Dec. 28, 1937. K. POSTHUMUS ET AL 2,103,338

ULTRAHIGH FREQUENCY OSCILLATOR

Filed June 15, 1935

Fig. 1

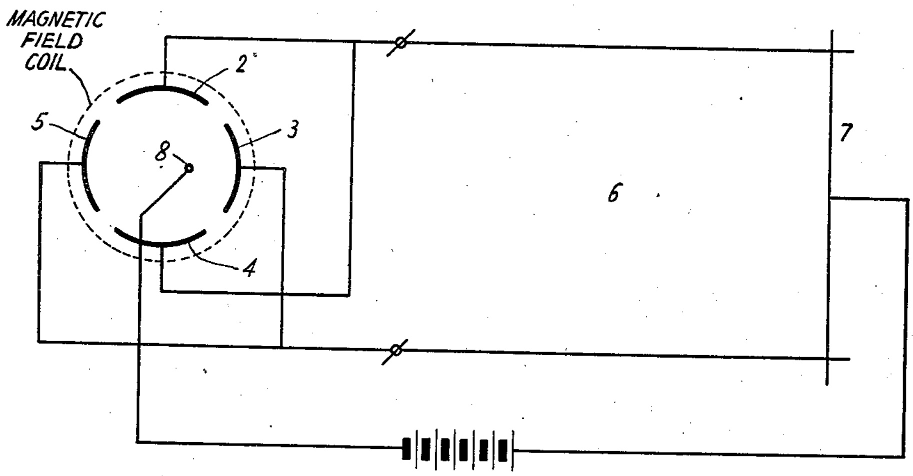


Fig. 2

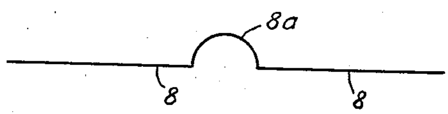
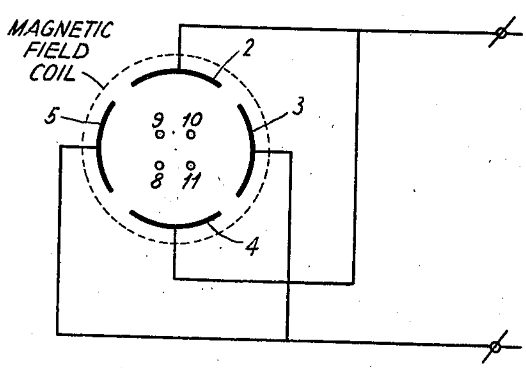


Fig. 3



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Patented Dec. 28, 1937

2,103,338

UNITED STATES PATENT OFFICE

2,103,338

ULTRAHIGH FREQUENCY OSCILLATOR

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Application June 15, 1935, Serial No. 26,760
In the Netherlands July 7, 1934

10 Claims. (Cl. 250—36)

This invention relates to a thermionic oscillator of the kind in which oscillations are generated by the action of a magnetic field. The oscillations generated by means of the known oscillators of this type were hitherto divided into two groups.

The first group comprises oscillations generated, for instance, by means of an oscillator having a cylindrical anode which is symmetrically arranged around a linear cathode. Oscillations generated by such an oscillator have a frequency whose time of oscillation is of the same order of magnitude as the time of circulation of the electrons inside the tube. These oscillations are of the same kind as the oscillations generated in a triode, in which the grid is at a higher positive potential than the anode with respect to the cathode, these oscillations being called "electron oscillations". The frequency of these oscillations is directly proportional to the intensity of the field H.

The second group comprises the oscillations generated with the aid of an oscillator in which two or more anodes are symmetrically arranged with respect to a cathode, a negative resistance occurring if a potential difference is set up between two opposite anodes. As a result of this, an oscillatory circuit, connected between two opposite anodes, will produce oscillations whose frequency is determined by the natural frequency of said circuit.

The present invention relates to an oscillator comprising two or more anodes connected in a known manner to an oscillatory circuit. The characteristic feature of the circuit arrangement of the present invention is that the intensity of the field, in deviation from that which is used in practice by the oscillators referred to, is greater than the intensity at which the anode current is suppressed. According to the invention, the intensity of the field is given such a value that oscillations are generated having a frequency which is substantially inversely proportional to the intensity of the field. Due to the chosen value of the field, the nature of the oscillations which it is possible to generate with the oscillator of the invention, is entirely different from the nature of the oscillations generated by the known oscillators. In fact, since the oscillations generated by the oscillator, according to the invention, are inversely proportional to the intensity of the field, they can neither be classified under the oscillations which are independent of the field, nor under the known electron oscillations that are directly proportional to the field. However, the oscillations in question are electron oscillations indeed, but their nature is entirely different from those hitherto known.

As a matter of fact, the occurrence of oscillations has been experimentally shown and can also be ascertained with the aid of the equations of motion for the electrons inside the tube. It follows from these equations that once a small alternating voltage is set up between both anodes of an oscillator tube having two anodes, the electrons can reach the anode after covering a spiral path at a constant angular velocity. The linear velocity at which the electrons strike the anode, appears to be much smaller than the velocity corresponding to the direct voltage of the anode, so that strong oscillations can be generated. The frequency of the generated oscillations is substantially determined by the equation:

$$\omega=\frac{2Va}{r^2_aH}$$

where $\omega=2\pi$ times the frequency, Va represents the direct voltage of the anode, r_a the distance of the symmetry axis up to the anodes, and H the magnetic intensity of the field for an oscillator tube having two plates.

The oscillator of the present invention has the advantage over known oscillators in that its efficiency is much greater than that of the known oscillators. An oscillator, according to this invention, may have an efficiency of more than 50% whereas known oscillators have an efficiency of 30% at the most.

The invention preferably applies to a thermionic oscillator comprising two pairs of anodes which are connected to an output impedance in such a manner that the potential of each anode is opposite in phase with respect to the adjacent anodes. By means of such an oscillator, oscillations can be generated whose frequency is determined by the equation

$$\omega=\frac{4Va}{r^2_aH}$$

This frequency is about twice as high as that of the oscillations produced by an oscillator tube having two anodes. When oscillations having a still higher frequency are desired, the invention may be used in a thermionic oscillator comprising three or more pairs of anodes.

It has been found that the tendency to self-oscillate at a definite intensity of the field decreases as the number of anodes of a thermionic oscillator increases. Furthermore, it has been found that in the case of an increasing intensity of the field the tendency to self-oscillate decreases with a definite oscillator tube. In order to avoid this drawback (and according to the invention) the cathode, the anodes or the magnetization coil are so formed with respect to one another, that the magnetic field and/or the electric alternating field between the anodes are/is unsymmetrical with respect to at least part of the cathode.

In the drawing, Figs. 1 and 3 illustrate different embodiments of the invention, and Fig. 2 illustrates a modification of the cathode element which may be used.

Fig. 1 represents one form of construction of a thermionic oscillator, according to the invention, in which the last-mentioned measure is taken. This figure shows only those parts that are necessary for a correct understanding of the oscillator of the invention. The oscillator represented in Fig. 1 comprises two pairs of anodes **2**, **4** and **3**, **5** which are alternately directly connected together. An oscillatory circuit **6**, which is tuned to the frequency to be generated and consists of evenly distributed self-induction and capacity, is interposed between the pair of anodes **2**, **4** and the pair of anodes **3**, **5**. One side of the source of anode voltage is connected to a point of the bridge **7** which serves for tuning the circuit **6**, and the other side to the cathode **8** of the oscillator tube. The cathode **8** is rectilinear and extends perpendicularly to the plane of the drawing. The magnetization coil is fed with rectified alternating current or direct current and is so arranged that the lines of force extend parallel with the cathode. The intensity of the magnetic field is so many times greater than the intensity of the field at which the anode current is suppressed, that the oscillator described permits the generation of oscillations whose frequency is substantially inversely proportional to the intensity of the field and approximately satisfies the equation

$$\omega=\frac{4Va}{r^2_aH}$$

According to the invention, the distance of the cathode with respect to the anodes **2**, **3**, **4** and **5** is different, due to which the electric alternating field between the anodes is unsymmetrical relative to the cathode. Owing to this the region in which the electrons are located is off-center before oscillations begin, in other words, the electrons are staying in areas where an electric alternating field is set up as soon as a small anode alternating voltage is available between both pairs of anodes **2**, **4** and **3**, **5**. Due to the presence of the tangential alternating force exerted by the electric alternating field on the electrons, the latter can reach the anode along spiral paths and oscillations can be generated. As the magnetic intensity of the field increases, the area where the electrons are staying before the generating of oscillations is more remote from the area where the tangential field occurs and the eccentricity of the filament must be greater. The same holds good for a discharge tube having a larger number of anode pairs at a definite intensity of the field, since in this case the area where the electric alternating field is set up, lies more in the vicinity of the anodes and is consequently more remote from the area where the electrons are staying.

In another form of construction of the oscillator, according to the invention, a cathode is used which for the greater part is rectilinear and is positioned symmetrically relative to the anodes, and for the remaining part is curved. Fig. 2 shows an example of such a cathode, the cathode being denoted by **8** and the curved part by *8a*. The desired effect is achieved with an oscillator tube comprising such a cathode, since, before oscillations are produced, the electrons emitted by the curved part *8a*, are in an area where the electric alternating field is set up.

In another form of construction a cathode consisting of two or more parallel wires is used. This form of construction is represented in section in Fig. 3 of the drawing, wherein **8**, **9**, **10** and **11** denote the rectilinear parts of the cathode.

In another form of construction a rectilinear cathode is used which is at an angle with the axis of symmetry of the anodes.

The desired effect can also be achieved by making use of a discharge tube having a central rectilinear cathode, by displacing over a certain distance the axis of the magnetization coil relative to the cathode so that this axis is still parallel with the cathode, but does no longer coincide therewith. If desired, this measure may be taken in combination with one of those referred to above.

What is claimed is:

1. An oscillation generator comprising an electron discharge device having within an evacuated container a cathode and a plurality of anodes surrounding said cathode, means for suitably energizing said cathode and anodes and for applying a magnetic field to the electrons emanating from said cathode to produce oscillations, said cathode being located unsymmetrically with respect to said anodes.

2. An oscillation generator comprising an electron discharge device having within an envelope a substantially linear cathode and a plurality of pairs of anodes surrounding said cathode, said anodes having a common center, connections conductively connecting alternate anodes together, said cathode having at least a portion located off-center with respect to said anodes, an oscillatory circuit having opposite terminals connected to adjacent anodes, and means for applying a magnetic field to between said anodes whose lines of force are parallel with said cathode.

3. An oscillation generator in accordance with claim 2, characterized in this that said discharge device is a vacuum tube and there are provided two pairs of anodes for said device.

4. An oscillation generator comprising an electron discharge device having within an envelope, a plurality of filamentary rectilinear cathodes located around a center point of said envelope, a plurality of pairs of anodes surrounding said cathodes, connections conductively connecting alternately located anodes together, an oscillatory circuit having opposite terminals connected to adjacent anodes, and means for applying a magnetic field to said device whose lines of force are substantially parallel with said cathodes.

5. An oscillation generator in accordance with claim 2, characterized in this that there are four such cathodes and two pairs of anodes.

6. The method of generating oscillations in an electron discharge device having a filamentary cathode and a plurality of anodes which comprises producing electrons which at their emergence are unsymmetrically located with respect to said anodes, and applying a magnetic field to said device whose intensity exceeds that at which anode current is suppressed, whereby oscillations are generated the frequency of which is

substantially inversely proportional to the intensity of said magnetic field.

7. The method of generating oscillations in an evacuated electron discharge device having a filamentary cathode, and a plurality of anodes which comprises applying a uni-directional magnetic field to said device which is unsymmetrical to at least part of the cathode and whose lines of force are substantially parallel with said cathode.

8. An oscillation generator comprising an electron discharge device having within an evacuated container a linear cathode and a plurality of anodes surrounding said cathode, means for suitably energizing said cathode and for applying a unidirectional magnetic field to the electrons emanating from said cathode to produce oscillations, said cathode being located unsymmetrically with respect to said anodes.

9. An oscillation generator comprising an electron discharge device having within an evacuated container a linear cathode and a plurality of anodes surrounding said cathode, means for suitably energizing said cathode and for applying a unidirectional magnetic field to the electrons emanating from said cathode to produce oscillations, said cathode being located unsymmetrically with respect to said magnetic field.

10. The method of generating oscillations in an electron discharge device having a linear cathode and a plurality of anodes, which comprises applying a magnetic field to said device whose intensity exceeds that at which anode current is suppressed, producing electrons which at their emergence are unsymmetrically located with respect to said magnetic field, whereby oscillations are generated, the frequency of which is substantially inversely proportional to the intensity of said magnetic field.

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