where the power amplification passes a million.

Tubes of the type described above, utilizing my novel method of producing electrical oscillations, are extremely high in efficiency. All of the anode energy may be converted to radio frequency energy and the heat loss in the tube is small; first, because when the electrons are collected by the anode they have a minimum velocity and second, during operation the electrons do not contact either absorption electrode, and third, inasmuch as the device is a power amplifier, the gun current supplied to the device may be very small in comparison to the output power.

While I have chosen a particular structure to illustrate my new method of generating electrical oscillations, it should be distinctly understood that the structure shown is illustrative of the method only and other structures may be utilized to perform my method within the scope of the appended claims.

I claim:

1. In combination an envelope containing a pair of opposed electrodes and an anode therebetween adapted to be energized to a positive potential with respect to said electrodes, one of said electrodes having an aperture therein, means for projecting a stream of electrons into the space between said electrodes through said aperture, means for oscillating said electrons between said electrodes without collection there-

by, whereby potentials oscillating with respect to said projecting means are induced on said apertured electrode, the edges of said aperture being positioned to control the number of electrons entering said space in accordance with the potential induced on the apertured electrode.

2. In a combination of the type described in claim 1, a modulating means for varying the number of electrons passing through said aperture.

3. The method of oscillation generation which comprises creating a centrally directed accelerating field, generating a stream of electrons outside of said field and directed toward the center thereof to cause oscillation of said electrons about said center, and causing changes of potential within the field consequent on said oscillation to control the number of electrons from said stream which enters said field.

4. In a method of the type described in claim 3 the step of additionally modulating said stream.

5. The method of oscillation generation which comprises creating a centrally directed accelerating field, generating a stream of electrons outside of said field and directed toward the center thereof to cause oscillation of said electrons about said center, controlling the number of electrons from said stream which enters said field solely by changes of potential within the field due to the oscillation of said electrons about the center of said field.

6. In a method of the type described in claim 5 the additional step of modulating said electron stream before it enters said accelerating field.

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