Dec. 17, 1940. W. DÄLLENBACH ET AL 2,225,259

ULTRA-HIGH-FREQUENCY GENERATOR

Filed June 23, 1938 2 Sheets-Sheet 1

Fig.1

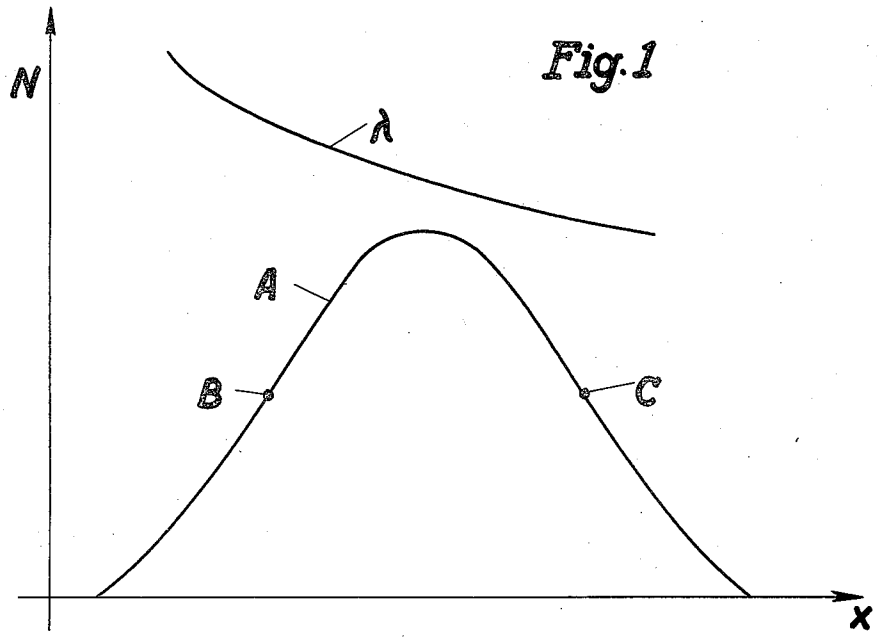


Fig.2

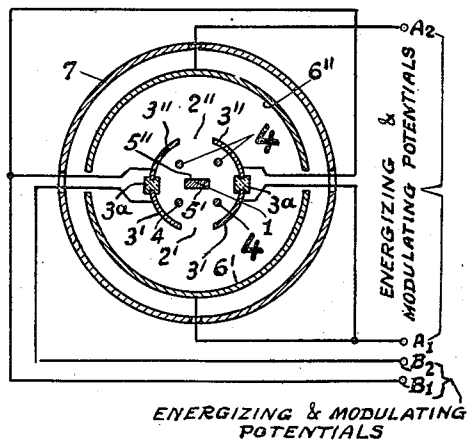
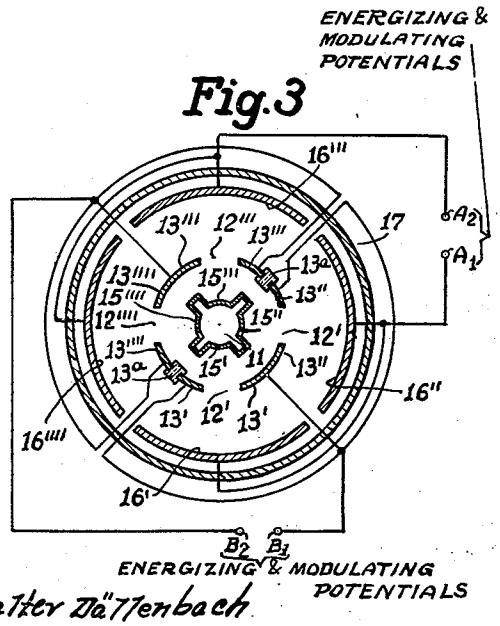


Fig.3



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Fig.4a

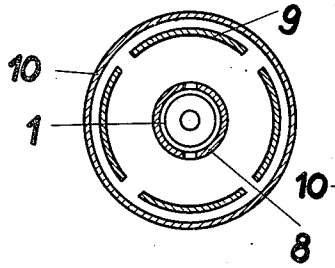
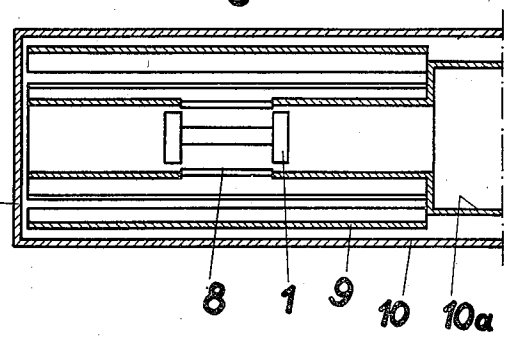


Fig.4b



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UNITED STATES PATENT OFFICE

2,225,259

ULTRA-HIGH-FREQUENCY GENERATOR

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Application June 23, 1938, Serial No. 215,474
In Germany June 28, 1937

12 Claims. (Cl. 179—171.5)

This invention relates to the production of ultra-high-frequency electromagnetic oscillations, and consists of a method and apparatus for the modulation of ultra-short-wave generators.

If, in the case of ultra-short-wave generators of the decimetre and centimetre ranges, one endeavours to produce a pure amplitude modulation, it is found that a frequency-modulation accompanies this amplitude modulation. The accurate investigation of this phenomenon shows that the frequency modulation is brought about substantially by the fact that the electron stream that serves for the production of the waves is, under the influence of the alternating potentials of the frequency-determining generator, not only a generator of effective currents but also a generator of wattless or reactive currents.

The characteristic of this generator for reactive currents depends, in a manner analogous to that of the characteristic of the generator for effective currents, on the time of transit of the electrons and consequently on the potentials applied to the electron tubes, the magnetic fields, etc. Now, if one of the physical magnitudes, for example the magnetic field, or the anode potentials, or a braking-electrode potential, is varied for the purpose of amplitude modulation, there also varies with it the reactive current delivered by the generator and consequently the frequency of the ultra-high-frequency power given off.

It is already known, for the purpose of preventing these frequency variations, to cause two electron tubes to work on different parts of their modulation curves and thus compensate the frequency variation of one electron tube by an opposite frequency variation of the other.

The present invention relates to a method and apparatus for the production and modulation of ultra-high-frequency oscillations. According to the invention two streams of electrons, which act upon a resonator in such a manner that the undesired frequency variations occurring on amplitude modulation are compensated, are produced in one and the same electron-tube arrangement; preferably in an electron-tube arrangement with, as a resonator, a chamber bounded by metallic surfaces, so that the electron-tube arrangement forms a constructional unit.

Figure 1 is a graph showing the curves of relationships between the oscillatory and physical energies and between generator frequency and physical energy occurring in the operation of this invention.

Figure 2 is a schematic cross section of a form of this invention having two electrode systems.

Figure 3 is a schematic cross section of a form of the invention having four electrode systems.

Figure 4*a* is a schematic cross section of a third form of the invention.

Figure 4*b* is a schematic longitudinal section of said third form.

In Figure 1 the curve A represents the modulation curves of the two electron streams, which are assumed to be alike. The curve A shows the variation of the oscillatory power N with variation of a physical magnitude, for example the grid potential x of a braking-field electron tube. λ is the curve showing the variation of the frequency of the generator with variation of the magnitude x. It will be clear that if two electron streams are, starting from B and C respectively, modulated counter-phasally, the frequency variations will be compensated.

Compensation of the undesired frequency variation takes place, in detail, as follows. The modulation of an oscillation produced in a return coupling tube by varying the potential of the control grid in the rhythm of the modulation, is well known. Likewise, it is possible, according to the well known method, to modulate an oscillation generated in a braking or damping field tube or in a magnetron tube by varying, in the first case, the potential of the damping electrodes or that of the grid electrodes or the potentials of both electrodes in rhythm with the modulation, or, with a magnetron tube, the potential of the anode. So long as the period of the electrons is small as compared with the duration of the generated oscillation, the variations of the electrode preliminary potentials in the rhythm of the modulation are without any special action, except for the variation of the oscillatory load caused thereby, and this leads to modulation of the oscillations. If, however, the period of the electrons comparably approaches the oscillation duration, variation of the electrode preliminary potential produces also variation of the period of the electrons. If the electron current active in a tube serves for generating ultra high frequency oscillations, the oscillatory duration of which is comparable with the period of the electrons, then not only is a work component of the oscillatory load produced, but also, as a result of the increased or decreased velocity of the electrodes caused by varying the electrode preliminary potential, an undesired component of the oscillatory load. This is due to the fact that, so to speak, through the variation of the electrode preliminary poten-

tial, the movement of the electrons undergoes a phase displacement relative to such of the electrons which are in unison with the oscillation at constant electrode preliminary potential. The effect of the undesired components of the oscillatory load passes to the exterior as a frequency variation of the oscillation generated. Therefore, if, by means of a second electron current or a plurality of other electron currents, the undesired components of the oscillatory loads produced by the first electron current are compensated for, then the resultant frequency variation is equal to zero, this being independent of variation of the electrode preliminary potential. A generator for ultra short waves balanced with respect to said undesired components thus always produces modulated ultra short waves of constant frequency.

Figure 2 diagrammatically shows an electrode construction as advantageously adapted for use in an arrangement according to the invention. Disposed about a strip-form cathode 1, which emits preferably from its wide surfaces 5' and 5'', are segment-like conductors 3' and 3'', which are supported by the parts 3*a*, which at the same time insulate them from each other. The conductors 3' and 3'' form slotted openings 2' and 2'' which extend parallel with the cathode and which serve as the openings of a grid, so that each of the conductors 3' and 3'' with their respective openings 2' and 2'' forms a semi-circular grid disposed about the cathode. In the space between the grids and the cathode there can also be advantageously disposed special control electrodes 4, which receive a suitable preliminary potential with respect to the cathode, and by means of which either the intensity of the electron currents passing from the surfaces 5' or 5'' can be controlled, or through which the direction of these electron currents can be influenced, particularly in order that they may be directed exclusively to the grid openings 2' and 2''. Concentric to the grids and with their centres opposite the grid openings are two other semi-circular conductors 6' and 6'', which serve as further electrodes. The cathode 1 and the two grids 3', 2' or 3'', 2'' and the two electrodes 6', 6'' accordingly form two electrode systems in which the electron currents passing from the surfaces 5' and 5'' act. By means of these electron currents, ultra high frequency oscillations can be excited, in that, for example, the two electrode systems act as damping field systems or return reaction coupling systems.

Figure 3 shows an electrode arrangement like that of Figure 2, but for four electrode systems. The cathode 11 emits only on the surfaces 15', 15'', 15''', 15'''' and from these strip-like surfaces, which extend parallel with the cathode axis, emit four electron currents, which pass through the slots 12', 12'', 12''', 12'''' of the conductors 13', 13'', 13''', 13'''' serving as grid electrodes and supported by the insulators 13*a*, and can be controlled by the grid electrodes. Disposed about the grid electrodes are the counter-electrodes 16', 16'', 16''', 16'''', which, in case the electrode systems operate as damping field systems, act as damping electrodes, and in the case in which the electrode systems act in return coupling connection, serve as anodes. Here also the feed lines serving to conduct the electrode preliminary potential lead to the connecting ponts A_1, A_2; B_1, B_2.

At the points A_1, A_2; B_1, B_2, of the arrangements according to Figure 2 or 3, not only can the preliminary potentials for the electrodes of the individual electrode systems be applied, but modulation potentials flow over these points also to one or both groups of electrodes, whereby the components of the modulation oscillations flow to the electrodes of the individual systems. For example, the damping electrodes 6' and 6'' of the arrangement according to Figure 2, when this operates in damping field connection, are relatively phase-displaced so that the frequency variation caused by the modulation amplitude in the one system is instantaneously the same as, but oppositely directed to, the frequency variation produced by the modulation amplitude in the other system. The resultant frequency variation between both systems is then equal to zero at each instant. In similar manner, it is possible to direct modulation amplitudes to the electrodes of Figure 3 over the feed lines with such relative phase position that the frequency variations resulting from the action of the modulation mutually nullify each other, so that the resulting frequency variation is equal to zero, and the arrangement produces ultra high frequency oscillations of constant frequency. It is thereby immaterial whether, as shown on Figure 3, two adjacent systems are connected together, so that the arrangement of Figure 3 operates like that of Figure 2, or whether all four electrode systems separately receive absolutely independent modulation components. The latter possibility offers the advantage that the stimulating intensity of each of the four electron currents can be varied independently, so that it is easier to cause the sum of the actions of the resultant undesired load components of all four systems to become zero than is possible with only two independent electrode systems. Finally, the arrangement of the present invention is not limited to two or four electrode systems, as shown on Figure 2 or 3, but any number of electrode systems can be provided which receive independent components of the modulation amplitudes which are so calculated with respect to their phase positions that the sum of the resultant frequency variations is again equal to zero.

Particularly when the arrangement of the electrodes according to the invention is used in the case of electron tubes with, as a resonator, a chamber bounded by metallic surfaces, it may be advantageous, for the purpose of facilitating the construction to couple capacitively a braking-field electrode, which is split two or more times, with another closed metallic casing 7, as is shown in Figure 2. The casing 7 may then constitute the exterior member of a concentric dielectric guide, the interior member of which is formed by the continuations of the screens 3 (Figure 2) or 8 (Figure 3) and in that case the direct-current or low-frequency separation of the screens 3 or 8 by the insulating pieces 3*a* or 8*a* must be observed. In this case the high-frequency energy impinging on the anode (braking electrode) can be transmitted by capacitive coupling to the external conductor of the electron tube and thus to that of the concentric dielectric guide.

It is possible to compensate similarly as regards its frequency a per se unsplit magnetron. A construction for this purpose is shown in Figures 4*a* and 4*b*, which show two sections through an electron tube formed as a chamber-resonator electron tube. The anode is divided into two or more parts, which, in contradistinction from the split magnetron, always possess the same high-frequency potential on the same cross-section.

In these figures, 1 indicates again the cathode, 8 the screening plates, which allow the electron streams to pass through to the anode 9 merely through the gaps between the plates 8. The parts 10 close the electron tube as regards radiation losses. At the same time the parts 10 serve as the exterior member of the dielectric guide to which the high-frequency energy that impinges upon the anode segments 9, as in the hereinbefore described constructional example, is transmitted by capacitive coupling.

The part 10*a*, which is connected with 8, forms the internal conductor of a concentric energy lead. The diminishing of the parts 10 and 10*a* is such that the surge impedance of the dielectric guide is less than that of the resonator of the electron tube.

For the purpose of modulation either two adjacent anode segments 9 or two opposite anode segments 9 should be connected together and fed with modulation voltages in the same way as described above with reference to Figures 2 or 3. It will be understood that the anode segments 9 constitute the energization segments.

With reference to Figures 4*a* and 4*b* the same thing is true. The anode segments 9 constitute the energizing segments.

In the case of electron-tube cartridges it may in particular be very advantageous to place the tuning chamber not between the generator and the utilizing device but to arrange the tuning chamber and the utilizing device on different sides of the generator.

In accordance with the provisions of the patent statutes, we have described the principle of operation of our invention, together with the apparatus which we now consider to represent the best embodiment thereof; but we desire to have it understood that the apparatus shown and described is only illustrative and that the invention may be carried out by other means.

What we claim is:

1. Apparatus for generating modulated ultra high frequency electro-magnetic oscillations of constant frequency, comprising a hollow walled vacuum chamber forming an elongated frequency-determining resonator, at least two electron current generating electrode systems within the resonator in the same cross section perpendicular to an axis of the chamber, whereby the electron currents radiate from this axis and excite the resonator to ultra high frequency oscillations, means for operating said systems on different portions of their frequency characteristic, and means for modulating said systems in phases different from each other whereby undesired components of the oscillatory currents generated thereby mutually nullify each other.

2. The apparatus of claim 1, wherein the electrode systems have a single cathode in common.

3. The apparatus of claim 1, wherein the generating systems are located in the resonator in the same loop of a potential wave.

4. The apparatus of claim 1, wherein the electrode systems include a common cathode, anodes, and a plurality of electrodes spaced evenly around said cathode, said systems having control means disposed between each of said electrodes and an anode.

5. The apparatus of claim 1, wherein the electrode systems include a common cathode, anodes, and a plurality of electrodes spaced evenly around said cathode, said systems having control means disposed between each of said electrodes and an anode, said control means controlling the direction of electron flow from the cathode.

6. Apparatus for producing modulated ultra high frequency electro-magnetic oscillations of constant frequency, comprising a frequency-determining resonator formed as a hollow chamber enclosed all around by metallic walls, the latter delimiting a vacuum chamber, at least two electrode systems in said chamber producing electron currents and so disposed in the same cross section perpendicular to the axis of the chamber that the electron currents radiate from this axis, whereby said electron currents stimulate the resonator to ultra high frequency oscillations, means for operating said systems on different portions of their frequency characteristic, and means for modulating said systems in phases different from each other whereby the unwanted components of the oscillatory loads mutually nullify each other.

7. Apparatus for producing modulated ultra high frequency electro-magnetic oscillations of constant frequency, comprising a frequency-determining resonator, two vacuum surrounded electrode systems in said resonator generating electron currents, the electrodes of the electrode systems consisting of a strip-like cathode common to both systems, segment-like conductors insulated from each other and disposed concentric with each other to encompass the cathode, the said conductors serving as a grid and including slotted openings parallel with the sides of the cathode, and other electrodes surrounding said conductors, means for operating said systems on different portions of their frequency characteristic, and means for modulating said systems in phases different from each other whereby the unwanted components of the oscillatory loads mutually nullify each other.

8. Apparatus for generating modulated ultra high frequency electro-magnetic oscillations of constant frequency, comprising a frequency-determining resonator, four vacuum surrounded electrode systems in said resonator generating electron currents, the electrodes of the electrode systems consisting of a cathode common to the four systems, segment-like conductors insulated from and concentric with each other, each encompassing the cathode over a quarter circle, the conductors serving as a grid and having slotted openings parallel with the cathode, and other electrodes arranged to form an almost closed hollow cylinder surrounding the grid, means for operating said systems on different portions of their frequency characteristic, and means for modulating said systems in phases different from each other whereby the unwanted components mutually nullify each other.

9. Apparatus for generating modulated ultra high frequency electro-magnetic oscillations of constant frequency, comprising a frequency-determining resonator, at least two vacuum surrounded electrode systems within said resonator for generating electron currents, the electrodes of the electrode systems consisting of a cathode common to both systems, segment-like conductors insulated from and concentric with the cathode and each semi-circularly encompassing the cathode, said conductors serving as a grid having slotted openings parallel with the cathode, and other electrodes surrounding the conductors and forming a substantially closed hollow cylinder, means for operating said systems on different portions of their frequency characteristic, and means for modulating said systems in phases

different from each other so that the thereby produced unwanted components of the oscillatory loads mutually nullify each other, said systems including means for directing the electron currents passing from the cathode through the slots of the grids.

10. The apparatus of claim 9, wherein the cathode is provided with flat emission surfaces confronting the slots in the grid.

11. In apparatus for the purpose described, a hollow metal walled resonator forming a vacuum chamber, a plurality of electron current generating systems in said resonator and arranged about a common central point, said systems including a plurality of spaced segmental outer electrodes in capacitative relation to the wall of the chamber, a plurality of other spaced segmental electrodes arranged in concentrically opposed relation to the first electrodes, the last electrodes being slotted opposite the centers of the first electrodes, and a single cathode common to the several systems and positioned at the common center of the segmental electrodes.

12. In apparatus for the purpose described, a hollow metal walled resonator forming a vacuum chamber, a plurality of electron current generating systems in said resonator and arranged about a common central point, said systems including a plurality of spaced segmental outer electrodes in capacitative relation to the wall of the chamber, a plurality of other spaced segmental electrodes arranged in concentrically opposed relation to the first electrodes, the last electrodes being slotted opposite the centers of the first electrodes, a single cathode common to the several systems and positioned at the common center of the segmental electrodes, and guide means for electron currents emanating from the cathode disposed between the cathode and the slots in the second mentioned electrodes.

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